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Research Report

Modernizing Demand-Responsive Transportation for the Age of New Mobility

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AARP Public Policy Institute

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AARP's Public Policy Institute (AARP PPI) informs and stimulates public debate on the issues we face as we age. Through research, analysis, and dialogue with the nation's leading experts, PPI promotes development of sound, creative policies to address our common need for economic security, health care, and quality of life. The views expressed herein are for information, debate, and discussion, and do not necessarily represent official policies of AARP.

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Executive Summary

THE NEED TO MODERNIZE DEMAND-RESPONSIVE TRANSPORTATION: BACKGROUND AND RATIONALE

America's inadequate demand-responsive transportation (DRT) infrastructure imposes a high cost on individuals, communities, the health care sector, and the economy. Demand-responsive services are transportation options that do not follow fixed routes or schedules; examples include dial-a-ride, Americans with Disabilities Act (ADA) complementary paratransit, taxis, app-based ride-hailing, ride sharing, car sharing, bike sharing, and other technology-enabled transportation. Many public transit systems in small towns and rural areas operate on a demand-responsive basis as do most human services transportation providers.

Demand-responsive services are critical for people who cannot drive or access regular public transportation, including people with disabilities; older people who are frail, ill, or have stopped driving; people with low incomes; and residents of rural areas. These services should be modernized to allow them to function as part of the emerging mobility ecosystem commonly called mobility-as-a-service (MaaS), in which users can personalize their trips and access via a smartphone or computer seamless, on-demand transportation. Until recently, the lack of adequate technology has been a major obstacle to this coordination.

This paper from AARP Public Policy Institute (AARP PPI) shows how a new data specification called the transactional data specification for demand-responsive transportation (TDS), published in 2019 by the National Academies of Sciences, Engineering, and Medicine's Transportation Research Board, addresses this need.

Photo credit: Mirjam Evers

EXPLAINING THE TRANSACTIONAL DATA SPECIFICATION FOR DEMAND RESPONSIVE TRANSPORTATION

This paper explains the terminology of data specifications, discusses the functionality and advantages of the new TDS, and offers case studies of how transportation providers have used data specifications in their systems.

Transportation providers that adopt the common data format provided by the TDS can seamlessly transfer and share data about requested trips within a network of providers, automate the task of assigning service and vehicles, and improve service coordination. Some data exchange is already taking place via other methods—but with limitations and challenges. The TDS makes interoperating easier, reduces complexity, lowers the cost of the process, and improves service to travelers.

Both *specification* and *standard* are terms that describe a common format for data exchange—a blueprint for how data should be formatted so that it can be shared by different providers. This sharing is the critical behind-the-scenes data communication that powers MaaS and the future of transportation. A specification becomes a standard when it is endorsed by an industry group, often through a formal process involving a working group. The hope is for the DRT industry to embrace the TDS, refine it as the industry implements pilot projects, and ultimately adopt it as an industry standard. This paper recommends several steps for achieving that goal. The challenge lies in the immediate moment: software companies are competitors within a highly siloed environment and fear that they may lose market share if all software products speak the same "language" and can therefore interoperate.

The paper explores FlexDanmark, a publicly owned IT company in Denmark with two decades of experience coordinating rides using a transactional data standard. FlexDanmark has overcome the challenge of anticompetitive practices through strong public-sector leadership. FlexDanmark manages approximately 6 million trips annually and is recognized for efficient service, streamlined data communications, and large-scale trip optimization across hundreds of private transportation providers and numerous software systems. This success is powered by optimal use of a transactional data standard. FlexDanmark is the exemplar, serving as a beacon for what could be achieved in the United States by embracing modern technology and market competition.

CASE STUDIES

This paper also provides case studies of US systems in various stages of adopting the new data specification:

- **The Denver Trip Exchange**. This case study examines how large human service transportation providers and the Denver Regional Transportation District created one of the nation's first technology-based models of coordinated service delivery, for which standardized data communications is a foundational element, and explains what other systems can learn from that process.
- **The Atlanta Regional Commission (ARC)** will create a transactional data exchange using the TDS between two community transportation providers, the Center for Pan Asian Community Services and Gwinnett County Transit.
- **Greater Minnesota MaaS Ecosystem.** The Office of Transit and Active Transportation at the Minnesota Department of Transportation received federal funding in 2020 to develop a regional MaaS platform as a pilot proof-of-concept for a potential statewide system. The TDS will likely undergird data sharing within this new platform.
- **Metropolitan Transportation Commission (MTC) Bay Area Complete Trip Deployment.** The MTC in San Francisco is seeking to improve service by integrating the TDS into the regional 511 San Francisco Bay Travel Info and Transit Data System.
- **ITNAmerica**. ITN recently began migrating its ITNRides software platform to SalesForce and including the TDS in the system architecture to streamline data sharing among ITNCountry communities.
- **A Proof of Concept in Rural Oregon**. Two nonprofits in rural Lake County, Oregon, are

the first transportation providers to commit to using the TDS. Funded by AARP, this pilot will demonstrate how the TDS can be integrated with Google Sheets, a cloud-based spreadsheet, to coordinate service without e-mails or phone calls.

RECOMMENDATIONS AND NEXT STEPS

Several important steps are needed to encourage and/or require wide-scale adoption of the TDS by DRT providers.

These steps include educating stakeholders; developing a robust and tailored communications strategy; supporting pilot and demonstration projects, including learning communities and evaluation; establishing a governance structure with an institutional host (several possible institutions are nominated); mandating uptake through federal legislation and rulemaking; developing procurement language and engaging industry groups to help systems require their software vendors to use the new specification; and ensuring adequate funding to encourage data sharing, discourage funding of small one-off technology pilots, and create a market for TDS-based systems.

The paper concludes with recommendations for key influencers and actors: Congress; the Federal Transit Administration; the Centers for Medicare & Medicaid Services; demand-responsive transportation providers (public and private, human services, and nonprofit); software developers and technology companies; technical assistance centers, membership organizations, and research organizations; and philanthropic and state and local government funders.

What Is Demand Responsive Transportation?

In DRT, a rider requests a trip at a certain time to a certain place. Unlike city buses or trains, demand responsive services do not follow fixed routes or schedules. Dial-a-ride, public transit in small towns and rural areas, Americans with Disabilities Act (ADA) complementary paratransit, taxis, app-based ride-hailing, ride sharing, car sharing, bike sharing, and other technology-enabled transportation are examples of DRT.

For people who are unable to drive or use regular public transportation, DRT can be a lifeline—the only way to get to crucial destinations such as jobs, medical appointments, or the grocery store. That is why the option is so important for people with disabilities, older nondrivers, and residents of rural areas.

Photo credit: Capacity Builders, Farmington, NM

Introduction

Transportation tomorrow will look very different than it does today, but already we can glimpse the changes ahead. We can easily pull up an app on our smartphones and see several travel options, schedule a ride-hail, or rent an electric scooter—and, often even pay for those trips. Many different actors are working hard to create opportunities for the traveling public to access a wide-ranging and coordinated package of transportation services.

Commonly called mobility-as-a-service (MaaS), these aspirational mobility ecosystems allow users to personalize their trips by tapping different forms of transportation through a smartphone or a computer. For example, after looking up the schedule, someone might hop on a neighborhood bus, transfer to the train, and then complete the last mile of the journey by scheduling a ride-hail trip or by unlocking a shared-use dockless bike or scooter. One app, one payment, one seamless trip will become the norm.

A key question is whether the profound changes taking place in the transportation sector will also be deployed to make it easier for those who have been traditionally underserved to get around, regardless of age, disability, income, or geographic location.

This paper aims to show how a new data specification—the transactional data specification for demand responsive transportation (TDS)—can be used to modernize demand responsive transportation (DRT) services so that they can interoperate with one another, with other mobility options, and with the new mobility platforms under development. Through this rather simple technological advancement, we can achieve a stronger and more equitable transportation system.

THE COST OF INADEQUATE TRANSPORTATION

Those who depend on DRT in America—including older nondrivers, people with disabilities, and

Photo credit: Mirjam Evers

residents of rural areas—face significant barriers because of its limitations. Riders may not be able to reach a regional destination because their transportation provider is unable to cross county boundaries. Their transportation provider may have funding for medical trips but not for rides to visit friends. Medical appointments may be missed because of late-arriving buses. Patients may find themselves stranded after a dialysis appointment that ran long. Riders are rarely able to travel spontaneously because a 24- to 48-hour advance reservation is often required.

America's inadequate DRT infrastructure imposes a high cost to individuals, families, the health care sector, and the economy. Transportation is the glue that connects people to friends, jobs, and doctors' appointments, and it enables them to shop and otherwise participate in the economic and social life of their communities. Those without adequate transportation options are at a serious disadvantage.

Transportation barriers can be a particular problem for older people of color. More than one-third of Americans ages 65 and older and of Asian and Hispanic origin do not drive. Nearly one-third of Black elders are nondrivers. By comparison, nearly 9 in 10 White individuals of the same age do drive.[1]

Poor transportation options also exacerbate social isolation—another serious issue for older adults. One-third of adults ages 75 and older do not leave home on a given day.[2] Thirty-five percent of women ages 75 and older do not drive.[3] The health effects of social isolation cost Medicare $6.7 billion annually.[4]

Missed medical appointments constitute another related challenge. In 2017, 5.8 million people in the United States delayed medical care because they did not have transportation.[5] Missed appointments cost the health care sector $150 billion annually.[6]

Transportation barriers to health care have a disproportionate impact on patients who are poor and have chronic conditions. An analysis of the National Health Interview Survey found that, even though Medicaid provides a mandatory nonemergency medical transportation benefit, Medicaid beneficiaries were still more likely to report encountering a transportation barrier. The researchers also found that those who reported having appointments delayed by transportation were also more likely to report multiple visits to an emergency room for care; this undoubtedly translates into higher health care costs.[7]

EFFORTS TO ADDRESS FRAGMENTED SERVICES ARE INSUFFICIENT

Fragmentation of DRT services is as much to blame as insufficient funding. There may be a dozen or more human services and other providers of door-to-door transportation in a given region, but each may operate in a silo, leading to both duplicative services and denials of trip requests.

Transportation coordination efforts to date have been stymied by existing technology.

Another common problem is lack of awareness. Residents may simply not know about transportation services available in their community, and patients may be unaware of transportation benefits available through their insurance provider—either Medicaid or a private payer. The dually eligible, those who qualify for both Medicare and Medicaid, may face the greatest barriers. Traditional Medicare fee-for-service plans do not cover transportation costs, but far too often, providers caring for dually eligible individuals are not aware of—or do not help patients coordinate—the medical transportation benefit they might be eligible to receive through Medicaid. This is a serious problem, because access to the doctor, prescriptions, and long-term supports for community living are critical; being dually eligible is the single most powerful predictor of poor health outcomes;[8] and inadequate transportation is cited as the third-largest barrier to accessing health care.[9]

The transportation sector has worked for decades to try to address these problems. In 2004, President George W. Bush signed Executive Order 13330 establishing the interagency Coordinating Council on Access and Mobility (CCAM). The

CCAM is charged with organizing efforts among the federal agencies that fund transportation services for targeted populations. This is no easy task, considering that there are 130 unique federal programs under 9 separate agencies that can fund transportation for people with disabilities, older adults, and low-income individuals.[10]

In 2007, the Federal Transit Administration (FTA) began to require its grant recipients to prepare "coordinated plans" with input from older adults; individuals with disabilities; and representatives of public, private, and nonprofit transportation and human services providers.[11] These plans must be approved by local policy makers before transportation funding for older adults and people with disabilities can be disbursed.

More recently, FTA established the National Center for Mobility Management (NCMM) to provide technical assistance to support mobility managers—professionals whose job is to help communities and individuals create and manage mobility options. NCMM offers numerous publications and resources on transportation coordination.

Transportation coordination efforts to date have resulted in better information sharing among regional actors, including the establishment of one-call/one-click transportation centers where customers can find all their mobility options in one place, and, in a few cases, the comingling of multiple agencies' customers to take advantage of excess capacity in vehicles.

