Research Report

Connecting Community Transportation: Lessons Learned from Transactional Data Specification Demonstration Projects

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About the Shared-Use Mobility Center

The Shared-Use Mobility Center is a public-interest organization dedicated to achieving equitable, affordable, and environmentally sound mobility across the United States through the efficient sharing of transportation assets. By connecting the public and private sectors, piloting programs, conducting new research, and providing policy and technical expertise to cities and regions, SUMC seeks to extend the benefits of shared mobility for all.

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The AARP Public Policy Institute (PPI) informs and stimulates public debate on the issues we face as we age. PPI promotes the development of sound, creative policies to address our common need for economic security, health care, and quality of life.

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Introduction

When someone needs a ride, but buses and other standard methods of public transportation are not an option, demand-responsive transportation (DRT) providers fill the need. For the past several decades, DRT providers have sought efficient ways to coordinate with one another to improve service for their customers, who are typically nondrivers or those without access to a personal vehicle and include many older adults, people with disabilities, and individuals with low incomes. Until recently, such coordination has been stymied in part by the lack of cost-effective technology; that changes with the advent of the transactional data specification (TDS) for DRT.

Demand-responsive transportation has existed for decades. The typical DRT service is a door-to-door one and includes everything from dial-a-ride and ADA (Americans with Disabilities Act) complementary paratransit to volunteer driver programs, taxis, and ride-hailing services like Uber. Scheduling rides on one or many of these options can be hard. That's where the TDS enters.

Figure 1. Driver assisting older man with walker out of transit van

Credit: MTA Flint, Flint MI | Photo Resource Gallery | NADTC

Specifically designed for DRT, the TDS allows these various services to work together to meet riders' needs. The TDS is a common data format that enables a network of transportation providers to view and transfer information about requested trips. It defines how transportation data are handled so that the different providers' scheduling systems can directly communicate with one another electronically.

Contemporary DRT service management platforms encompass multiple software systems that work together to help automate the trip. These systems include ride-booking that interfaces with the customer, vehicle scheduling, dispatching, administration, reporting, and sometimes fare payment/ticket management. Not all DRT providers, particularly small rural agencies and nonprofits, use sophisticated platforms; many track their ride requests with Excel spreadsheets and pass along manifests to their drivers via email.

Since it was first introduced in 2020, the TDS has gained traction in the industry, with a handful of public agencies and small, nonprofit organizations undergoing projects to explore the specification's potential. Based on interviews with early implementers and prior research, this paper explores the state of the TDS, shares takeaways from these early demonstration projects, and outlines a path for expansion in the United States. The accompanying "Connecting Community Transportation: A Roadmap for Implementation" offers key considerations and steps for planning, designing, and implementing the TDS. The roadmap is not exhaustive; rather, it is designed to guide interested agencies in adopting the TDS.

What is demand-responsive transportation?

DRT services began in the United States in the early 1970s, with the first digital computer-controlled services implemented in Rochester, New York. By the late 1980s, DRT was providing rides to clients in several hundred small cities and suburbs. Initially, DRT services were mainly dial-a-ride programs,

Figure 2. DRT services vehicle

Credit: Photo Resource Gallery | NADTC

named because ride requests were initiated by a phone call to a booking center. DRT services have since expanded and are run by various providers, including those that serve target populations such as clients of human service agencies and persons requiring non-emergency medical transportation (NEMT).

These rides do not follow a fixed route or schedule and typically require the passenger to book a ride 24 to 72 hours in advance, although providers may try to accommodate spontaneous travel. DRT is a shared-ride service where each customer's trip is potentially mixed with other customers, and the dynamic routing of the vehicle may be controlled by a DRT service management platform (see sidebar). This means one vehicle may pick up or drop off two, three, or more customers.

Quick Terminology Tutorial

Contemporary DRT service management platforms encompass multiple software systems working together to automate a trip. This complex setup includes a ride-booking system that interfaces with the customer to confirm a request and assign a timeframe for pickup using a vehicle scheduling system, a dispatching system, an administrative system (which itself has subsystems), a reporting system, and sometimes a fare payment/ticket management system. This paper uses the terms *platform* and *scheduling software* to denote this broader set of system functionality. The terms *ride* and *trip* are also used interchangeably.

DRT is an effective form of local transportation in communities that lack sufficient population density or public transportation need to support a fixed-route bus service. By its nature, DRT responds to demand levels, thus allowing it to be dialed down or increased by one vehicle at a time as ridership merits—something harder for a fixed-route bus operation to do. Thus, DRT is common in rural areas.

While a definitive census of DRT services in the United States is not available, an analysis of information from the National Transit Database and state departments of transportation with known DRT services suggests that currently 900 to 1,000 services are in operation. They offer rides to the general public or, in the case of human service agencies restricted to older adults, individuals with disabilities, low-income workers, or other clientele. An additional 400 or more ADA paratransit services are in operation.[1]

TDS background, benefits, and use cases

Data specifications and standards are fundamental in modern transportation systems. They support the electronic sharing of information in the transit and shared-mobility spaces and have robustly improved the quality of information readily available to transit customers. They provide a blueprint for how data should be formatted so that information can be shared among providers and with the traveling public.[2]

Data standards and specifications define the fields of data, how information in each field is to be formatted, and the order of operations to be taken.

Data specifications constitute the foundation of truly interoperable data systems and are thus crucial for both travelers and transportation agencies. Reliable, accessible, and commonly understood frameworks for communicating and exchanging information allow travelers to easily plan trips using multiple services and allow transportation providers to better understand transportation needs. Already, customers using different transportation modes have reaped the benefits of data specifications. For example, fixed-route bus and rail systems in the United States and around the world can format their route and schedule information into the General Transit Feed Specification (GTFS). When transit riders access real-time information via smartphone apps like Google Maps or Transit, they see the GTFS in action. Shared micromobility also has strong open-source data infrastructure with the General Bikeshare Feed Specification, allowing users to see the location of available

1 DemandTrans Solutions analysis of the 2022 National Transit Database and data from state departments of transportation for a National Center for Applied Transit Technology ridership forecasting model.

2 https://learn.sharedusemobilitycenter.org/casestudy/the-role-of-data-specifications-in-creating-an-integrated-transportation-system/

bikes on a map and unlock one with the click of a button on a smartphone.

Data sharing is key for transportation coordination. A variety of health and human service transportation programs exist, and effective coordination among them ensures that needed rides can be delivered productively, efficiently, and with as few impediments as possible. The federal government has long recognized the role of transportation coordination in mitigating human service transportation (HST) access barriers–faced particularly by older adults, people with disabilities, and individuals with low incomes. In 2004, President George W. Bush signed an executive order.[3] The executive order highlights the critical role transportation plays in providing access to employment, medical and health care, education, and other community services and amenities. It also acknowledges the variety of programs in existence and that these resources "are often difficult for citizens to understand and access, and are more costly than necessary."[4]

Building on CCAM's continued work, the federal government launched other initiatives to test coordination among transportation services, including the FTA's Research and Innovation grant programs–in particular, the Integrated Mobility Innovation, Accelerating Innovative Mobility (AIM), and Enhancing Mobility Innovation (EMI) grants.[5] Many of the funded projects test the industry's ability to leverage and integrate mobility innovations with existing services and examine the impact on agency operations and traveler experience. CCAM and these discretionary grant programs demonstrate the federal government's interest in transportation coordination and mitigating the barriers customers face.

Specifications also allow service providers to perform needed transactions among one another and with their customers, such as trip booking, vehicle dispatching, and payment. When these standards are communicated in a common data format and built around a community of users, they fall under a broad framework of open-source data solutions. Open-source data solutions do not mean that personal travel data and information are available for anybody to access, but rather that the appropriate levels of information are securely communicated via a nonproprietary industry framework to meet agency and rider needs. Open-source data solutions are key to scaling interoperability across modes and platforms.[6]

Data specifications and standards can make transportation networks more user-friendly, efficient, transparent, and responsive to the needs of riders. This is particularly important for many older adults, people with disabilities, and others with limited, inadequate, or unaffordable travel options.
—Modernizing Demand Responsive Transportation for the Age of New Mobility, AARP Public Policy Institute, December 2020

Open-source data specifications have the potential to transform DRT, but significant gaps exist. Unlike other modes of shared mobility, DRT lacks a widely deployed open-source data specification, thus disadvantaging a wide swath of customers dependent on dial-a-ride, paratransit, microtransit, NEMT, and HST. To address this shortfall, transit agencies and other industry leaders have called for the creation and adoption of the TDS specifically geared toward these modes. The TDS was introduced in 2020 in the Transportation Research Board technical paper *TCRP Research Report 210 Development of Transactional Data Specifications for Demand-Responsive Transportation*. The TDS supports trip booking and confirmation among two or more DRT service providers. It allows these service providers to coordinate and exchange trip information electronically without having to use a phone or send an email or fax.

3 https://www.presidency.ucsb.edu/documents/executive-order-13330-human-service-transportation-coordination

4 https://www.govinfo.gov/content/pkg/WCPD-2004-03-01/pdf/WCPD-2004-03-01-Pg280.pdf

5 https://www.transit.dot.gov/research-innovation

6 https://learn.sharedusemobilitycenter.org/casestudy/the-role-of-data-specifications-in-creating-an-integrated-transportation-system/

Microtransit *is a technology-enabled transit service that uses multipassenger vehicles, flexible virtual stops, and dynamic routing, scheduling, and dispatching for flexible, shared, on-demand rides.*

Defining the TDS data that are communicated. *TCRP Research Report 210 refers to the data that are passed from one API to another as telegrams, while other software and API developers often use the term messages. For the purposes of this report, these communicated TDS data are referred to as data messages or messages.*

Although many transportation technology vendors share their data through proprietary application programming interfaces (APIs), this is not the same as an open-source data specification. Proprietary APIs limit the data from being used openly across platforms. For integration to take place, the owner of the API must share the key. In comparison, the TDS and other open-source specifications promote on-demand information exchange through platform-agnostic solutions. Open-source code standardizes how data is shared by outlining a clear script for how codes are written. Interoperability and the use of open-source data solutions are gaining traction in the industry. For example, the Mobility Data Interoperability Principles outline a set of guiding principles and are backed by a coalition of government agencies, mobility service providers, and nonprofit organizations promoting the adoption of open-source data solutions by the transportation sector.[7] The following graphics illustrate this concept. The first diagram shows how interoperability is limited through a proprietary API, as each integration is a unique instance; the second diagram demonstrates how the TDS can support interoperability by using its common data language.

The image below illustrates the flow of operations in an open-source data exchange and common TDS messages necessary for a rider and agency to reserve, schedule, perform, and report/bill a trip.

About this paper

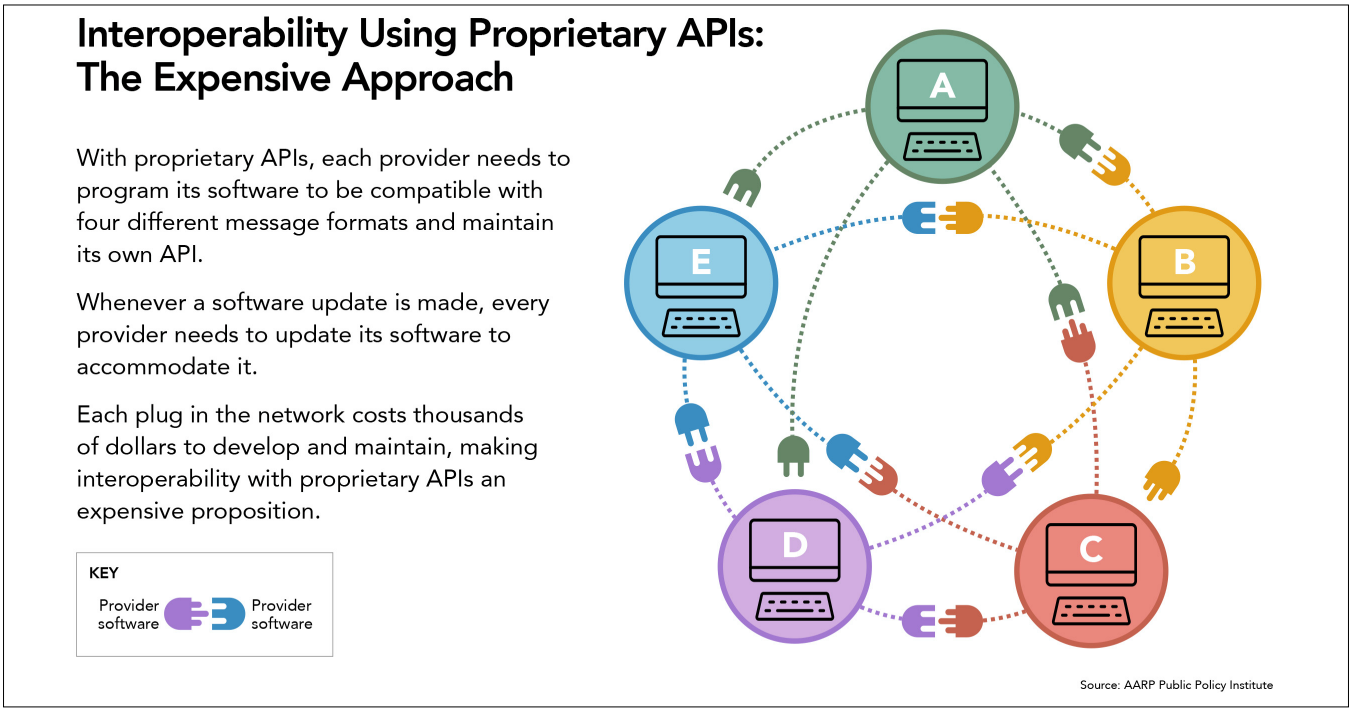
Since the release of *TCRP Research Report 210*, the TDS has gained traction in the industry. TDS-related demonstration projects are in various planning and implementation phases to test functions of the TDS and its potential to coordinate DRT services. These projects exist in several regions, and their focus varies from rural dial-a-ride public transportation and volunteer driver programs to microtransit and paratransit services. Various deployments offer insights into how a more established TDS might come about, highlighting the importance of bridging the gap between a technical report about a data specification and lessons from on-the-ground implementation efforts.

