# Integrated Dynamic Transit Operations (IDTO)
# Concept of Operations

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16. Abstract

In support of USDOT's Intelligent Transportation Systems' (ITS) Mobility Program, the Dynamic Mobility Applications (DMA) program seeks to create applications that fully leverage frequently collected and rapidly disseminated multi-source data gathered from connected travelers, vehicles and infrastructure to increase efficiency and improve individual mobility while reducing negative environmental impacts and safety risks. There are three Integrated Dynamic Transit Operations (IDTO) applications: Connection Protection (T-CONNECT); Dynamic Transit Operations (T-DISP); and Dynamic Ridesharing (D-RIDE). The T-CONNECT application will provide transit users and riders the means to ensure successful transit transfers. T-DISP will allow travelers to make real-time trip requests through personal mobile devices. D-RIDE will identify and accept potential ridesharing opportunities along a given travel route.

This Concept of Operations (ConOps) document provides a conceptual overview of the proposed IDTO applications and the high-level quantitative and qualitative characteristics of the applications to users, developers and other stakeholders. In addition to the system concepts, this document also describes the modes of operation, user classes, support environment, operational scenarios, discusses the operational, organizational, and other impacts of the IDTO applications, and provides an analysis of the benefits, limitations, advantages/disadvantages, alternatives, and trade-offs considered for the proposed applications.

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# Preface

In support of USDOT's Intelligent Transportation Systems' (ITS) Mobility Program, several of the Department's agencies are fully engaged in exploiting active interaction between fixed and mobile transportation system entities both in the way new forms of data are being exchanged and in the opportunities that are afforded to extend the geographic scope, precision and control of our Nation's surface transportation system. An important initiative within the framework of this strategic effort is the Dynamic Mobility Applications (DMA) program which, in part, seeks to create applications that fully leverage frequently collected and rapidly disseminated multi-source data gathered from connected travelers, vehicles and infrastructure, and that increase efficiency and improve individual mobility while reducing negative environmental impacts and safety risks.

To that end, the Integrated Dynamic Transit Operations (IDTO) applications, which are the subject of this document, will provide transit users and riders the means to ensure successful transit transfers (T-CONNECT), to make real-time trip requests through personal mobile devices (T-DISP), and to identify and accept potential ridesharing opportunities along a given travel route (D-RIDE). This Concept of Operations (ConOps) document provides a conceptual overview of the proposed IDTO applications. The ConOps is intended to support the development and eventual near-term deployment of subsets of or the entire IDTO application bundle. Moreover, the ConOps is a living document and will be coordinated in a collaborative manner with agency, industry, and public stakeholders to ensure the viability of the concepts represented.

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# Chapter 1. Scope

The *Integrated Dynamic Transit Operations (IDTO) Concept of Operations (ConOps)* document describes the desired characteristics of the operational IDTO application bundle. Section 1 provides an overview of this ConOps document, and a brief description of the Dynamic Mobility Application (DMA) program and the three IDTO applications.

## 1.1 Identification

This document is identified by the title and effective date.

## 1.2 Document Overview

The *IDTO ConOps* document serves as a vehicle to communicate the high-level quantitative and qualitative characteristics of the IDTO applications to users, developers and other stakeholders. The ideas expressed in the *IDTO ConOps* are the result of analyzing the challenges involved in the near-term development and deployment of the IDTO application bundle. Lastly, there are no security or privacy considerations attached to the use or distribution of this document.

- **Section 1** describes the IDTO ConOps document, the Dynamic Mobility Application program, and the three IDTO applications.
- **Section 2** provides a list of reference documentation that was used in the creation of the document.
- **Section 3** describes the systems currently used for IDTO-related functions.
- **Section 4** discusses the justification for and nature of changes based on the most current information.
- **Section 5** of the document provides information on proposed system concepts.
- **Section 6** describes operational scenarios.
- **Section 7** summarizes operational, organizational, and other impacts of the IDTO applications.
- **Section 8** analyzes the proposed IDTO system.
- **Appendix A** provides a list of participating IDTO stakeholders.
- **Appendix B** provides a glossary of terms used herein.

## 1.3 System Overview

The USDOT has identified a portfolio of ten high-priority mobility applications, including a common bundle collectively identified as Integrated Dynamic Transit Operations (IDTO), as part of the Dynamic Mobility Applications (DMA) program (see Figure 1-1 below).

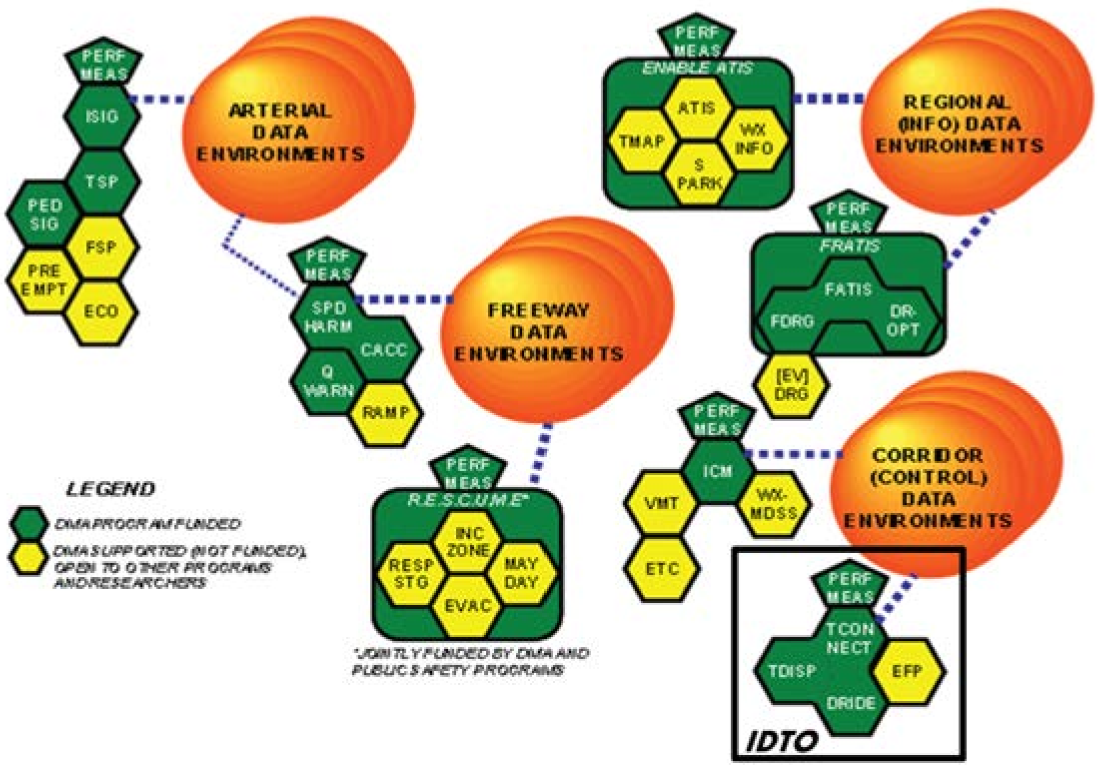


**Figure 1-1. Dynamic Mobility Applications (DMA) Program Bundles**

The DMA program seeks to create applications that fully leverage frequently collected and rapidly disseminated multi-source data gathered from connected travelers, vehicles and infrastructure, and that increase efficiency and improve individual mobility while reducing negative environmental impacts and safety risks. The three applications under the IDTO bundle (Connection Protection, Dynamic Transit Operations and Dynamic Ridesharing) will ultimately enable transit systems to provide better information to travelers and increase the quality of service that they are able to provide. Being able to improve the transit experience will increase the use of public transit, allowing the program to meet its goals of improving the environment and increasing mobility.

In selecting these applications, the USDOT sought applications that had the potential to be transformative (i.e., they significantly alter existing transit services and result in substantial mobility improvements), are achievable in the near-term, and leverage the opportunities provided through connected entities. In the transit domain, this led to the selection of applications that already exist in some fashion today. These are applications that can be evolved from their current state leveraging Connected Vehicle technology to offer significant transformative impacts while minimizing a number of the risks and delays inherent in developing entirely new concepts.

This philosophy of identifying applications that can be deployed in the near-term is in keeping with the USDOT's goals of quickly moving these applications from the research stage to adoption in the field. Other considerations that will promote this wide-spread implementation include carefully considering user needs and requirements, ensuring the availability of required data sources, identifying potential barriers to implementation, and (wherever possible) using non-proprietary and/or open source approaches that can readily be adopted by a wide variety of potential end users in both the public and private sector.

The purpose of the IDTO ConOps is to describe system concepts, operational scenarios and the rationale for key concept decisions that reflect the transformative goals (with respect to mobility, environment and safety impacts) that might be realized with the deployment of the IDTO bundle of applications. The IDTO ConOps will be used to develop the functional and performance requirements, and high-level data and communication needs for IDTO. Further, this ConOps will facilitate the identification and assessment of key technical and non-technical issues related to field-testing the IDTO bundle and its individual component applications.

The following subsections present a brief overview of the three applications that comprise the IDTO bundle: Connection Protection (T-CONNECT), Dynamic Transit Operations (T-DISP) and Dynamic Ridesharing (D-RIDE).

### 1.3.1 T-CONNECT

The goal of T-CONNECT is to improve rider satisfaction and reduce expected trip time for multimodal travelers by increasing the probability of automatic intermodal or intra-modal connections. T-CONNECT will protect transfers between both transit (e.g., bus, subway and commuter rail) and non-transit (e.g., shared ride modes) modes, and will facilitate coordination between multiple agencies to accomplish the tasks. In certain situations, integration with other IDTO bundle applications (T-DISP and D-RIDE) may be required to coordinate connections between transit and non-transit modes.

### 1.3.2 T-DISP

T-DISP seeks to expand transportation options by leveraging available services from multiple modes of transportation. Travelers would be able to request a trip via a handheld mobile device (or phone or personal computer) and have itineraries containing multiple transportation services (public transportation modes, private transportation services, shared-ride, walking and biking) sent to them via the same handheld device. T-DISP builds on existing technology systems such as computer-aided dispatch/automated vehicle location (CAD/AVL) systems and automated scheduling software. These systems will have to be expanded to incorporate business and organizational structures that aim to better coordinate transportation services in a region. A physical or virtual central system, such as a travel management coordination center (TMCC) would dynamically schedule and dispatch trips. T-DISP enhances communications with travelers to enable them to be presented with the broadest range of travel options when making a trip.

### 1.3.3 D-RIDE

The Dynamic Ridesharing (D-RIDE) application is an approach to carpooling in which drivers and riders arrange trips within a relatively short time in advance of departure. Through the D-RIDE application, a person could arrange daily transportation to reach a variety of destinations, including those that are not serviced by transit. D-RIDE serves as a complement subsystem within the IDTO bundle by providing an alternative to transit when it is not a feasible mode of transport or unavailable within a certain geographic area. The D-RIDE system would usually be used on a one-time, trip-by-trip basis, and would provide drivers and riders with the flexibility of making real-time transportation decisions. The two main goals for the D-RIDE application are to increase the use of non-transit ride-sharing options including carpooling and vanpooling, and to improve the accuracy of vehicle capacity detection for occupancy enforcement and revenue collection on managed lanes. As a result of accomplishing these two goals, a myriad of other benefits could exist that benefit transit systems including that D-RIDE could help reduce peak demand for public transit so the public transit system can be designed more affordably and can have greater customer satisfaction during spikes in ridership.

# Chapter 2. Referenced Documents

Section 2 lists the documents referenced in this ConOps including title, revision, and date of the documents.

| Title | Revision | Date |
|---|---|---|
| Integrated Dynamic Transit Operations (IDTO) Workbook | 1.0 | January 27, 2012 |
| Report on Assessment of Relevant Prior and Ongoing Research for the Concept Development and Needs Identification for Integrated Dynamic Transit Operations | 0.4 | Nov 2, 2011 |
| Report on Stakeholder Input on Transformational Goals, Performance Measures and User Needs for Integrated Dynamic Transit Operations | 3.2 | Feb 17, 2012 |
| Systems Engineering Guidebook for Intelligent Transportation Systems | 3.0 | Nov 21, 2009 |
| Service Interface for Real Time Information (SIRI) CEN/TS 15531 (prCEN/TS-OO278181), available at: http://www.kizoom.com/standards/siri/index.htm | 1.3 | April 17, 2011 |

# Chapter 3. Current System or Situation

Section 3 describes the current existing system(s) as identified from the *Report on Assessment of Relevant Prior and Ongoing Research for the Concept Development and Needs Identification for IDTO,* inputs from the stakeholder group meetings and workshops, and the experiences of the study team. Operational examples will be used to illustrate the major characteristics, where applicable. This will enable the identification of various modules that collectively could form the basic building blocks of the IDTO Applications. In addition, this section identifies the user classes currently involved as well as the institutional structures supporting the user groups and classes, and interactions between them.

## 3.1 Background, Objectives, and Scope

A study of relevant prior and ongoing research related to dynamic transit operations was conducted to assess the current state of the practice and to ascertain the potential benefits and impacts of a deployed IDTO system. This section provides the key findings from this research.

## 3.2 Operational Policies and Constraints

There are a number of operational policies and constraints that currently limit the impact of IDTO-related applications and systems, and may potentially impact the eventual deployment of subsets of or the entire IDTO bundle of applications. See Section 3.3 (Description of the Current System or Situation) and Section 4 (Justification for and Nature of Changes) for a more detailed discussion of these constraints. The key constraints that affect the current practice of dynamic transit operations include:

- Lack of service coordination among transit agencies
- Unresolved strategies for financing necessary technology procurement, implementation, and on-going operations and maintenance
- Lack of developed inter-agency coordination plans for data and information exchange
- Communications network limitations (i.e., interfaces are lacking among mode-specific systems)
- Lack of ITS technical experience and expertise (in terms of both human and computer resources)

## 3.3 Description of the Current System or Situation

This section presents a description of the current situation of the three applications that comprise the IDTO bundle: T-CONNECT, T-DISP and D-RIDE.

### 3.3.1 T-CONNECT

The goal of T-CONNECT is to enable public transportation providers and travelers to communicate to improve the probability of successful transit transfers. Today, most of the current vendors'/system integrators' transfer connection protection (TCP) functionality for fixed-route vehicle to fixed-route vehicle (the most prevalent is between buses) works in the following way:

1. Mobile data terminals (MDTs) are mounted on transit vehicles. The MDTs typically contain a GPS receiver that provides vehicle location information to an operations control center;
2. When a passenger is interested in a transfer, the driver of the vehicle that the passenger boarded enters the transfer information into the MDT. This information is relayed to the TCP subsystem (within a computer-aided dispatch (CAD)/automatic vehicle location (AVL) system) at the central dispatch site/operations control center, and it automatically calculates which vehicle will be impacted by the requested transfer;
3. Immediately, the TCP system determines whether the vehicle that the passenger is transferring to should be held (protecting the connection) and how long this vehicle should wait without serious impact to the schedule; and
4. An automated message is sent to the operator of the vehicle that the passenger is transferring to, instructing him/her to wait a specific amount of time for the arriving vehicle.

Analyses of two existing TCP systems, which incorporate the steps outlined above, are discussed below. (More detailed discussion of these programs can be found in Sections 3.1 and 4.1 of the *Report on Assessment of Relevant Prior and Ongoing Research for the Concept Development and Needs Identification for Integrated Dynamic Transit Operations*.)

In 2003, the Utah Transit Authority launched a connection protection service in Salt Lake City for transfers from the higher frequency light rail TRAX trains to the lower frequency bus services. Results showed high satisfaction rates among travelers, though less positive feedback from transit vehicle operators, due to the high number of TCP messages they received that were considered unnecessary. Additionally, downstream bus-to-bus connections were found to be jeopardized due to late departures at TRAX stations due to operator's wait as per "hold until" instructions.

A study to measure the rider experience with commuter rail-to-fixed-route bus connections was recently conducted in Brampton, Ontario, Canada. The study modeled passenger waiting time using a simulation model and considered the combined waiting times of transferring passengers, in-vehicle passengers, and downstream passengers. The study mainly focused on operational strategies and did not address the underlying technologies. However, their findings can be useful in developing the algorithms that may be used by a T-CONNECT system to determine appropriate "hold-until" times. The "hold-until" time was found to be a result of a trade-off between various passenger waiting times in order to ensure the efficiency of transfers. One of the key findings of the research was that the outgoing transit vehicle should be held if the incoming vehicle is experiencing "moderate" (to be defined by agencies based on headways) delays. However, in the event of "long" (to be defined by agencies based on headways) delays with the incoming vehicle, the outgoing vehicle should operate according to its schedule.

**Current Limitations**

The current TCP approach, as described above, is not sufficient to enable protect transfers among more than two modes between multiple agencies; nor is it convenient for transit customers–they must request a transfer verbally when they board a transit vehicle and may not be informed about whether or not they can actually make the transfer. Furthermore, even though studies have been done describing how multi-agency TCP could be deployed, it has never been widely implemented in the U.S. Currently, all instances of TCP have only been deployed within single agencies.