Still, technology—or the lack thereof—has continued to be a major obstacle to providing better-coordinated DRT. When different transportation providers use different scheduling software, their systems do not readily interoperate with one another, meaning that they cannot exchange the information about vehicle capacity, schedules, or routes that is needed to plan and deliver trips that occur in the same service environment. The TDS—that is now available and that is the focus of this paper—would enable these systems to perform as one integrated network.

The Transactional Data Specification

Although data specifications and standards are not new to many transportation-sector professionals, they may be unfamiliar to some DRT stakeholders. Here's what one needs to know about data specifications and standards—and why they're so important.

DEFINING TERMS: DATA SPECIFICATIONS AND DATA STANDARDS

To software developers, the terms *specification* and *standard* describe a common format for data exchange. A data specification or standard can be thought of as a blueprint for how data should be formatted. A specification becomes a standard when it is endorsed by an industry group that will use it. To keep it relevant, it must be sufficiently used by enough industry players to have established some level of formal organization behind it. Standards are often established by a neutral third party through a formal process involving a working group.

A data specification is not software; rather, a specification is a clearly defined format that allows software to interpret and act on information. When all providers in a network agree to use a specification, their software systems can use the data without the need for special software conversions or for staff to manually send information via e-mail, fax, or phone.

EXAMPLES OF OTHER DATA SPECIFICATIONS AND STANDARDS

Data standards are used in many industries to facilitate electronic communication and data sharing among vendors. In the public transit sphere, for example, the General Transit Feed Specification (GTFS) defines the format for public transportation data. When public transit agencies publish their route and schedule data in this format, the information can be easily used by Google Maps and other trip planners. The GTFS-Flex is an extension of the GTFS that allows customers to view their DRT options.

Similarly, every airline today uses Passenger Name Records (PNRs), which are defined by data specifications. Using PNRs allows airlines to share a booking among themselves (as in the case of two legs of a flight provided by two different airlines), with online travel agencies such as Expedia or Orbitz, and, more recently, with hotels and rental car companies.

> *When all providers in a network agree to use a specification, their software systems can exchange trip data without the need for staff to manually send information via e-mail, fax, or phone.*

A data specification allows the computer systems of different providers to communicate directly with one another. It provides a framework for every step of data exchange and storage by defining how the data are packaged and moved. A data specification needs to have clear elements, definitions, and formatting rules to create data in a form that all can use.

UNDERSTANDING TRANSACTIONAL DATA

DRT produces two types of data: discovery data and transactional data. Discovery data are the information made available to potential customers so they may "discover" their travel options. For instance, trip-planning apps that consume the GTFS or GTFS-Flex specification enable customers to "discover" information about the next bus or train. But neither GTFS nor GTFS-Flex allow customers to *schedule* a trip.

Transactional data are the information that needs to be exchanged so the customer can book and pay for a ride on a demand-responsive service, and for DRT providers to schedule and complete the trip. As with airline booking platforms, this data exchange enables DRT providers to conduct "transactions" for the customer.

WHAT'S NEW: A TRANSACTIONAL DATA SPECIFICATION FOR DEMAND RESPONSIVE TRANSPORTATION

In 2019, in response to the challenges of coordinating DRT, the National Academies of Sciences, Engineering, and Medicine's Transportation Research Board (TRB) published *Development of Transactional Data Specifications for Demand-Responsive Transportation*.[12] The TDS can be used by transportation providers to seamlessly transfer and share data about a trip among a network of providers. Coordination is possible when all players agree to exchange data about each trip in a common data format, automating the task of assigning a customer to a service and vehicle.

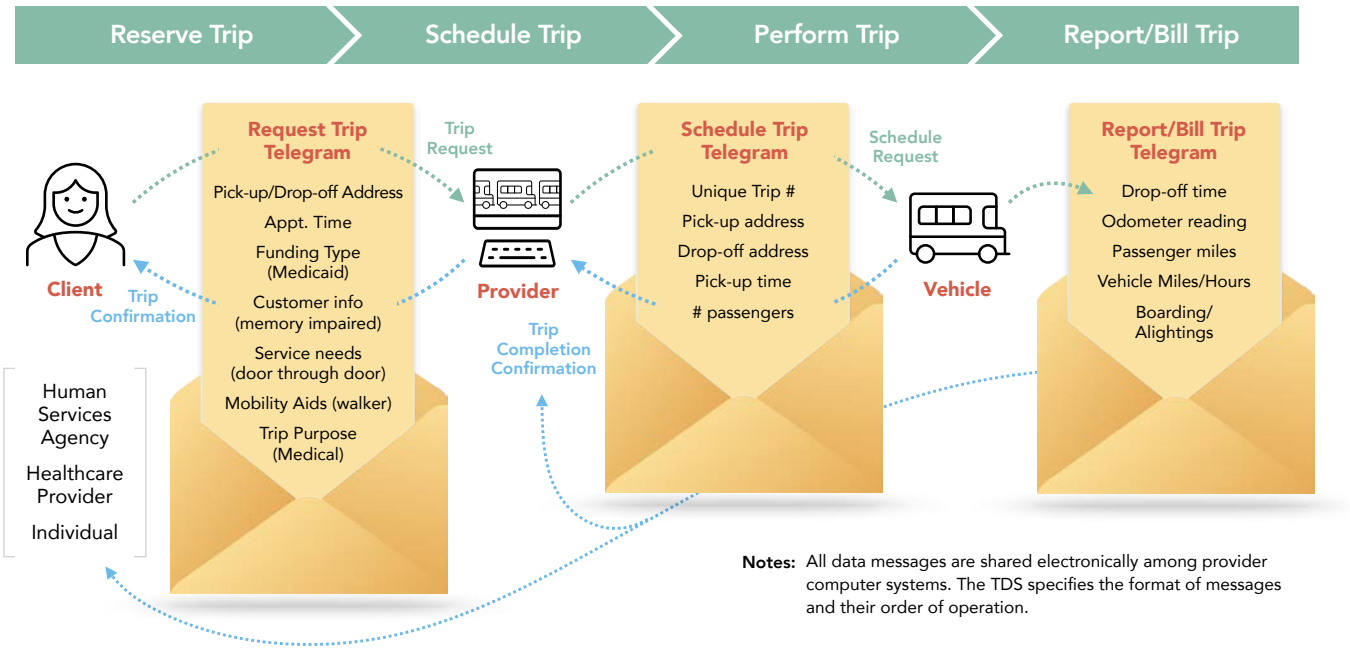
COMMON MISCONCEPTIONS ABOUT DATA SPECIFICATIONS AND APIs

An application programming interface (API) is a software intermediary that allows two applications to "talk" to each other. It is made up of a set of specifications used to describe communication between two computer systems or applications. The specifications cover a wide range of needs, including transmission, encryption, user authentication, and data formatting. Data specifications come into play to ensure that the information can be understood once it is delivered from one system to another through the Internet.

This paper is concerned with web APIs, which rely on Internet-based standards. Web APIs are ubiquitous in modern life for the transmission of information. Think of the share icon on a website that allows an individual to share an article on social media. Think of trip-planning apps that compare likely trip durations for an Uber versus a bus.

The Uber case is an example of an API that is "open," in the sense that documentation for

DRT Trip Cycle Supported by TDS



Notes: All data messages are shared electronically among provider computer systems. The TDS specifies the format of messages and their order of operation.

Source: AARP Public Policy Institute

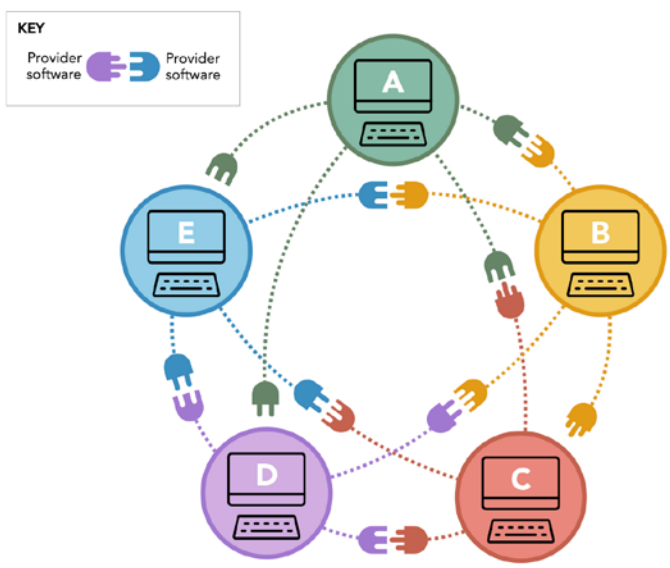
how it works is publicly available, but "closed" (i.e., proprietary) in the sense that Lyft or other transportation providers cannot use it to present their own services. Anyone interested in accessing the services of multiple ride-hailing services (like Uber or Lyft) would need to design their system to work with each and every API involved.

The TDS results in an API that is open in the fullest sense. With the data specification in place, it would not be necessary for another provider's software to directly use proprietary APIs to exchange data messages between and among providers; however, a vendor may still opt to maintain its own unique API to maintain compatibility with its internal databases.

DATA TRANSLATORS

In the absence of a single data specification, any two agencies that use different systems but wish to share data must convert those data via data translators. Translators transform the unique format used by one vendor into a format that can be used by another vendor.

This solution is not easy or sufficient in many situations. It is not transferrable and may need adjustment any time either software application goes through an upgrade. If a third provider wishes to join the network and uses a third vendor, two translators will need to be written so that provider C can exchange data with both provider A and provider B, and so forth. A single metropolitan area that wishes to coordinate its DRT offerings might have as many as 50 unique providers using many different software systems. If they all wish to exchange data, a large number of translators would be needed, each at significant cost.

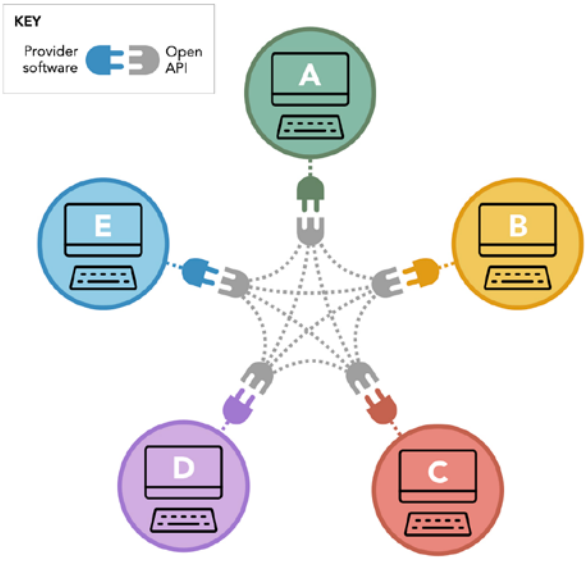


Interoperability Using Proprietary APIs: The Expensive Approach

With proprietary APIs, each provider needs to program its software to be compatible with four different message formats and maintain its own API.

Whenever a software update is made, every provider needs to update its software to accommodate it.

Each plug in the network costs thousands of dollars to develop and maintain, making interoperability with proprietary APIs an expensive proposition.



Interoperability Using the TDS: The Cost-effective Approach

With the TDS, an open API, providers need only program their software to exchange data using one set of message formats.

If software updates are made compatible with the TDS, interoperability with all providers is maintained. Those other providers need not take any action.

Source: AARP Public Policy Institute

Translators do not easily accommodate real-time data exchange, nor do they offer the durability of a data standard. Relying on them raises the cost of interoperability significantly, both initially and over time. Overall, translators are brittle technology that scale poorly.

Depending on myriad translators also places a great deal of control in the hands of software vendors. The more streamlined approach would be for software vendors to embed the transactional data specification for demand-responsive transportation into their software applications.

VENDOR LOCK

Depending on translators also places a great deal of control in the hands of software vendors, some of which may seek their own profit by encouraging providers to switch vendors rather than supporting interoperability with a competitor. Vendors may also reduce or withdraw support for translators arbitrarily or without advance notice.[13] Providers can become overly reliant on a single vendor in a relationship sometimes referred to as "vendor lock."

The more streamlined approach would be for all transportation providers in a network to agree to interoperate via a standardized way to exchange uniform data. In other words, they would all agree to work with their software vendors to embed the TDS into their software applications.