This paper explores these early implementation projects and reflects on trends, patterns, and lessons learned that may help advance widespread TDS adoption. Key takeaways include the following:

- Use of the TDS is appropriate for both urban and rural DRT services.
- Community engagement, particularly involving riders dependent on demand-responsive transportation services, is critical for success.
- Project leads will want to build institutional relationships and cross-jurisdictional alliances.
- Technology vendors should be involved early to define use cases and doable solutions.
- Funding for demonstration projects exists but not from a single source. It is wise to identify funding to support participation in governance activities, in addition to project-based work.
- Two implementation approaches exist. The *universal transactional data format* is preferred because it avoids vendor lock-in and results in a more stable, cost-effective, longer-term solution. The *data translation middleware* approach offers a work-around for the challenge of getting all software vendors to integrate the TDS within their existing APIs.

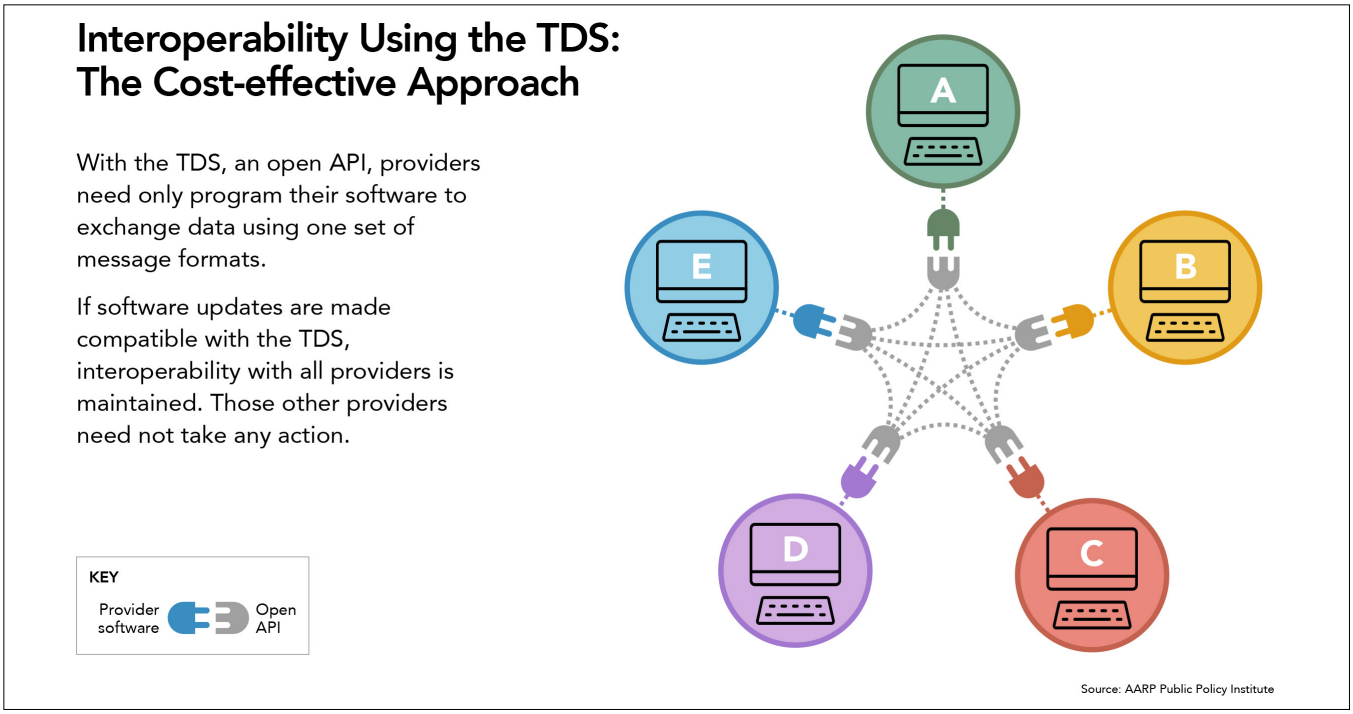
7 https://www.interoperablemobility.org/

Figure 3A. 3A and 3B are images illustrating the difference between proprietary APIs and open-source data specifications like the TDS.



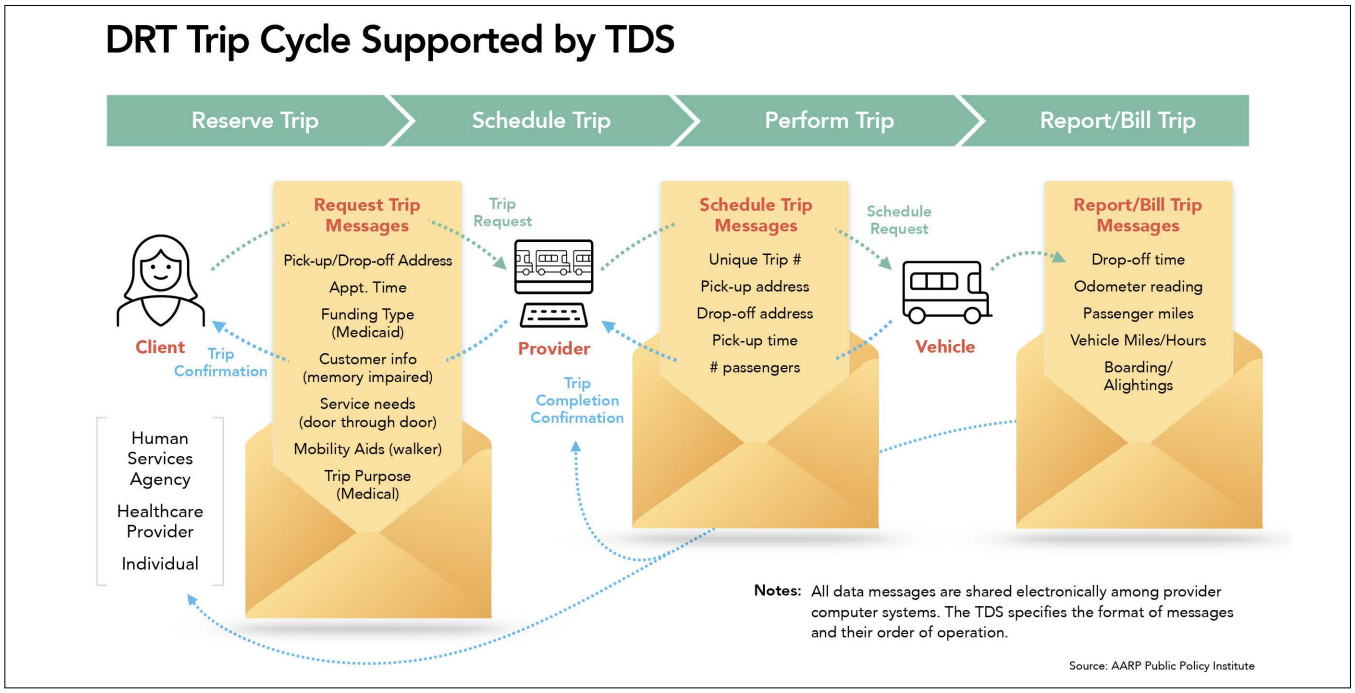
Credit: Originally published in *Modernizing Demand-Responsive Transportation for the Age of New Mobility*, AARP Public Policy Institute, December 2020.

Figure 3B. 3A and 3B are images illustrating the difference between proprietary APIs and open-source data specifications like the TDS.



Credit: Originally published in *Modernizing Demand-Responsive Transportation for the Age of New Mobility*, AARP Public Policy Institute, December 2020.

Figure 4. Image illustrating the flow of operations and common TDS messages necessary to carry out a TDS-based trip.



Credit: Originally published in *Modernizing Demand-Responsive Transportation for the Age of New Mobility*, AARP Public Policy Institute, December 2020.

- There is an immediate need for a TDS governance framework now that several implementation projects are underway. An organized means for collaboration and decision-making helps to ensure that changes and enhancements made to TDS messages and protocols are shared beyond individual project partners.
- Opportunities exist to expand use of the TDS to NEMT, mobility management platforms, and more rural public transportation services.

TDS demonstration project summaries

North Front Range Metropolitan Planning Organization/RideNoCo, Northern Colorado

- Goal: Improve service for riders by streamlining the distribution of transit customer information and trip requests between the regional call center and volunteer driver programs.
- Use Cases: Project partners are developing TDS-compliant APIs to share customer information and trip requests across four regional volunteer driver programs, using

three scheduling software systems, in the North Front Range Colorado region. The RideNoCo coordination project has three use cases:

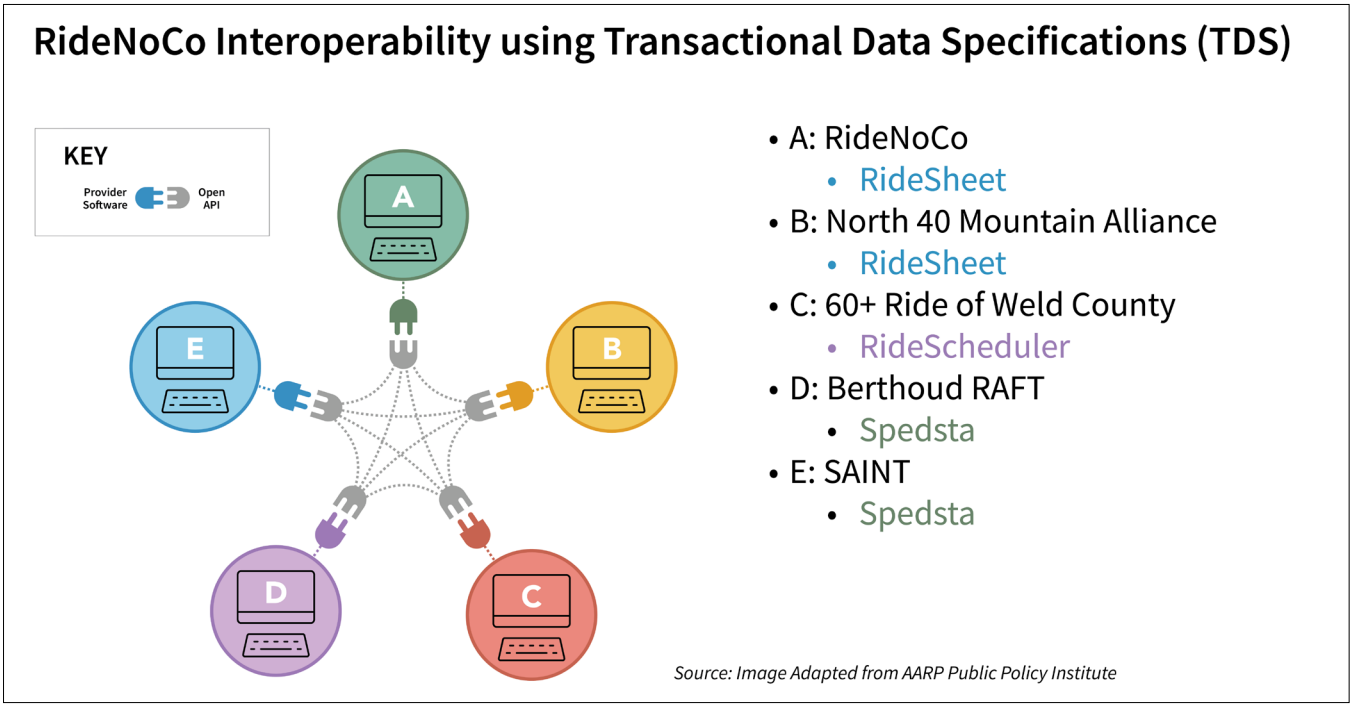
1. Customer referrals. Participating agencies can exchange customer

information, reducing the level of effort required for customer intake.