## 3.3.2 T-DISP

The goal of T-DISP is to link available transportation service resources with travelers through dynamic transit vehicle scheduling, dispatching, and routing capabilities to enable travelers to make real-time trip requests through a variety of media, including personal mobile devices, phone, or personal computer. Today, the current options available for travelers to explore and assess different travel options through transit, paratransit, taxi, human service agency and other transportation providers are highly fragmented. Some communities have expanded options through websites and call centers, in particular through '511' and other transit agency efforts. However, these efforts are typically for information and referral-type services, (e.g., providing information to a traveler, who would in turn contact a specific transportation provider to obtain information about the service needed). Four major ongoing T-DISP related programs, two in the U.S. and two in Europe, are discussed below. (More detailed discussion of these programs can be found in Section 4.2 of the *Report on Assessment of Relevant Prior and Ongoing Research for the Concept Development and Needs Identification for Integrated Dynamic Transit Operations*.)

*USDOT's United We Ride / Mobility Services for All Americans (UWR/MSAA) initiative* has pursued the planning, design and deployment of technology to facilitate service coordination and improve mobility services. Eight sites across the United States were chosen for grant awards for the planning and designing of traveler management coordination centers (TMCCs). Examples of the initiative's successful service coordination activities includes the integration of dispatching and scheduling information from multiple regional transportation providers, introduction of a universal cashless fare payment system and automated billing functions to enhance human service transportation operations, and call center improvement to include customer-oriented features, such as automated telephone and Internet-based trip reservations and management.

*Lynx*, the public transit agency in Orlando, FL, developed a concept of operations, functional requirements, and implementation and business plans for FlexBus service. The project is currently entering the demonstration phase. The proposed FlexBus service consists of operating a station-to-station transit service that utilizes certain roadway improvements and ITS applications to improve mobility in the Altamonte Springs area, a major activity center in the northern part of the Orlando metropolitan area. The service will operate between designated locations such as Altamonte Mall, Florida Hospital and the future commuter rail station. The FlexBus concept of operations is to serve stations at designated locations according to the user's request rather than by a fixed schedule. The FlexBus service will be integrated with the proposed commuter rail service, and the existing and future bus networks. The intent of the FlexBus system is to achieve greater operational effectiveness, cost efficiencies, travel speeds and customer responsiveness than traditional transit services.

Outside the U.S., examples of flexibly-routed service using technology provide insight to T-DISP. The Belgian city of Hasselt with a population of 150,000 implemented a flexibly-routed service called *Belbus*. The service was implemented to replace earlier fixed route service and functioned similarly to demand-response service. Customers call one hour before they need to be picked up. They walk to a designated stop to be picked up. Drivers receive manifests on-board the vehicle's mobile data computer as each trip is scheduled. Belbus uses in-house software called RING for scheduling, dispatching and automatic vehicle location. Their communications systems include Mobitex (analogous to text messaging service for cellular service) and a radio. Belbus service was replicated throughout several rural areas throughout Belgium.

Another example of flexibly-routed service using technology is in Gothenburg, Sweden, which has a population of 500,000. Looking to reduce costs for the Special Transport Services (demand response service), a flexibly-routed service called Flexlinje was implemented. The service operates with two fixed end points between which vehicles depart every 30 or 60 minutes. The vehicles operate to "meeting points" between the two points – only points for which a reservation was made are served. These "meeting points" are no further than 150 meters from a customer's origin (typically their home). The service uses PLANET, which was developed in the early 1990s as an advanced demand response reservations, scheduling and dispatching software. Passengers make a reservation using interactive voice response (IVR) system and receive an automated trip notification 15 minutes prior to their pick up. The use of a magnetic card (swipe card) allows passengers to book their return trip within 15 minutes of departure.

**Current Limitations**

Review of current and planned demand responsive transportation implementations has shown that while flexible services have been successful in improving mobility and access to services among the elderly and disabled, there are also a number of significant limitations: The ability for transportation providers to communicate with each other is fragmented, even within the same agency. Demand response transit is frequently operated by transportation providers unaffiliated with fixed-route bus and rail service operators, often utilizing different communications and technology systems. Private transportation providers such as taxi services typically have their own means of communication. Thus transportation providers cannot easily communicate with each other and are not able to leverage their services through dynamic routing, dispatching, or scheduling based on real-time conditions. As a result, while there are a number of transit agencies that provide flexibly-routed services and use some degree of technology, the overall use of flexibly-routed service with a technology component as defined by T-DISP is limited today.

### 3.3.3 D-RIDE

The goal of D-RIDE is to enable drivers (using in-vehicle devices or telephone systems or hand-held devices) and riders (using hand-held devices or telephone systems or web-based applications, etc.) to dynamically identify and accept potential ridesharing opportunities along a given travel route. Today, many business entities, both privately and publicly funded, are currently researching, testing, and implementing D-RIDE technologies. Two major publicly sponsored projects, in Washington State and Santa Barbara, CA, and several privately sponsored programs are discussed below. (More detailed discussion of these programs can be found in Section 4.3 of the *Report on Assessment of Relevant Prior and Ongoing Research for the Concept Development and Needs Identification for Integrated Dynamic Transit Operations*.)

Washington State is currently conducting a rideshare pilot project along the SR 520 corridor to determine whether D-RIDE could help mitigate traffic congestion and to provide a detailed cost-benefits analysis of D-RIDE technology. The rideshare system was provided by Avego and consists of an application for GPS-enabled iPhones that provided ride verification, captured trip travel time, location and distance, and allowed for micro-payment capabilities between drivers and riders based on miles traveled. The program also included security features such as a pre-screening process for participants and a user evaluation system.

The Santa Barbara County Association of Governments (SBCAG) was awarded a 2010 Federal Highway Administration (FHWA) Value Pricing Pilot Program (VPPP) grant to pilot a D-RIDE project in two corridors of Highway 101 in Santa Barbara County. The purpose of the pilot is to assess D-RIDE to determine its potential to mitigate traffic, to test how cash incentives and automated cost sharing systems affect travel behavior, to determine the number of participants needed to support a D-RIDE system, and to determine what type of trips are most conducive to D-RIDE. (SBCAG has not yet awarded a contract to a D-RIDE provider, so results have not yet been published on the details of the technology or its operation.)

*RideAmigos*, which began as a taxi-sharing network in New York City, has developed into a website for travelers to make consistent carpool arrangements. Users enter their desired commutes, and can then either contact a matching “amigo” or post a commute if no match is found. Once matched, it is up to the user to arrange meeting times and locations with their matches. RideAmigos also provides ridesharing arrangements for major events, such as the Grammy Awards.

*Carticipate* is a real-time ridesharing application for the iPhone. It is a free application, available to the public, world-wide. The Carticipate system identifies the user’s location using the phone’s GPS capabilities. The user enters his or her start and end locations and arrival times to search for real-time or scheduled rides with other users who are seeking riders or drivers at the same time. As of May 2010, Carticipate has 2,944 registered users, and the application has been downloaded 30,000 times.

*TerpRiders* is a carpool program at the University of Maryland intended to reduce the number of single occupancy vehicles on campus. Utilizing an online social-networking application (Facebook), interested riders can post messages and exchange information regarding both regularly scheduled, temporary, and/or ad-hoc carpooling opportunities with other TerpRiders. Students and faculty can arrange carpools and receive a TerpRider permit when they turn in two regular parking permits. TerpRider permits save users 50% off the cost of their parking registration, and they are eligible for priority parking in convenient locations on campus.

**Current Limitations**

Findings from preliminary D-RIDE research showed that a fear of strangers was often cited as a reason for not sharing rides, highlighting the need to allow potential carpoolers to target others who are part of their social networks. Also, a lack of a familiar, commonly-known meeting points and drop-off locations has been shown to negatively impact rideshare participation. Finally, marketing is necessary to draw an initial crowd to a D-RIDE system, and incentives (e.g., iPhones offered by Avego or free BART tickets offered by RideNow) could be used to draw in more users.

## 3.4 User Classes and Other Involved Personnel

### 3.4.1 T-CONNECT

The following describes the key users of current transfer connection protection (TCP) systems.

***Dispatcher.*** In the context of TCP, dispatchers are responsible for monitoring real-time vehicle locations, transfer requests, and status of operational resources.

***Executive Manager.*** Executive managers are responsible for establishing TCP operational scenarios.

***Rider.*** Rider interaction with the TCP system is limited to making verbal transfer requests to the operator upon boarding a transit vehicle. Riders are not typically informed about whether or not they can actually make the transfer.

***System Manager.*** System managers are responsible for establishing and maintaining communication between transit vehicles, traffic management centers, agencies, and the TCP system to ensure information is exchanged properly.

**Vehicle Operator.** Vehicle operators are responsible for accepting and inputting customer connection protection requests and monitoring the TCP system for schedule recommendations.

### 3.4.2 T-DISP

The following describes the key users of current technology-enabled flexible route dispatching systems:

***Travel Management Coordination Center (TMCC).*** The TMCC is responsible for generating and disseminating transit routes and schedules based on real-time trip requests received.

***Transportation Providers.*** In conjunction with the TMCC-generated recommendations, transportation providers are responsible for coordinating and implementing transportation services to riders. They are also responsible for generating and sharing real-time fleet location data, which is used by the TMCC to make route and schedule decisions.

***Software Vendors.*** Software vendors will play a critical role in the development of appropriate scheduling and routing programs to be used by flexible route dispatching applications.

***Travelers.*** Traveler interaction with the system is through phone/IVR or web interfaces to make trip reservations and receive status information. Information provided should be accessible to travelers with disabilities such as vision impaired, wheelchair and seniors or aging population.

### 3.4.3 D-RIDE

The following describes the key users of current rideshare systems:

***Driver.*** Driver interaction with current rideshare systems is through GPS-enabled smartphone applications (e.g., Avego's ridematching iPhone application). Drivers use this application to discover nearby riders to pick up, accept ride matches, and receive payment for rides provided.

***Passenger.*** Like drivers, passengers interact with current rideshare systems via GPS-enabled smartphone applications. Passengers use this application to discover nearby drivers, receive and accept ride matches, and pay for rides given.

***Software Vendor.*** Commercial software developers play the critical role of developing the architecture, systems, and applications for the identification and payment transacting of ridematches.

## 3.5 Support Environment

The IDTO application bundle operates within the Connected Vehicle environment, with access to information from the other Dynamic Mobility Applications (DMAs) via shared arterial, freeway, regional (info), and corridor (control) data environments. Additionally, because the IDTO applications are not constrained by the minimum data latency requirements that some of the other bundles must operate under, IDTO can utilize a wider variety of communication means, including standard commercial cellular technology and even social media, to achieve its goals.

# Chapter 4. Justification For and Nature of Changes

Section 4 describes the known limitations of existing transit systems, specifically those that relate to transfer connection protection, transit dispatch and dynamic ridesharing. Justifications for the development of new applications that use connected vehicle or similar wireless technology to improve services in these specific areas are considered. The section represents the transition from the transit systems that exist today to the system(s) or applications desired that use connected vehicle technology as a catalyst. Under desired changes we may expect: new application development; standards changes; capability changes; system processing changes; interface changes; personnel changes; operational environment changes; support changes and other changes. To help guide future development, discussion of priorities amongst these changes may be necessary. Also described in this section are any applicable changes that were considered but not included specifically as recommended changes.

## 4.1 Justification of Changes

As was discussed in Section 3 (Current System or Situation), there are limitations in the manner in which transfer connection protection, transit dispatch, and dynamic ridesharing is accomplished with transit agencies and the transit ridership they wish to serve. One of the issues with the current situation is that inadequate applications exist (or no applications exist) to achieve the functionality and enhanced services envisioned by the T-CONNECT, T-DISP, and D-RIDE applications.

This ConOps is intended to be a generic ConOps, non-specific to any single regional deployment or group of stakeholders. This section discusses common, all-purpose justification for changes to deploy the referenced Transit Dynamic Mobility Applications in any applicable U.S. market.

The known rationalizations for implementing the T-CONNECT, T-DISP and D-RIDE Dynamic Mobility Applications are as follows:

1. ***Limitations of existing Systems or Applications*** - The existing systems or applications that perform the functions intended by these DMAs have limited capabilities or in certain cases do not exist at all.

    a. T-CONNECT: Although transfer connection protection (TCP) applications are available on the market today (developed mostly by the major CAD/AVL vendors), they are typically designed to work within one fleet or mode by the single agency using them, and not between modes or agencies. See Table 4-1 for a summary of the mode coverage of the major current TCP deployments.

b. T-DISP: The application of T-DISP has been somewhat limited in the US transit industry to date. There are some agencies that provide flexibly-routed services and use some degree of technology (e.g. FlexBus in Orlando, Florida), but overall there are few agencies or system applications that offer flexibly routed service using technology.

c. D-RIDE: Of the three applications being discussed here, D-RIDE is the one application that has seen a number of different deployments by different companies and programs including some wireless applications. Examples include RideAmigos, Avego, Carticipate, Trip Convergences, and TerpRiders. However, use of connected vehicle technology or equivalent is not really in use with these deployments to help improve functionality, usefulness and benefits.

2. ***Connected Vehicle Technology*** – Through the leadership and efforts of USDOT, connected vehicle research, technology, framework and standards development efforts have paved the way for use of CV technology in many areas including the development of Dynamic Mobility Applications. The DMA program seeks to create applications that fully leverage frequently collected and rapidly disseminated multi-source data gathered from connected travelers, vehicles and infrastructure. Through use and dissemination of this data, it is envisioned that these applications will be transformative in their ability increase efficiency and improve individual mobility while reducing negative environmental impacts and safety risks.

3. **Benefits to Transit Riders and Commuters** - The research presented in the "Report on Assessment of Relevant Prior and Ongoing Research for the Concept Development and Needs Identification for Integrated Dynamic Transit Operations" shows that a great deal of benefit can be obtained through the deployment of these DMA applications. Specific benefits include the following:

**T-CONNECT**

- Reduced frequency of missed connections for transit users
- Fewer cascading delays
- Decrease in expected travel time
- Increase in travel time reliability
- More reliable, more accessible, and a greater amount of information available to transit users regarding connections
- Decreased uncertainty among transit users regarding missed connections

**T-DISP**

- Synthesized travel options made available to travelers
- Improved understanding of travel options to transit users
- Decreased uncertainty among transit users regarding public transportation trips
- Decreased travel time for transit users

- Increased system capacity and efficiency

**D-RIDE**

- The benefits of D-RIDE can affect multiple aspects of society, including the environment. By increasing the flexibility of ridesharing, D-RIDE can create enough of a mode shift to reduce vehicle load on the roadway, mitigating traffic congestion, and subsequently lowering emissions and energy consumption. Research has shown that enhancing policies to increase carpooling is the most effective strategy to reduce energy consumption aside from prohibiting driving.
- D-RIDE is capable of improving network efficiency by allowing transportation infrastructure to be used more effectively by focusing on "person throughput versus vehicle throughput," minimizing the frequency of repair and construction costs to government agencies.
- D-RIDE programs can provide socially-necessary transportation alternatives to certain groups who may not have easy access to public transportation, such as senior citizens and college students
- Participants in carpool arrangements save money due to shared travel costs, and time due to the availability of HOV Lanes. Their employers benefit from the reduced demand for parking infrastructure.
- Peak demand on a transit agency could be reduced through the use of alternative transit systems such as D-RIDE.

4. ***Improved Public Opinion -*** These applications promise to improve the transit rider experience by giving them: improved and more efficient transit connects; flexible, dynamic transit connections to all locations and improved ridership choices and cost reduction through carpooling/ridesharing options. Some research results have proven these points. As an example, based on a transit connection application developed by UTA, 86% of the users were satisfied with their new connection experiences.

5. ***Overall Improved System Performance*** – The IDTO DMA applications have the potential for significant improvement in performance measures including some transformative performance targets. Discussion of the specifics of these improved performance measures and targets are detailed in Section 5.

**Table 4-1. Current State of Transfer Connection Protection (TCP) Implementation by Mode**

| | FR Bus | Flex/DR/ Para Bus | Light/Heavy Rail | Commuter Rail | Ferry |
|---|---|---|---|---|---|
| • Fixed-route Bus | Y | N | N | N | N |
| • Flexible/Demand Response/Paratransit Bus | N | N | N | N | N |
| • Light/Heavy Rail | Y | N | N | N | N |
| • Commuter Rail | Y | N | N | Y | N |
| • Ferry | N | N | N | N | N |

# 4.2 Description of Desired Changes

In order to implement the IDTO bundle, the following changes must occur. Note that these changes represent those that typically would be needed, but not all of these items may necessarily be required for all of the IDTO applications, all deployment locations or all scenarios.

## 4.2.1 Establish Corridor Data Environment

The USDOT initiated the Data Capture and Management Program as part of the Mobility program "to assess the potential of a multi-source, active-acquisition data paradigm to enhance current operational practices and transform future surface transportation systems management." The objectives of the program are to:

- Enable systematic data capture from vehicles, mobile devices, and infrastructure;
- Develop data environments that enable the integration of data from multiple sources for use in transportation management and performance measurement; and
- Reduce costs of data management and eliminate technical and institutional barriers to the capture, management, and sharing of data.

The Corridor Data Environment is critical to establishing how data will be exchanged between the applications and from other applications to other infrastructure and system components.