In its current form, the TDS defines a core set of standardized trip data. Translation to an individual vendor's data structure is still needed, but over time, as more data follow agreed-upon standards, the level of effort required to support the specification will decrease. For example, the data specification today enables a trip to be scheduled and completed; in the future, the specification could also define the data format and procedures for trip payment.

When all entities use the same format for exchanging data, data mapping or translation needs to be done only once per vendor system. Using a specification or standard for data exchange can improve data quality and compatibility. It can reduce redundancy, time, and effort spent on reconciliation, the number of iterations, manual interventions, exception flows, and corrections. Last but not least, using the TDS would reduce the complexity and the cost of the information exchange.

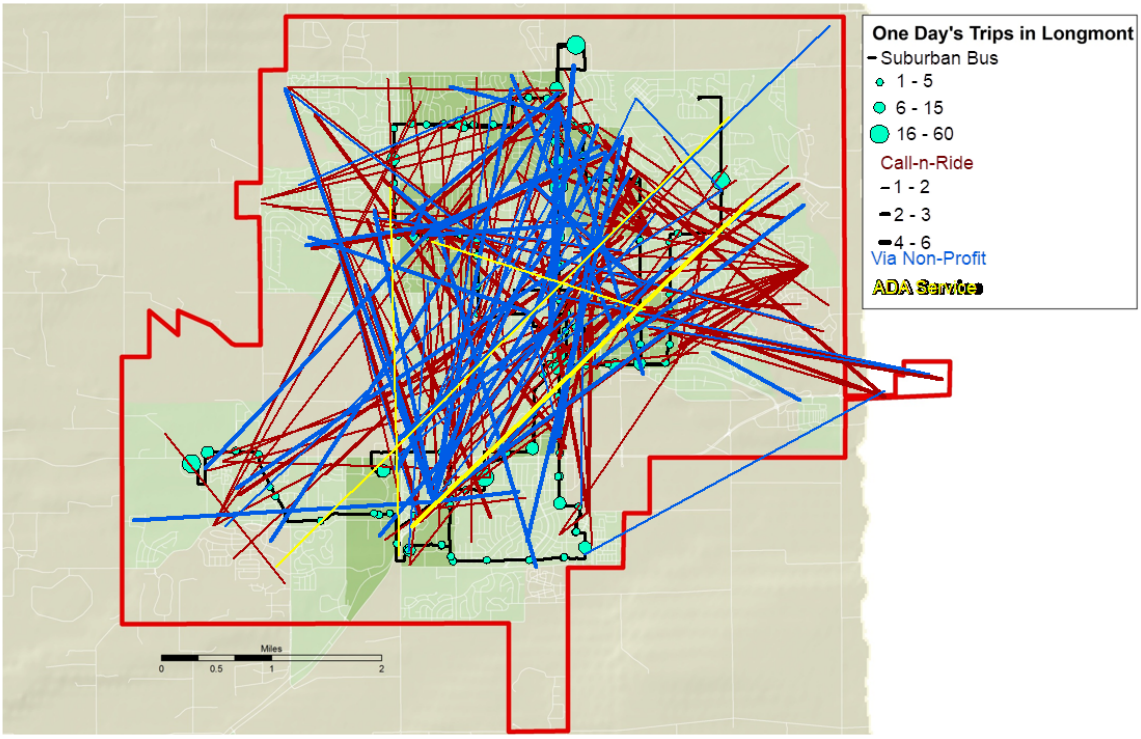
Evolution of the Denver Automated Trip Exchange

For the past decade, public and private nonprofit transportation organizations in Denver that provide service to people with enhanced mobility needs have worked to transform a goal of "coordination" into the provision of *additional* transportation for clients. The Trip Exchange model that emerged from this multiyear, multiphase process has been implemented with a technology platform that enables data interoperability among service providers and operational services beginning in October 2020. Denver's experience offers insights into the institutional and technology groundwork needed to establish a coordinated transportation model in the United States, the important role of transactional data specifications, and the challenges that can arise.

EARLY WINS IN THE EVOLUTIONARY APPROACH TO TECHNOLOGY-ENABLED COORDINATED TRANSPORTATION

The Denver Regional Transportation District (RTD) and a large, private nonprofit transportation provider, Via Mobility Services (Via), created one of the nation's first coordinated

Duplicative Services Highlight the Need for Coordination



Source: Courtesy of Denver Regional Transportation District

The lines on this map show the substantial duplication of DRT service in the city of Longmont.

service delivery models in 2011 in the city of Longmont. Both organizations provided DRT service in Longmont. Recognizing that their services overlapped substantially, RTD and Via developed the Longmont Coordination System (LCS) to enable capacity sharing. Via vehicles and drivers could transport RTD passengers during the midday period when they would otherwise be underutilized, and RTD transported Via passengers who did not need special assistance when Via lacked capacity. The figure below shows the overlap between RTD (red lines) and Via trips (blue lines) in Longmont.

The resulting software solution enabled the partners' DRT technology systems (RTD: DemandTrans Solutions' MobilityDR; Via: RouteMatch) to exchange trip request data every few minutes using a standardized data protocol. Either system, based on internal rules and service capacity, could "push" a trip request to the other.

"RTD and partners could have done in weeks what took years had there been a data standard in place," Roger Teal, President, DemandTrans and technical consultant to the Denver Trip Exchange project

The receiving system would schedule the trip onto a vehicle it controlled—assuming capacity was available—and would return the trip scheduling information (e.g., pickup time, vehicle ID) to the originating system. By rearranging vehicle tours and swapping trips, the coordination scheme made better use of available seats on RTD and Via vehicles. As a result, fewer customers had trip requests denied and ridership increased.

However, the Longmont coordination system had significant limitations, including incomplete automation capabilities. In 2015, a broader group of organizations—the City and County of Broomfield and the Seniors' Resource Center, along with RTD and Via—successfully applied for a federal Mobility Services for All Americans (MSAA) grant to create an automated Trip Exchange for the northwestern Denver region. The project area included Jefferson, Broomfield, and Boulder Counties and the city of Longmont. Both Seniors' Resource Center and Broomfield serve adults ages 60 and older and individuals with qualifying disabilities.

HOW THE AUTOMATED TRIP EXCHANGE MODEL WORKS

The resulting automated Trip Exchange enables participating organizations to create and claim trip requests; report results (e.g., trip duration, pickup time, etc.); and view ticket status (e.g., withdrawn, expired, or completed).[14]

The process generally works as follows:

1. A DRT provider receives a customer trip request that it cannot complete. The provider posts the request to the Trip Exchange through a structured data message known as a trip ticket. The provider specifies how much it is willing to pay for the trip (accomplished via a pricing formula, but prices can be changed manually after the trip ticket has been posted in the Exchange).
2. The Trip Exchange makes the ticket visible to providers identified as potential matches (e.g., by geographic service area) and enables them to claim the ticket. Providers' systems query the Trip Exchange frequently, such as every two minutes.
3. Providers with visibility to the trip ticket can choose to claim the trip, which causes the Exchange to import the trip ticket into their software platform.
4. Prior to claiming a trip, a provider would determine if the trip can be scheduled onto one of its vehicles and at what cost.
5. Trip-ticket claiming can be done through the Trip Exchange user interface—which enables users to see a list of trips, with key details, that are available for claiming—or via automated mechanisms in the provider's software system that claim the trip directly.
6. Each provider can program its own system to claim trips based on criteria specific to its mission and operating objectives; the Trip Exchange merely executes its requests.

7. The system assigns the ticket to the provider that can perform the trip at the lowest cost; providers can manually change their costs via the user interface to the Exchange.
8. Once the trip has been completed, the provider ("claimant") sends the result back to the Trip Exchange via an execution ticket.

Participants control when and whether to post and claim tickets. The Trip Exchange is a decentralized system allowing individual providers to retain their own methods of booking and scheduling trips. External software systems can automatically claim trips; use of the application's user interface for viewing and claiming trip tickets is entirely optional. Fully automated use of the Exchange's capabilities is dependent on the functional capabilities of the external DRT software application.

BOTH TECHNOLOGICAL AND NON-TECHNOLOGICAL SYSTEMS ARE IMPORTANT

Due to MSAA grant restrictions, the Trip Exchange software could not be used for actual operations during that project, but it was tested in production-like settings and demonstrated to be of operational quality. This was a significant accomplishment, as it meant that a workable software platform existed that the region could use. Moreover, because the software was developed with public funds, its source code is publicly available and cannot be copyrighted for commercial use or made proprietary.

The Trip Exchange software was only one of two key project accomplishments. The other was the development of an institutional framework for transportation coordination in the Denver region. The agencies participating in the MSAA project—and the two software companies—forged strong working relationships and a collective set of objectives for the evolution of human services transportation. Working across organizational boundaries to achieve collective capabilities became accepted practice. Participants shaped the functionality of technology systems to enable the coordination of resources.

To achieve this level of coordination, the partners had to overcome numerous challenges, some of which were not technology-related: aligning