2. Trip referrals. Participating agencies can refer trips to other agencies to see if those providers can provide a trip that the original requestor cannot.
3. Coordinated trips. The project allows multiple transportation providers to coordinate to deliver a trip across multiple agencies (typically these are longer-distance trips).

- Target Population: Volunteer driver organization customers, particularly older adults, individuals with disabilities, individuals with low incomes, rural residents
- Status: In design and implementation phases
- Project Partners (software vendor or role):
  - North Front Range Metropolitan Planning Organization (NFRMPO; lead implementing agency)[8]
  - RideNoCo is NFRMPO's regional mobility management program providing information, assistance, referrals, and intake assistance
  - Regional volunteer transportation providers:
    - North 40 Mountain Alliance (RideSheet scheduling tool)
    - 60+ Ride of Weld County (RideScheduler scheduling software)
    - Berthoud Rural Alternative for Transportation (RAFT; Spedsta scheduling software)
    - SAINT Volunteer Transportation (SAINT; Spedsta scheduling software)
  - TransitPlus is serving as the project facilitator.
  - Full Path Transit Technology (Full Path; software developer of RideSheet, an open-source scheduling tool)
  - Spedsta (software provider)
  - RideScheduler (software provider)
- Service Information: Volunteer driver programs serving the northern Colorado region
  - North 40 Mountain Alliance (Larimer County)

Figure 5. RideNoCo Volunteer Driver Programs and Scheduling Software



Credit: Adapted from *Modernizing Demand-Responsive Transportation for the Age of New Mobility*, AARP Public Policy Institute, December 2020.

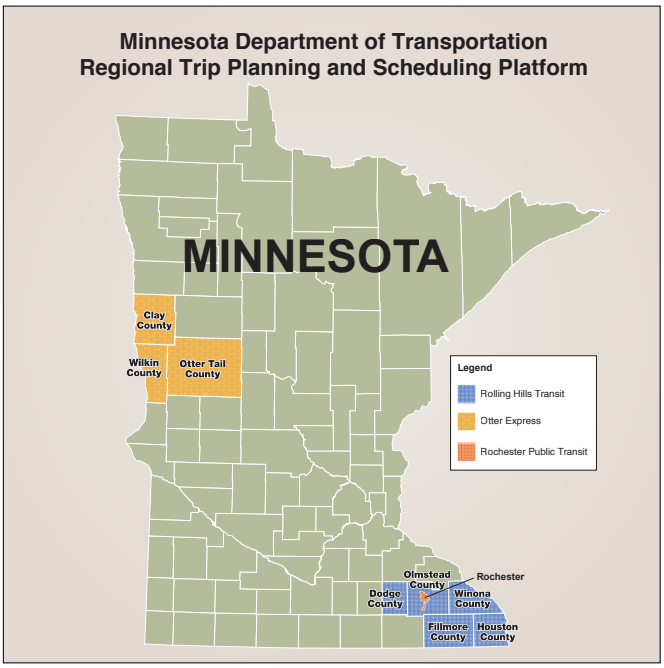
8 https://nfrmpo.org/overview/

- 60+ Ride (Weld County)
- RAFT (Berthoud Fire Protection District, which includes parts of Larimer, Boulder, and Weld counties)
- SAINT (cities of Fort Collins and Loveland)

- Urban Form: Mixed (urban, suburban, rural)
- TDS Funding: Colorado Department of Transportation Multimodal Transportation and Mitigation Options Fund

Because of the rural nature of large parts of Boulder, Larimer, and Weld Counties in Colorado, not all residents are able to find the rides they need. A 2014 survey of 1,500 households with a high likelihood of having an adult age 60 or older revealed that only 70 percent of respondents noted excellent or good ease of getting to places they frequent, down 7 percentage points in just four years—this despite having 16 unique transportation services in the region.[9] The 2017 transportation needs assessment for Larimer County recommended expanded service, public education about transportation options, better technology, and funding for mobility coordination as ways to address transportation gaps. RideNoCo formed in 2021 after NFRMPO and Larimer County authored their Senior Transportation Implementation Plan calling for the creation of a regional mobility management program. RideNoCo set out to develop a one-call/one-click center that fields trip requests and assigns passengers to mobility providers based on needs and geography. Since then, RideNoCo has partnered with volunteer transportation providers across Larimer and Weld Counties, along with technology vendors, to develop a TDS-supported integration that supports coordination so RideNoCo and volunteer driver organizations can exchange customer and trip information—with the goal of providing more trips to more customers. Among other features, the TDS integration will offer new data exchanged to help determine rider eligibility. Some eligibility criteria include age, income, and veteran status. RideNoCo's demonstration is one of the more robust TDS implementations at this time and will result in a TDS platform that will be adaptable to additional service providers and geographic areas. A more detailed case study of RideNoCo is available in the *TDS Demonstration Project Case Studies* section.

Minnesota Department of Transportation regional trip planning and scheduling platform, southern and western Minnesota



- Goal: Enable rural public transportation and ADA paratransit customers to seamlessly plan, book, and pay for a trip using a smartphone app or website.
- Use Case: Create an open-source TDS module to facilitate communication between trip planning applications and transit agencies' scheduling software. Streamlined trip planning and scheduling are wins for both transit customers and transit providers.
- Target Population: General population of rural public transportation riders and qualifying ADA paratransit customers
- Status: Planned TDS implementation November 2023
- Project Partners (software vendor or role):
  - Minnesota Department of Transportation (MnDOT; lead implementing agency)

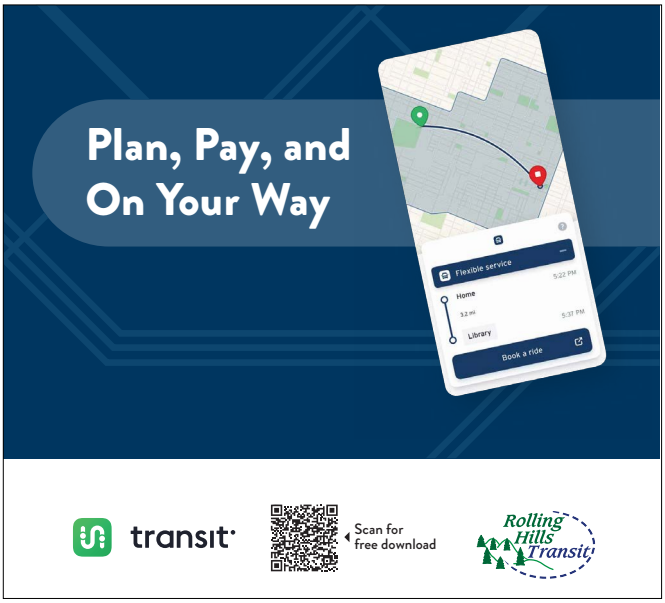
9 https://www.larimer.org/sites/default/files/uploads/2017/larimer_county_transportation_needs_assessment_final_071317_wo_appendices_0.pdf

- Rolling Hills Transit (CTS TripMaster)
- Otter Express (CTS TripMaster)
- Rochester Public Transit (RPT; CTS TripMaster)
- Cambridge Systematics (technical consultant/lead developer of both the TDS module and a web-based trip-planning application built upon OpenTripPlanner)
- Transit (the company's public-facing trip planner interacts with CTS TripMaster via the TDS module)
- Trillium (provides GTFS Feeds)

- Service Information:
  - RPT covers the city of Rochester with paratransit services
  - Rolling Hills Transit covers the part of Olmsted County not covered by RPT and Dodge, Fillmore, Houston, and Winona Counties in southeast Minnesota with curb-to-curb demand-responsive public transportation and paratransit services
  - Otter Express offers demand-responsive service in Clay, Otter Tail, and Wilkin Counties in western Minnesota. Customers may request door-to-door assistance.
- Urban Form: Mixed (urban, suburban, rural)
- TDS Funding: FTA AIM grant, FTA COVID-19 Research Demonstration Grant

Minnesotans without access to a personal vehicle can struggle to find transportation to employment, education, and health care as well as to run errands or make social visits. The current shared-mobility landscape makes identifying and comparing transportation options by mode, cost, and time difficult and inconvenient. In response, MnDOT applied for and received two federal innovation and research demonstration grants to support the construction of a regional mobility-as-a-service (MaaS) platform for shared mobility customers in the state's southern and western regions. The TDS implementation project is an important piece of this larger initiative. MnDOT is working to implement a TDS solution for a limited geography within the larger MaaS project service area. This TDS pilot is geared toward public DRT and ADA paratransit customers and aims to streamline ride booking for both the customer and the agencies. Through this platform, transit customers will enjoy a more convenient way to manage trips, while agencies can take some of the burden off customer service agents handling over-the-phone scheduling. A newly built TDS module will be portable and not tied to any specific mobility provider or software vendor. The TDS module launched in January, 2024. A more detailed case study of MnDOT's demonstration project is available in the *TDS Demonstration Project Case Studies* section.

Figure 6. Promotional material for Rolling Hills Transit directing users to the trip planning application.



Credit: Minnesota Department of Transportation

Mobility-as-a-service (MaaS) is a digital ecosystem that, using a single interface, allows for the integration of various modes of transportation (e.g., public transportation, ADA paratransit, bike, scooter, and carshare). Through a fully developed MaaS platform, customers can pan, book, and pay for their entire multimodal journeys in one convenient place.—Universal Mobility as a Service: A Bold Vision for Harnessing the Opportunity of Disruption, AARP Public Policy Institute, December 2020

NEORide EZConnect, northeast and southwest Ohio

- Goal: Increase access to on-demand service for paratransit and microtransit customers by enabling interoperability among partner agency scheduling systems.
- Use Case: Enable DRT systems to electronically share customer profile and eligibility information, trip requests, and booking confirmations by building a middleware application that includes TDS translation capability, resulting in easier client management and booking.[10]
- Target Populations: General public and those who qualify for ADA paratransit service
- Status: In design phase
- Project Partners (software vendor or role):
  - NEORide (lead implementing agency)
  - Southwest Ohio Regional Transit Authority (SORTA; Trapeze PASS software for ADA paratransit and Via for microtransit)
  - Community Action Agency of Columbiana County Community Action Rural Transit System (CARTS; CTS TripMaster software for advance-reservation trips and Via for same-day trips)
  - Arcadis IBI (system architecture for the EZConnect platform)
  - DemandTrans Solutions (design and development of the middleware application with TDS translation capabilities)
- Service Information:
  - CARTS serves Columbiana County in NE Ohio with advanced reservation rural DRT public transit, microtransit in a limited service area, and a 13-stop route-deviated shuttle service in East Liverpool and Calcutta.[11]
  - SORTA serves Cincinnati and Hamilton Counties with fixed-route, microtransit, and ADA paratransit service.
- Urban Form: Mixed (urban, suburban, rural)
- TDS Funding: FTA EMI grant

NEORide is a council of governments focused on coordinating 18 public transit agencies in Ohio, Kentucky, Michigan, West Virginia, and Arkansas. Its member agencies have spent the past several years exploring how to better pool their call centers and scheduling resources to enhance customer service. Through a recent FTA EMI grant it intends to build and test the TDS in two smaller geographic areas in Ohio, facilitating open data exchange among NEORide, SORTA, CARTS, and their associated software vendors.[12] The TDS-compliant middleware will enable each provider's client management platform to share customer profile and eligibility information, trip requests and booking confirmations, vehicle information such as location and accessibility

10 https://www.transit.dot.gov/research-innovation/fy21-enhancing-mobility-innovation-projects

11 Route deviation is when a customer can request a pickup or dropoff location within three quarters of a mile from the fixed route.

12 https://highways.dot.gov/newsroom/us-department-transportation-awards-183-million-ohios-neoride-improve-access-transit#:~:text=WASHINGTON%20%E2%80%93%20Today%2C%20the%20U.S.%20Department,and%20multimodal%20connections%20for%20Ohioans

features, scheduled dropoff time and location, vehicle and driver identity, and trip performance status (e.g., on time, delayed). This will streamline the booking process for customers and make it much easier for them to take advantage of on-demand service.

The TDS implementation is the latest piece of a multipronged approach to improving transportation service in the region. NEORide also received state and federal funding for the creation of EZConnect, a one-call/one-click system.[13] EZConnect will support member agencies with phone and website booking hosted at a central location. Microtransit and paratransit programs at NEORide's member agencies will be able to use EZConnect to support their booking and scheduling operations, including automated verification of customer eligibility.[14]

Currently in the planning and design stage, the TDS-compliant middleware will be the core element of the transactional functionality of EZConnect. The middleware will be a software module that manages data exchange using TDS translation capability. It will make it possible for transactional data to be sent to and retrieved from the Via, Trapeze, and CTS platforms with no required coding changes to those platforms' APIs, and it will ensure that all relevant trip data is transmitted dynamically.