## 4.2.2 Develop/Modify ITS Standards

For the DCM and DMA Programs to be successful it is imperative that the exchange of information, as well as the exchanged information itself, be defined in a standard consistent manner. There are currently many existing ITS standards relating to the Connected Vehicle Initiative. The challenge is to build on this existing set of standards to determine if any additional standards, or if any modifications to the existing standards will be needed for the IDTO Bundle to be successful. USDOT is developing a DCM/DMA Standards Coordination Plan (SCP) to assist in the effort for development of the correct interface requirement and interface standards.

## 4.2.3 Develop IDTO Applications

The applications themselves need to be developed, by private sector or public sector entities using the data environments and interface standards that are in place. It is assumed that these applications can work independently or work in concert with the other IDTO applications to make a "more powerful" combined application suite. The applications are:

- ***T-DISP:*** This application will allow travelers to request trips using a variety of media and seeks to enhance existing on-board and central systems to provide public transportation and shared-ride services. A central system, such as a Travel Management Coordination Center, or decentralized system would dynamically schedule and dispatch or modify the route of an in-service vehicle by matching compatible trips together. The application may consider both public and private (e.g., taxi) transportation providers and may include paratransit, fixed -route bus, flex-route bus, and rail transit services.

- ***T-CONNECT:*** The proposed transit multi-modal and multi-agency application will enable public transportation providers and travelers to communicate to improve the probability of successful transit transfers. Travelers can initiate a request for connection protection anytime during the trip using a personal mobile device, or potentially via transit vehicle or personal automobile onboard equipment / interface, and receive a confirmation based on a set of criteria indicating whether the request is accepted.

- ***D-RIDE:*** This proposed application will make use of personal information gathering systems (such as in-vehicle and hand-held devices) to allow ride-matching, thereby reducing congestion, pollution, and travel costs to the individual with a low initial investment. Under one implementation scenario, it is proposed that the D-RIDE application will integrate carpooling functions into a vehicle computer so voice activated ridesharing technology can be built into the vehicle's interface enabling the driver to find and accept potential ride matches along his/her route without having to divert concentration from the roadway. By combining existing mobile ridesharing applications (phone, web, kiosk) with in-vehicle and roadway based technology, a number of problems associated with carpooling can be solved.

### 4.2.4 Develop Performance Measure System(s)

A key aspect of this program is the means to measure performance metrics and validate that the developed applications are meeting the identified transformative targets. The system, systems or subsystems must be in place with the correct reporting capabilities to measure and report this. Going hand-in-hand with this PM system is an archived database to store the correct database fields and values.

### 4.2.5 Perform Infrastructure and System Enhancements

A number of enhancements are needed to existing systems and infrastructure to make these applications work. Some are a high priority, while others are a lower priority. It should be noted, that some of these applications can potentially be built with little or no enhancements to existing systems, but their functionality would be limited if such enhancements do not occur. The suggested enhancements are:

- ***Vehicle communications technology.*** Installation or modification of CAD/AVL systems is needed for the precise tracking of transit vehicle and potentially other carpool/vanpool locations. Additionally, modifications to existing transit dispatch systems and software are needed to assist with the dynamic ride matching as well as to provide data and system interfaces with the wireless applications themselves.

- ***Agency Control Center/Transportation Management Center Systems.*** Systems are in use by transit system providers and DOTs to help with management, routing and dispatch of transit vehicles as well as to monitoring and manage traffic conditions on roadways. Aspects of these systems may likely need enhancements to, at a minimum, allow the correct exchange of information associated with the IDTO applications and data environments. They will also need modification as it relates to certain logic and decision support.

- ***In-Vehicle Navigation Systems.*** These systems may need modification to support the IDTO bundle. One example would be in the D-RIDE application where vehicle computer is integrated with voice activated ridesharing technology enabling the driver to find and accept potential ride matches along his/her route without having to divert concentration from the roadway. Human factors research and local policies around distracted driving must considered when designing new in-vehicle systems.

- ***Transit Vehicle Computers and/or Mobile Data Terminals (MDT).*** As necessary, information will need to be relayed to transit vehicles via mobile data terminals or vehicle computers to support these applications. For example, bus drivers would need immediate notification via MDT (or other dispatch application) to hold the vehicle in support of T-CONNECT.
- ***Transit Traveler Information Systems (TTIS).*** Transit Traveler Information Systems (TTIS) will potentially need modification, especially those that transmit next vehicle arrival information via visual or audible means at bus and rail stops. This also may include real-time travel information via the web and smartphones. TTIS may also provide information about route and mode alternatives (e.g., comparisons of cost, estimated carbon footprint, calories burned, etc.)
- ***511 Systems.*** Many 511 traveler information systems include real-time transit information via internet websites and Interactive Voice responsive (IVR) 511 systems. These systems may need modification as it relates to these new applications.
- ***Existing Dynamic Ridesharing Systems.*** There are existing dynamic ride sharing systems or websites in place, these may need modification to accommodate the new connected vehicle based D-RIDE dynamic mobility application.

## 4.3 Priorities among Changes

The table below represents the suggested priority for each of the changes described above. Priority is assigned a value between 1 and 3 with “1” being the highest priority.

| Recommended Changes | Priority |
|---|---|
| Transit Vehicle Computers and/or Mobile Data Terminals (MDT) Enhancements | 1 |
| Develop/Modify ITS Standards. | 1 |
| Develop IDTO Applications | 1 |
| Improve vehicle communications technology | 1 |
| Establish Corridor Data Environment | 2 |
| Develop Performance Measure System(s) | 2 |
| In Vehicle Navigation System Enhancements | 2 |
| Existing Dynamic Ridesharing System Enhancements | 2 |
| Agency Control Center/Transportation Management Center Systems Enhancements | 3 |
| Transit Traveler Information System (TTIS) Enhancements | 3 |
| 511 System Enhancements | 3 |

## 4.4 Changes Considered but Not Included

There are none.

# Chapter 5. Concepts for the Proposed System

Section 5 includes the overview of the family of potential IDTO applications with their now understood background, mission, objectives and scope. In the case of the IDTO, part of the motivation for new systems is likely to include new opportunities for the procurement of real-time data sources and their incorporation into powerful processing systems. This section includes how the goals for new systems may be achieved, supported by modified strategies, solutions, tactics, methods and techniques. The scope of the new systems is defined through the modes of operation, classes of users and interfaces to the operational environment. A description of the system concepts and rationale for concept decisions is included. In addition to the scope of the new system, the possible connections among the three applications are also described.

## 5.1 Background, Objectives, and Scope

The first task of the project was to perform a scan of relevant prior and ongoing research related to dynamic transit operations and to assess the current state of the practice in order to ascertain the potential benefits and impacts of a deployed IDTO system (see Section 3). The second task of the project was to assemble an IDTO stakeholder group, comprising transit expertise from academia and public and private sectors, to solicit their input on the transformative benefits, performance measures, and user needs associated with the IDTO applications. Findings from this task are discussed in this subsection.

### 5.1.1 T-CONNECT

Goals:

- Implement a system that enhances system efficiency and increases resource utilization by improving inter and intra-modal transfer opportunities for travelers using public, private and shared ride transportation modes
- Build upon efficiently and effectively scheduled transfers, and improve the probability of successful transfers/connections when needed
- Optimize rider satisfaction regarding the length of their total travel time and overall transfer connection experience
- Include traveler preference and priority to account for frequency and time of travel (i.e., hold the last trip of the day longer, or for daily commuters)

Objectives:

- Allow for agency-defined system configurations to balance traveler expectations regarding making connections and waiting time while on-board
- Allow for transfer/connection times to be configurable by mode and route, depending on the specific operating environment (local, arterial, freeway)
- Allow for system configurations based on modal priority (e.g. buses wait longer than trains)
- Increase the probability of transfers to be completed without a disruption in on-time performance (depending on the on-time performance standard)
- Reduce overall trip time for trips requiring a transfer
- Improve accuracy and relevance of real-time information for a traveler's complete journey, which may include providing information about transfers on-board using an automated announcement system

### 5.1.2 T-DISP

Goals:

- Provide travelers, including those with special needs,with trip availability and cost information dynamically and in real-time about public, private and shared-ride transportation options
- Allow travelers to explore and assess different travel options from multiple transportation providers and modes with predictable times and cost
- Dynamically schedule and dispatch multiple transportation modes by matching compatible traveler trip requests

Objectives:

- Provide demand-responsive transportation services utilizing travelers' personal mobile devices and other accessible media formats in combination with transportation providers' on-board and central system technologies
- Provide a system to support coordinated communication among transportation providers and leverage services from public and private providers through dynamic routing, dispatching and scheduling based on real-time conditions
- Promote the use of multiple transportation providers and types of services within a region to provide effective service to the community
- Develop a business model and rules that support a cooperative and/or competitive arrangement for trip assignment
- Define configurations and parameters within the system to schedule trips based on trip requests, available vehicles and vehicle capacity, trip time, trip location, in order to meet the stated business rules (e.g., maximize number of trips, reduce travel times, provide service to low density areas).
- Provide service at a cost-neutral or lower operating cost, while providing the same or more service to the community

### 5.1.3 D-RIDE

Goals:

- Increase both transit and non-transit options by providing a number of options to customers.
- Improve accuracy of vehicle capacity detection to allow for vehicle capacity detection.

Objectives:

- Increase use of passenger information gathering systems (such as in-vehicle and/or hand held mobile devices) to support increasing the use of non-transit ride sharing options for travelers.
- Ensure passenger information gathering systems are usable by a wide variety of audiences, including ensuring travelers with disabilities such as vision impaired, wheelchair and seniors or aging population can use the D-RIDE application.
- Increase use of passenger information gathering systems to support non-transit ride sharing options (shifting from single-occupant vehicles) for tolling authorities and departments of transportation.
- Improve feasibility and convenience of  ride-sharing options for travelers.
- Ensure security for drivers and passengers
- Increase non-transit ride sharing mode share and thereby reduce congestion.
- Provide methods for location-based data and reporting on vehicle occupancy status on capacity restricted and/or managed lanes, including HOV and HOT.

## 5.2 Operational Policies and Constraints

The DMA program seeks to promote applications that can be moved quickly from the research stage to adoption in the field.  These applications shall fully leverage frequently collected and rapidly disseminated multi-source data gathered from connected travelers, vehicles and infrastructure, and that increase efficiency and improve individual mobility while reducing negative environmental impacts and safety risks.

Constraints as currently known that may impact the full or partial deployment of the IDTO application bundle are provided as follows:

- Potential for near-term deployment
- Availability of required data sources
- Use of non-proprietary and/or open source approaches that can readily be adopted by a wide variety of potential end users in both the public and private sector

## 5.3 Description of the Proposed System

This section presents a description of the Proposed System for the three applications that comprise the IDTO bundle: Connection Protection (T-CONNECT), Dynamic Transit Operations (T-DISP), and Dynamic Ridesharing (D-RIDE). Also provided are the related operational components and system characteristics for each application.

### 5.3.1 T-CONNECT

T-CONNECT will provide travelers the ability to request a transfer using their personal devices or on-board transit vehicles (with assistance from drivers or using agency-equipped on-board interactive devices). Based on the system configuration (system schedule, schedule adherence status and delay thresholds, and service variability), connection protection rules and traveler requests, the system will automatically determine the feasibility of a requested transfer. When a transfer request can be met, the system will automatically notify the traveler and the driver of the vehicle to which the traveler intended to transfer. T-CONNECT will be designed to work in both single agency and multi-agency environments across single or multiple modes of transportation.

While making decision on a transfer request, the T-CONNECT system is expected to take into account the overall state of the transportation system, including connection protection requests made by other travelers as well as real-time and historical travel conditions for the services affected, and pre-determined connection protection rules agreed upon by the participating agencies and transit modes, as indicated earlier. The system will also take into account the preferences and priorities about connection protection for those travelers who choose to provide that information to the T-CONNECT system.

Also, T-CONNECT will be integrated with the two other IDTO applications: T-DISP and D-RIDE to:

- Provide trip alternatives to travelers for whom a connection cannot be protected; and
- Provide connection opportunities to the users of T-DISP and D-RIDE.

The system will also continue to monitor the situation and provide connection protection status to notify agency dispatchers and travelers regarding any updates to the connection protection requests. While agency dispatchers may view status in real-time directly on the T-CONNECT system, the T-CONNECT system will notify travelers as appropriate on their personal devices. In addition, travelers onboard affected (e.g., delayed) transit vehicles (such as buses waiting at a commuter rail station for a delayed train) may also receive information through onboard devices, such as dynamic message signs (DMS), indicating the vehicle is waiting for other travelers.

An overview of the activities involved in completing a transfer connection protection request as part of the T-CONNECT application is provided in Figure 5-1.

#### *5.3.1.1 Operational Components*

The operational components of the T-CONNECT application are as follows:

**Real-time Scheduling/Request Brokerage System**

There will be a need to implement a central transfer request brokerage system for processing transfer requests. This tool will be particularly critical in an intermodal, multimodal or interagency environment since the existing CAD/AVL systems at individual agencies may not have the ability to share or process real-time data available from various external sources (e.g., multi-agency and multimodal operational subsystems) to determine the feasibility of a connection protection request. The system will first determine the feasibility of a transfer based on fixed-schedule and then monitor the real-time status using input from the control center(s).

Further, based on the availability of real-time coordination between various transportation management systems (e.g., ridesharing systems, taxi dispatch systems), the brokerage system will be able to determine (e.g., with the help of T-DISP and D-RIDE) non-transit connection alternatives when needed. Such system configuration will also assist T-CONNECT in addressing circumstances when transit alternatives are not available (e.g., determine D-RIDE alternative when the last bus of the day cannot be held any longer).

**Control Center**

Control centers will be critical to the T-CONNECT application. These centers will continuously monitor the status of the current status of the vehicles involved in the transfer and their expected time of arrival (ETA) at the transfer point. In the event any manual intervention is necessary, the system will notify the dispatchers. Sometimes, these control centers will also represent a centralized intermodal dispatch center for regional providers (when coordination is required) or .a multimodal agency (when intermodal vehicles are dispatched and monitored by a multi-modal agency from the same location). Control centers will also be connected to regional traffic management centers for obtaining real-time traffic information for determining the ETA appropriately.

**Voice and Data Communication Systems**

Vehicles will exchange data with the fixed-end components via wireless communication. Further vehicle operators will have access to a voice communication in their vehicles in the event they need to talk to the dispatcher. Additionally fixed-end T-CONNECT system components will be connected with vehicles subsystems and other relevant systems for exchanging data when needed.

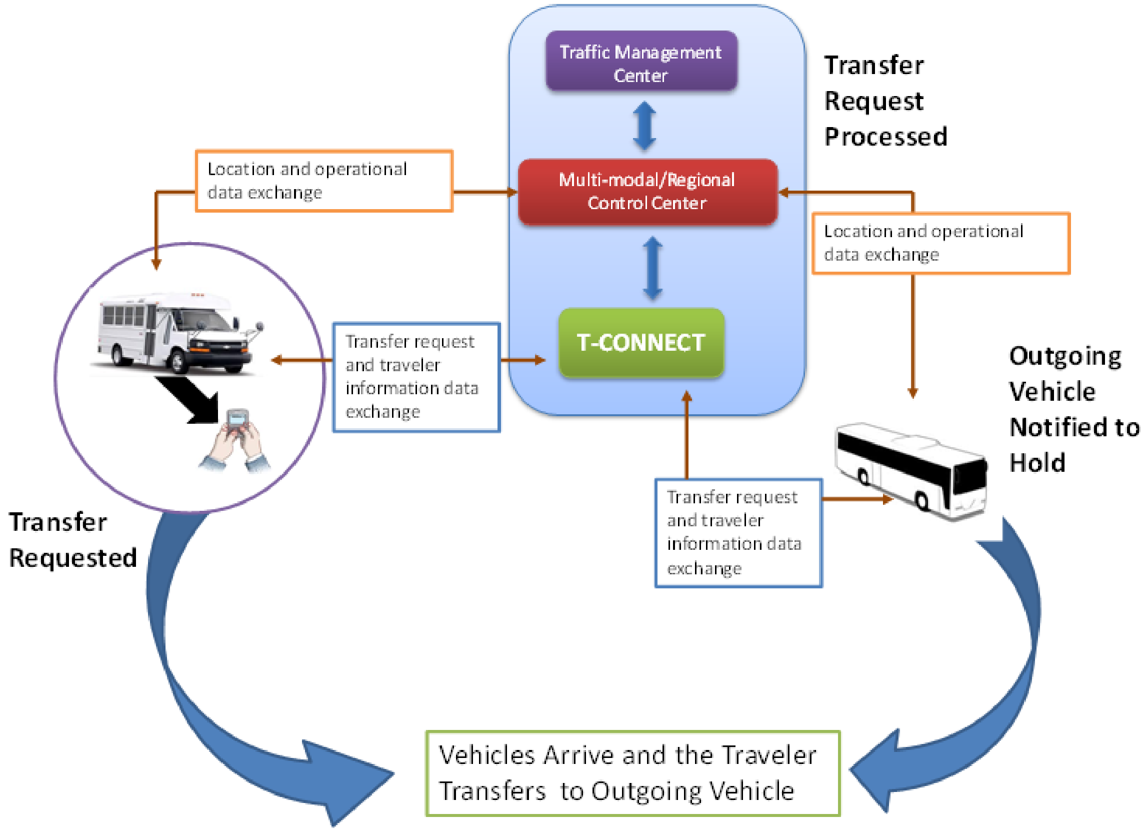


**Figure 5-1. T-CONNECT Concept Overview**

**Traveler Information System**

Traveler information system will constantly monitor the current status of the traveler requests and will notify them about the real-time status as per their preferences. Travelers will also be able to monitor the status of their requests using their web-enabled devices or via conventional phones.