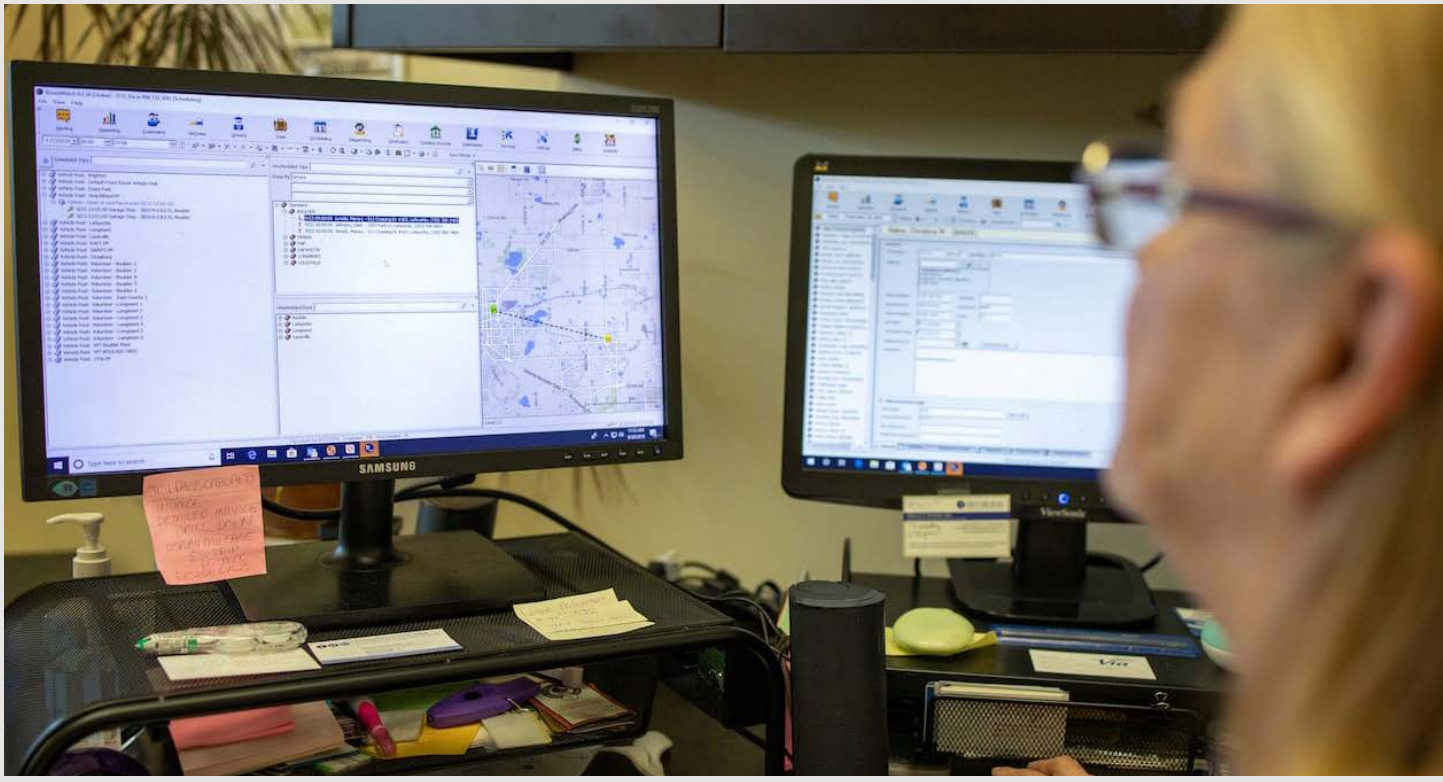


Photo credit: National Aging and Disability Transportation Center

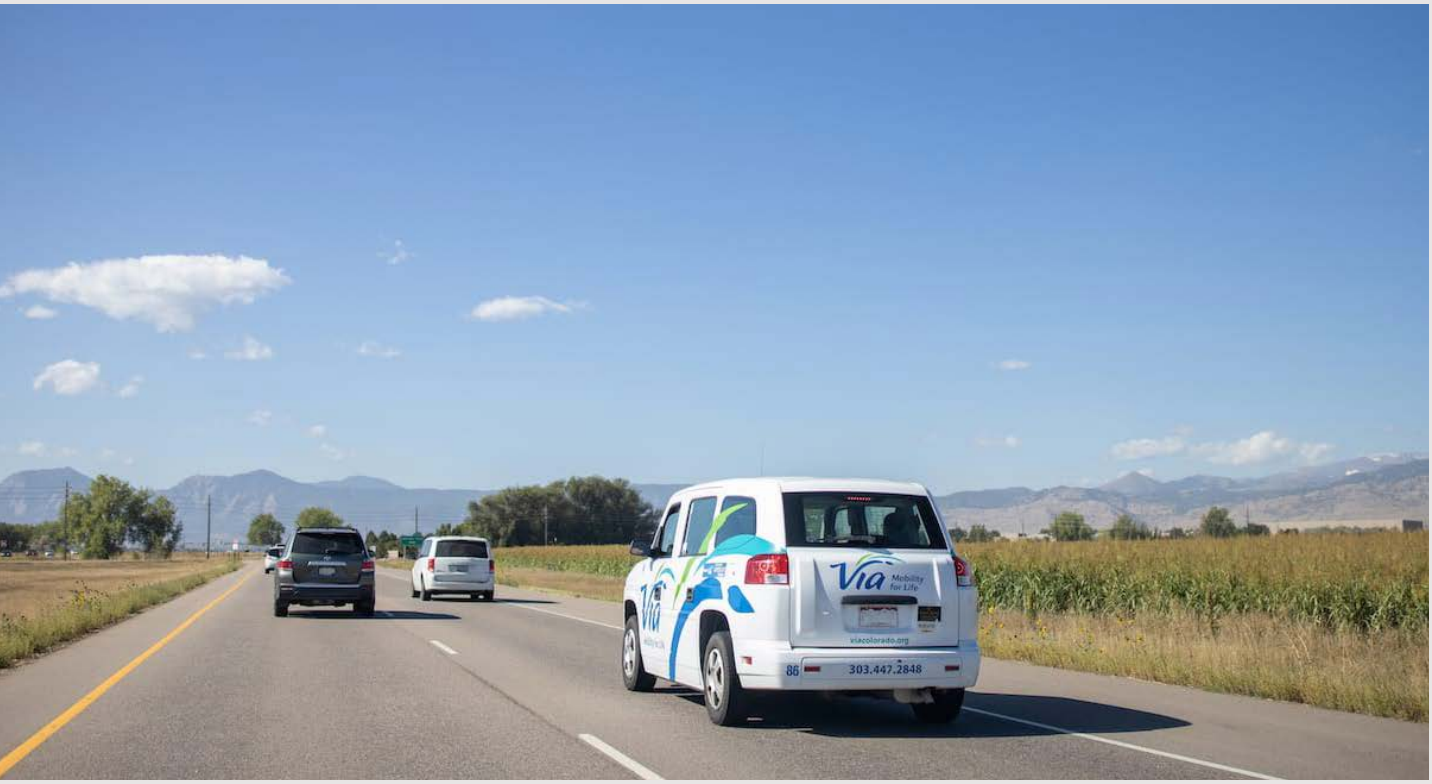


Photo credit: National Aging and Disability Transportation Center

service area boundaries, installing seatbelts on all vehicles, and bringing all providers up to the same level of service (door-to-door rather than curb-to-curb).[15] To facilitate accurate reimbursement and ensure accountability, agreements were negotiated to address differing fares, eligibility categories, and funding sources. Trip messages had to include customer profiles to capture the need for mobility aids (e.g., a wheelchair), the need for assistance to/from the building entrance, which building entrance should be used, and whether the rider would be accompanied by an escort or service animal. This information must be collected and stored within the system to ensure vehicle manifests reflect sufficient time for boarding.

FURTHER EVOLUTION OF THE TRIP EXCHANGE SOFTWARE SYSTEM: THE RIDE ALLIANCE PROGRAM

As noted previously, the Trip Exchange software was not placed into production use during the MSAA project. Fortunately, the Denver region received a second large federal grant and created the Ride Alliance. Ride Alliance partners include the City and County of Broomfield, Douglas County, the Denver Regional Mobility & Access Council (DRMAC), the Denver Regional Council of Governments (DRCOG), the Seniors' Resource Center, RTD and Via. Between 2018 and 2020, the administrator of that grant, DRCOG, decided to spend substantial funds to implement the Trip Exchange model in the region. This included software improvements that would allow semi-automated pricing of trips and a variety of new capabilities for filtering trip tickets and reporting on activities within the Exchange. It now supports price negotiations and generates reports on trip posting and claiming activities and financial settlements associated with trip claims.

In addition, DRCOG purchased RouteMatch software so it could be the "front end" for individuals with mobility needs who did not have agency affiliations, and for human service agencies that did not have transportation programs but whose clients needed transportation. This enabled DRCOG to become another "node" on the Trip Exchange that could create trip tickets.

COORDINATION CHALLENGES: A ROLE FOR DATA STANDARDIZATION

Denver has forged a path toward integration that can inform the work of other communities interested in improving coordination and service. After years of careful work and cooperation, the Trip Exchange partners have crafted a framework that can accommodate for-profit, nonprofit, and volunteer services, and they are hoping that more of the region's DRT providers will join the network.

The Trip Exchange is designed to rely solely on its own transactional data specifications and API functionality to exchange trip information among providers. Nonetheless, RouteMatch postponed its API integration until a software update scheduled for late 2021, opting to rely on a communication approach that requires translation software to inter-operate between CSV file formats and the API data structures of the Trip Exchange itself. This process is more complicated and less desirable; considerable time and resources have been devoted to making it work properly. This provides evidence for the need to get all players fully onboard and the role of strong public-sector leadership to promote buy-in. The Trip Exchange coordinators expect that all future connections by DRT provider software systems will be done through APIs.

Now that a common format for data exchange has been established, developers for the region's other DRT providers will need to program the integration only once to allow their software to send and receive messages based on the Trip Exchange's data specification. Any vendor that updates software to send and receive messages based on that data specification can share trips with other providers in the system. The more DRT providers with specification-compatible scheduling software, the bigger the benefit the region will get from its investment in DRT services.

When RTD and partners began, there was no well-defined pathway for integration. Roger Teal, a technical consultant to the project, voiced that RTD and partners "could have done in weeks what took years, had there been a data standard in place."

The Denver model shows what commitment and cooperation can achieve in strengthening DRT options. It also shows how important data specifications are in this process, and the real-world challenges of getting all key software players aligned with data specifications and a common data communication approach.

European View: FlexDanmark and the Scandinavian SUTI Standard

Denmark offers a global model for truly coordinated DRT service and optimal use of a transactional data standard. Obligated by law to provide transportation, Danish governmental entities wish to give their constituents additional high-quality services. FlexDanmark, a nationwide technology company owned by five Danish regional public transportation authorities, was created to address inefficiencies in DRT delivery. It accomplishes this by integrating more than 550 unique private transportation providers into a single system that serves both urban and rural customers throughout Denmark.

FlexDanmark manages an average of 16,500 daily trips (approximately 6 million trips annually) and is recognized for efficient and customer-satisfying service. FlexDanmark exists because

Photo credit: Mirjam Evers

The FlexPatient bus intercepts smaller buses and passenger vehicles to take residents who live outside cities to their regional hospital appointments.

Photo credit: Mirjam Evers

FlexTrafik personnel ensure that the buses run smoothly, payors are properly billed, and services coordinated.

municipalities and regional governments are willing to pay for high quality transportation services for their constituents. The result is large-scale trip optimization across many providers and software systems, facilitated by streamlined specification-based communications.[16]

HISTORY OF FLEXDANMARK

FlexDanmark began in 1997 when two regional public transportation authorities joined forces; over a 10-year period, all five Danish regional public transportation authorities joined FlexDanmark.

Factors that drove creation of FlexDanmark included rising costs, system inefficiencies, an aging population, and growing demand for services. Previously, authorities had fulfilled their federal mandate to provide medical transportation to qualifying citizens by using private taxis, while each municipality separately arranged transportation for people with disabilities. These factors, combined with inefficiencies of rural services, meant that the cost of this approach was unsustainable.

LEGISLATIVE BACKGROUND

FlexDanmark developed from the ground up, without specific legislation or a requirement to use a data standard, but its institutional structure was influenced by two major pieces of Danish legislation and new public management principles taking hold in Europe.

The Structural Reform Act of 2007 addressed the economic competitiveness of Denmark's welfare state and has been described as "the most important reform for a generation by the government."[17] It sought to reduce duplication of services by establishing clear responsibility among government bodies, and it streamlined government, abolishing Denmark's 14 counties, creating 5 regional governments, and consolidating 271 municipalities into 98 larger units.

The second notable piece of legislation is the 2007 Law for Public Transportation, which established a network of regional public transportation authorities (PTAs). Each PTA is tasked with planning, financing, and managing fixed-route public bus and some regional rail services, including fares and ticketing.

Photo credit: Mirjam Evers

Both municipalities and regional governments have transportation obligations under national law; both *must* meet their statutory obligations for the provision of fixed-route public transportation through their PTA. Municipalities *must* use FlexDanmark to deliver DRT to their residents with qualifying disabilities. Regional governments *may* opt to use FlexDanmark's services to meet their nonemergency medical transportation obligations. Both municipal and regional government *may* fund additional FlexDanmark service for their constituents.

In 2012, FlexDanmark became an independent company governed and publicly owned by five of Denmark's six PTAs.

HOW FLEXDANMARK WORKS: FLEXTRAFIK SERVICES

The FlexTrafik services platform houses several fully integrated FlexDanmark functions. Four of the five PTAs have their own call centers, which are integrated through a national central dispatch system. The fifth is the Copenhagen call center, which operates 24 hours a day and covers calls from the other four centers when they are closed. FlexDanmark manages the shared IT department. Travelers schedule rides online or through a call center, but requests can also be made through any number of remote online ordering modules used by many different authorities. For example, hospitals, medical offices, and human services agencies easily connect their clients via the FlexDanmark portal. Medical transportation is free to customers and nonmedical trips are reduced fare.

FlexDanmark's services are sub-branded under the FlexTrafik suite, however, all services are comingled regardless of target market. As such, customers receiving subsidies from different payers and programs will share the same FlexTrafik vehicles. The suite of services includes:

- **FlexPatient** provides free transportation from home to hospital for patients who cannot use regular public transportation because of illness, disability, frailty, or lack of adequate rural transit service. Guaranteed by national law and paid for by the regional government, these subsidized trips are available 24 hour a day and accounted for about 25 percent of all FlexTrafik trips in 2019.
- **FlexHandicap** serves individuals with severe mobility impairment, disability, or frailty. Danish municipalities are required by federal law to provide 104 one-way social, religious, or leisure trips per year to these citizens at an out-of-pocket cost no higher than the

cost of public transportation. Guaranteed by national law and paid for by the municipal government, these subsidized trips are available 24 hour a day and made up about 15 percent of all FlexTrafik trips in 2019.