Metropolitan Transportation Commission, Bay Area, California

- Goal: ADA paratransit customers will experience streamlined multijurisdictional and multiprovider trip booking, facilitating rider transfers when a single provider cannot offer point-to-point service and thus improving customer experience.
- Use Case: Enhanced TDS message sets will enable communication between two unique types of paratransit scheduling software.
- Target Population: ADA paratransit customers
- Status: In development phase

- Project Partners (software vendor or role):
  - Metropolitan Transportation Commission (MTC; lead implementing agency)
  - East Bay Paratransit (Adept software)
  - Valley Transportation Authority (VTA; Trapeze Pass software)
  - Bay Area Partnership Accessibility Committee (BAPAC; a regional coordination forum for all paratransit service providers)
- Service information:
  - East Bay Paratransit serves Alameda and parts of Contra Costa Counties.
  - VTA provides paratransit services in Santa Clara County.
- Urban Form: Urban and suburban
- TDS Funding: FTA EMI grant

San Francisco Bay region's ADA paratransit customers face significant barriers when attempting to cross county boundaries. They report extremely long wait times at poorly lit transfer locations that too often lack an accessible restroom. Paratransit providers also struggle to coordinate cross-jurisdictional

13 https://learn.sharedusemobilitycenter.org/casestudy/one-account-many-transit-agencies-integrating-transit-payments-with-neoride-ezfare/

14 https://www.neoride.org/post/ezconnect and https://www.ezconnect.org/

Figure 7. An ADA Paratransit rider.

Credit: Metropolitan Transportation Commission

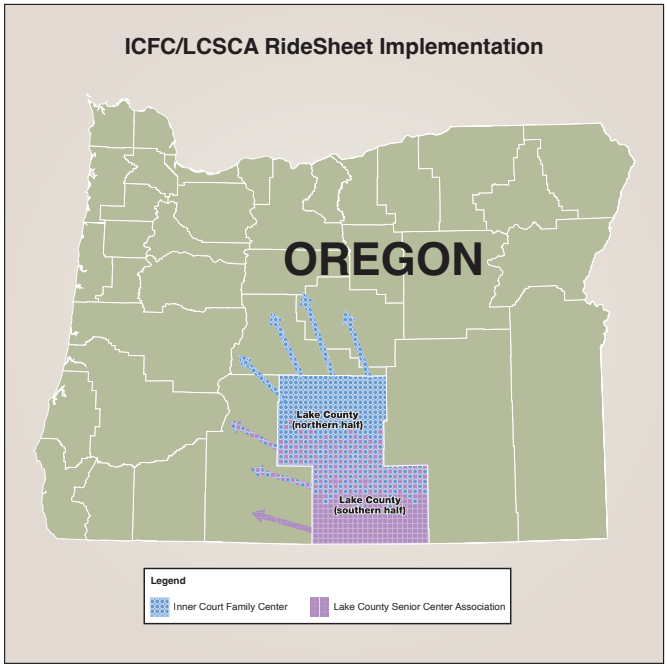
transfers.[15] To address these needs, the MTC is developing a shared booking tool for East Bay Paratransit in Alameda County and VTA in Santa Clara County to be used by the paratransit operators' booking agents.

The tool will allow riders to travel from one county to the other without booking two trips through two different agencies. It will interface with each operators' booking and scheduling software through exposed APIs, with the aim to improve interagency workflow. The new software will enable the agency in the county of origin to coordinate and book a trip for passengers with the other respective agency. The booking software facilitates all parts of the journey across multiple jurisdictions. Booking agents can also use the tool to cancel an entire trip or any leg of the trip.

The TDS is the supporting open-source data communication protocol for the software. Existing technology vendors for East Bay Paratransit and VTA are supporting the software development. Until vendors can directly exchange data using the enhanced TDS message sets, the MTC's tool must convert those messages. The agency hopes that as the system matures and technology procurement opportunities occur, it will be able to encourage technology vendors to offer TDS-compliant APIs, eliminating the need for TDS translation.

In developing its TDS-supported software, MTC is working with BAPAC, a regional forum for paratransit service providers. The commission hopes to expand the system regionally beyond the two-county demonstration project area.

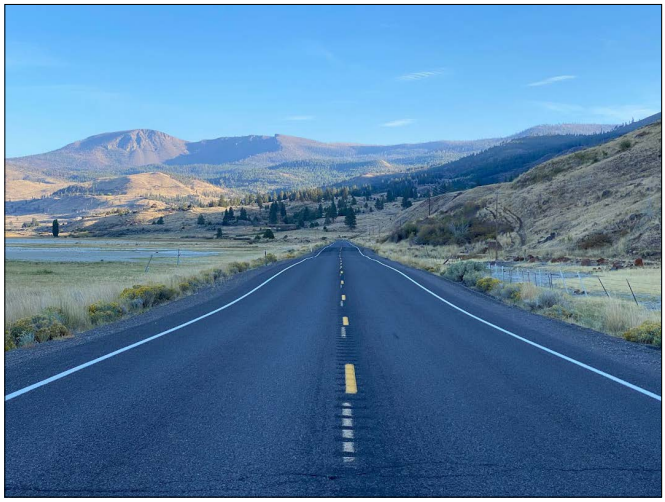
RideSheet, Lake County, Oregon



- Goal: Offer residents of highly rural Lake County, Oregon, more opportunities to travel short and long distances to medical appointments, grocery shopping, social engagements, and other destinations.
- Use Case: The TDS-compatible RideSheet tool aims to streamline communication and trip coordination between the participating nonprofit transportation providers—without the need for email, fax, or phone calls.
- Target Population: Older adults, people with disabilities, and others without access to a personal vehicle.
- Status: Deployed with two nonprofits in Lake County, Oregon
- Project Partners:
  - Inner Court Family Center (ICFC)
  - Lake County Senior Center Association (LCSCA)
  - Full Path (developed the RideSheet scheduling tool)

15 https://mtc.ca.gov/sites/default/files/MTC_Coordinated_Plan_Web_Temp.pdf

Figure 8. Road in Lake County, OR.



Credit: Kevin Chambers

- Service information:
  - ICFC relies on volunteer drivers using their own vehicles to transport customers, predominantly in the northern half of Lake County.
  - LCSCA operates a combination of buses and vans they own and operate with paid drivers, largely serving the county's southern portion.[16]
  - Both organizations make long-distance trips to take clients to medical appointments as far away as Bend and Portland, distances of more than 150 and 350 miles, respectively.
- Urban Form: Mixed (rural with service to urban areas)
- TDS Funding: AARP funded RideSheet's initial proof of concept.

In highly rural Lake County, Oregon, more than 25 percent of the population is over the age of 65, and many of these older residents depend on the ICFC and LCSCA for transportation. In 2021, ICFC and LCSCA partnered with Full Path to build an open-source tool called RideSheet. This DRT scheduling and reporting tool is among the first initiatives to demonstrate how the TDS can facilitate HST coordination. AARP funded the proof of concept for the RideSheet tool.[17] ICFC and LCSCA offer volunteer and paid driver-supported rides for older customers and others who do not have access to a personal vehicle.[18] RideSheet is a user-friendly, practical tool that uses Google Workspace. Prior to RideSheet, LCSCA used a paper-based system, and ICFC used spreadsheets to schedule trips. Although the tool is programmed to allow automatic ride scheduling on either service, the TDS is currently used on a limited basis; each agency manually assigns trips requested through one agency to the other as needed. The TDS is not a single communication point but a framework for communication between the two providers. Through the TDS, ICFC and LCSCA can see the manifests, vehicle status, and location of both providers. This allows one agency to add their riders directly to the itinerary of the other's scheduled trips. Such a feature is significant in a county where residents must travel more than 100 miles to reach a health care specialist. By facilitating shared rides across two agencies, RideSheet helps free up community resources otherwise spent on providing solo transportation.

King County Mobility Coalition, Seattle, Washington

- Goal: Streamline and centralize requests for HST in the Seattle region through the Find a Ride platform. In subsequent project phases Hopelink anticipates using the TDS to allow customers to easily see a variety of available DRT options and communicate with HST providers to schedule trips.
- Use Case: TDS use case is not yet defined.
- Target Population: HST providers and clients
- Status: Find a Ride platform in testing phases
- Project Partners:
  - Hopelink/King County Mobility Coalition (KCMC; lead implementing agency)

16 https://www.lakecountyexam.com/lifestyles/senior-center-increases-transportation-program/article_647d45e2-bef5-11e5-8326-d32eba6fdd7d.html

17 https://nationalcenterformobilitymanagement.org/wp-content/uploads/2022/12/RideSheet-Project.pdf

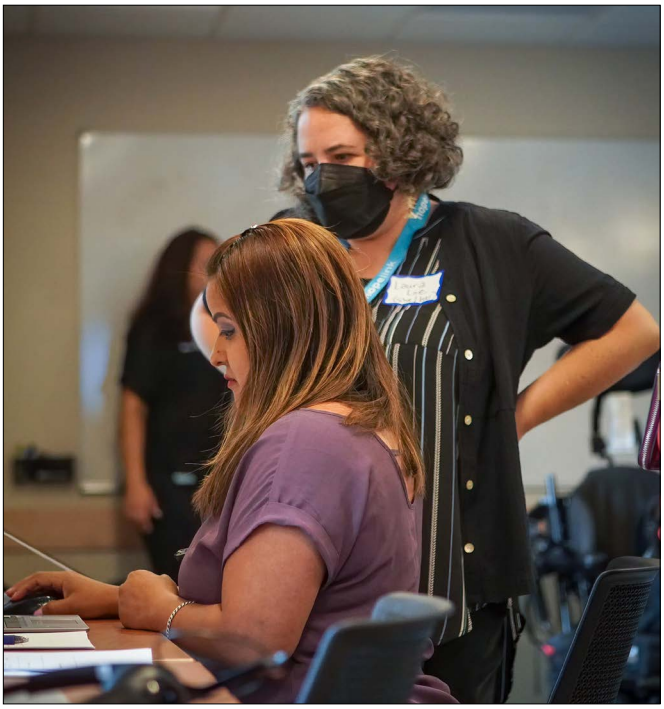
18 https://www.aarp.org/pri/topics/livable-communities/transportation/ridesheet-rural-transportation-benefits-new-coordination-technology.html

- Find a Ride Advisory Committee with participation from Washington Department of Transportation, human service transportation providers, other state and local government agencies, and community members
- Full Path (technical consultant)

- Service Information: Three counties across the Seattle, Washington, area
- Urban Form: Urban, suburban
- Funding: Federal Administration for Community Living Inclusive Planning grant, Washington State Department of Transportation Consolidated grant; funding for TDS implementation to be determined

KCMC is committed to creating a future where transportation becomes a resource rather than a barrier, and its efforts in Washington to launch Find a Ride, a one-call/one-click platform, move the region closer to this goal and offer a model for conducting community engagement and building institutional relationships for TDS implementation. In addition to ongoing engagement with the Find a Ride advisory committee, KCMC has conducted many community engagement activities including summits, a hackathon, listening sessions, and surveys. The coalition

Figure 9. Hopelink staff testing the Find a Ride platform.



Credit: Hopelink

will continue to work with the advisory committee as it tests and deploys Find a Ride. In developing the platform, KCMC incorporated data specifications like GTFS and GTFS-Flex and is working to add approximately 30 human service transportation providers, representing roughly 50 transportation services by the end of 2024. Find a Ride will allow transit customers to see available transit options and point them to a chosen HST provider to schedule a trip.[19] KCMC hopes to adopt the TDS into Find a Ride at a future date.

TDS demonstration project case studies

TDS implementation for volunteer drivers through RideNoCo

RideNoCo, which handles mobility management for NFRMPO, hopes that adopting the TDS will better facilitate the coordination of trip booking and delivery, improving both customer and driver experiences. Although RideNoCo works with numerous DRT providers throughout the region, the demonstration project involves four volunteer driver programs: the North Forty Mountain Alliance, 60+ Ride, Berthoud

19 https://www.findaride.org/

Figure 10. Cover of the Larimer County Senior Transportation Implementation Plan.

Credit: North Front Range Metropolitan Planning Organization

Rural Alternative for Transportation (RAFT), and SAINT Volunteer Transportation (SAINT). The willingness of the four volunteer-driver programs—and that of their technology vendors—to collaborate and explore DRT coordination solutions was a significant factor in driving the TDS implementation effort.

Implementing the TDS is part of a phased trip integration rollout for RideNoCo, which was formed in 2021 to fulfill a need for a one-call/one-click center to coordinate rides among mobility providers based on geography and service type.20 As a first phase of the one-call/one-click center build, a trip-planning tool using GTFS-Flex was developed in 2022.21 RideNoCo originally thought each member agency would migrate its operations to a single regional DRT-scheduling platform. Providers, however, were reluctant to make this switch given the financial investment and office staff and driver training required. This led RideNoCo down the TDS path.