### *5.3.1.2 System Characteristics*

A description of performance characteristics is provided in the following paragraphs. Further, this section provides an overview of significant technical and operational factors that will be critical to the T-CONNECT application.

**Performance Characteristics**

Certain quantitative and qualitative performance measures have been identified with the help of Stakeholders to measure how T-CONNECT system meets the intended goals and objectives. However, please note that different agencies, organizations and entities may have existing performance measures that may be complementary or in conflict. As performance measures were determined based on stakeholder input, the idea that exact measures would vary by the size and complexity of the operating environment has been considered. As such, the performance measures may be more narrowly or broadly defined when applied to a specific agency or set of organization.

- Total trip time per passenger
- Trip time reliability
- Transfer passenger waiting time from incoming vehicle (average, peak and extreme
- In-vehicle passenger waiting time for the "outgoing" vehicle (average, peak and extreme)
- Downstream passenger waiting time for outgoing vehicle (average, peak and extreme)
- Successful Low Latency Connections Achieved (average, peak and extreme) (a connection that occurs within 1 minute)
- Successful Mid Latency Connections Achieved (average, peak and extreme) (a connection that occurs within 2 minutes)
- Percentage of successful connections involving more than one agency
- Percentage of successful connections involving more than one mode
- Number of successful connection by mode;
- Increased rider satisfaction based on trip time and perceived trip time
- Percentage of reduced complaints from customers regarding transfers
- Reduction in missed connections
- Increased number of subscribers and agencies providing T-CONNECT.

Note that the current implementations of T-CONNECT as described in Section 3 are quite rudimentary and not sufficient to enable and protect multi-modal transfers per the goals and objectives determined by the Stakeholders. Several improvements to the underlying technology and operational procedures are required before T-CONNECT can be fully-functional. Based on the SAIC Team's field experience with current transfer connection protection (TCP) implementations, the following technical and operational factors must be considered in order to implement a fully-functional multi-modal T-CONNECT concept.

**Technology Factors**

Several technology elements are critical to T-CONNECT system. Some of the major factors can be described as follows:

- ***Data Communication:*** Data communication is necessary for the timely transport of information between vehicles and central dispatch/operations control. If the communication system experiences any problems that result in the inability to send critical information, this will impact the TCP subsystem's ability to timely determine the most appropriate "hold-until" time and inform operators in a timely manner. The limitation of data communication systems will be more significant in larger transit agencies if they rely on traditional data radio networks, which typically have limited bandwidth. Another factor is the rate at which vehicles are polled for their location (e.g., 1-2 minutes intervals). Thus, data messages critical to a TCP algorithm (discussed below) may not be delivered when needed.

- ***Automatic Vehicle Location (AVL):*** Real-time vehicle location is key to a successful T-CONNECT-type system. T-CONNECT algorithms determine whether or not a vehicle should be held based on the last known location of incoming and outgoing vehicles. If vehicle locations are outdated, inappropriate decisions will be made and drivers will be notified with potentially incorrect “hold-until” messages.

- ***Route and Schedule Adherence (RSA):*** Similar to AVL information, RSA is critical to determining TCP accuracy. TCP decisions are made based on the estimated time of arrival of the “incoming” vehicle as discussed below, which will rely on accurate RSA information.

- ***Arrival Prediction:*** In order to successfully determine whether or not a transfer is in jeopardy, an automated T-CONNECT system should have access to the most accurate predicted arrival time information. Predicted arrival times are dependent not only on AVL and RSA information discussed above, but also on several other operational factors such as travel time variability which may depend on the real-time traffic conditions. Real-time traffic data may be available from the regional traffic management center(s) (TMCs) and must be utilized to generate accurate predictions.

- ***Vehicle Capacity:*** Real-time information on the capacity of a vehicle to accommodate additional passengers, especially passengers with special needs (e.g., wheelchair passengers) is very important to ensure that valid TCP decisions are being made by T-CONNECT.

- ***User Preferences:*** The system must be flexible enough to accommodate user preferences (for various system users including travelers) so that T-CONNECT can make decisions relevant to each user, particularly to address traveler preferences (e.g., preference is to have up to five minutes to make any connection).

- ***Dynamic Schedule Management:*** CAD/AVL systems must have dynamic schedule management components built-in in order to provide T-CONNECT functionality. This capability will allow the support systems of T-CONNECT (e.g., CAD/AVL and arrival prediction systems) to be informed about any real-time service changes (e.g., detours, short-turning a vehicle) or other operational changes (e.g., insertion of an additional run or a trip, or short turning of a bus) made by operations personnel.

**Operational Factors**

Key operational factors can be described as follows:

- ***Data Sharing and Service Coordination for Interagency and Intermodal Transfers:*** In order to enable real-time data exchange, a transit agency should have data sharing arrangements in place, especially in the event that manual intervention is required from dispatch in a multi-modal/ multi-agency environment. Ideally, a T-CONNECT system should have access to real-time information for connecting vehicles from a common operational database for multiple agencies or modes to avoid message processing delays due to data exchange between transit management systems for individual modes/agencies, and inherent data communication network latency issues. In order to minimize delays with real-time data exchange between various systems involved in T-CONNECT implementations, standards similar to Service Interface for Real-time Information (SIRI) should be followed.

Also, policies and procedures need to be in place where manual intervention is required. For example, sometimes, transfers may be denied by the automated T-CONNECT system due to anticipated downstream impact on the service performance or predefined transfers of the route for which a TCP was issued. However, dispatchers may be in a position to issue a “hold-until” message based on their previous experience with routes, vehicles and operators involved in a particular transfer in such situations. Thus, policies should be determined by agencies, especially in a multi-modal and multi-agency environment, which should illustrate on scenarios under which dispatcher can intervene.

Also, procedures to be followed under these situations (e.g., seeking approval from supervisors or transportation managers, coordination with control centers at other agencies, if applicable) should be developed as well. Policies and procedures should be updated at a regular interval (e.g., every sixth month) by agencies based on field data collected on TCP requests (e.g., number of automatic approvals/denials and corresponding scenarios, number of manual approvals/denials and corresponding procedures followed by dispatchers).

- ***Agency Policy for “Holding” Vehicles:*** Agencies should establish a policy for determining the amount of time a vehicle should be held. Various factors that should be considered in determining the “hold-until” time are as follows:
  - Consider the trade-off between “hold-until” times and the maximum allowable threshold for schedule deviations;
  - Consider travel time variability based on historic travel time and/or current traffic conditions;
  - Consider service anomalies and disruptions;
  - Account for “on-time” and other service standards for different agencies or modes to determine the impact on schedules when vehicles from different agencies and modes are involved in a transfer;
  - Determine an acceptable waiting time for passengers based on the following: transfer waiting time, in-vehicle waiting time and downstream waiting time;
  - Consider the impact of dwell time for the “outgoing vehicle” when determining the impact on downstream stops. Particularly, elements such as wheelchair boarding time should be considered; and
  - Capacity of the “outgoing” vehicle should be considered by the T-CONNECT vehicle algorithm.

## 5.3.2 T-DISP

The vision of T-DISP is a highly-coordinated transportation system that provides a comprehensive selection of transportation services for travelers through the use of a variety of technologies utilized by the aforementioned entities and users.

T-DISP is envisioned to consist of the high-level components and features shown in Figure 5-2.


**Figure 5-2. T-DISP Concept Overview**

The following systems will be included in the T-DISP application:

- Voice radio communications to facilitate interactions between drivers and dispatchers, and to serve as a back-up if data communication fails;
- Data communication to exchange data and trip information between the Control Center and vehicles
- Computer aided dispatch/automatic vehicle location (CAD/AVL) systems to track vehicle locations and assist in messaging between drivers and dispatchers;
- A common interface between CAD/AVL and messaging systems, especially in the case of a multiple agency/multiple transportation provider environment;
- A common network interface that extracts information from both legacy and new technology systems, facilitates communication among such systems, and provides outputs to end users and external systems;
- A multi-modal scheduling system that can dynamically schedule service based on traveler preferences and requests, and match them to available vehicles. This system would enhance the basic functionality that exists within existing demand-response scheduling software to include a series of business rules and scheduling parameters that allow dynamic scheduling and dispatching; and
- A customer messaging and information system to serve as the traveler interface for service requests, especially for travelers with disabilities, or special needs.

The following entities will be included in T-DISP:

- Public transit agencies;
- Private transportation providers;
- Traffic management center; and
- Coordination center, either as part of an existing entity or a new entity.

In its simplest form, T-DISP seeks to match travelers' requests for trips with available transportation providers' services. This matching occurs within a Control Center and by the use of systems that communicate with customers and vehicles, and schedule trips for customers.

#### *5.3.2.1 Operational Components*

Based on the vision for T-DISP, there are a number of high-level components that encompass the necessary business structure and technology. A critical element of the business structure is the relationship between the transportation providers in the application. There is an assumption inherent in the T-DISP application that there are service needs for travelers that are not being met, i.e. individuals would like to make trips using public or private transportation services and cannot do so. Also, there is an assumption that there are transportation services that could be provided to meet that need. Essentially, the assumption is that there is unmet demand for service and excess capacity to provide service. The basic element of the business structure for T-DISP is to match this demand with the capacity. Also, there may be an opportunity to explore more efficient options for providing the service and the T-DISP application would be able discover those more efficient options. However, in developing the concepts for how T-DISP could operate, there is an understanding that it would be applied throughout the US, across many types of operating environments, and between an assortment of relationships among transportation providers.

Therefore in developing the business structure, consideration must be given to a range of organizational constructs. One model could be based on cooperative agreements and relationships, whereby participating entities volunteer to provide service in a more coordinated manner. Another model would be based on competitive arrangements whereby the incentives to participate are more critical, and perhaps profit minded. A third model could include elements of both cooperative agreements and competitive arrangements. All three models would require extensive effort by the participating agencies and transportation providers to determine which model would ultimately work best for the participating entities. Elements to consider as the structure is developed would include the following:

- What are the total number of potential passengers and trips? What is the service area or area of coverage?
- What is the percentage of trips allocated to or provided by public vs. private modes?
- What safety regulations are applicable to which modes?
- What level of driver training is required to participate?
- What are the incentives to participate in the system?

Supplementing the overall business structure would be the underlying business rules that would be followed during day-to-day operation. These rules would be agreed to by all involved transportation providers, public and private, and would be linked to the overall business structure. These rules will dictate the parameters of how trips are assigned during day to day operations. Examples of parameters include the following:

- Vehicle location;
- Geographic or service area;
- Vehicle speed;
- Passenger capacity on vehicle;
- Wheelchair capacity on vehicle;

- Bike rack capacity;
- Demand-response and paratransit scheduling parameters; and
- Fixed-route (rail and bus) scheduling parameters.

#### *5.3.2.2 System Characteristics*

The system characteristics of T-DISP revolve around technology and the supporting systems that will enable T-DISP to be deployed. Presently, a number of systems exist and are in use by both public and private transportation providers. These systems can be enhanced or modified to meet the functional needs of the T-DISP application.

CAD/AVL systems that facilitate communication between dispatch centers and vehicles are a critical element of the T-DISP application. CAD/AVL systems will enable how vehicles receive and transmit information about their location and availability back to the TMCC. The basic functionality of existing CAD/AVL systems can support the T-DISP application. However, because of the proprietary nature of most of the existing CAD/AVL systems, existing systems may or may not be able to communicate with each other. An interface to exchange data among these systems to determine vehicle availability will be necessary.

The TMCC could be an expansion of an existing dispatch center since some of the necessary infrastructure would exist, at least in part. Or the TMCC could be an extension or expansion of an existing Traffic Management Center. Or the TMCC could be a new entity in a new location. At a high level, the TMCC needs to be able to receive information and data from both the Traveler and the participating Transportation Providers.

The TMCC will need technology that is capable of dynamically scheduling and assigning Traveler trip requests to the appropriate mode and provider (based on the previously agreed upon business rules), and ultimately to a vehicle. Three systems exist that could form the backbone of a multi-modal scheduling system: (1) trip planning programs, (2) automated demand-response scheduling software, and (3) fixed route scheduling software. As an example, many of the trip planning programs, like Google Transit, allow users to plan a trip and then provide alternatives for making that trip. Depending on the Travelers' locations, driving, walking, biking and public transit may be offered as options. A multi-modal scheduling system would expand on this concept by including all applicable modes of service participating in the system, including private transportation. The system would have an option for users to pay for a premium service, most likely a private transportation option, such as a taxi or a shuttle.

The TMCC will need to be able to communicate with Travelers to receive their requests for service, to send trip options to them, and to receive a confirmed trip request. This customer communication software would need to be able to receive trip requests and send them to the multi-modal scheduling system. The multi-modal scheduling system would determine, based on the business rules, related scheduling parameters and traveler preferences what services/vehicles are available for the trip. The multi-modal scheduling system would provide the trip options to the customer communication software, which would push the trip options to the Traveler. The multi-modal scheduling software and customer communication system do not need to be standalone systems - these systems could be modules within one software package. Within the multi-modal scheduling system, the level of automation by which trips are scheduled should be balanced. There is a need to allow for some level of manual intervention (e.g., by the dispatcher) and approval over the scheduled trips. There is a need for the multi-modal scheduling system to search for trip options based on the cost to provide service. The concept is that the lowest cost service (in most cases fixed-route public transit service) would be offered as the first option to meet the customer's request. Then the next lowest cost would be offered, etc. This hierarchy would incorporate the business structure, business rules and traveler preferences that guide how the participants in the system interact.

The Traveler will be requesting a trip including the details about their origin (the pick–up location) and destination (the drop-off location), and the arrival or departure times for the trip. Potentially, they could book a return trip, in which the origin and destination is reversed. In order to optimize user preferences and utilize technology available to the traveler, Travelers should be able to send this information using a telephone (fixed or mobile) or the Internet. The Traveler would register for the T-DISP service by creating a user profile and a password. The user profile will include a set of user preferences:

- Maximum transfer wait time
- Range of arrival time, i.e. +/- five minutes at destination
- Maximum walking or travelling distance to pick-up and/oror drop-off location based on actual walking paths, i.e. not as the crow flies, or buffers
- Mode preferences
- Willingness to pay for private service
- Customized traveler needs, particularly for those with disabilities (e.g., wheelchair, mobility device, service animal)

The following high-level T-DISP characteristics include:

- The multimodal scheduling system accepts requests for trips from the customer communication system;
- The customer communication system allows for inputs for trip requests and pushes trip options to Travelers;
- The CAD/AVL system needs to be able to send vehicle availability data directly to the multi-modal scheduling system, or to an interface to the system;
- The CAD/AVL system needs to monitor the arrival status of customers (vehicles) in order to adjust for downstream changes to the remaining trips.
- The CAD/AVL system needs to be able to receive trip requests and modifications to its schedule for that day (i.e. updated trip manifests); and
- The business rules of the system can be updated and configured to account for new entities that will provide service, or to account for changes in the service area or service offerings.

As described previously, the T-DISP application would build on the elements of systems that already exist today. The components of existing systems would include the following:

- GIS-based visualization platform (baseline capability) – to allow for Dispatchers to visually confirm vehicle location and schedule trips to vehicles

- Source(s) of real-time data (baseline capability) – from the CAD/AVL systems to provide vehicle availability data
- Source(s) of historical data (baseline capability) – from the CAD/AVL systems to track vehicles after the fact to investigate incidents, accidents, and to feed into future planning
- Persistent data storage (baseline capability)
- Business Process engine (baseline capability) – to account for the business rules and to effectively schedule service
- Traffic-responsive algorithms (optional capability) – to include real-time traffic conditions into the multi-modal scheduling system
- Predictive algorithms (baseline capability) – to be included in the multi-modal scheduling system
- Real-time simulation/tools or off-line modeling (optional capability) – to allow for planning and analysis; especially important for determining service allocations between providers

## 5.3.3 D-RIDE

At the highest level, D-RIDE is an approach to carpooling in which drivers and riders can arrange trips in real time. Current systems do not have the functionality to dynamically match passengers to drivers no matter their location and usually require preplanning of carpool trips. The D-RIDE application allows travelers to arrange carpool trips through a stand-alone personal device with a wireless connection and/or an automated ridematching system (e.g., call center or web-based application loaded on a personal computer or kiosk at a transit facility).

The D-RIDE application follows the process flow shown below in Figure 5-3. As you go through the application, inputs are needed from both passengers and drivers pre-trip (blue), during the trip (green), and post-trip (purple). These inputs are then translated into “optimal” pairings between passengers and drivers to provide both with a convenient route between their two origin and destination locations. After the trip, information is provided back to the application to improve the user’s experience for future trips and monitor use of high-occupancy lanes.