Municipalities have the option of subsidizing other services within the FlexTrafik platform as well. For example:

- **FlexMunicipality** is transportation to preventive medical care, including dental and rehabilitation appointments and is an obligation of municipalities per national law. About half of municipalities meet this obligation by contracting with FlexDanmark. FlexMunicipality trips are available 24 hour a day and made up about 50 percent of all FlexTrafik trips in 2019.
- **PlusTur** is FlexDanmark's first/last-mile service to public transportation stations. Similar to PlusTur, **FlexTur** allows any citizen to arrange demand responsive public transportation. More than half of Danish municipalities invest in FlexTur and PlusTur, which are available from 6 a.m. to 11 p.m. Riders share the cost of transportation with their sponsoring municipality.

Transportation funding in Denmark differs distinctly from the US approach. Municipalities can levy taxes; regional governments cannot. Regions are funded by the state (national government) and, to a lesser extent, municipalities. Health care, including nonemergency medical transportation to regional hospitals, accounts for roughly 90 percent of regional government budgets. PTAs cannot levy taxes but do generate fare revenue. They also receive reimbursement from municipalities and regional governments for services rendered on their behalf, such as the provision of fixed-route and demand responsive public transportation.

SUTI: THE DATA STANDARD THAT SUPPORTS FLEXDANMARK

FlexDanmark's scheduling system uses the SUTI (Standardiserat Utbyte av Trafik Information) data standard. Originally developed in Sweden, the SUTI standard allows data exchange across multiple providers and platforms. A huge volume of exchangeable data, including recurring trips, individual trip requests made in advance, and real-time trips, can be managed by SUTI-compliant software applications.

When a trip is requested, the system selects a vehicle, and the dispatch system automatically places the trip request on the driver's electronic manifest, which is directly connected to the FlexTrafik scheduling system through the SUTI data standard. The system matches customers to drivers in real time, so a driver knows only the next passenger to be picked up.

Service delivery in Denmark is more market oriented than that in the United States

The system is dynamic, constantly optimizing routes and changing vehicle assignments as trips are added or canceled. Unless there is an emergency, delay, or other disruption, drivers do not exchange e-mail or text messages with their dispatch center or with FlexDanmark personnel.

FlexDanmark has taken an active role in investing in and institutionalizing the SUTI standard. SUTI is baked into FlexDanmark's procurement process, and all 550 transportation providers are required to have the necessary technology in place to exchange automated messages between FlexDanmark's traffic operations system and their own vehicles. Each provider may choose its in-vehicle hardware, provided that it integrates the SUTI standard using one of eight technology vendors approved by FlexDanmark. The open data standard is made available at no cost to providers and software vendors.

FlexDanmark requires approved technology vendors to meet high standards. Vendors must guarantee their systems will be operational for 99.9 percent of FlexDanmark's operating hours. If a system breakdown occurs during this period, the technology company must have personnel available to troubleshoot with FlexDanmark's traffic operations center staff by phone within 15 minutes.

HOW FLEXDANMARK USES TECHNOLOGY TO CONTROL COSTS

FlexDanmark constantly orchestrates vehicles for optimal service. When a ride request comes in, the IT system scans all available vehicles and then uses algorithms to match the customer to the most cost-effective vehicle, prioritizing the filling of "pre-paid" seats. Vehicle selection is based on the lowest generalized costs, considering factors such as

- Vehicle operating costs (as established in procurement contracts);
- Company quality rating;
- Vehicle proximity to the rider;
- Arrival and departure time requirements;
- Service level (e.g., customer's wait and travel time);
- Customer needs (e.g, wheelchair-accessible vehicle);
- Time of day; and
- Rush-hour traffic.

"When you have an obligation to [provide] a service, there will always be a tendency that the private market or the public sector will be a monopoly," notes Dorthe Nohr Pedersen, CEO of Movia, one of FlexDanmark's five Public Transportation Authorities. "When you have a monopoly, . . . you usually see prices going up and services fail to meet the standards. . . . We have good competition."

Customer convenience is balanced with the service level for which subsidizing agencies are willing to pay. For instance, a nurse placing a trip order on behalf of a dialysis patient may request that the patient ride alone on the return trip. FlexDanmark bills the hospital more for this individualized service, but the trip satisfies the medical needs of the patient. The system also ensures that larger, wheelchair-accessible vehicles are largely used only as needed. The majority of rides are shared and/or sequential, significantly reducing the cost of "deadhead" miles (when the vehicle is traveling without a paying passenger).

Time is also accounted for in the system's scheduling algorithm—this might be the amount of time required to load passengers and his or her equipment or to wheel a passenger from a particular parking area to a particular doctor's office within a hospital ward. The IT system databases contain rider profiles, characteristics of each vehicle, and even the layout of each hospital to minimize walk time. PTA staff is responsible for continually updating these databases.

GOOD ACCOUNTING AND INVOICING SYSTEMS GENERATE PAYER CONFIDENCE

Two of FlexDanmark's most important features are proper accounting and accurate billing for every trip. FlexDanmark's vendor management system is transparent and reduces administrative costs because it handles all back-office payment functions—no small feat given more than 500 different payers, 27 laws governing transportation service provision, 5 regional governments responsible for health insurance, and nearly 100 municipalities.

The process uses reverse invoicing, meaning that the system generates instructions to pay vendors automatically and directly, without the vendor being required to create an invoice. This is possible because FlexDanmark time- and geo-stamps each pickup and drop-off location, so it knows the travel time, distance, and which vendor provided each ride.

Expenses are distributed after the trip, and FlexDanmark sends invoices monthly to the various payers, accounting for services received, subsidies for each rider, and any portion of the trip shared with other passengers. Every payer pays the same for equivalent service. This transparency, backed up by detailed records generated through the technology platform, provides payers with the confidence that they are paying their fair share and nothing more.

COMPETITIVE CONTRACTING AND COMPARISONS TO THE UNITED STATES

Denmark's coordinated approach to DRT offers for the United States many lessons that should appeal to fiscal conservatives and progressives alike. Although the Danish welfare state model provides free or highly subsidized transportation services for large numbers of transportation-disadvantaged individuals, FlexDanmark reins in costs in a manner that is actually more competitive and market oriented than that in the United States. It does this through a competitive procurement process and through efficient service delivery. In fact, a study by Deloitte found that, even with increased administrative costs, Danish municipalities participating in FlexDanmark save about 10 to 15 percent of their annual operating costs.[18]

Since 2007, Denmark has been a European front-runner in applying New Public Management (NPM) reforms to its transportation system. NPM reforms call for market competition, the use of performance measures, unbundling the public sector into corporatized units, and private-sector styles of management.[19] Today, FlexDanmark contracts are awarded to private-sector service providers through an annual competitive procurement—essentially an auction—managed regionally by the five public transit authorities.

Authorities choose vendors based on price and commitment to availability and vehicle mix; they then negotiate the number of dedicated vehicles needed by day of week, time of day, and wheelchair accessibility. Some companies guarantee minimum availability in exchange for an assured level of payment; others offer vehicle availability only during off-peak hours, when the demand for market-rate trips drops.

Once contracts are written, drivers are not allowed to refuse trips without good cause. This procurement process gives FlexDanmark access to approximately 1,700 vehicles, albeit not all at the same time.

Another striking difference between Denmark and the United States is the sheer number of private transportation providers utilized by FlexDanmark. Although some American transportation brokerage systems tap several public and private providers, none integrates providers via technology the way FlexDanmark does.

The Danish system is also business-friendly. Sole-source contracts with individual transportation providers and software vendors are common in the United States, but FlexDanmark's use of the SUTI data standard and precertified technology solutions has lowered the market-entry costs for new (often small) transportation business owners and made it easier for smaller companies to compete alongside larger ones.

This competitive nature of the procurement process and the flexible use of privately owned dedicated and nondedicated vehicles contribute to savings and provide a strong incentive for companies to deliver high-quality service. Both factors are possible because of the use of the SUTI data standard, without which FlexDanmark would be unable to coordinate 550 providers into a single network.

POSITIVE USER EXPERIENCES FOR FLEXDANMARK

The outcomes for passengers in this highly coordinated system are impressive.

- Ninety-five percent of trips are on time, defined as a vehicle arriving no later than 15 minutes after its scheduled arrival time, never earlier.
- Drivers are well trained, receiving six weeks of in-person training—four weeks on becoming certified commercial operators; one week on learning to serve special-needs populations, including using a wheelchair stair lift; and one week on emergency medical protocols.
- Scheduling is flexible. The system supports real-time operations, although customers are asked to schedule a trip two hours in advance, if possible, to maximize ride sharing. Trips can also be scheduled up to two weeks in advance.
- Pricing is attractive compared with market-rate transportation. Riders can obtain transportation to a doctor's appointment or other destination at a more affordable price than that offered by a private taxi,

both because of subsidies and because FlexDanmark can quickly identify another customer with whom to share a ride.

- Service hours are extensive. Medical and FlexHandicap services are available around the clock, while FlexTur and PlusTur are available between the hours of 6 a.m. and 11 p.m. One of the busiest days of the year for FlexDanmark and its providers is a Danish Holiday.

WHAT'S NEXT: CONTINUING UPGRADES AND EXPANSION AT FLEXDANMARK

FlexDanmark is now procuring a new platform solution to replace the one it has been using for the past 20 years. The new vehicle communication system will integrate the SUTI standard and accommodate the business-critical functions that FlexTrafik stakeholders have come to depend on. The use of more up-to-date technology built for today's needs and IT environment will give FlexDanmark a more streamlined and efficient platform, opening opportunities for more public–private collaboration.

FlexDanmark is also working with its public transit authorities to develop MaaS. The country already has a customizable travel planning app, Rejesplanen, that serves 1 million customers daily. The new MinRejseplan multimodal app will integrate FlexTrafik's demand responsive services, including taxis and carpools, ensuring that people in rural areas are mobile regardless of private car ownership. It will also integrate Rejsekort—the existing smart trip card and electronic ticketing system—for public bus, train, and metro. Further buildout plans would integrate private transportation services.

Photo credit: Jana Lynott

How to Advance Wide-Scale Adoption of the Transactional Data Specification

The TDS offers an important tool to help American DRT providers modernize their service offering. Intentionally created to be a simplified cousin of the SUTI standard used by FlexDanmark, the TDS could help the US public mobility sector take the first steps toward data standardization. To realize those benefits, however, DRT providers and their software companies will need to embrace the specification by choice or be required to use it.

GREEN SHOOTS

Scattered throughout this section are several "green shoots" denoted in a text box by a green sprout. They highlight emerging interest in the TDS. These examples, and others like them, could spark widescale adoption of the specification.

MODERNIZING DRT IN "THE MOST DIVERSE SQUARE MILE"

The Atlanta Regional Commission (ARC) recently received federal funding to implement on-demand mobility in Clarkston, Georgia, a lower-income, ethnically diverse small suburb of northeast Atlanta. Clarkston is often referred to as "the most diverse square mile in America" where an agglomeration of refugee resettlement and immigrant services agencies has made a home for people from six continents speaking dozens of languages. Two community transportation providers (Center for Pan Asian Community Services and Gwinnett County Transit) will be integrated through a transactional data exchange using the TDS. Ultimately the system could one day include other transportation modes, such as bikeshare, volunteer transportation services, and microtransit, as adoption of the data standard is more fully realized. Through this work, ARC intends to build a user-informed technology platform that will reduce travel stress, build pride among participants, and yield greater independence for Clarkston's population of older adults and people with disabilities.

Photo credit: Center for Pan Asian Community Services

The following activities would move the United States in the right direction by helping institutionalize the specification's use. These measures are not mutually exclusive; rather, they build on one another and are interrelated. For instance, the development of data standards typically takes place within a governance structure that gathers momentum from pilot projects in the field. Those pilots and evolving standards, in turn, help create a market for wider adoption. Multiple actors can work on different aspects of adoption simultaneously.

Widescale adoption of the TDS may require public-sector mandates.