Supported by grant funding, RideNoCo partnered with several technology vendors including Full Path (RideSheet), RideScheduler, and Spedsta to implement the TDS as part of a phased trip integration rollout. Working with the project facilitator TransitPlus, RideNoCo sought to understand the software and operational needs of the various DRT providers and software vendors (RideScheduler, Spedsta, and RideSheet). That led to the development of a system design plan that described what information needs to be transmitted when, and how.

Figure 11. A RAFT vehicle

Credit: RideNoCo

Necessary changes made to the TDS schema that was originally developed through the 2020 Transit Cooperative Research Project (TCRP) project are documented on GitHub.

RideNoCo's project has several use cases for the TDS that are aimed at improving service for riders, including allowing for intake and referral functionality and processing multileg trips. Customer calls to RideNoCo can be processed by passing the customer's information to the appropriate transportation provider, streamlining the intake. Refinements to the TDS will also help determine rider eligibility, including ensuring that provider-specific eligibility criteria such as age, income, and veteran status are met. RideNoCo's solution also includes an open data field for additional information, such as who can request rides on a customer's behalf, or which

20 https://nfrmpo.org/wp-content/uploads/senior-transportation-implementation-plan.pdf

21 https://discover.rideno.co/#/

building entrance is preferred for customer dropoff. The TDS also helps mitigate issues that arise when a trip request cannot be fulfilled. The provider can electronically pass along (refer) the trip request to other providers in the network without having to make a phone call or send an email. This increases options for transit customers while making operations more efficient. Finally, plans exist to use the TDS to streamline long-distance trips. When customers have multileg trips via multiple service providers, the TDS will share the trip information and coordinate a designated meeting location, giving all providers access to the same data and eliminating the need for the trip and customer information to be entered separately into multiple systems.

TDS in action

The data exchange among RideNoCo and the software systems used by volunteer driver providers will be accomplished through TDS-compliant APIs. RideNoCo's call center uses RideSheet for customer intake and trip referrals to volunteer driver programs. RideSheet communicates that information via a TDS-compliant API to Spedsta and RideScheduler, the other software systems. Spedsta and RideScheduler are also amending their DRT scheduling software to receive this trip information from RideSheet and transmit booking information back to RideNoCo using the TDS. Their compliant APIs also enable them to communicate directly with one another. RideNoCo uses a limited set of messages from *TCRP Research Report 210* and is developing its own messages. It is also giving instructions on formatting those messages and where the messages fall in the order of operations. One of these new messages allows providers to verify a customer's eligibility for services with age or income limitations.

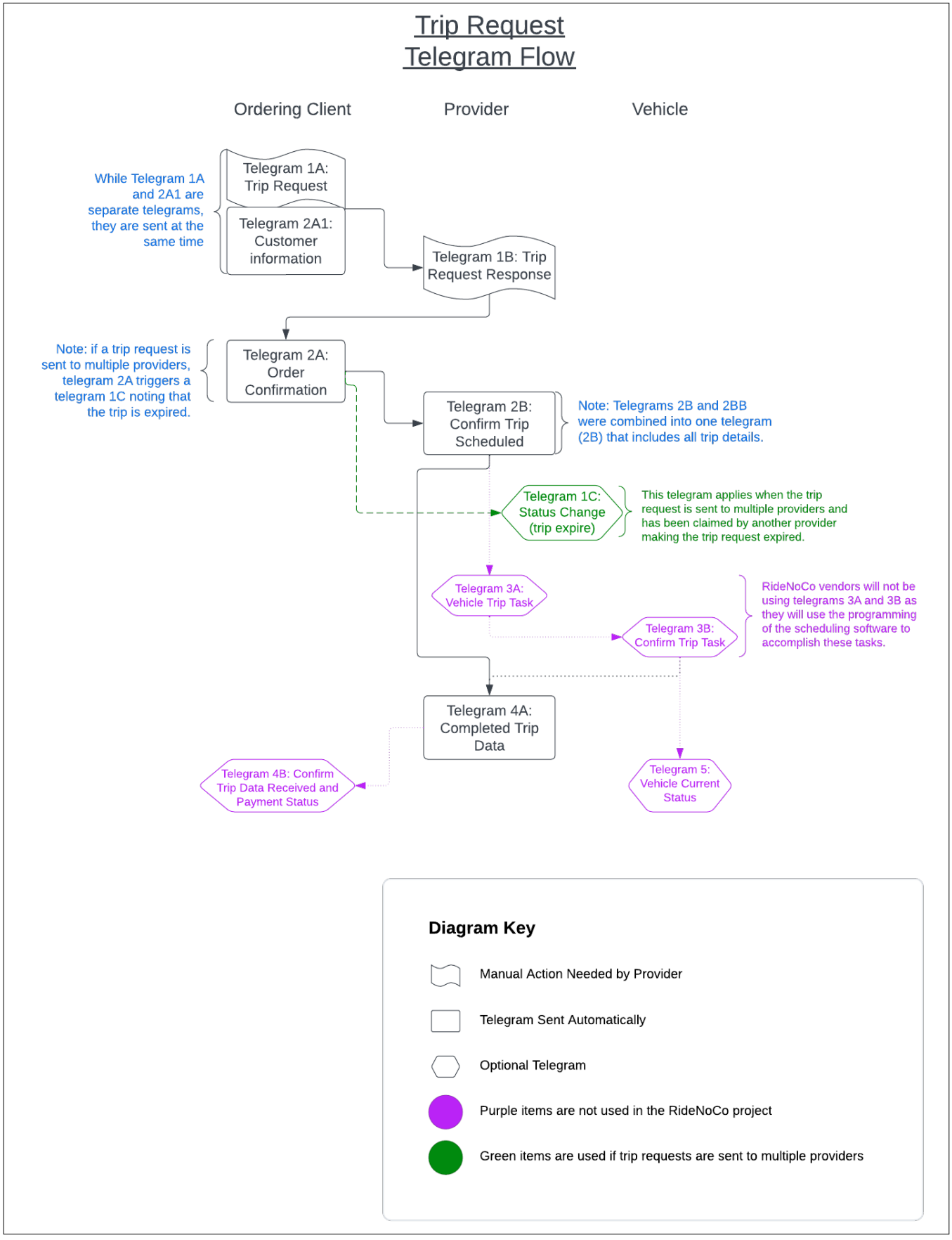
The trip request telegram flowchart (Figure 12) illustrates the TDS functionality. When a trip request is made, "Telegram 1A: Trip Request" is paired with "Telegram 2A1: Customer Information," and the trip request is then followed by an optional trip request response (Telegram 1B) and a confirmation (Telegram 2A) from a mobility provider. Next, the trip is scheduled (Telegram 2B), and ongoing communication is carried out between the rider, the provider accepting and performing the trip, and RideNoCo, which oversees the trip scheduling and dispatch. Finally, data about the completed trip are automatically sent (Telegram 4A). Four TDS telegrams (shown in purple) are not used in the RideNoCo project: vehicle trip tasks (Telegram 3A), confirm trip task (Telegram 3B), payment status (Telegram 4B), and vehicle status (Telegram 5) either because that functionality is picked up within the participating software vendor platforms or because they are not needed. Further details on the data messages that RideNoCo is planning to develop are discussed in appendix B.

Short timeline made possible by strong institutional foundation

RideNoCo's TDS implementation project is proceeding at a fast clip, with a planned launch date of March 2024. The TDS system design phase began in June 2023; API development began in November and is expected to extend through January 2024. Participating agencies will begin testing the TDS APIs in February 2024. The timeline of less than a year is possible because of the institutional coordination, having champions from each agency, and a solid senior transportation plan.

Reliance on vendor APIs that are TDS-compliant enables not only interoperability of current partners but also affordability, which facilitates the inclusion of future partners that could expand the geographic reach. RideNoCo hopes to extend to public transportation agencies next.

Figure 12. RideNoCo trip request telegram flowchart.



Credit: RideNoCo TDS Development timeline

Minnesota Department of Transportation TDS pilot

In 2020, the MnDOT TDS pilot began by partnering with transit agencies and mobility providers to implement a regional trip planning platform across the southern and western regions of the state.[22] Launched in late 2023, the platform enables customers to plan trips on public transit and other forms of shared mobility. Customers use the Transit app to enter their origin, destination, and planned travel times; the app then recommends which services, schedules, and routes to use based on real-time data. Customers have real-time information on transit services through GTFS and GTFS-Flex data feeds. Part of MnDOT's initiative also involves testing a TDS solution in a limited geographic area served by RPT, Rolling Hills Transit, and the Otter Express.

TDS in action

MnDOT rolled out the TDS pilot for rural dial-a-ride and ADA paratransit services with its three transit agency partners in late 2023. Customers who request a DRT trip online through the Transit app trigger the TDS module. The TDS module takes the trip request and communicates with the CTS scheduling software used by each of the three transit agencies, putting the request in their queue. First-time customers are prompted to set up an account, which stores their information for future use. Dispatchers at the receiving agency can accept or deny the trip within their system based on customer eligibility and vehicle and driver availability. Once a trip is booked or denied, the CTS software sends a message back to the TDS module and on to the trip-planning application through TDS-compliant APIs; this allows the customer to see the status of the trip, including scheduled arrival time and any updates. The customer can also review other upcoming trips and cancel a booked trip through the Transit app. All information exchanged about trip planning, booking, dispatch, and updates is more streamlined for both the customer and transit agency personnel.

The Minnesota TDS solution also uses a limited number of messages from *TCRP Research Report 210*, and, like the RideNoCo project, MnDOT created several new messages necessary for this local use case (the messages used in the TDS module are discussed in Appendix B).

With the TDS, MnDOT envisions a system that allows customers to book and mobility providers to accept and schedule rides without phone calls or email. Customers are no longer limited to booking their rides during daytime call center hours. Although MnDOT's TDS module supports automated booking, transit agencies requested that dispatchers still manually accept and schedule trip requests. The image above features screenshots of the trip-planning app in action in the MnDOT Regional MaaS pilot.

Commitment to open-source principles

MnDOT's commitment to building a replicable MaaS solution that is not beholden to any one software vendor or platform is illustrated through three important decisions.

First, trip planning within the MnDOT system architecture is platform agnostic. Customers can use either the Transit app (a proprietary trip discovery tool) or MnTransitPlanner.com, a web- based trip planner built using the OpenTripPlanner search engine, an open-source solution.[23] Each has integrated flexible DRT services (in this case, rural public transit and ADA paratransit) by consuming GTFS-Flex service data from transit agencies, which they then present to the traveling public. In the future, Google Maps, Moovit, and other companies that offer their own trip planning applications could choose to do the same.

Second, the TDS module is publicly available for use by other agencies and companies looking for a solution to a similar use case.

Third, the TDS module is distinct from a translator. Rather than translating proprietary trip messages from the software vendor into TDS-compatible messages, the software vendor (in this case, CTS) has modified its API to be TDS compliant. Because of the current limitations of the TDS, the vendor's API is still used, but as the TDS grows its functionality through an open governance process,

22 https://learn.sharedusemobilitycenter.org/casestudy/maas-in-minnesota-developing-a-regional-trip-planning-platform/

23 The TDS booking module is available only on the Transit app for this pilot and not on MnTransitPlanner.com.

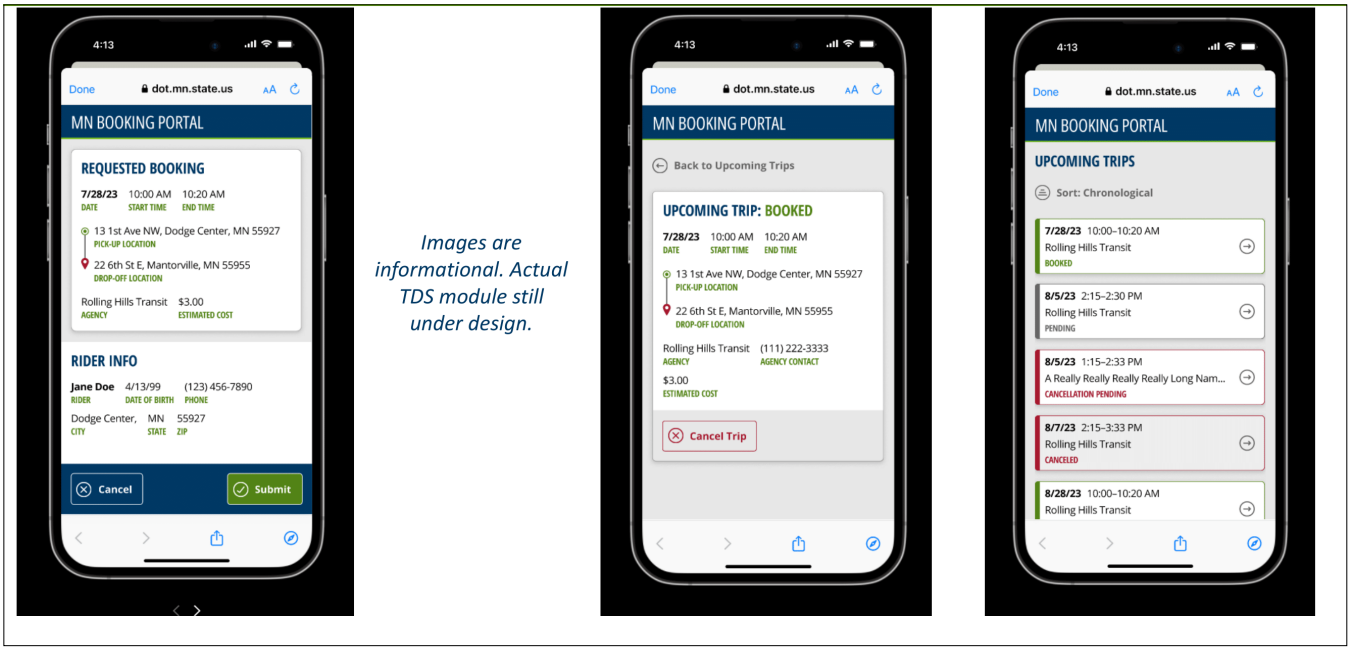
transportation partners will be able to rely on it for an increasing number of functions.