### *5.3.3.1 Operational Components*

The D-RIDE application is comprised of the following operational components:

- D-RIDE application software for entering and communicating ridematch information to users, including ridematch optimization software/algorithm.
- Platform/mechanism for communicating information to passengers and drivers.
- Passenger information gathering systems for requesting and tracking ridematches that are accessible for travelers with special needs
- Data center to optimize, communicate, and store D-RIDE data
- Automated rideshare data entry system (e.g., call center)
- In-vehicle device to collect location information

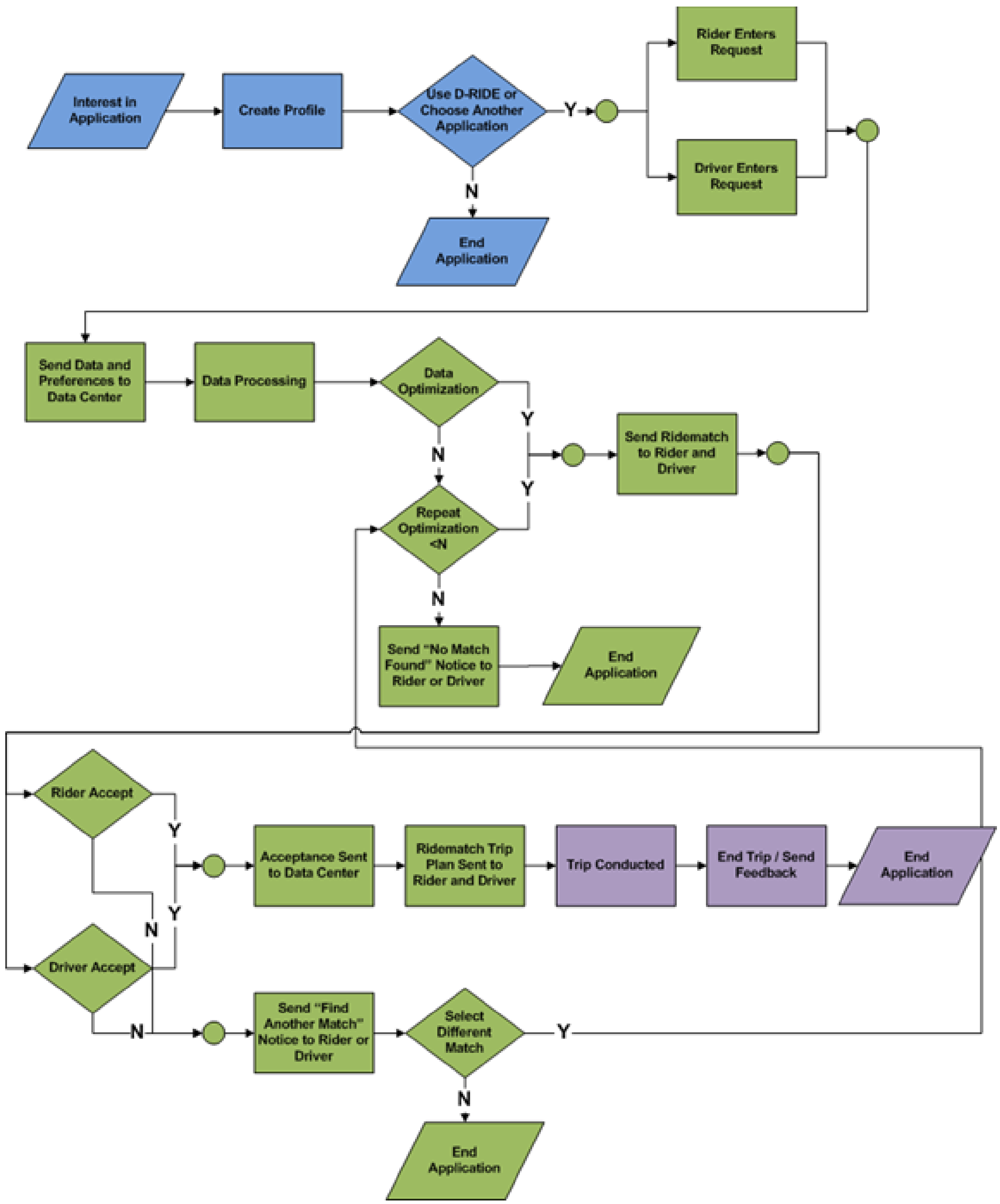


**Figure 5-3. D-RIDE Concept Overview**

The following diagram demonstrates the major system components and the interconnection between those components. Users and devices input information through the D-RIDE application software, which is transmitted to the D-RIDE data center. The data center processes the information, optimizes the ridematch request, and outputs results of the optimization back to the users. The communication process is a simple two-way flow facilitated by application software and the data center.

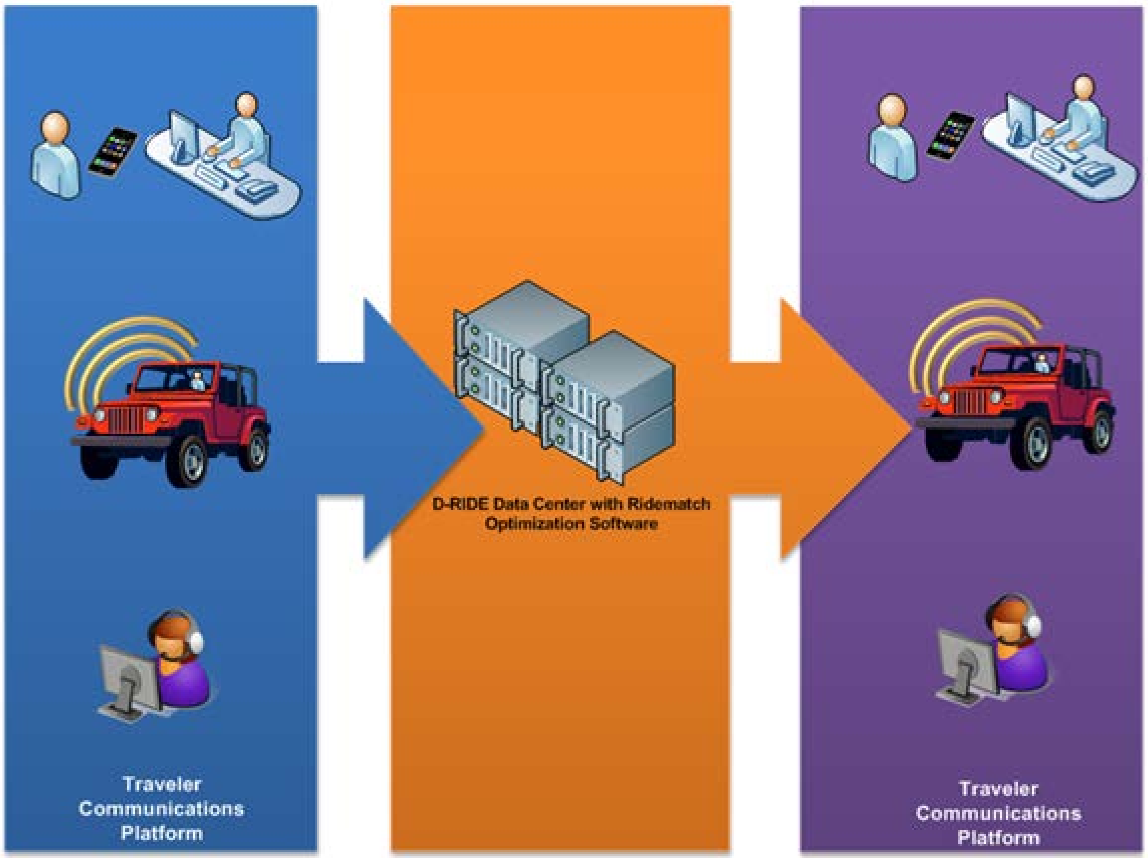


**Figure 5-4. Communication Flow between Application Components**

The D-RIDE application serves two main functions: to provide ridematches between a passenger and driver in real-time as well as to report vehicle occupancy status data on capacity restricted and/or managed lanes, including high-occupancy vehicle (HOV) and high-occupancy toll (HOT).

The application is an integrated, connected, and often (depending on the specific implementation) portable system that allows for real time requests and data exchanges to be made. The application should available through many different user interfaces and has flexibility since it can be accessed via a user interface on the personal information gathering system. The optimization software allows for efficient data processing that promotes fast information exchanges to suit use of the application when users are mobile or in motion.  Operational risk factors for this application include safety risks in matching users who are unknown to one another. This can be mitigated through including security information that must be input into the user profile or through identity verification. Other operational risks include not being able to match users during optimization. This risk for this is reduced by increasing the size of the user base from which to draw matches.

#### *5.3.3.2 System Characteristics*

**Performance Characteristics**

The performance characteristics of the D-RIDE application that should be monitored include application penetration, user experience, and operational metrics. The following is a breakdown of each performance characteristic as it relates to the D-RIDE application:

- Application penetration
  - Number of participants in the system measured as a percentage of the number of registered vehicles in the 'service area'
  - Number of repeat riders and new riders
  - Concentration of participants in the system as defined by a number per n radius miles
- User experience
  - Participant satisfaction with safety/security of riders and drivers
  - Participant perception of economic benefits in terms of trip costs
- Operations
  - Passenger waiting time (average, peak, extreme) is equal to n minutes or less
  - Percentage of ride matches to requests as defined by ride matches per n trip requests
  - Response time to customers regarding found rides
  - Number of ride matches versus unfulfilled trip requests

## 5.4 Modes of Operation

This section describes the various modes of operation under which the proposed IDTO applications are expected to perform. The modes discussed here are intended to reflect those conditions that present a significant impact on the operational aspects of the system, reflecting the different classes of users (as documented in Section 5.5) and key operational scenarios (as documented in Section 6).

### 5.4.1 T-CONNECT

T-CONNECT will be designed to perform under various operational modes as described in the following.

**Normal Mode**

T-CONNECT will be designed to perform normally in most situations per the pre-determined standard operating procedures. In normal operational mode, T-CONNECT will receive and process transfer requests and notify users about the real-time status of the requests when appropriate. Please note that the standard operating procedures required for the normal mode of T-CONNECT operations will be agency-specific and will be developed by individual agencies deploying T-CONNECT.

**Overloaded/Degraded Mode**
The system may not be able to complete transfer requests entirely based on user preferences, due to the number of such requests from travelers, or due to system constraints (e.g., issues with individual system components within T-CONNECT or operational/service constraints). In these situations, T-CONNECT may operate with limited functionality and may offer connections to only vehicles associated with a limited numbers of agencies and transportation modes.

**Priority/Emergency Mode**
A priority connection may be offered when a transfer is requested under an emergency situation (e.g., breakdown of incoming vehicle). Relevant policies and procedures should be developed for handling priority and emergency scenarios and business rules should be defined in T-CONNECT accordingly. These business rules will be agency-specific and will be determined by individual agencies deploying T-CONNECT.

**Premium Mode**
As recommended by the Stakeholders, T-CONNECT could consider offering guaranteed connections for a premium price according to traveler preferences (e.g., preferred transit mode). Innovative policies and procedures may be required for the development of premium T-CONNECT features to avoid any inconvenience to other travelers. For example, premium features may be available for limited use only for travelers who are entitled to premium services (e.g., once every week during rush hour). As stated earlier, these business rules will be agency-specific and will be determined by individual agencies deploying T-CONNECT.

**Exception Mode**
T-CONNECT may not be able to complete traveler requests under all situations. It will notify the appropriate system users about the failed transfer request in a timely way. Exceptions may occur due to various reasons such as the following:

- Technical issues with T-CONNECT components;
- Operational anomalies (e.g., delayed bus/train);
- Expected operational impacts (e.g., downstream delays); and
- Violation of transfer policies per standard operating procedures.

**Complete System Failure Mode**
There may be situations when T-CONNECT is completely non-operational due to planned (e.g., preventive system maintenance) or unplanned events (e.g., system crash).

When T-CONNECT is unavailable due to planned maintenance or other known reasons, system users must be notified ahead of time about any planned unavailability of the system. In these situations, the system users must be advised to use the fixed/fallback-schedule, as applicable.

Further, there should be provisions in the system to account for accidental system crashes by deploying a redundant system environment to ensure the "continuity of business." However, in extreme circumstances, the entire system may fail, in which case the system users must be notified to follow the fixed/fallback-schedule, as applicable.

**Test/Training Mode**
T-CONNECT should be configured with a test/training environment for system administrators and other relevant users. This configuration will ensure that the "live" system is not impacted due to inadvertent errors in configurations originally meant for testing or training modes of operations.

### 5.4.2 T-DISP

For the T-DISP application, two modes of operations are envisioned:

**Normal Operations Mode**
In normal operations mode, T-DISP operates under typical conditions and facilitates the exchange of information across all participating entities.

**Incident Management Mode**
Incident management mode, which is initiated for detours, weather events, and security events, requires specific operational agreements and action plans. It is suggested that for T-DISP, public transportation operations based on prior emergency management and evacuation planning, will take precedence over any trip request or T-DISP activity occurring during an incident.

### 5.4.3 D-RIDE

The D-RIDE application has modes of operation from a use perspective and from a support perspective. These are shown below.

**Normal Mode**
D-RIDE will be designed to perform normally in most situations per the pre-determined standard operating procedures. In normal operational mode, D-RIDE will receive and process ridesharing requests and notify users about the real-time status of the requests when appropriate.

**Overloaded/Degraded Mode**
The system may not be able to complete ridesharing requests entirely based on user preferences, due to the number of such requests from travelers, or due to system constraints (e.g., issues with individual system components within D-RIDE or operational/service constraints). In these situations, D-RIDE may operate with limited functionality and may offer connections to only vehicles associated with a limited numbers of agencies and transportation modes.

**Test/Training Mode**
D-RIDE should be configured with a test/training environment for system administrators and other relevant users. This configuration will ensure that the "live" system is not impacted due to inadvertent errors in configurations originally meant for testing or training modes of operations.

# 5.5 User Classes and Other Involved Personnel

## 5.5.1 T-CONNECT

The users of the T-CONNECT application and their respective roles and responsibilities are summarized in Table 5-1 below.

**Table 5-1. T-CONNECT Users and Roles/Responsibilities**

| User Class | User | Description of User | Roles/Responsibilities |
|---|---|---|---|
| System Implementers | Developers | This user class represents vendors who will implement the system. | Developers will implement the system and hence must have the clear understanding of all system requirements, interfaces, and data flows and installation configurations for appropriate implementation. |
| Service Providers | Executive Manager | This user class represents decision makers in an organization who would establish policies and procedures related to T-CONNECT | Executive Managers will develop the operational scenarios to be used by the automated T-CONNECT application. They will also determine how transfer policies and procedures and fare systems of regional partners are integrated so that the process is seamless to the rider. |
| | Dispatcher/Service Coordinator | Personnel responsible for monitoring the service operations list of requested transfers, their status and operational resources (agencies, vehicles, drivers) involved | Dispatchers will have access to and monitor the transfer requests, operational status of vehicles (location and schedule adherence), and relevant analytical tools (view real-time status, calculate ETA, determine need for an additional bus etc.)<br><br>Further, dispatcher will manually override the decision made by the T-CONNECT system in the event decision is going to have an impact on the operations due to real-time events not known to the automated system |
| | Supervisors/ Operations Managers | Needs to have access to real-time status of overall operations. | Operations Managers will monitor the real-time status of the entire operations since dispatchers may be assigned work according to their individual shifts (e.g., fixed-route service only) and may not have access to the real-time status of the entire operations to make any decisions in the event of exceptions.<br><br>Supervisors will also coordinate with Executive Managers and System Managers as needed.<br><br>Further, supervisors will coordinate in training activities. |

| User Class | User | Description of User | Roles/Responsibilities |
|---|---|---|---|
| | Vehicle operator | This user class represents the drivers of incoming and outgoing vehicles | Drivers will perform actions per the policies and procedures of their agencies. Sometimes, they will issue transfer requests on travelers' behalf. |
| | System Manager | This user class represents the information technology personnel and intelligent transportation system coordinators | System Managers will be responsible for ensuring the connectivity between vehicles and fixed-end systems and individual system components of T-CONNECT. Further, System Managers will monitor the status of system components and any need for upgrades and updates. |
| Supporting Entities | External Users | This set of users will represent all parties external to a T-CONNECT system who either provide data or use data from T-CONNECT but are not directly involved in T-CONNECT operations (e.g., Traffic Management Center coordinator) | External users will be provided access to the system as needed. The system will be flexible enough to grant access to limited components only to avoid inadvertent intrusions. |
| Passengers | Traveler | Primary user of the T-CONNECT who will initiate transfer requests | Travelers will submit transfer requests and provide their preferences. Further they will notify about any changes to their travel plans. |

## 5.5.2 T-DISP

T-DISP users are shown in Table 5-2 along with their respective roles and responsibilities.