EDUCATE STAKEHOLDERS

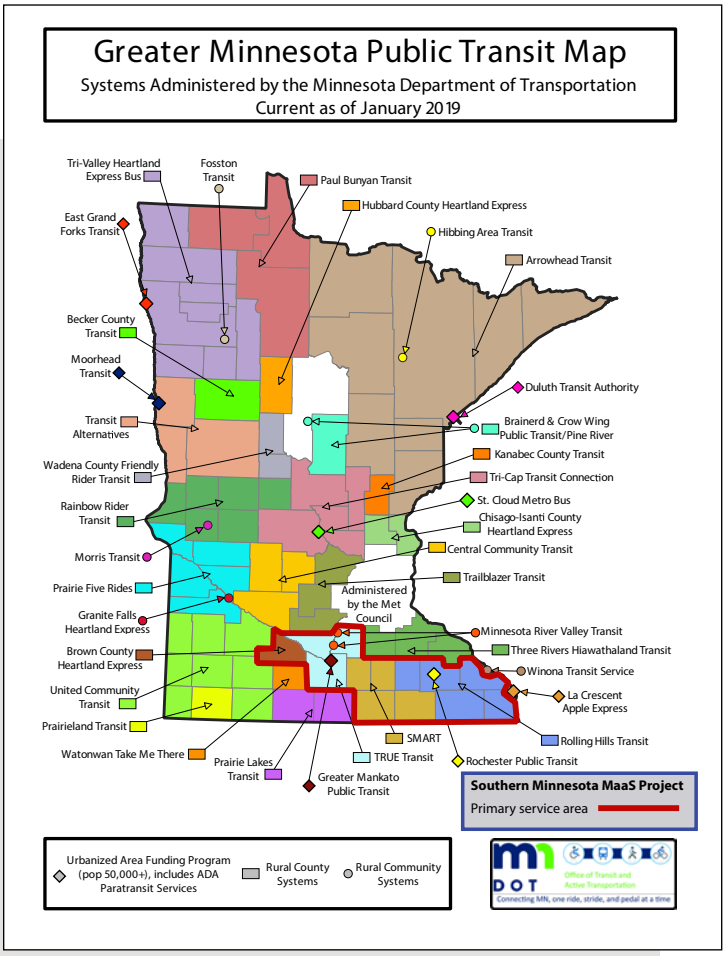
Developing a specification and recommending how it can be technically implemented is the easy part in advancing DRT modernization; the greater challenge is building a sufficient knowledge base among natural, but as yet uncommitted advocates.

The concept of data specifications and standards is new and obscure for some nontechnical DRT stakeholders, including transportation program managers, policy makers, and funders. As such, they may not fully grasp the opportunity or see themselves in a clear role to help advance implementation.

Stakeholders will need to acquire a variety of new perspectives. Public transportation providers will need to be knowledgeable enough to demand that their software vendors integrate the specification into their products. Human services transportation providers will come to accept that some transactions for their clients can be automated and need not directly involve their staff. Health care providers must begin to explore multi-provider service models—rather than signing contracts with a single transportation provider. Funding agencies and foundations will understand the need to require

MINNESOTA DEPARTMENT OF TRANSPORTATION MOBILITY-AS-A-SERVICE

The Office of Transit and Active Transportation at the Minnesota Department of Transportation (MnDOT) is developing a regional MaaS platform as a pilot proof-of-concept. In addition to improving shared mobility and transit riders' ability to see transportation options and plan trips, MnDOT is seeking better coordination of demand response services in the pilot area. The project will work with existing demand-responsive services and current dispatching and booking software providers to implement a transactional data standard, likely building upon the specification published by TRB. This will facilitate the kind of data sharing necessary to make the MaaS platform function and improve regional ride coordination. MnDOT hopes the data standard used in this pilot can eventually be implemented statewide and spur the adoption of an industry-wide standard in the United States.



integration of the specification into grant-funded projects. Congress should demand a schedule for interoperability as it did for the health care sector and food stamp program (SNAP Electronic Balance Transfer cards).

IMPLEMENT A COMMUNICATIONS STRATEGY

At the November 2019 roundtable, participants suggested developing information materials that define the problems that can be solved by adoption of the TDS and identifying the people and entities who will benefit from interoperability. Materials should be tailored for each unique audience. Participants also suggested that the TDS definition be condensed into a memorable tagline to make the terminology accessible to nontechnical audiences.

Professional associations (e.g., American Public Transportation Association, Community Transportation Association of America [CTAA]), technical assistance centers (e.g., NCMM, National Aging and Disability Transportation Center (NADTC), Shared Use Mobility Center [SUMC]), and relevant research organizations (e.g., AARP PPI, Transportation Research Board [TRB], Eno Center for Transportation, Urbanism Next) can be avenues to reach target audiences with tailored messaging.

Some of this work has already begun. In April 2020, TRB offered a webinar on the TDS.[20] SUMC held two related virtual workshops in spring 2020.[21] AARP PPI, Eno Transportation Weekly, and the American Society on Aging have all published articles to increase their audiences' familiarity with the data specification. [22,23,24,] AARP PPI offers a set of resources about the TDS on its Future of Transportation website. [25] That said, more resources will need to be produced and disseminated to ensure that all pertinent audiences have the information they need to join the push for specification adoption and use.

ITNAMERICA: TAPPING THE INVALUABLE RESOURCE OF VOLUNTEERS

Independent Transportation Network of America (ITN) is a national nonprofit organization that has 23 affiliates and ITNCountry communities in 12 states. ITN offers volunteer-provided "arm-through-arm, door-through-door" transportation services to older and vision-impaired adults. ITN recently began migrating its ITNRides software platform to SalesForce. During the discovery phase, ITN's software developers will include the TDS in the system architecture. ITN plans to seek additional funding for coding. Initially ITN envisions using the Specification as a streamlined way to share data messages among ITNCountry communities. Eventually, ITN hopes to connect the services of nonprofit volunteer-provided, human service, and public transit providers to better address the needs of rural communities. The Transactional Data Specification creates an opportunity to maximize the invaluable resource provided by ITN volunteers.

Photo credit: INTAmerica

METROPOLITAN TRANSPORTATION COMMISSION BAY AREA COMPLETE TRIP DEPLOYMENT

The Metropolitan Transportation Commission (MTC) is actively seeking funding to integrate the TDS into the regional 511 San Francisco Bay Travel Info and Transit Data System. This will allow the traveling public to discover their available transportation options and have their travel needs met through a regional DRT brokerage service. USDOT defines a complete trip as the ability to go from origin to destination without gaps in the travel chain. If one segment of the trip is inaccessible, unreliable, or inefficient, then access to subsequent segments is broken, and the trip cannot be completed. The concept is particularly relevant to people with disabilities, older adults, those with limited English proficiency, and other transportation-disadvantaged groups. MTC's Complete Trip deployment aims to help those who rely on public and private transportation services to get to jobs, education, healthcare, and other activities.

BUILD A "CONCEPT OF OPERATIONS" THROUGH PILOT PROJECTS

Pilot projects are needed in the United States to demonstrate the efficacy of the TDS and to establish a body of work through which the development of a standard can occur.

These pilots need to happen in both urban and rural environments. Pilots should involve diverse actors, from large transit agencies with sophisticated ride-scheduling and dispatch technology, to small nonprofit providers using the most basic technology (e.g., Microsoft Excel) to schedule and track rides, to information and referral agencies such as 2-1-1 and Aging and Disability Resource Centers.

It is now the time in the United States to put public investment of one-off solutions behind us and modernize this sector through a scalable, nationwide solution to interoperability in demand-responsive transportation.

Funding for pilots is especially needed in rural areas, where most communities lack the funds to experiment. One roundtable participant representing regional government lamented that, in her state, "we are managing the decline of our transportation system. We must make the case for using transit money wisely," implying that they have no money with which to experiment on their own.

It is imperative that all pilots document and share their information architecture and detailed concept of operations, and that they design an evaluation mechanism up front. Too often in the past, technology investments in this sector have funded one-off projects, with few documented lessons for other entities interested in similar investments. Consequently, there has been too little transferability of insights and experience and no movement toward a nationwide standard. It is now the time in the United States to put public investment of one-off solutions behind us and modernize this sector through a scalable, nationwide solution to interoperability in DRT.

SUPPORT PILOT PROGRAMS

Pilots need to be nurtured and both their successes and their failures documented so that the data will become available to support large-scale use and adoption of the specification. One model incubator is the Mobility on Demand (MOD) Innovation and Knowledge Accelerator (IKA) project. To help existing MOD Sandbox pilots exchange ideas, discuss lessons learned, and offer mutual support, FTA hired SUMC to provide a structured learning community. A similar support model could be offered for pilots using the TDS. SUMC or another qualified technical assistance center could help pilot stakeholders develop a concept of operations and implementation plan, connect them to partners, and facilitate peer learning.

Roundtable participants also suggested it would be important to award funding to pilot demonstrations and partner locations that are

PROOF OF CONCEPT: RURAL NONPROFITS PILOT TDS WITH GOOGLE SHEETS

One overriding benefit of the TDS is that it can integrate unique entities into a single network. It takes a minimum of just two independent transportation providers to prove the technology can work as their only means of digital communication.

Rural America may be the place to start this experiment. Although rural communities may have fewer technology resources and tech-savvy personnel, they may have an advantage over urban systems because their environments demand less complex coordination and require fewer partners.

In fact, two nonprofits in rural Lake County, Oregon, have become the first transportation providers to commit to using the TDS. Funded by AARP, this pilot will demonstrate how the TDS can be integrated with Google Sheets to push data between providers using a cloud-based spreadsheet, resulting in service coordination that does not require e-mails or phone calls.

Should either nonprofit switch to more robust scheduling software at a future date, the vendor would need to integrate the TDS, which is a specification that is documented, public, and already working, rather than a specification controlled by another vendor. This greatly facilitates the ease of interoperability and enables resource-constrained agencies to avoid vendor lock-in.

Photo credit: US Forest Service Pacific Northwest Region

unlikely to fail, in order to build momentum and a set of use cases that prove the efficacy of the specification. Key criteria could include locations that can demonstrate a strong commitment to regional coordination as evidenced by an up-to-date coordinated plan and other activities.

ESTABLISH A GOVERNANCE STRUCTURE

The more widely the TDS is accepted, the greater its utility and benefit will be. The process of developing, pilot testing, and achieving widespread adoption of a data specification can take a decade or more—and even thereafter requires ongoing refinement to ensure that it remains responsive to current conditions.

This lengthy timeline underscores the important role a governance body would have in this process.

Specification refinement and standards development are typically done through a formal process spearheaded by private or nongovernmental organizations that facilitate voluntary collaboration among technical experts and other stakeholders. Such a governance body can play the crucial role of providing a framework for transportation providers and software developers to work together to refine the code, approve changes through consensus, and maintain the integrity of the specification.

As a new and not-yet-implemented format, the TDS does not yet have the backing of a governance structure.

The following two standards-development processes illustrate approaches used in two different sectors that could inform the process of establishing a governance structure for the TDS.

HL7 INTERNATIONAL

Within the health care sector, Health Level Seven International (HL7) is one of several American

National Standards Institute (ANSI)–accredited standards-developing organizations (SDOs).

The HL7 vision is of "a world in which everyone can securely access and use the right health care data when and where they need it." It aims to empower global health data interoperability by developing standards and enabling their adoption and implementation. HL7 members include health care providers, vendors, payers, consultants, government groups, and others with an interest in the development and advancement of clinical and administrative standards for health care. The work is volunteer-driven and carried out by consensus.