MnDOT's open-platform architecture is important for sustainability, particularly in an industry where software vendors come and go frequently. Moreover, if the TDS were built within a proprietary software vendor application, it would limit MnDOT to using only that software vendor's platform, effectively limiting new software vendors from entering the market. Although the MnDOT TDS demonstration project is limited in scope and geography, it offers important lessons on an open-source TDS module for mobility providers in Minnesota and elsewhere.

On the horizon

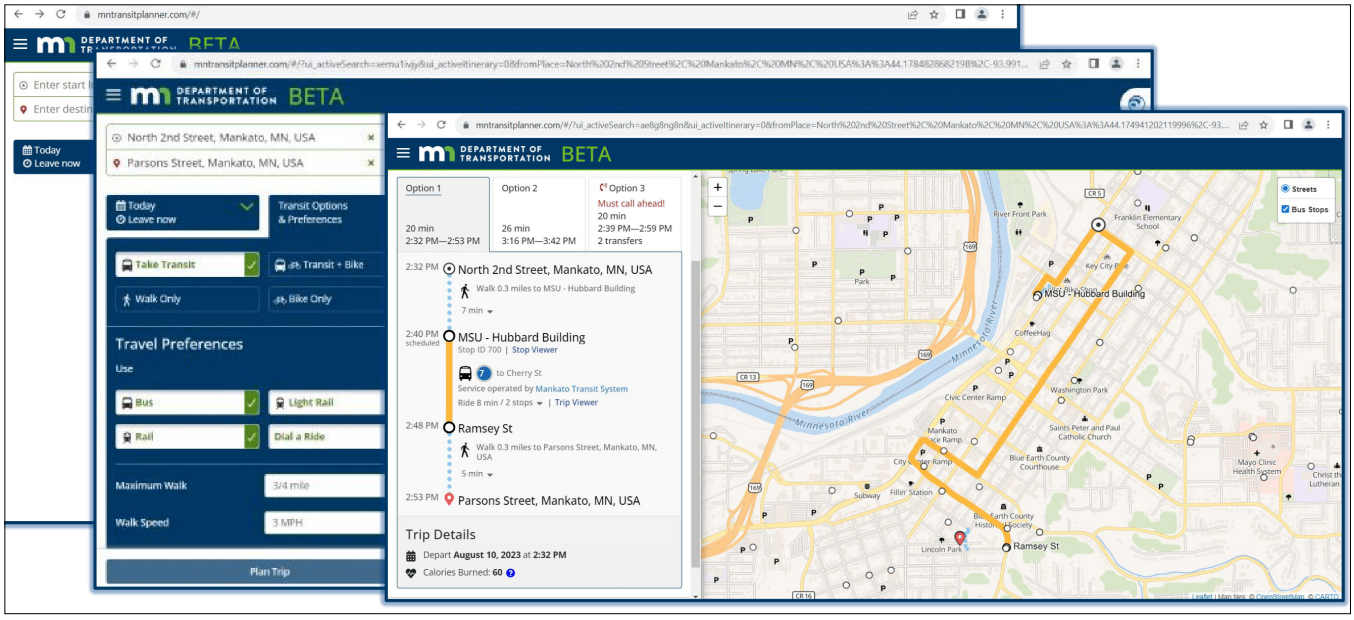
As MnDOT wraps up this phase of the project, the agency is envisioning additional use cases

Figure 13. Screenshots of MnDOT's Regional MaaS demonstration platform.



Credit: Minnesota Department of Transportation

Figure 14. Screenshots of MnDOT's web-based trip planner.



Credit: Minnesota Department of Transportation

and functionality for its MaaS platform. MnDOT would like to provide real-time status updates to customers, in addition to scheduled arrival time. The Transit app interface could also allow customers to track their bus on the app's map.

Currently, TDS messages do not cover payment. MnDOT ultimately wants to build a vendor-agnostic payment system as part of the platform. In the interim, the agency is using Token Transit for mobile payment transactions through a pop-up for customers on the Transit app.

MnDOT would also like to bring more transportation providers into the fold, including NEMT providers and intercity bus services such as Jefferson Lines. This will require additional resources and likely a more complex set of agency agreements.

Key takeaways from TDS demonstration projects

The demonstration projects are all at different stages, but they offer important considerations regarding community engagement, partnership building, the involvement of technology vendors, service parameters, funding, and technical considerations.

Community engagement

Community engagement—and coalition building more broadly—has played an important role in the demonstration projects. Because TDS efforts are novel, community engagement should play a central role in informing demonstration projects and evolving the TDS.

KCMC used an Inclusive Planning grant from the Administration for Community Living to organize a community-based advisory committee, in addition to conducting a swath of other outreach activities, such as holding workshops, listening sessions, and conducting surveys. Now that its platform, Find a Ride, is nearing launch, KCMC also convenes an advisory committee to solicit feedback about the platform and facilitate community support and adoption. The Metropolitan Transportation Commission, a metropolitan planning organization, consults with BAPAC, a consortium of paratransit services, on the implementation of its TDS-compliant ride-booking software for East Bay Paratransit and VTA.

Figure 15. KCMC Find a Ride community outreach.

Credit: Hopelink

Community engagement offers many benefits, most importantly, a place to understand rider and community mobility needs—so new technology solutions can meet those needs. Working with a community organization builds trust with transit customers, allowing meaningful feedback to be obtained. While community engagement requires time and resources, it ultimately helps TDS implementation because a community of riders will grow from this initial work. It also helps avoid costly retrofits caused by ill-conceived technology "solutions" that are not accessible or do not actually help the people they intend to serve.

The King County Mobility Coalition (KCMC) spent the past few years developing a one-call/one-click platform called Find a Ride. When deployed, the platform will pair customers with human service transportation providers to arrange ride appointments based on needs and schedules. Approximately 30 human service transportation mobility providers, representing roughly 50 transportation services by the end of 2024 are participating in Find a Ride. Although Find a Ride does not currently use the TDS, staff at KCMC hope to adopt the specification later. Find a Ride creates a foundation for successful specification adoption, as it was built on vigorous community outreach efforts.

Partnerships

TDS implementation relies on public partnerships, institutional relationships, and cross-jurisdictional alliances. The TDS commonly serves low-density areas that lack sufficient regular, fixed-route transit services. Moreover, many of these TDS demonstrations serve entire regions or metropolitan areas, not just cities or counties. For this reason, metropolitan planning organizations (MPOs), state departments of transportation (DOTs), and other regional governments are strong candidates to oversee and facilitate upcoming demonstrations. The TDS is well suited to serve larger geographic areas and smooth the way for coordination among multiple mobility providers.

Institution building and stakeholder involvement are critical. Along with MPOs and state DOTs, partnership building should include transit agencies, county and city government, nonprofit human service transportation providers, and mobility managers/brokers.

Forming these relationships can help tackle the various public agencies' common concerns, including competition for funding, limited driver and vehicle capacity, limited technical capacity and institutional knowledge, reluctance to move to a fully automated scheduling platform, and different service models and operational frameworks. Discussion should occur early and throughout the planning and implementation processes. Acknowledging and addressing the needs and operations of the different agencies and mobility providers, along with their role in the process, will build an important foundation for this work.

Partnership building involves working with neighboring transportation providers; understanding their technical capacity, needs, and operations; and ensuring the necessary public and private stakeholders have a voice at the table. These partnerships can guide collective decision making on the role of technology and achieving a balance between implementing a fully automatic scheduling solution and retaining a human connection. For example, Hopelink is careful in its language with the Find a Ride platform in that the platform itself is not a tool for riders to schedule trips. This was in part a result of the mobility managers and HST providers wanting to retain the ability to work with the transit customers they serve to help them find the most appropriate transportation.

Public agency TDS roles

- State DOTs have a unique position to fund regional- and state-level initiatives. The MnDOT regional MaaS platform is a good example of such an effort. State DOTs are also in a good position to apply for funding from the Federal Highway Administration (FHWA), FTA, and other federal agencies. State DOTs vary in their attitudes toward public transit and mobility data standards. Some states that have led the charge are Vermont, California, Washington, Minnesota, and Oregon.
- MPOs are responsible for regional transportation planning and coordination; they are also often responsible for human service transportation planning where the TDS could potentially integrate.
- County and city governments' role in public transit varies depending on the local framework. For example, in small towns and rural communities, the county government might be responsible for coordinating HST or other mobility services. In larger metropolitan areas, the county government may directly operate transit services, or it may facilitate partnerships across other public agencies.
- Transit agencies are important players in TDS implementation, as they operate the transit service in a community and are often responsible for paratransit and other DRT services.
- Nonprofit human services agencies often directly provide transportation for their clients or arrange needed transportation. The agencies often know their transit customers the best and can facilitate trust within the community.
- Mobility managers/brokers have a deep understanding of the mobility needs, options, and gaps in service within a community. Bringing mobility managers onto the team can build stronger ties to the community and available DRT services.

Technology vendor involvement

Data standardization and interoperability is not a passing fad. It is clearly on the rise across many industries, and it is critical to find supportive partner vendors. Procuring services from private software vendors is a necessary step for carrying out TDS demonstration projects. It requires finding forward-thinking private partners that support the work and understand its limitations and scalability. Software vendors should have a demonstrated willingness to participate in open-source data solution projects and be comfortable sharing the TDS refinements and platform development work with other agencies and software developers. This will allow for the work to be adapted and improved services brought to scale across the United States.

Often transportation agencies are locked into multiyear contracts with software vendors. But those vendors who are willing to play a key role in developing this technology standard will be well positioned in the market to capture new service contracts. Large, established software vendors may not be as nimble as smaller vendors, or they may require a larger financial payback before upgrading their scheduling software to become TDS compliant. In the short term, agencies that wish to create a network of TDS-compliant transportation providers will need to persuade these companies on the merits. If unsuccessful, TDS compatibility can be a criterion in future procurement.

Service areas and travel modes

The early TDS adopters featured in this paper represent regions with a mix of small cities, suburbs, and rural areas, as opposed to large cities. This is not surprising given the roots of DRT in America's rural heartland. Many of the demonstration projects are based in areas with higher proportions of older adults who have limited transportation options. As more demonstration projects get underway, such as an MTC expansion project in the Bay Area and TDS implementation in King County, Washington, we may see more urban examples.

The initial projects demonstrate an assortment of TDS use cases for a variety of travel modes, including rural public transportation, human service transportation, ADA paratransit, microtransit, and volunteer driver-based transportation. A variety of use cases will help refine the TDS so that it accounts for a greater variety of DRT communication needs, such as customer eligibility, which was not originally accounted for in *TCRP Research Report 210.*

Figure 16. Man assisting woman with cane exiting vehicle.

Credit: Metrolina Association for the Blind, Charlotte, NC, Photo Resource Gallery | NADTC

Funding

Funding is among the top considerations, and 11 federal agencies administer grant programs that can support human service transportation. The FTA has funded some current TDS demonstration projects to test and prove new approaches, technologies, and service models, but U.S. Department of Transportation is not the only potential source of funding. Additional funding sources have included state DOTs, MPOs, local agencies, and philanthropic organizations, such as the United Way. Additional funding could be used to pilot more demonstration projects to refine the TDS data protocols, establish a governance model and other supporting specification technical needs, and promote the use of open-source data mobility solutions in federally funded projects.