**Table 5-2. T-DISP Users and Roles/Responsibilities**

| User Class | User | Description of User | Roles/Responsibilities |
|---|---|---|---|
| Passengers | Travelers / public transit customers | End users of the transportation services | Request trips; use public and private transportation services |

| User Class | User | Description of User | Roles/Responsibilities |
|---|---|---|---|
| | Travelers with special needs/ paratransit customers | End users of the paratransit transportation | Request trips based on accessibility needs; use public and paratransit services |
| System Implementers | Multimodal transportation planners | Plan transportation service | Analyze and review the performance of the T-DISP application in order to make any needed adjustments or changes to how service could be deployed |
| | Bicycle and Pedestrian Planners | Plan bicycle and pedestrian networks | Provide bicycle and pedestrian network information to the multi-modal scheduling system |
| Service Providers | TMCC | Controls and monitors communications from all entities | Has access to real-time data (from multiple modes and jurisdictions) and access to network configuration data from one or more sources<br><br>Sends trip options / description characteristics back to travelers<br><br>Has business rules to guide decisions about how trips are distributed to transportation providers |
| | Public and Private Transportation Providers | Provide transportation services | Generates and provides vehicle availability and location information to a TMCC.<br><br>Has business rules to guide decisions about how trips are distributed to transportation providers |
| | ITS IT managers | Manage information technology and services | Develop ITS-specific IT hardware and software standards and deploy IT equipment and applications |
| | ITS IT maintenance staff | Manage and maintain technology and services | Operate and maintain equipment |

| User Class | User | Description of User | Roles/Responsibilities |
|---|---|---|---|
| | Parking facility staff | Staff at parking lots | Operate, monitor and maintain parking facilities including park and ride;<br><br>Provide information to the TMCC about park and ride space availability |
| | Shared-ride / Carpool / Vanpool Entities | Manage shared-ride services | Provide information on available shared ride, carpool, vanpool services to the TMCC / Multi-modal scheduling system |
| | Transit operations managers | Manage the transportation services | Plan, manage, and dispatch transit operations throughout the transportation network |
| | Transit Supervisors and Dispatchers | Manage day-to-day operations; includes staff at a TMCC | Maintain communications with transit drivers and monitor transit vehicle schedule adherence, breakdowns, on-board incidents, and safety issues, implement training |
| | Transit operators | Driver and operation the vehicles | Operate vehicles |
| | Private transportation providers | Drivers, managers, dispatchers, and maintenance staff for private vehicle fleets | (Same roles and responsibilities as public transportation providers) |
| | Transit maintenance<br><br>Transit customer service centers | Maintain onboard equipment<br><br>Provide customer service | Monitor status of onboard equipment<br><br>Interface with the transit users, providing assistance and answering questions<br><br>Receive calls for requests for trips and input them into the Multi-modal Scheduling System |

## 5.5.3 D-RIDE

The D-RIDE users are shown in Table 5-3 along with their respective roles and responsibilities.

**Table 5-3. D-RIDE Users and Roles/Responsibilities**

| User Class | User | Roles and Responsibilities | Discussion |
|---|---|---|---|
| Passengers | Persons without access to reliable transit | Obtain ridematches using D-RIDE application. | Area traveling through has under-served transit service. |
| | Carpool riders | Obtain ridematches using D-RIDE application. | Find traditional carpools inconvenient in the event of an emergency or when working later than a scheduled carpool pick-up. |
| | Transit commuters | Obtain ridematches using D-RIDE application. | Typical transit route could be delayed due to congestion or involves indirect routes and transfers that create longer commute times. |
| Drivers | Commuters with an open seat | Obtain ridematches using D-RIDE application. | Would like to utilize a HOV or HOT lane with the flexibility of not dedicating daily commutes to full-time carpooling. |
| System Implementers | Tolling Authorities | Use D-RIDE application to track utilization of HOV/HOT lane usage. | Better understand of use of system and enforcement. |
| | State and Local Agencies | Use D-RIDE application to improve mobility in areas with technology deployed. | Better use of existing highway and arterial networks. |
| | USDOT | Promote D-RIDE strategically across the country as a means for improving mobility and its environmental benefits in markets where it makes sense to deploy the application. | Benefit from rich data set gathered through application. |

| User Class | User | Roles and Responsibilities | Discussion |
|---|---|---|---|
| | Developers (companies, entrepreneurs, maintainers) | Create the D-RIDE application for implementation. | Will take Concept of Operations for D-RIDE and make a reality. |
| | Transit Agencies | Create a better networked transit system through the inclusion of the D-RIDE application. | Better utilization of multi-modal options for transit. |

These user classes interact using the following type of interaction flow, shown in Figure 5-5. Passengers communicate with the data center with ridematch needs, as do drivers, and then the data center will communicate the ridematches back to both parties and then the trips are conducted. This data gathered before, during, and after rides will then be shared with implementers and stored for potential future use.

In addition to these user groups, and overlapping some of these groups, are a diverse set of stakeholders who have a vested interest in the D-RIDE application's success. To make D-RIDE a reality, a number of stakeholder groups beyond the potential passengers and drivers are involved. These stakeholder groups either will influence D-RIDE policy, impact implementation of D-RIDE, and be party to the data needs and privacy concerns that will be addressed both before, during, and after D-RIDE is functional.

For each D-RIDE application implementation, various stakeholders will be involved, including state and local agencies [e.g. departments of transportation (DOTs), chambers of commerce, local governments, metropolitan planning organizations (MPOs)], large employers, private companies/entrepreneurs, and firms with transit benefits.  A diagram summarizing these stakeholder groups is below in Figure 5-6.

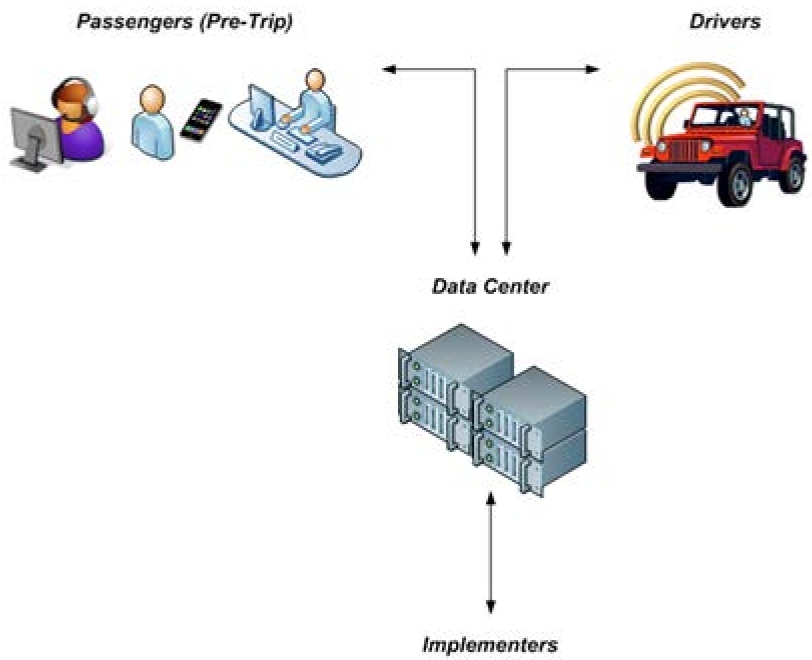


**Figure 5-5. User Class Interactions**

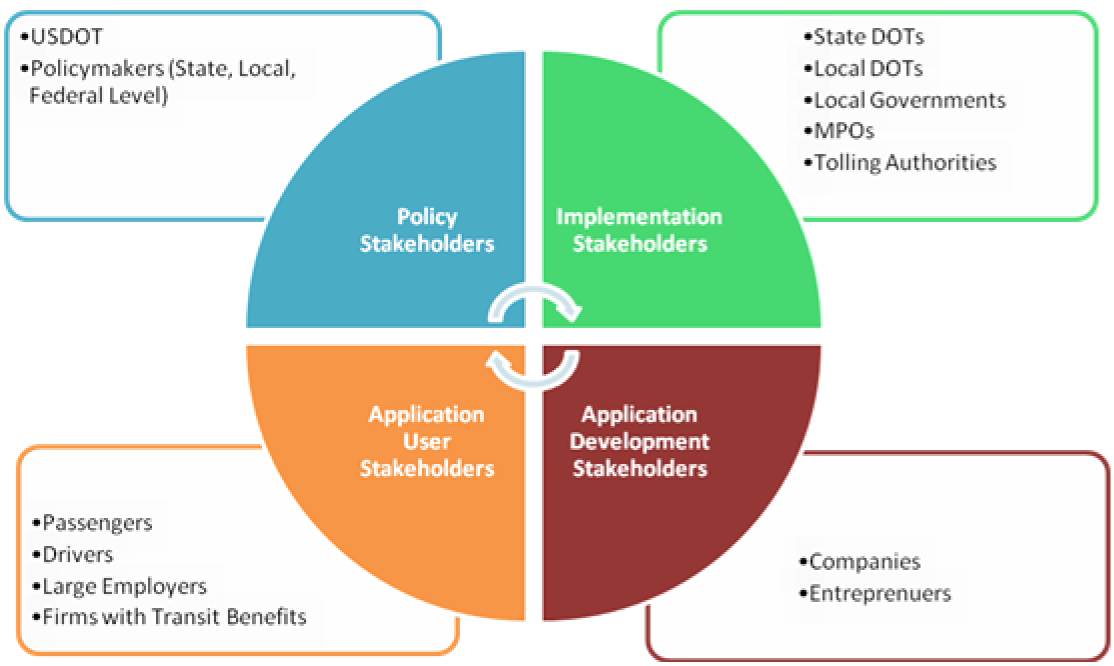


**Figure 5-6. D-RIDE Application Stakeholders.**

# 5.6 Support Environment

## 5.6.1 T-CONNECT

T-CONNECT operational components described in Section 0 will need assistance of the following systems, organizations, and entities:

**Planning/Scheduling**
Vehicle and operator schedules are the key elements of any transit operation since operational performance is measured against those schedules. Schedulers must ensure that sufficient connection time is built into the schedules at transfer points. Also, sufficient running time must be built into the schedule to avoid operational anomalies. Further, in a transfer situation where walking between two points is required, the walking distance should be minimized to avoid any unnecessary delays for the traveler.

**Operations**
Operations will be the most important element of T-CONNECT since the current operations will directly affect the ability to protect a requested transfer. The ability of the technology and operations personnel to ensure that operations are going according to the schedule will facilitate the use of T-CONNECT under a normal mode of operation. However, the application and operations personnel will rely on the capabilities of the underlying technologies (e.g., CAD/AVL systems that include in-vehicle subsystems, fixed-end subsystems and wireless subsystems). These underlying technologies must be able to provide information on vehicle location, route and schedule adherence (RSA) status, arrival predictions, vehicle capacity and real-time schedule adjustments as needed by operations personnel and T-CONNECT. Further, in some situations, T-CONNECT may need to interact with the D-RIDE and T-DISP applications. When T-CONNECT requires coordination with T-DISP or D-RIDE, standards-based real-time data exchange must be ensured so that T-CONNECT can make informed decisions.

**System Management, Maintenance and Support**
Since T-CONNECT will be a completely automated system, the computer infrastructure should be fail-safe. "Server redundancy" and "high availability" concepts must be implemented to avoid any exceptions in the T-CONNECT application due to technical issues.

**Vehicle Maintenance**
The operating conditions of vehicles and on-board technology will be critical to successful intra-agency and interagency transfers. Thus, maintenance must monitor and report the status of each vehicle before pullout. Also, a sufficient spare ratio (to be determined by deploying agencies) should be maintained to account for any vehicle incidents or breakdowns.

**Internal Data Consolidation System**
T-CONNECT must have the capability to acquire and process data in real-time from a variety of systems and subsystems. The location of a data center for this purpose may be determined as part of the high-level design but the design must ensure that the data center is highly redundant.

**External Data Providers**

In most situations, data from external entities (e.g., real-time traffic and road closure) may be required for the systems supporting T-CONNECT (e.g., CAD/AVL systems) to make informed decisions. Appropriate policies and procedures should be developed for the utilization of such data.

### 5.6.2 T-DISP

The support environment for T-DISP will include the following:

**Planning/Scheduling**
Planning and scheduling are key elements as the availability of service is related to the schedules and manifests developed by the transit agencies or private transportation providers.

**Voice and Data Communication Systems**
T-DISP must be able to utilize enhanced or new voice and data communications, including interfaces that facilitate inter-agency communication.

**Dispatching and Operations**
T-DISP will rely on the participating agencies and private transportation providers dispatching and operations systems. However, there would be changes in dispatching and operations based on responding to and being able to provide trips as part of the T-DISP system.

**System Management, Maintenance and Support**
T-DISP would rely on the participating agency's system management, maintenance and support systems.

**Vehicle Maintenance**
T-DISP would rely on the participating agencies and private transportation providers to maintain vehicles and ensure operating conditions on-board the vehicles.

**Internal Data Consolidation System**
T-DISP must have the capability to acquire and process data in real-time from a variety of systems and subsystems. The location of a data center for this purpose may be determined as part of the high-level design but the design must ensure that the data center is highly redundant, highly available and connected to external systems via a secure, fast and redundant network gateway.

**External Data Providers**
In most situations, data from external entities (e.g., real-time traffic and road closure) may be required for the systems supporting T-DISP (e.g., CAD/AVL systems) to make informed decisions. Appropriate policies and procedures should be developed for the utilization of such data.

**TMCCs**
New TMCC or expanding capabilities within an existing TMCC or similar Control Center will be needed to support the coordination of services and manage traveler's requests for service.

### 5.6.3 D-RIDE

The operational and support environments for the D-RIDE application are described below, and include five operational components, which are described in detail in Table 5-4. As has been emphasized throughout this section, the D-RIDE application will operate in multiple environments (e.g., in vehicles, on personal devices, via a call center interface, and in a data center), each of which will require different levels of support. These support levels are broken down by application component.

As D-RIDE is a specific application, there are different types of support (e.g., facilities, personnel, equipment, hardware, software, and other vendors) who have a role in maintaining the D-RIDE application, as well as various reasons for including each type of support. These are all summarized in the table below.

**Table 5-4. D-RIDE Operational and Support Environment**

| Application Component | Types of Support Required | | | | | | Description of Support | Reason for Including |
|---|---|---|---|---|---|---|---|---|
| | Facilities | Equipment | Hardware | Software | Personnel | Outside Vendor | | |
| Personal Device for Requesting Ridematch | | | | ✔ | | ✔ | The developer for the D-RIDE application will not be responsible for maintaining each user's personal device for requesting ridematch – rather, they will be responsible for maintaining the application software and ensuring its usability across multiple platforms. | Define the limitations for the scope of work for application developer; liability for device misuse lies with the individual user. |

| Application Component | Types of Support Required | | | | | | Description of Support | Reason for Including |
|---|---|---|---|---|---|---|---|---|
| | Facilities | Equipment | Hardware | Software | Personnel | Outside Vendor | | |
| Automated Rideshare Data Entry System (e.g. phone center, web-application, or kiosk) | ✓ | ✓ | ✓ | ✓ | ✓ | | The center will be used track ridematch requests from those users who do not have access or who do not wish to use their personal device for ridematching. The center will log requests from users and pass along information to the data center. Center personnel will ensure the center maintains 24/7 operations. | The center serves as the back-bone for one of the two modes of operation for the D-RIDE application. |
| D-RIDE Application Software | | | | ✓ | ✓ | | The application software will be maintained by developers and rolled out via regularly scheduled updates to users via their personal device updating procedures. All application updates will be tested and approved in advance of roll-out to users. | The application software will likely change over time as needs arise. Having staff in place to provide this support in a timely fashion is critical. |
| In-Vehicle System | | ✓ | ✓ | ✓ | ✓ | | The in-vehicle system will be maintained through an outside source. D-RIDE specific application software will be maintained remotely and pushed to the in-vehicle system as updates occur. | This limits the scope of what the D-RIDE application developer will be responsible for supporting. |
| Data Center | ✓ | ✓ | ✓ | ✓ | ✓ | | The data center will serve as the medium for collecting, parsing, optimizing, and transmitting information between all of the D-RIDE components listed above in this table. The data center will be fully staffed to ensure 24/7 up-time and will have fully backed-up data systems and hardware to ensure no downtime in the event of a failure. | This scopes what the D-RIDE application data center will need to support, and will be further defined in any future Operations and Maintenance documentation development. |

# Chapter 6. Operational Scenarios

Section 6 is based on a limited number of working scenarios. High-level data flows using ITS Architecture Market Packages and time-sequenced descriptions are used to describe the manner in which the various parts of the proposed system function and interact. The scenarios tie together the systems, the users and the institutions. This use of scenarios enables stakeholders and readers of the ConOps document to grasp the operational significance of the proposed system, user roles, how the system should operate and the broad features to be provided. Scenarios illustrate key decision points where IDTO components are used. Both near-term (1-3 years) and long-term (10+ years) scenarios are included.

## 6.1 T-CONNECT Operational Scenarios

Four operational scenarios are discussed in this section to describe T-CONNECT from the perspective of travelers and service providers. Please note that the media used for enabling T-CONNECT (in-vehicle MDTs and mobile devices used by customers) in this section are just examples. Agencies will be able to deploy additional media which can be used by their customers for requesting transfers (e.g., kiosks at transfer centers) and obtaining the real-time status of their requests.

### 6.1.1 Scenario 1: T-CONNECT Operation Based on Fixed Schedule

This scenario represents what travelers would do if they make their travel plans long before initiating a trip. It would require them to define transfer points for their trips. Thereafter, the T-CONNECT system will determine the transfer feasibility. An overview of the scenario is described in Figure 6-1 below.