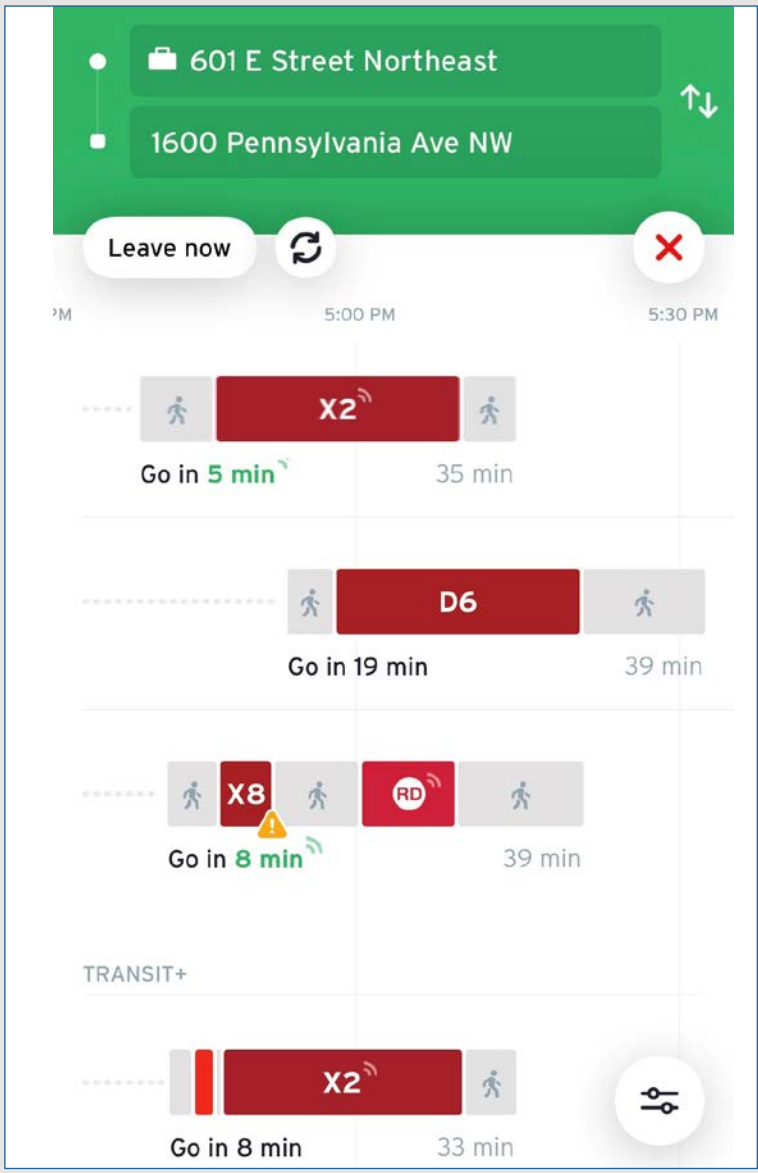
Like all ANSI-accredited SDOs, HL7 International adheres to a strict and well-defined set of operating procedures to ensure consensus, openness, and balance of interest. Members participate in one or more of HL7's 50-plus working groups, ranging in topics from mobile health to clinical quality information. A technical steering committee oversees and coordinates the efforts of the working groups. Working group projects culminate in a ballot process. When 75 percent of responses are registered as affirmatives, and all negatives withdrawn, a document is ready for publication as an HL7 International Standard.

Thirty-five HL7 standards received ANSI approval in 2019 alone. Two relatively well-known products emanating from the standards-development process are the Electronic Health Record System Functional Model and the more recent Fast Healthcare Interoperability Resources (FHIR). HL7 International has an annual operating budget of approximately US $7 million, generated through membership fees, meeting registrations, and educational offerings, such as FHIR training.

MOBILITYDATA IO

MobilityData, based in Montreal, Canada, was established as an independent nonprofit organization in 2019 to lead the improvement and expansion of the de facto worldwide standard for public transit data: the General Transit Feed Specification (GTFS) format.

Today, MobilityData also leads ongoing development of the General Bikeshare Feed Specification, in partnership with the North American Bikeshare Association. In addition, through a partnership with TransitScreen, MobilityData now hosts OpenMobilityData.org, a worldwide repository of GTFS data sets.



Source: Screen shot of Transit trip planning app

The GTFS dates back to 2005, when Portland's (Oregon) transit agency, TriMet, began imagining a future where mapping services incorporated transit options. TriMet approached Google to ask if this was something it had considered.[26] Serendipitously, Google was already exploring something similar while seeking transit data for Google Maps.

A partnership was born, and Google and TriMet began working together to prepare TriMet's route

and schedule information in a format that would work with Google Maps. Initially, the format was known as the Google Transit Feed Specification. Later the name was changed to reflect the openness of the format available to any third-party app developer. Today, more than 1,000 transit providers around the world provide open GTFS data. The data underlie all trip-planning apps available to customers today—not just Google Maps, but Apple Maps, Transit, Moovit, and many others worldwide.

Between 2015 and 2018, the work catalyzed by TriMet and Google was taken over by the Rocky Mountain Institute (RMI). RMI developed a GTFS Best Practices working group and ultimately incubated MobilityData IO, created specifically to convene the industry to manage and expand GTFS. MobilityData drafts specification enhancements and facilitates conversations with the community to accelerate development.

MobilityData IO sustains the original grassroots governance model by providing facilitation and leadership to enhance the specifications. GTFS follows a bottom-up model of governance. The organizations that produce and consume transit data drive new specification features. Members of MobilityData, and participants in the GTFS standards process, include technology companies; transportation authorities; mobility data consulting firms; and a range of smaller mobility companies, vendors, and public and nonprofit organizations. MobilityData has an international board of directors, a staff of just 16, and an annual budget of US $1.5 million.[27]

POSSIBLE GOVERNANCE HOSTS FOR THE TRANSACTIONAL DATA SPECIFICATION

Advocates will need to organize and engage with experts in the field to find the appropriate governance body for the TDS if they are to nurture it toward becoming an industry standard. Standards-development organizations that could be tapped to lead the TDS development include the following:

- **MobilityData IO** could be a logical host, given the organization's current work on the GTFS-Flex specification for DRT discovery data. Initial conversations with organization leadership suggest that MobilityData IO would consider hosting the TDS only once real-world use case tests have been identified.
- The **American Public Transportation Association** (APTA) leads the Transit Communications Interface Profiles (TCIP) efforts within the overall structure of the National Intelligent Transportation Systems Architecture. The TCIP standard describes the data elements and other building blocks of information used to transfer information among transit systems. APTA has a structured program to development industry standards for public transportation providers. DRT would be a new business area.

Ongoing federal intervention has helped create a business environment in the health care sector that favors data sharing rather than data siloes.

- **The Open Mobility Foundation** (OMF) offers a governance structure for open-source mobility tools aimed at helping public agencies accomplish their policy aims. The OMF's first and, to date, only tool is the Mobility Data Specification, which is used to manage dockless micromobility programs such as shared electric bikes and scooters. One potential disadvantage of governance through the OMF is that industry serves in an advisory role only, which could make it difficult to achieve industry buy-in as the specification evolves.
- **SAE International** is a global association of more than 128,000 engineers and related technical experts in the aerospace, automotive, and commercial vehicle industries. The organization creates and manages more aerospace and ground vehicle standards than any other entity in the world. Recently, SAE convened public and private mobility partners to establish a framework on micromobility data sharing. Public transit and DRT would be new areas for SAE International.

CREATE A MARKET FOR ADOPTION

Standards are typically developed through a voluntary, industry-initiated process; however, achieving widescale adoption of those standards may require public-sector involvement. That is what happened in Denmark, where FlexDanmark mandated that service providers and technology companies adhere to the SUTI standard if they wanted to participate in the FlexDanmark system.[28] FlexDanmark became the point of access for private-sector players in Denmark to compete for most publicly funded DRT contracts, so industry players were highly motivated to get on board with SUTI.

Public-sector leadership also undergirds the success of HL7 International's voluntary standards development, including FHIR implementation efforts. Ongoing federal intervention has helped create in the health care sector a business environment that favors data sharing rather than data siloes.[29] In 2004, President George W. Bush created the Office of the National Coordinator for Health Information Technology (ONC) by executive order, and Congress mandated it in the HITECH Act of 2009, giving rise to a proliferation of electronic health records adoption. Nonetheless, it was only after passage of the 21st Century Cures Act of 2016 that key players were pushed toward data sharing.[30,31] This happened because the Cures Act empowered the ONC to define the parameters around which interoperability would be driven.

As FlexDanmark has demonstrated, use of the SUTI standard helped create more efficient service delivery, which allowed the public sector to put more DRT service in place. The result was a greater number of trips, more private-sector providers under contract, more seats filled, and more-efficient service.

On May 1, 2020, the Centers for Medicare & Medicaid Services (CMS) published a Interoperability and Patient Access final rule intended to move the health care ecosystem in the direction of interoperability.[32] The rule covers broad changes in transparency and access to data and effectively makingFHIR the fundamental building block of interoperability.[33] Software developers have rapidly introduced FHIR-based solutions in the past couple of years. One reason is that standards allow software developers to reuse many open-source solutions available from

Photo credit: Mirjam Evers

other industries to accelerate the development of health care solutions. This has reduced the barrier to entry by encouraging more developers to join health care IT.[34] "FHIR has democratized health care technology development and by doing so, has drastically reduced the cost of building innovative solutions," says Dr. Pawan Jindal, founder of MyMipsScore.

A carrot-and-stick approach could encourage widescale adoption of the TDS.

LEGISLATION AND RULEMAKING COULD STIMULATE STANDARDS DEVELOPMENT AND ADOPTION

Congress could exercise similar federal leadership to that in the healthcare sector and stimulate adoption of the TDS through legislation and rulemaking. A carrot-and-stick approach could encourage widescale adoption. Once a sufficient number of use case tests have demonstrated the efficacy of the data specification, Congress may want to tie its adoption to existing federal funding.

The current transportation law, the Fixing America's Surface Transportation Act, is set to expire in 2021. A reauthorization bill could include funding for pilot projects and structured technical assistance as described above in the *Build a "Concept of Operations" through Pilot Projects* section.

On the human services side, Title XIX of the Social Security Act established the Medicaid program and provides funding for medical and health-related services for persons with limited income, including older adults and people with disabilities. Nonemergency medical transportation (NEMT) is an important service covered by Medicaid for those who need transportation to medical appointments, and it is the largest single source of funding for DRT in the United States. CMS and state Medicaid offices could require NEMT brokers to integrate their systems with their providers' systems using the TDS so that service can be delivered more efficiently and with greater transparency. Transition funding for software development may be necessary.

The transition to a more integrated DRT climate will require investment, which will be money well spent. As FlexDanmark has demonstrated, use of the SUTI standard helped create more efficient service delivery, which allowed the public sector to put more DRT service in place. The result was a greater number of trips, more private-sector providers under contract, more seats filled, and more-efficient service.[35]

TARGETED GRANTS COULD FOSTER A MARKET FOR DATA SHARING

By aligning criteria for grants and vendor procurement, the public sector could also help create a market for data standards. Federal agency leaders are increasingly recognizing the importance of data standards and interoperability; to date, however, federal agencies have funded one-off technology pilots rather than strategically directing resources toward the establishment of technology standards that could benefit communities across the country.

Both the Administration for Community Living and FTA offer grants that could be used for the spec integration and pilot tests of its implementation. The following grant opportunities are just samples of potential federal funding opportunities and are by no means exhaustive. Funding opportunities take the form of formula grants, discretionary grants offered through technical assistance centers, and episodic grants made available through FTA's Office of Research, Demonstration, and Innovation and other United States Department of Transportation (USDOT) offices. Although data spec integration could be an eligible expenditure for any of these grants, it is not required by any of them. Congressional or regulatory action to change that would greatly propel the establishment of a nationwide transactional data standard.

Federal agencies should evaluate how their technical assistance centers can support a standardized way for sharing demand responsive trip data through targeted funding and expertise.

Formula Grants

Several FTA formula grant programs provide funding to support DRT, such as section 5310 (Seniors and Individuals with Disabilities), section 5311 (Rural Transit), and section 5307-funded complementary ADA paratransit. Mobility management investments are eligible capital expenses under each of these programs. As the TDS is a mobility management-enabling technology, to the extent that state and local recipients use the funding for technology solutions, FTA could ensure that those solutions are programmed to integrate the TDS.Because formula programs are currently underfunded, additional resources are needed to ensure that service levels would not be negatively affected in the process of modernizing DRT at a larger scale.