TDS implementation approaches

As the pilots and implementation projects advance, leaders and affiliates gain an understanding of what it takes to move a data specification from a technical report (as outlined in *TCRP Research Report 210*) to meeting the ride scheduling and other operational needs of local transportation providers. On-

the-ground demonstrations reveal necessary adjustments to the specification so that the TDS responds properly to the needs of communities and mobility providers. One of the most important decision points that must be made early in a project is the chosen implementation approach. (Other technical decisions regarding system architecture, new messages that may be required to satisfy project specific use cases, and message validation are also necessary. Appendix B provides a summary of such topics.)

The DRT Data Specification Working Group identified two primary TDS deployment pathways: a universal transactional data format and data translation middleware.[24]

Universal transactional data format

With this approach, each software vendor makes their scheduling software internally compliant with the standard.

RideNoCo is a relatively simple implementation of this approach, where three software providers made their APIs compliant with the TDS and other standardized protocols specific to their project (e.g., eligibility).

This approach is exemplified by FlexDanmark, the publicly owned company that operates the nationwide DRT trip management system in Denmark.[25] FlexDanmark requires all vendors to make their scheduling software SUTI compliant.[26] The SUTI standard is a sophisticated set of DRT-related data specifications that governs how DRT data will be shared. To offer government-funded services, transportation providers must certify that their software adheres to the standard. Over more than 25 years, the SUTI standard has expanded from fewer than 20 messages to more than 75.

With SUTI as a foundation, extremely complex DRT operations, involving hundreds of entities (transportation providers, human service agencies, health care organizations, and technology companies) can be developed. FlexDanmark facilitates as many as 20,000 trips per day. It procures more than 800 transportation providers to deliver DRT service—all privately owned companies of varying sizes. Trips are planned in a "pool," which allows the software to identify the most efficient route and schedule based on origin, destination, travel time, traffic conditions, and other specific traveler needs, such as appointment time and the need for a wheelchair accessible vehicle.

Two major benefits of the universal transactional data format approach are that it avoids vendor lock-in and results in a more stable system. For example, if one technology vendor makes changes to its in-vehicle driver terminal and application, no change in FlexDanmark's centralized dispatching software is necessary. FlexDanmark continues to send messages in the SUTI format to inform the driver about their next trip. Similarly, software vendors need not react to software updates by other vendors—as long as those vendors make SUTI-compliant changes. This stands in sharp contrast to the common proprietary API approach used in the United States, in which a software change by one necessitates software updates by all to maintain interoperability.

The universal transactional data format approach results in a more stable system. This stands in sharp contrast to the common proprietary API approach used in the United States, in which a software change by one necessitates software updates by all in order to maintain interoperability.

This model is the most sustainable approach for transactional interoperability, but it requires all players to come to the table to agree on a single data-sharing protocol—a formidable challenge requiring substantial technical collaboration among entities. It also entails the highest initial development cost

24 DRT Data Specifications Working Group discussion in November 2021 where two TDS deployment solutions were first presented by DemandTrans Solutions. Terms have been renamed for clarity.

25 For more information on the FlexDanmark system, see https://www.aarp.org/pri/topics/livable-communities/transportation/modernizing-demand-responsive-transportation/ and videos on www.aarp.org/futureoftransportation.

26 SUTI is short for Standardiserat Utbyte av Trafik Information (Standardized Exchange of Traffic Information).

for software vendors, given that each has its unique API message structure and content that will need to be refined. Nonetheless, the success in Denmark and other Scandinavian countries demonstrates the value of this upfront investment.

Data translation middleware

This approach offers a work-around for the challenge of getting all players to adopt a standard in the absence of an industry-wide governance process (see discussion in next section).

With the middleware model, all data transactions among DRT software platforms are routed via a dynamic translation "middleware" application. It works by "translating" a proprietary API format into the standard TDS format. This model entails the least upfront cost for software vendors, as they simply use their existing API functionality. The NEORide project is the best example of data translation middleware.

Although the middleware model requires the least upfront cost for software vendors and is conceptually straightforward, the approach means developing a sophisticated software to accomplish the dynamic data translation. These development costs would typically be borne by the public sector. A major limitation of this model is that the middleware must continually update its code whenever participating software vendors make a change to theirs, thus requiring ongoing public support to sustain interoperability.

Working toward a governance model

The DRT Data Specifications Working Group and its members recognize the need to work toward implementing a TDS governance framework. A governance model offers a framework for how a data specification or standard is maintained and updated.[27] Public agencies, community representatives, and software vendors should all be involved in this work, but governance should be led by an independent, impartial organization that engages all stakeholders—most notably, software vendors that will be called on to implement the TDS within their platforms.

An organized means for collaboration and decision making helps to ensure that changes and enhancements made to TDS messages and protocols are shared beyond individual project partners. Each project may be encountering similar barriers but solving them in different ways. A governance framework would bring alignment, avoiding multiple technical refinements for similar issues that result in more than one specification.

Each implementation project is adding messages and otherwise refining the TDS as it pulls the specification into its APIs and translators. These changes must be considered by the community of TDS implementers, and TDS refinement decisions must be executed and documented in a publicly available open-source repository such as Github. This governance framework is sorely missing.

This project review underscores the need for a more formal governance structure. In addition to the new data messages created by each implementation team, resultant TDS-compliant APIs use two different software architectures. After much technical debate, the RideNoCo team and other demonstration projects are updating the TDS structure itself. For example, *TCRP Research Report 210* calls for a single end-point API. However, the RideNoCo and NEORide demonstration projects will build RESTful APIs. Redesigning the TDS to be a RESTful API will allow easier integration with modern software and accommodate expansion opportunities. In contrast, MnDOT's TDS module retains the use of a single end-point API. This is one example of the importance of a governance structure for debate, resolution, and formal specification refinement.

Looking once again across the Atlantic, the SUTI standard has a strong governance structure in place. The Swedish government-initiated DRT data standardization in the 1990s to enable local governments funding DRT services to change software and transportation providers without undue cost and adverse disruptions in service.[28] The resultant SUTI

27 https://learn.sharedusemobilitycenter.org/casestudy/mobility-interoperability-logic-model-summary/

28 TCRP Report 210

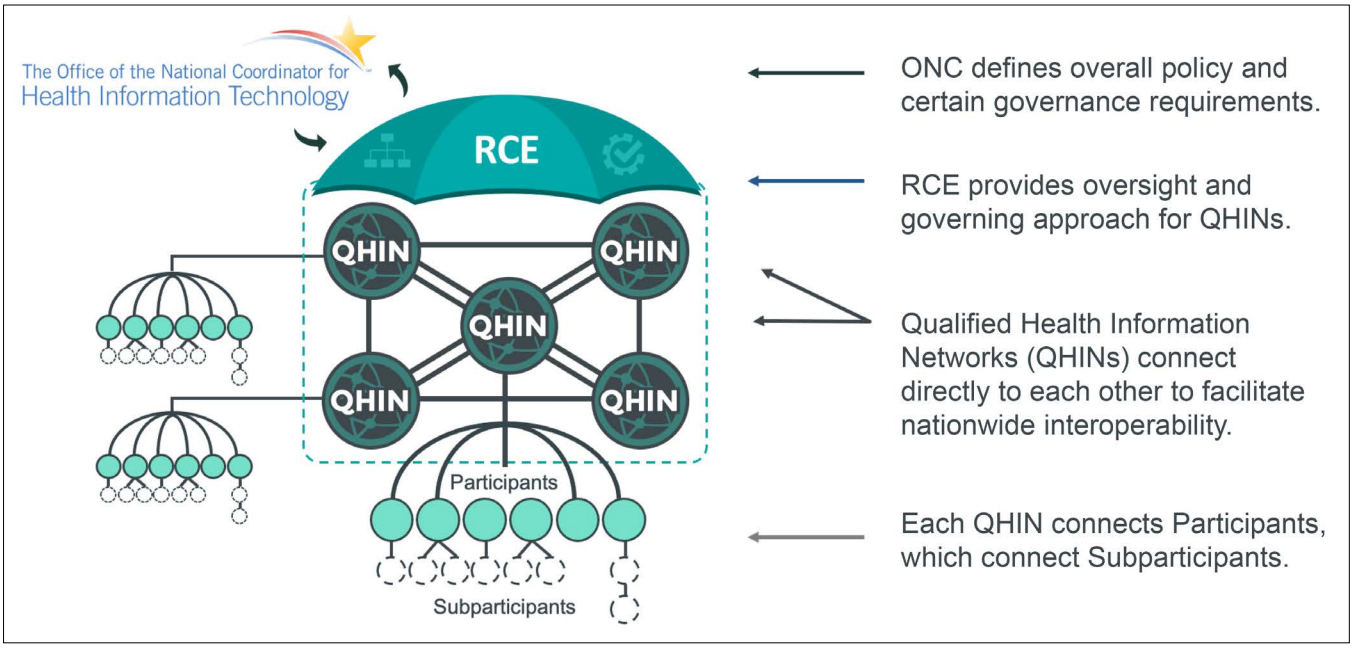
standard has since been widely adopted in Scandinavia. The standard is managed by a not-for-profit consortium of more than 40 members (quasi-private companies like FlexDanmark, private transportation companies with vehicles and drivers, and private software companies). Each member owns a technology platform or related DRT component that integrates the SUTI standard. The public sector that funds DRT service does not formally govern SUTI.

A lesson from the health care industry

The health care industry has a well-established framework that can inform TDS adoption and its governance model. Two pieces of legislation were instrumental in facilitating industry adoption of secure health data sharing: the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 and the 21st Century Cures Act of 2016. HITECH legislatively mandated the Office of the National Coordinator for Health Information Technology (ONC), which was created in 2004 by executive order. HITECH also encouraged health care providers to adopt electronic health records (EHRs) that could be used by hospitals and ambulatory physicians nationwide. The need was obvious. One study estimated 98,000 Americans die every year from preventable medical errors,[29] and 80 percent of medical errors are initiated through miscommunications.[30] In response to the federal action, EHR adoption increased to 96 percent of hospitals and 90 percent of ambulatory physicians by 2019.

Siloed use of EHR by each medical provider, however, does not solve the communications problem. EHRs must be securely shared among doctors, other clinical providers, and patients. The 21st Century Cures Act empowered the ONC to define the parameters around which interoperability would be driven, and the ONC has played an important role in expediting the adoption of standardized data sharing. The agency created an industry task force to study the adoption of Fast Healthcare Interoperability Resources (FHIR), a data standard created and maintained by HL7, an industry-led standards development organization. ONC also adopted the Trusted Exchange Framework and Common Agreement (TEFCA), a policy that "establish[es] a universal

Figure 17. Diagram of TEFCA



Credit: The Sequoia Project, User's Guide to the TEFCA, January 2022

29 https://pubmed.ncbi.nlm.nih.gov/25077248/

30 https://jamanetwork.com/journals/jama/fullarticle/200289

floor for interoperability across the country."[31] ONC has used TEFCA to contract with a nonprofit called the Recognized Coordinating Entity, which oversees and guides the adoption of FHIR and interoperability across Qualified Health Information Networks. Over the years ONC has also provided grant funding to HL7 to support standards development.

According to HL7 CEO Charles Jaffee, "Few developments were as impactful as the naming of HL7 FHIR by US regulatory authorities (in 2020), notably ONC and CMS [Centers for Medicare & Medicaid Services]," [32] making FHIR the building blocks of interoperability. Software developers receive certification from ONC that health IT products adhere to interoperability criteria adopted by the Department of Health and Human Services.[33,34] Although certification is voluntary, the program is a huge incentive for software developers because health care providers must ensure their EHRs can be electronically shared. In other words, health care providers would be very unlikely to purchase EHR software platforms that are not FHIR compliant.

Additional demonstration project opportunities

There are many additional opportunities for communities and DRT service providers to demonstrate TDS capabilities. In particular, the TDS can play a role in modernizing NEMT service, facilitating health care coordination, and assisting with mobility management.

NEMT service

The NEMT industry is already standardizing NEMT service terminology. The Non-Emergency Medical Transportation Accreditation Commission, a nonprofit data standards organization accredited by the American National Standards Institute, is leading the effort. This is an important precursor to cross-provider communications.[35] Such efforts demonstrate the positive impacts that data standards can have on NEMT service models and may foster additional NEMT standardization.