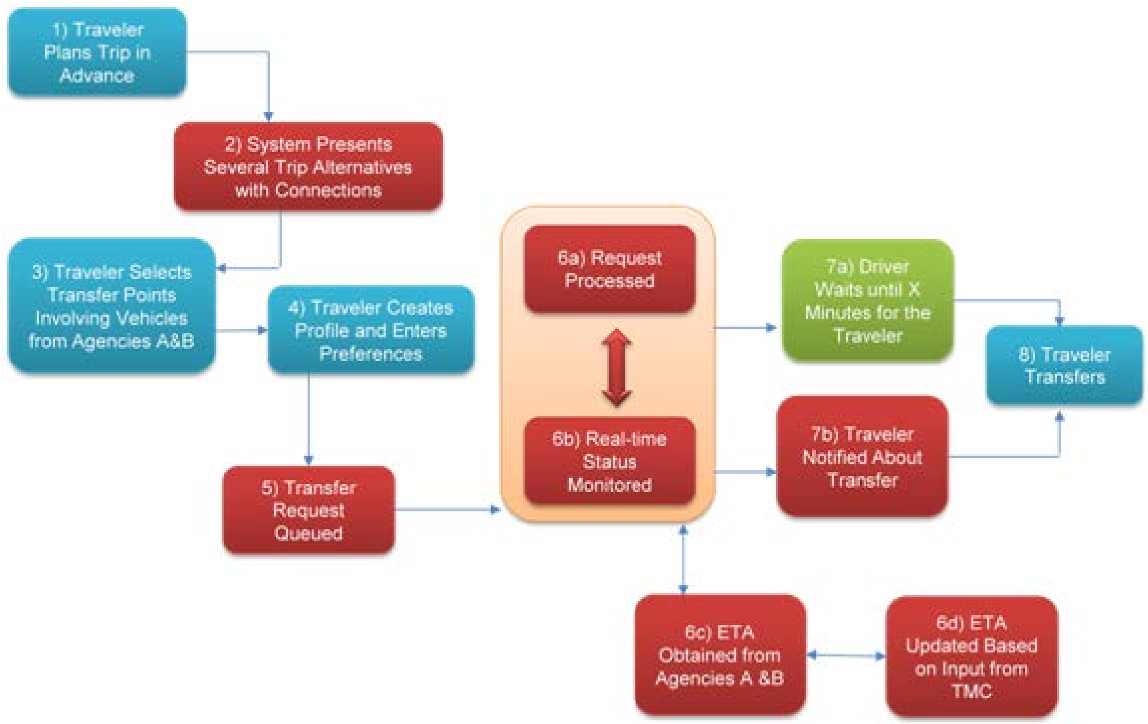


**Figure 6-1. T-CONNECT Scenario 1: Operation Based on Fixed Schedule**

**Steps:**

1. Traveler plans the trip four hours in advance using a regional trip planner.
2. The regional trip planner suggests several trip alternatives and provides information on the number of connections required, a list of agencies involved and the transit modes to be used.
3. Traveler selects the trip alternative that requires only one connection but involves two agencies: Agency A and B.
4. Further, the traveler launches the T-CONNECT application and enters connection protection request for the Agency B vehicle. The T-CONNECT system asks the traveler to enter any preferences (e.g., real-time information alerts). The traveler creates a profile by registering with T-CONNECT and providing his/her preferences.
5. T-CONNECT queues the traveler request in the system since the trip is still four hours away. T-CONNECT determines the feasibility of the transfer based on fixed-route schedule data and notifies the traveler of the feasibility.
6. T-CONNECT monitors the real-time status (e.g., estimated time of arrival [ETA]) of the Agency B vehicle using Agency B's CAD/AVL system. T-CONNECT also monitors the ETA of the Agency A vehicle where traveler is now on-board (see 6a, 6b, 6c and 6d in the Scenario 1 diagram).
7. When the Agency B vehicle is X minutes away, the driver of the Agency B vehicle is notified to hold for 2 additional minutes for an incoming passenger. Traveler is also reminded about the upcoming transfer at the same time. Further, automated vehicle announcement (AVA) system notifies the on-board passengers about additional wait time for 2 minutes at the upcoming stop (see 7a and7b in the Scenario 1 diagram).
8. When Vehicle A arrives at the stop, the Traveler transfers to Vehicle B.

9. Once traveler is on-board, the driver notifies T-CONNECT of the successful transfer using the MDT and T-CONNECT marks the transfer as complete and archives the data.

### 6.1.2 Scenario 2: Reconfiguring Fixed Schedules Based on Dispatcher Input

This scenario represents what dispatchers would do when T-CONNECT knows that a transfer/connection is in jeopardy.

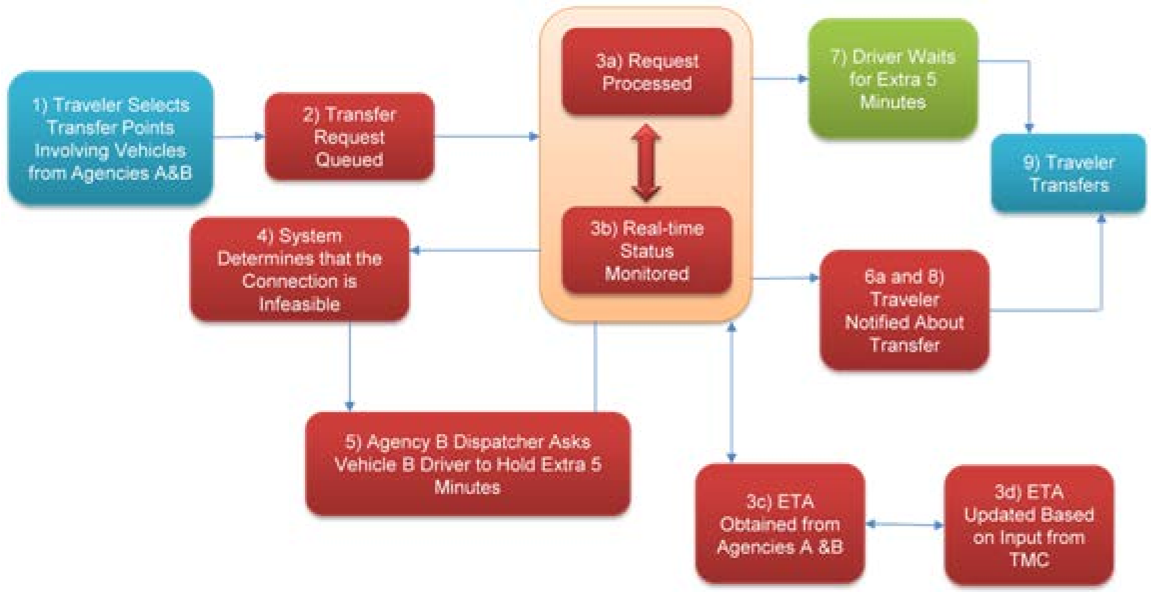


**Figure 6-2. T-CONNECT Scenario 2: Reconfiguring Fixed Schedules Based on Dispatcher Input**

**Steps:**

1. The traveler selects transfer points involving vehicles A and B and requests for transfer connection protection using the T-CONNECT application
2. T-CONNECT queues the request.
3. The transfer request is processed by T-CONNECT and the system determines based on the fixed-route schedule that the connection is not feasible due to a planned detour for the route being served by Agency B and requested by the traveler (see 3a, 3b, 3c and 3d in the Scenario 2 diagram).
4. The rejected transfer request is sent to the Agency B Dispatcher for further review and manual override.
5. The Agency B Dispatcher determines that another “outgoing” vehicle for a different route but serving Traveler’s destination will be early by few minutes and hence the transfer request can be completed.
6. T-CONNECT notifies the traveler that the transfer can be protected.
7. T-CONNECT asks the Driver of the outgoing vehicle to wait for another 5 minutes.

8. T-CONNECT system reminds the traveler about the upcoming transfer based on alert preferences. Further, the AVA system on Agency B vehicle notifies the on-board passengers about additional wait time for 5 minutes at the upcoming stop.
9. Traveler arrives at the transfer point and makes connection to the Agency B vehicle.
10. Once traveler is on-board the driver notifies T-CONNECT of the successful transfer using the MDT and T-CONNECT marks the transfer as complete and archives the data.

### 6.1.3 Scenario 3: Allowing Travelers to Request Information about a Connection

This scenario defines what would happen if travelers intervene based on the real-time information regarding the originally requested transfer.

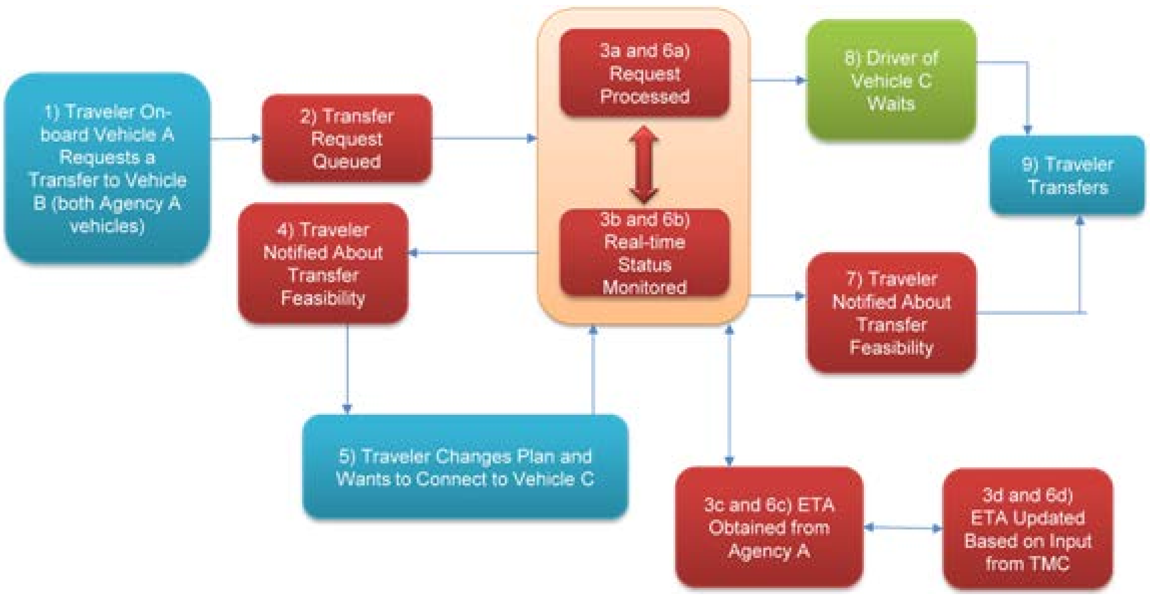


**Figure 6-3. T-CONNECT Scenario 3: Travelers Request Information about a Connection**

**Steps:**

1. Traveler is on-board Vehicle A and requests transfer to Vehicle B with the help of the Driver. The Driver enters the information in the T-CONNECT system using the MDT. Both vehicles A and B are operated by the same agency (Agency A).
2. Transfer request is queued in the system.
3. T-CONNECT processes the request and determines the transfer feasibility (see 3a, 3b, 3c and 3d in the Scenario 3 diagram).
4. T-CONNECT notifies the traveler about transfer feasibility
5. Traveler determines some change in the original travel plan and now wants to connect to vehicle C, also operated by Agency A. This time traveler enters the information using a personal mobile device.
6. Request is again queued in T-CONNECT. The system determines that the transfer is feasible (see 6a, 6b, 6c and 6d in the Scenario 3 diagram).

7. The system notifies the traveler about the transfer feasibility.
8. The system notifies the Driver of Vehicle C of the upcoming transfer and advises to wait until x minutes after the scheduled departure. Further, the AVA system on Vehicle C vehicle notifies the on-board passengers about additional wait for x minutes at the upcoming stop.
9. Vehicle A arrives at the transfer location and the traveler transfers to Vehicle C.
10. Once the traveler is on-board the driver notifies T-CONNECT of the successful transfer using the MDT and T-CONNECT marks the transfer as complete and archives the data.

### 6.1.4 Scenario 4: Monitoring and Continuous Improvement

This scenario defines a situation when the traveler misses a requested connection.

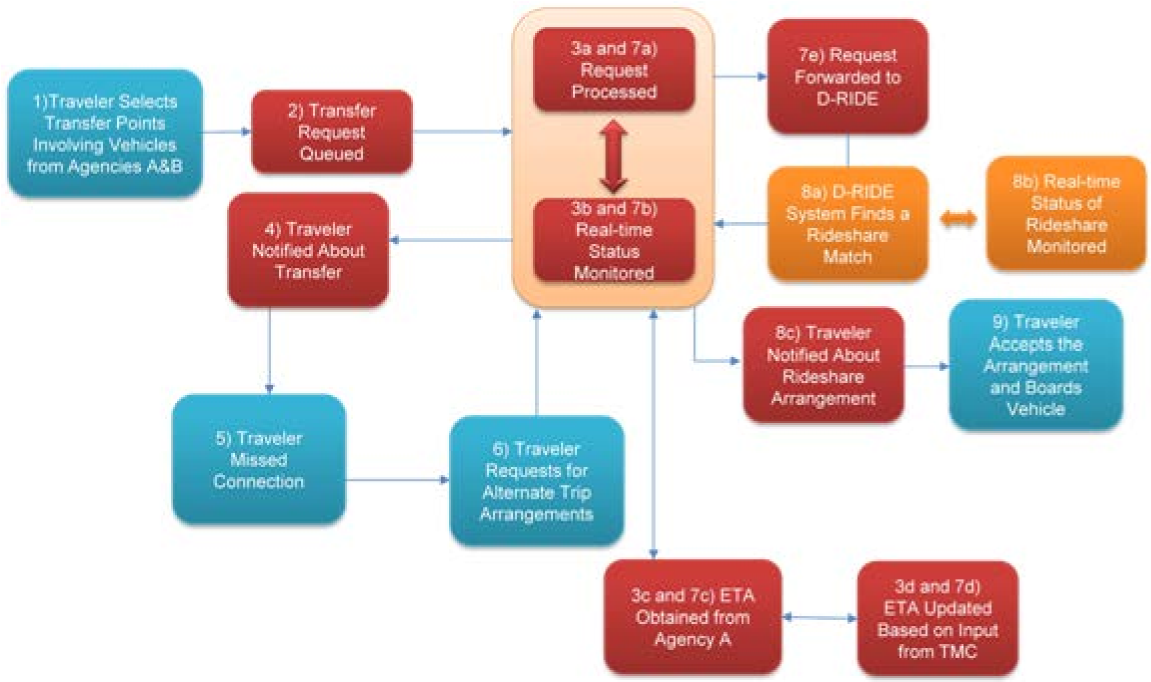


**Figure 6-4. T-CONNECT Scenario 4: Monitoring and Continuous Improvement**

**Steps:**

1. Traveler selects transfer points involving vehicles A and B and requests for transfer connection protection using the T-CONNECT application
2. T-CONNECT queues the request.
3. The request is processed by T-CONNECT and the system determines based on fixed-route schedule that the connection is feasible see 3a, 3b, 3c and 3d in the Scenario 4 diagram
4. T-CONNECT notifies the traveler accordingly.
5. Traveler boards Vehicle A and arrives at the transfer location. Traveler finds out the Vehicle from Agency B has already left due to a mandatory short-turning of the Agency B vehicle. Since the traveler did not sign up for real-time information alerts, T-CONNECT could not notify the traveler about the possible missed connection ahead of time.

6. Traveler requests T-CONNECT for an alternate trip arrangement.
7. T-CONNECT determines that no further transit connections can be provided even with regional partners. Thus, T-CONNECT contacts D-RIDE application for a rideshare match see 7a, 7b, 7c, 7d and 7e in the Scenario 4 diagram).
8. D-RIDE finds a rideshare match and advises the traveler to wait for 10 minutes for an upcoming vehicle for pickup. Pickup vehicle is also notified about the waiting traveler. D-RIDE system monitors the real-time status of the scheduled trip (see 8a, 8b, and 8c in the Scenario 4 diagram).
9. Pickup vehicle scheduled by D-RIDE arrives at the transfer location and the traveler boards the vehicle.
10. Once the traveler is on-board, the Driver of the pickup vehicle notified D-RIDE about the completed pickup. Also, D-RIDE system notifies T-CONNECT about the pickup and completed transfer. T-CONNECT marks the transfer request complete and archives the data.

## 6.2 T-DISP Operational Scenarios

T-DISP will provide more information to travelers about available transportation services and facilitate dynamic dispatching of transit assets to meet traveler's requests for service. Key T-DISP scenarios are discussed below.

### 6.2.1 Scenario 1: Fixed Route Service

This scenario describes a situation where Traveler A needs to go from Origin A to Destination B at Time C. A fixed route service option is available, which is accepted. (See Figure 6-5 and Figure 6-6.)

**Steps:**

1. Traveler inputs trip request using mobile device (but could call to request service or use a website) and receives trip itinerary options back within 15 seconds or less.
2. The first option offered is for fixed route service, which has the lowest customer fare and virtually no incremental cost for the agency operating that service (the vehicle is already out on the street).
3. Traveler accepts the trip and goes to catch the bus at the requested time.