Discretionary Grants Made Available through Federal Technical Assistance Centers

FTA currently funds four technical assistance centers, whose missions all intersect with DRT. These are the National Aging and Disability Transportation Center, the National Center for Mobility Management, the National Center for Applied Transit Technology, and the National Rural Transit Assistance Program. The US Department of Agriculture also supports the Rural & Tribal Passenger Transportation Technical Assistance Program. These centers administer grant opportunities on behalf of FTA and other federal agencies to support their missions. In addition to these formal centers, FTA -provided funding to SUMC to manage the MOD Innovation and IKA; the Administration for Community Living provides financial support to the Community Transportation Association of America to administer the Transit Planning 4 All grants. In 2020, the Transit Planning 4 All program explicitly welcomed proposals for projects that implement the TDS. Federal agencies should evaluate how their technical assistance centers can support a standardized way for sharing demand responsive trip data through targeted funding and expertise.

Competitive Research and Innovation Grants

The USDOT offers several episodic research and innovation funding opportunities that could support TDS implementation. For example, past grant opportunities from FTA's Office of Research, Demonstration, and Innovation included the MOD Sandbox Demonstration, Integrated Mobility Innovation, and Accelerating Innovative Mobility grants; all could have been used for TDS integration in the past and presumably could in the future.

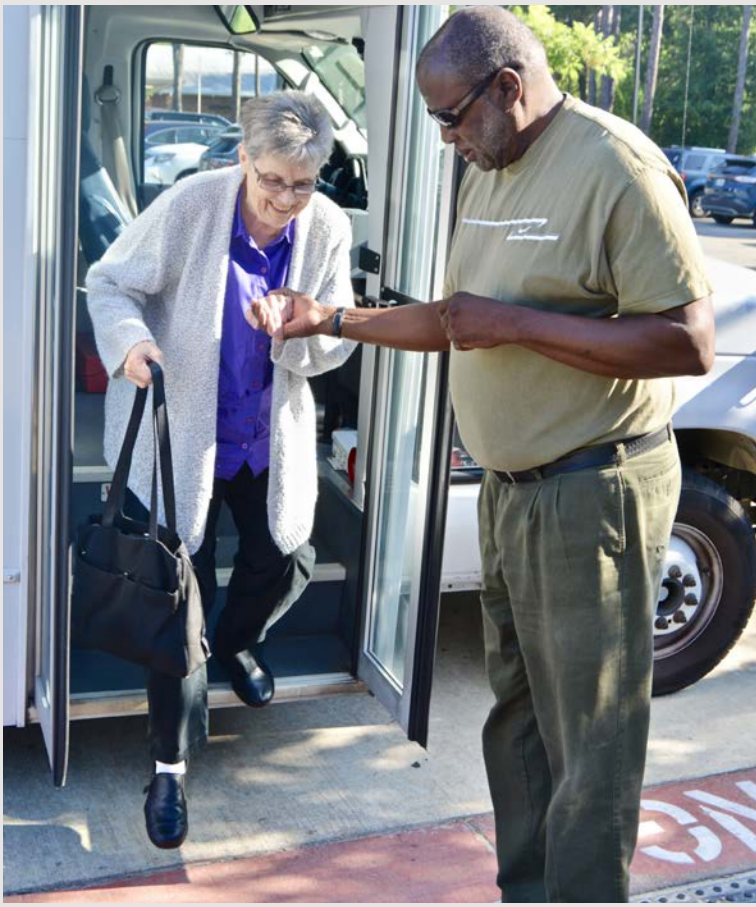


Photo credit: Meals on Wheels, Montgomery County, Conroe, Texas

The 2020 USDOT Intelligent Transportation Systems Joint Program Office Complete Trip ITS4US Deployment Program will make up to $40 million available to enable communities to showcase innovative business partnerships, technologies, and practices that promote independent mobility for all. Funding levels are high enough to support MaaS initiatives. DRT integration into MaaS platforms using the TDS would be appropriate.

State, Local, and Philanthropic Support

Depending on the location, state and local sources of funding may be available through

department of transportation and human services budgets for this purpose. A strong argument can be made for funding the data specification, as it should enhance service and help create a more efficient and transparent transportation system.

Those interested in implementing the specification could also tap philanthropic sources. Many national, state, and local foundations have missions that can be advanced through efficient, high-quality transportation services. Transportation is increasingly being recognized as a social determinant of health because, without access to health care, fresh produce, and other services and activities, it is much harder to remain healthy. A lack of transportation is too often a barrier to social connectedness in the community, and a growing body of literature is quantifying the cost of social isolation.[36] Foundations that target transportation choice, as well as those who wish to see improved health outcomes, will advance their missions through investment in projects that utilize the TDS.

MODEL PROCUREMENT LANGUAGE FOR NEXT-GENERATION SOFTWARE

Even without federal mandates, the public transportation industry can preemptively require its technology vendors to adopt the TDS.

APTA could lead this effort by identifying the 10 largest members (transit agencies) that will put DRT technology contracts out to bid in the next 24 months. APTA could assist these agencies in writing the use of the specification into those requests for proposals and bids. This would ensure that both their ADA paratransit services and emerging MaaS platforms would be positioned to benefit from partnerships with private providers using less expensive, nondedicated vehicles. That would include the taxicab industry as well as ride-hailing and micromobility companies. Getting the 10 largest systems to adopt the specification quickly would advance the goal of a nationwide transactional data standard and facilitate broad interoperability among US systems.

CTAA could do the same for small and rural DRT providers.

Photo credit: Kevin Chambers

As mentioned above, CMS and state Medicaid officials could facilitate use and adoption among nonemergency medical transportation by requiring TDS use by NEMT brokers.

The Transportation Alliance could help educate and prepare its taxi, limousine, and paratransit members for automated data sharing so that they too can take advantage of a changing environment.

Photo credit: National Aging and Disability Transportation Center

Recommendations

The following recommendations summarize the specific actions various stakeholder groups can take to realize the promise of the TDS.

FOR CONGRESS

- Set a schedule for achieving DRT interoperability and designate responsible agencies.
- Enact legislation that addresses anticompetitive practices among DRT software vendors that currently limit the exchange of trip information among providers.
- Endorse the TDS through policy and provide funding for pilots through reauthorizations of surface transportation legislation, the Older Americans Act, and the Social Security Act. Ensure sufficient funding levels for TDS implementation so that existing service levels for DRT customers are protected.
- Provide for the establishment of a governance structure for the TDS in transportation law and funding to support it.

FOR THE FEDERAL TRANSIT ADMINISTRATION

- Promote the value of the TDS through publications, webinars, and other means.
- Align federal grant criteria to implementation of the TDS; this should apply to formula, discretionary, and competitive research and innovation grants.
- Provide funding and direct technical assistance centers to develop tailored information materials.
- Require all relevant pilots (e.g., MaaS, DRT, microtransit, Transportation Network Company (TNC)-transit partnerships) that receive federal funding to integrate the TDS.
- Fund an existing technical assistance center to serve as a pilot incubator and convene all pilot programs to learn from one another.
- In collaboration with other stakeholders, identify the appropriate standards-development organization to convene a standards-development process and support the process with funding; participate in the process.

FOR THE CENTERS FOR MEDICARE & MEDICAID SERVICES

- In collaboration with state Medicaid directors and NEMT brokers, establish a mandatory timeline for TDS integration into NEMT brokerage systems and interoperability with provider scheduling software systems.
- Provide funding for pilots of TDS implementation.

FOR DRT TRANSPORTATION PROVIDERS (PUBLIC AND PRIVATE, HUMAN SERVICES, AND NONPROFIT)

- Become educated about the TDS and how it could improve the coordination of human services transportation and DRT services.
- Implement pilots; document the lessons learned from those pilots and share this information along with the project's architecture and concept of operations.
- Require software vendors to integrate the TDS as part of all future vendor contracts.

- Participate in the standards-development process to refine the TDS and move it toward a national standard; help fund that process as budgets allow.
- Include DRT TDS sessions in professional conferences and other meetings.

FOR SOFTWARE DEVELOPERS AND TECHNOLOGY COMPANIES

- Integrate the TDS into software applications.
- Assist transportation providers in implementing pilots.
- Participate in the standards-development process; help fund that process.

FOR TECHNICAL ASSISTANCE CENTERS, MEMBER ORGANIZATIONS, AND RESEARCH ORGANIZATIONS

- Develop and disseminate tailored education materials.
- Serve as a pilot incubator and convener to document and disseminate lessons learned; assist pilots in preparing information architecture and concept of operations.
- Develop model procurement language for next-generation software purchases, and disseminate it to membership.
- The NCMM could update its Mobility Management fact sheet to explicitly mention that TDS integration is an eligible capital expense.

FOR PHILANTHROPIC AND STATE/LOCAL GOVERNMENT FUNDERS

- Provide funding to support the development and dissemination of information materials, pilot projects, and standards-development process.
- Tie grant funding for DRT to implementation of the TDS.
- Require grantees to include the TDS in future contracts with DRT software vendors.

Photo credit: Tompkins County, NY Department of Social Services

Conclusion

The larger transformation of the transportation sector already underway may be creating a market for the TDS. As the industry moves in the direction of providing customers with MaaS, there is the inherent need for systems to interoperate or at a minimum share data efficiently. In fact, many companies embracing this future already see the benefit.[37] The challenge lies in the immediate moment, in which software companies are competitors within a highly siloed environment and fear that they may lose market share if all software products speak the same "language" with the external world and can therefore interoperate.

The TDS facilitates the participation of many software companies and transportation providers in regional MaaS platforms. This democratization of involvement helps ensure the most efficient delivery of high-quality services.

The bleak alternative to this open platform approach is a series of parallel "walled-garden" platforms owned by individual mobility companies. These platforms would not include all potential ride providers, and they may not be able to adequately serve all segments of the community—particularly those with incomes too low to purchase market-rate transportation or those whose physical or cognitive needs may be more expensive to accommodate.

A range of stakeholders can take several actions to deliver the industry from this uncertain, interim stage and to achieve full realization of the sector's potential. The public sector at all levels of government can demand interoperability from themselves and their software vendors. Transportation providers and the sector's software developers can come together to pilot projects and refine standardized ways for sharing data. Professional associations and technical assistance centers can support these efforts by offering a neutral, collaborative community that can form the basis of an ongoing governance structure.

DRT should be part of the new mobility ecosystem. Only when it is can we ensure that those who depend on DRT services tailored to their needs will be able to access the seamless, on-demand services of the future. The TDS is the fundamental building block.

Photo credit: Getty Images

Appendix: Acronyms

ADA	Americans with Disabilities Act
ANSI	American National Standards Institute
API	Application Programming Interface
APTA	American Public Transportation Association
ARC	Atlanta Regional Commission
CCAM	Coordinating Council on Access and Mobility
CMS	Centers for Medicare & Medicaid Services
CTAA	Community Transportation Association of America
DRCOG	Denver Regional Council of Governments
DRMAC	Denver Regional Mobility & Access Council
DRT	Demand-responsive Transportation
FHIR	Fast Healthcare Interoperability Resources
FTA	Federal Transit Administration
GTFS	General Transit Feed Specification
HITECH Act	The Health Information Technology for Economic and Clinical Health Act (2009)
HL7	Health Level 7 (a SDO)
IKA	Innovation and Knowledge Accelerator (FTA MOD project)
ITN	Independent Transportation Network of America
LCS	Longmont Coordination System (Colorado)
MaaS	Mobility-as-a-Service
MnDOT	Minnesota Department of Transportation
MOD	Mobility on Demand
MSAA	Mobility Services for All Americans (FTA grant)
MTC	Metropolitan Transportation Commission (San Francisco Bay Area)
NADTC	National Aging and Disability Transportation Center
NCMM	National Center for Mobility Management
NEMT	Nonemergency medical transportation
NPM	New Public Management
OMF	Open Mobility Foundation
ONC	Office of the National Coordinator for Health Information Technology
PNR	Passenger Name Record
PPI	Public Policy Institute

RMI	Rocky Mountain Institute
RTD	Denver Regional Transportation District
SDO	Standards Development Organization
SUMC	Shared Use Mobility Center
SUTI	Standardiserat Utbyte av Trafik Information (Scandinavian data standard)
TCIP	Transit Communications Interface Profiles
TDS	Transactional Data Specification for Demand-responsive Transportation
TNC	Transportation Network Company (e.g., Uber and Lyft)
TRB	Transportation Research Board
USDOT	United States Department of Transportation
Via	Via Mobility Services

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