Currently, only a few states coordinate Medicaid NEMT trips with other forms of public transportation, generally because of differences in contracting requirements and service standards. This lack of coordination can lead to inefficient use of resources and at times duplicative service. Better coordination can improve services and increase transportation access, and the TDS can potentially play a critical role. However, TDS advocates have mixed feelings: some recognize the benefits that the TDS could bring to interorganizational coordination and to improving how NEMT service is handled, while others worry that implementation would be too complicated given the current regulatory framework around Medicaid and NEMT. These challenges were noted by mobility providers and other stakeholders during the CMS- and FTA-sponsored listening sessions in 2022. Stakeholders nonetheless stressed the need for further coordination among NEMT and other transportation services to improve the NEMT benefit.[36]

Health care coordination

Some public transportation agencies have formed partnerships with hospitals and health care providers to coordinate transportation for patients to and from medical appointments. In

31 https://www.healthit.gov/topic/interoperability/policy/trusted-exchange-framework-and-common-agreement-tefca

32 https://www.hl7.org/documentcenter/public/HL7/HL7%202021%20Annual%20Report%20v071822%20FINAL.pdf

33 Department of Health and Human Services, Office of the Secretary, Office of the National Coordinator for Health Information Technology (ONC), 45 CFR Parts 170 and 171, RIN 0955-AA01, 21st Century Cures Act: Interoperability, Information Blocking, and the ONC Health IT Certification Program, Final Rule, Federal Register, Vol. 85, No. 85, Friday, May 1, 2020

34 Department of Health and Human Services Centers for Medicare & Medicaid Services (CMS) 42 CFR Parts 406, 407, 422, 423, 431, 438, 457, 482, and 485, Office of the Secretary, 45 CFR Part 156, [CMS-9115-F], RIN 0938-AT79, Medicare and Medicaid Programs; Patient Protection and Affordable Care Act; Interoperability and Patient Access for Medicare Advantage Organization and Medicaid Managed Care Plans, State Medicaid Agencies, CHIP Agencies and CHIP Managed Care Entities, Issuers of Qualified Health Plans on the Federally-Facilitated Exchanges, and Health Care Providers, Final Rule, Federal Register, Vol. 85, No. 85, May 1, 2020.

35 https://nemtac.co/standards/

36 https://www.nadtc.org/news/blog/a-recap-of-medicaid-non-emergency-medical-transportation-nemt-listening-sessions/

these partnerships, the transit agency provides DRT rides to and from the partner hospitals; the partnerships primarily serve rural areas, communities with poor fixed-route access, or clientele unable to use regular buses or trains. The TDS could help to better coordinate trips between hospitals and transit providers. TDS implementation in these partnerships could reduce missed appointments, inappropriate use of emergency services, and hospital readmissions due to transportation issues—altogether improving public health outcomes, patient quality of life, and hospital efficiency.

Mobility management

The main objective of mobility management is to "connect customers to the transportation options that are most responsive to their needs."[37] In this way, mobility managers coordinate service across multiple modes, services, and options, including NEMT and HST. They are directly involved in facilitating and/or delivering various transportation services—despite different scheduling platforms, limited provider coordination, and multiple jurisdictions and service boundaries.[38] TDS implementation can mitigate these barriers and increase capacity so that mobility managers can access larger networks of transportation providers. RideNoCo offers a good demonstration of a regional mobility manager that is looking to implement a TDS solution to coordinate volunteer driver programs serving older adults and people with disabilities. Additionally, TDS implementation by large mobility management agencies, such as regional MPOs, could dramatically expand the reach of the TDS and build buy-in across large markets.

TDS implementation can mitigate geographic and service area boundaries so that mobility managers can access larger networks of transportation providers to better address rider needs.

Figure 18. Woman in power wheelchair exiting bus off of lift.

Credit: Capacity Builders, Farmington, NM | Photo Resource Gallery | NADTC

National Rural Transit Assistance Program and RideSheet pilot

National Rural Transit Assistance Program (RTAP), an FTA technical assistance center serving public transportation providers in rural communities, has funded a pilot program to test TDS-supported RideSheet functionality and benefits. RideSheet, developed by Full Path with seed funding by AARP, helps transportation providers track customers and DRT trips, create driver manifests, automate reports, and manage multiple funding sources. Based on a Google Sheets solution, RideSheet is considered "lightweight" and potentially more cost effective for small-scale TDS solutions. Although the RTAP pilot is in its early stages, it is an opportunity to assist rural transit agencies in their scheduling and coordination efforts. At the same time, RTAP plans to assess the effectiveness of RideSheet for its stated uses. The RTAP RideSheet pilot is taking a phased approach, starting with three pilot locations in addition to that previously funded by AARP, in Lake County, Oregon. RTAP is working with the tool developer to create user documentation to allow other agencies to take advantage of this freely available resource.[39]

37 https://nationalcenterformobilitymanagement.org/for-mobility-managers/

38 https://www.aarp.org/pri/topics/livable-communities/transportation/emerging-innovations-mobility-managers/

39 https://www.nationalrtap.org/

Conclusion

Data sharing through standardized APIs is an important step to making transportation networks more efficient, reliable, and user-friendly. Currently, many fixed-route systems have strong open-source data infrastructure via widely deployed data standards like GTFS. However, it is equally important to consider the benefits that a transactional data standard can bring to other modes. The TDS, which is specifically geared toward DRT, can support coordination among multiple service providers and facilitate trip information exchange.

A handful of demonstration projects around the country have helped lay the foundation to a more established TDS model. In the words of Roger Teal, principal investigator of the TCRP project that led to the first iteration of the TDS, each of these early implementers is "probing the frontier," testing the TDS against their specific and limited use cases. These projects offer insights on practical geography, community engagement, and other technical and planning considerations. Despite these models' successes, institutional barriers remain. Widespread TDS adoption could revolutionize DRT and HST, and it is imperative that agencies continue testing and refining the TDS, through demonstration projects and other initiatives, to realize its full potential. The accompanying Roadamap for Implementation offers steps local agencies can take to plan and execute TDS demonstration projects. As uptake of the TDS grows, those involved must communicate and work toward a governance model so the diverse needs of DRT riders can be met. America's DRT riders deserve the improved service that the TDS offers.

Appendix A: Glossary

application programming interface (API): A set of protocols that allows two or more applications or software programs to communicate.

demand-responsive transportation (DRT): A public transportation service that operates on flexible routes with flexible schedules depending on passengers' requests.

General Transit Feed Specification (GTFS): An open-source data standard used for fixed-route public transportation systems. GTFS is used by most transit agencies in the United States and formats geographic and scheduling data so that trip planning applications can convey that information to riders.

GTFS-Flex: An open-source data standard that expands on traditional GTFS to include flexible modes, which include a variety of demand-responsive services in which the user defines the origin and destination.

Human Service Transportation (HST): A range of transportation services, including dial-a-ride, shuttles, volunteer transportation services, and sometimes NEMT, designed to meet specific needs of transportation-disadvantaged populations, such as people with disabilities, older nondrivers, and individuals with low incomes. Also known as specialized transportation. These services often take the form of DRT.

interoperability: The ability for a mobility technology component to exchange data in an open standard or schema with other components in that mobility technology system.[40] Digital interoperability of scheduling software is a means to institutional coordination among providers of transportation service.

microtransit: A technology-enabled transit service that uses multipassenger vehicles, flexible virtual stops, and dynamic routing, scheduling, and dispatching for flexible, shared, on-demand rides.

mobility management: Activities that connects customers to the transportation options that are most responsive to their needs. It encourages innovation and flexibility to find the best mobility options, strives for customer ease of use, and continually incorporates customer feedback to evaluate and adjust services. Mobility management plays an important role in helping connect customers to HST services.[41]

non-emergency medical transportation (NEMT): DRT services that help improve access to medical appointments and other health services. NEMT is often facilitated through a NEMT broker who coordinates the most appropriate services; Medicaid sometimes covers rides for eligible passengers.

on-demand transportation: This is a term with inconsistent usage. In its most limited usage, it refers to a service available immediately, such as Lyft and Uber. Trips that require reservations to be made 24 or 48 hours in advance are not "on demand." However, the term may be used synonymously with DRT where reservations are required.

paratransit: A term often used synonymously with DRT. Paratransit is service geared toward seniors, individuals with disabilities, and other eligible riders. One example is ADA paratransit, whereby federal law requires transit agencies to provide comparable service to qualifying riders within three quarters of a mile of a fixed-route bus line.

platform: A group of technologies that are used as a base on which other applications, processes, or technologies are developed. Contemporary DRT and microtransit software platforms encompass multiple systems that work together to automate the DRT trip life cycle. These include a booking system, a trip/vehicle scheduling system, a dispatching system, an administrative system (which itself has important subsystems), a reporting system, and sometimes a fare payment/ticket management system.[42]

validator software: A tool that verifies that the data messages meant to be shared are specification compliant. Some specific functionality to test could include invalid response codes, response rate, and API time-outs.[43]

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40 https://www.interoperablemobility.org/definitions/#interoperability

41 https://nationalcenterformobilitymanagement.org/for-mobility-managers/

42 https://www.ehidc.org/sites/default/files/resources/files/Understanding%20HL7%C2%AE%20FHIR%C2%AE%20for%20Non-Technical%20Executives_Workshop%2012.17.19.pdf

43 https://apidog.com/blog/invalid-api-response/

Appendix B: TDS technical considerations

TCRP Research Report 210's framework for input and output messages are high level. On-the-ground demonstrations reveal necessary adjustments to the specification so that the TDS responds properly to the needs of communities and mobility providers.

The TDS is modular in design and enables pilots to use the messages most relevant to their use cases. At the same time, technical limitations with the specification itself have surfaced and need to be addressed to meet the needs of real-life applications. This is true of any specification; as it evolves, it must be flexible in design to accommodate its varied uses. *TCRP Research Report 210* outlines various input and output messages that programmers can incorporate into the TDS. Some demonstrations revealed gaps and offered additional messages that can be incorporated into future iterations of the TDS. Some early adopters suggested refinements to the system architecture to better facilitate modernization and scalability.

MnDOT TDS use case details

The MnDOT TDS use case is designed around booking integration for DRT. In this scenario, the use case assumes that the transit customer knows from which transit agency they are seeking a ride. The TDS messages that MnDOT used from *TCRP Research Report 210* report are focused on the information needed to book trips. MnDOT added messages not included in *TCRP Research Report 210* to register new riders and check rider eligibility. MnDOT also added messages centered on managing the trip, including cancellations, and supplying updated and real-time arrival information. Although these messages were not included in *TCRP Research Report 210*, MnDOT recognized them as critical pieces to managing a TDS-related trip. The additional messages are currently using the scheduling software vendor's (CTS) existing API. MnDOT is exploring whether to use the software vendor's API moving forward or to develop these TDS data sets independently.

Here is a table that outlines the TDS messages that MnDOT is using for its TDS use case:

Table 1. MnDOT TDS Message Fields

DATA FIELD	ORIGIN
• Individual booking the ride • Time of trip appointment • Unique trip ID • Pickup address • Dropoff address • Scheduled pickup time • Number of passengers	Included in TCRP Research Report 210
• Checking rider eligibility/ retrieving rider ID (this is necessary for services that limit who can travel—e.g., service limited to individuals over age 60) • Registering a new eligible rider • Retrieving upcoming scheduled rides • Getting real-time information on an upcoming ride • Canceling an upcoming ride	New messages added to facilitate the MnDOT TDS use case

RideNoCo TDS use case details

The RideNoCo demonstration project underwent extensive TDS design and outreach with the participating software vendors. The TDS-compliant APIs for RideNoCo will facilitate rider intake, refer trips to mobility providers, assist in booking trips, and support multijurisdictional trips across political boundaries. RideNoCo will use *TCRP Research Report 210* data messages along with additional messages that it will develop to carry out the demonstration project goals. In addition to the TDS messages noted in the following table, RideNoCo is evaluating and updating other TDS protocols under the context of its implementation efforts.

RideNoCo's three TDS use cases are (1) customer referrals, (2) trip referrals, and (3) ride coordination. The following table demonstrates the TDS data specification fields used to exchange data relevant to these use cases.

Table 2. RideNoCo TDS Message Fields

DATA FIELD	ORIGIN
• Customer key/ID • Customer first name/legal name: Legal name as written in documents such as a passport (first name and legal name are updated data points) • Customer home address • Customer home phone • Mailing/billing address for the customer (mailing address is an updated data point) • Billing information (funding entity) • Funding type • Gender • Caregiver's contact information • Customer's emergency phone number • Customer's emergency contact name • Comment about care required • Date of birth/age • Fare type • Customer cell phone • Other (free text string)	Included in *TCRP Research Report 210*
• Customer nickname (the name people prefer to be listed as) • Customer middle name • Customer last name • Low-income to identify people at or below poverty level • Disability • Language • Race • Ethnicity • Email address • Veteran status • Customer's emergency contact relationship with customer	New messages added to facilitate the RideNoCo TDS use case

Validator software needed

Though not critical to the TDS development, as modifications to the TDS are made to accommodate local use cases, programmers and mobility providers would benefit from an updated validator software to ensure their code remains TDS compliant. Centralized governance of the TDS would synchronize future adjustments to the specification and independent validator software.

System architecture

As mentioned in the body of this paper, project partners deliberated on whether to maintain the single end-point API system architecture or adopt a RESTful API approach. All future projects will face this same decision point until the industry formally chooses a path through a collaborative standards development process.

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