### 6.2.2 Scenario 2: Flexible Route Service

This scenario describes a situation where Traveler A needs to go from Origin A to Destination B at Time C. No fixed route service option is available, so a flexibly routed service is dispatched. (See Figure 6-5 and Figure 6-6.)

**Steps:**

1. Traveler inputs trip request using mobile device (but could call to request service or access a website) and receives trip itinerary options back within 15 seconds or less.
2. There is not a fixed route service option, so a flexibly routed bus is determined to be available for pick-up at the requested time.
3. Traveler is sent this as an option along with the fare and either confirms or rejects this trip.

4. If trip is confirmed, the multi-modal scheduling system will send a trip to the CAD/AVL system (or through the interface if multiple CAD/AVL systems are being used).
5. The driver of the vehicle will accept the changes to the schedule or manifest.

### 6.2.3 Scenario 3: Demand Response Service

This scenario describes where Traveler A needs to go from Origin A to Destination B at Time C. Neither fixed route nor flexibly routed service options are available, so a public demand response (or an Americans with Disabilities complementary paratransit trip) is provided. (See Figure 6-5 and Figure 6-6.)

**Steps:**

1. Traveler inputs trip request using mobile device (but could call to request service or access a website) and receives trip itinerary options back within 15 seconds or less.
2. Neither fixed route nor flexibly routed services are available, so traveler is sent an option for a general public demand response trip along with the fare.
3. Traveler either confirms or rejects the trip.
4. If trip is confirmed, the multi-modal scheduling system will send a trip to the CAD/AVL system (or through the interface if multiple CAD/AVL systems are being used).
5. The driver of the vehicle will accept the changes to the schedule or manifest.

### 6.2.4 Scenario 4: Private Transportation Service

This scenario describes where Traveler A needs to go from Origin A to Destination B at Time C. No public transportation option is available, so a private transportation trip is provided. (See Figure 6-5 and Figure 6-6.)

**Steps:**

1. Traveler inputs trip request using mobile device (but could call to request service or access a website) and receives trip itinerary options back within 15 seconds or less.
2. No public transportation options are available, so traveler is sent an option for a private transportation service along with the fare.
3. Traveler either confirms or rejects the trip.
4. If trip is confirmed, the multi-modal scheduling system will send a trip to the CAD/AVL system (or through the interface if multiple CAD/AVL systems are being used).
5. The driver of the vehicle will accept the changes to the schedule or manifest.

Figure 6-5 and Figure 6-6 are examples of the components of the T-DISP application that meet the functional needs of the aforementioned scenarios. Figure 6-5 illustrates the operations for a single agency or authority. Figure 6-6 shows a multiple agency environment. The former scenario occurs more frequently in the US, since most communities have public transportation service provided through one entity. Figure 6-6 is more common in the largest metropolitan areas where multiple agencies provide service. Both figures include multiple modes (e.g., bus, BRT, rail).

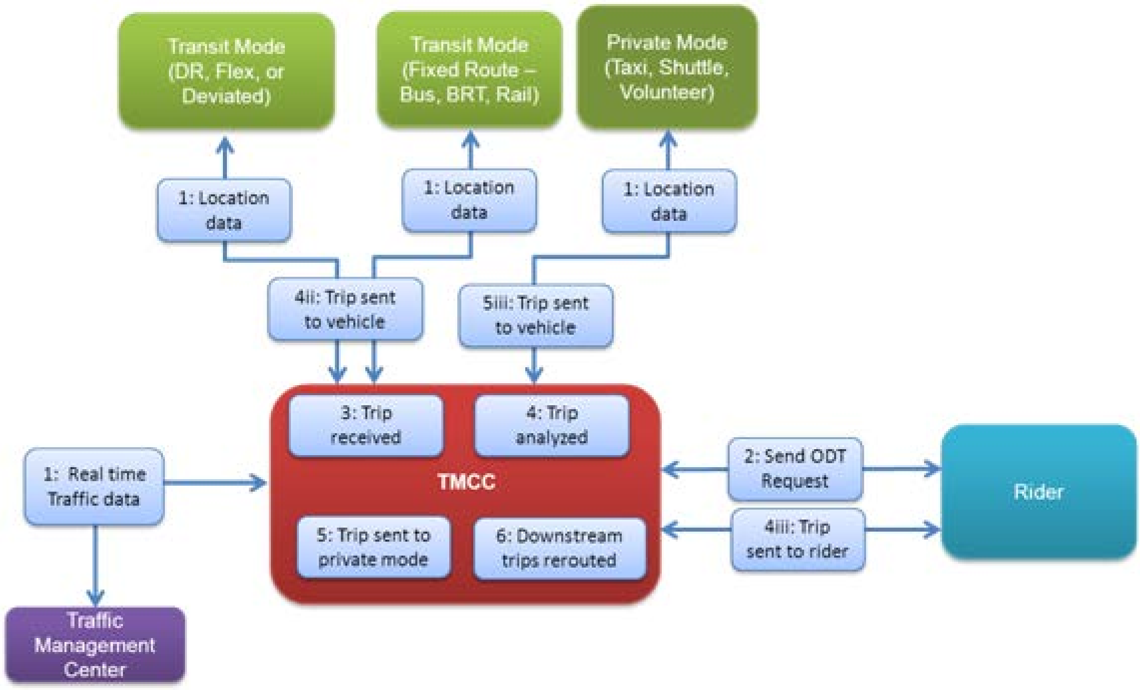


**Figure 6-5. T-DISP Scenario: Single Agency/Authority Environment**

In the single agency/authority environment, as depicted in Figure 6-5, a single transit provider operates multiple modes with the similar on-board systems and data communications systems.

**Transactions:**

1) Regular processes occurring on a daily basis, including:
   - CAD/AVL system sending location data for all vehicles in the system that are eligible for service every 30 seconds via cellular or data radio communications
   - Real-time traffic data sent to TMCC, and real-time “probe” data sent to Traffic Management Center
   - Data messages sent back and forth between TMCC and Transit Modes (i.e. vehicles) via cellular or data radio communications
   - Manifests or sets of trips are sent from TMCC to vehicles via cellular or data radio communications (or for fixed route modes are accessed at driver log on)
2) Rider requests a trip with origin, destination and time (ODT) and return trip using a web enabled mobile device with software application
3) Request received in TMCC that has route and schedule data available
4) Trip request analyzed:
   - Trip request approved through scheduling system
   - Message sent to vehicle that needs to deviate to pick up the rider

- o Message sent to rider that trip can be made

5) Trip request analyzed but denied:

- o Message sent to rider with information about private mode and cost of private mode
- o Rider approves private trip and cost
- o Message sent to Private Mode vehicle

6) Accepted trips are adjusted into remaining, downstream schedules for vehicles

In the multiple agency/authority environment, as depicted in Figure 6-6, multiple providers operate in a multimodal environment. An interface between systems for vehicle location and communications is necessary.

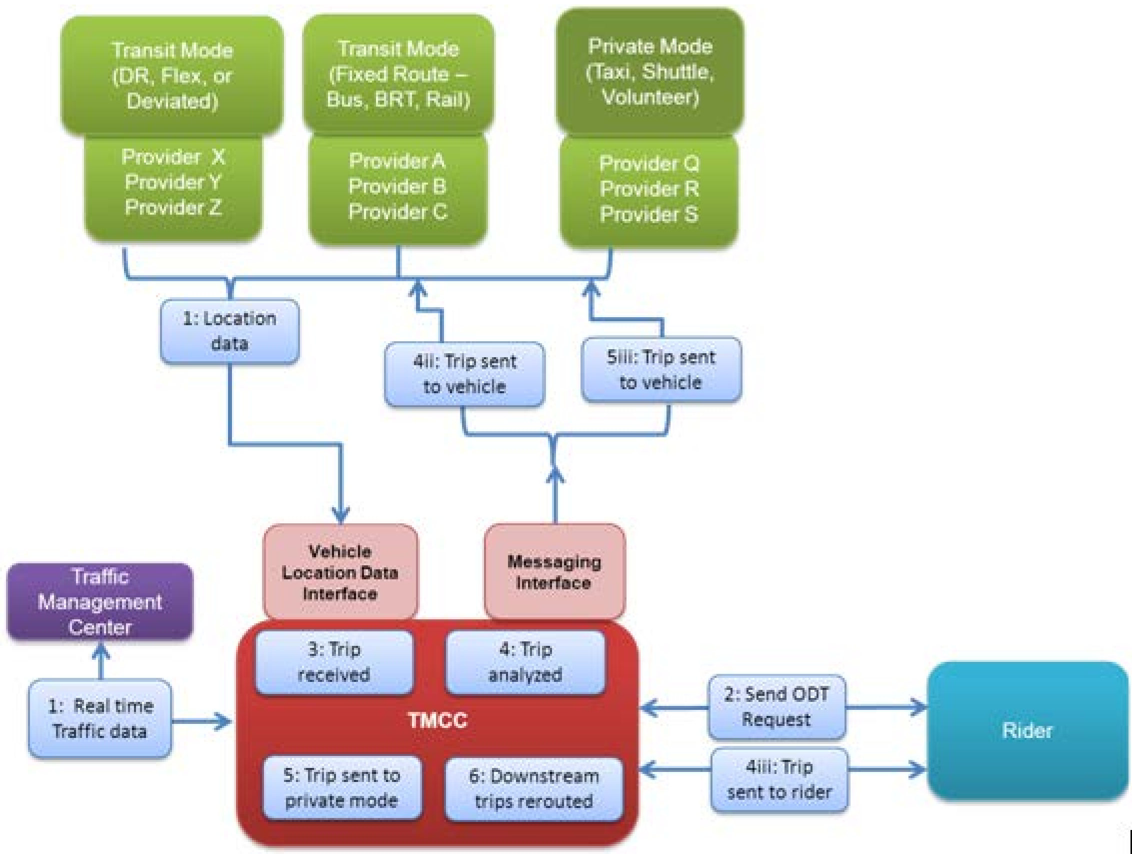


**Figure 6-6. T-DISP Scenario: Multiple Agency/Authority Environment**

**Transactions:**

1) Regular processes occurring on a daily basis, including:

- o CAD/AVL system sending location data for all vehicles in the system that are eligible for service every 30 seconds via cellular or data radio communications

- o Data messages sent back and forth between TMCC and Transit Modes (i.e. vehicles) via cellular or data radio communications
- o Real time traffic data sent to TMCC
- o Manifests or sets of trips are sent from TMCC to vehicles via cellular or data radio communications (or for fixed route modes are accessed at driver log on)
- o Multiple agencies sending location data to an interface that “neutralizes” the location data within the scheduling system

2) Rider requests a trip with origin, destination and time (ODT) and return trip using a web enabled mobile device with software application

3) Request sent to TMCC that has route and schedule data

4) Trip request analyzed:

- o Trip request approved through scheduling system
- o Message sent to vehicle that needs to deviate to pick up the rider Message sent to rider that trip can be made

5) Trip request analyzed but denied:

- o Message sent to rider with information about private mode and cost of private mode
- o Rider approves  private trip and cost
- o Message sent to Private Mode vehicle

6) Accepted trips are adjusted into remaining, downstream schedules for vehicles

## 6.3 D-RIDE Operational Scenario

One primary operational scenario has been defined and provides context for how the D-RIDE application will be used from the perspective of the user classes. This scenario describes the high-level processes and data flows and includes travelers (both drivers and passengers) registering for the application and requesting ridematches, D-RIDE identifying matches and notifying travelers, and D-RIDE monitoring the ridematches to completion of the trip.

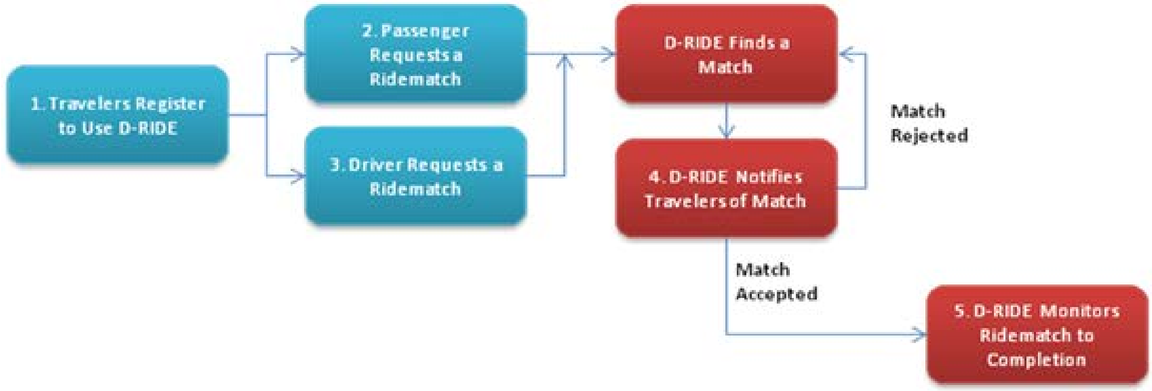


**Figure 6-7. D-RIDE Scenario: Primary Processes**

Note: This scenario is independent of any technology-specific application, but may reference the use of a personal electronic device, computer, or telephonic system. This is merely for readability but is not indicative of a technology solution.

#### *6.3.1.1 Process 1: Travelers Register to Use D-RIDE Application*

This process describes the user registration process. Travelers (i.e., passengers and drivers) must create a profile in the D-RIDE application to enable quick use of the application, to agree to terms of service, and to store preferences in the data center specific to individual users. The traveler enters profile information into a user interface in the D-RIDE application software (i.e., in a personal device, in-vehicle device, or through an automated ridematch system). This information is linked to individual user profiles and stored at the D-RIDE data center.

**Users Involved**

User Class: Passengers, specifically:

- Persons without access to reliable transit
- Carpool riders
- Transit commuters

User Class: Drivers, specifically drive-alone commuters

User Class: Implementers, specifically developers (in an operations/maintenance function only)

**Pre-Conditions**

Security protocols and procedures are in-place, in addition to the D-RIDE application itself, to ensure users can properly interact with the system.

**Steps**

The steps described below correspond to the diagram for the registration process in Figure 6-8.

1. The interested user goes to a D-RIDE profile user interface (e.g., website, mobile application software, or automated ridematch system) to create a profile enabling the user to join ridematches.
2. The user enters information for creating their profile, including personal identification information, traveler preferences, a user ID and password, information about the device they are using, and information necessary to complete payment transactions, if applicable.
3. The user accepts the terms and conditions of use at this stage and the profile is saved in the D-RIDE data center.
4. The user can then begin to use the application to find a ridematch.

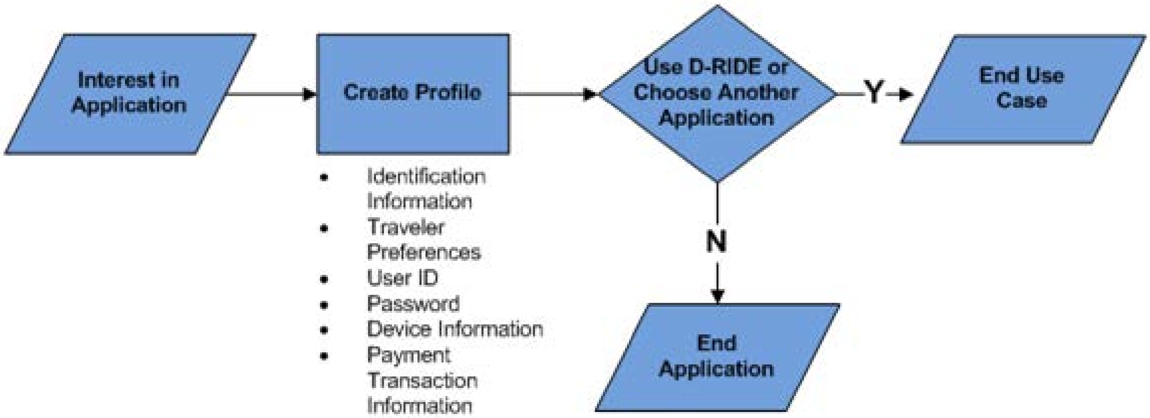


**Figure 6-8. D-RIDE Process and Data Flow for D-RIDE Registration**

**Service/Software Needed**

Software needed includes the D-RIDE user interface and the automated ridematch system as well as the data center. Also software should be tied to authenticated sources like other transit platforms in the area. The system should also provide a feedback mechanism for tips on how to use the system.

#### *6.3.1.2 Process 2: Passenger Requests a Ridematch*

In this process a passenger needs a ridematch from their origin (where they are now) to their destination. The passenger uses the D-RIDE application to request the ridematch and receive information on the upcoming ridematch, including information on the time/place to meet their driver.

**Users Involved (Actors)**

User Class: Passengers, specifically:

- Persons without access to reliable transit
- Carpool riders
- Transit commuters

User Class: Implementers, specifically developers (in an operations/maintenance function only)

### Pre-Condition

Passenger has already registered for the D-RIDE application. Passenger knows their origin and destination information. All other passengers in party, except children, are all pre-registered for the application and pre-authenticated. The process and data flow is shown in Figure 6-9 (light green reflects data processing outside of passenger's field of vision).

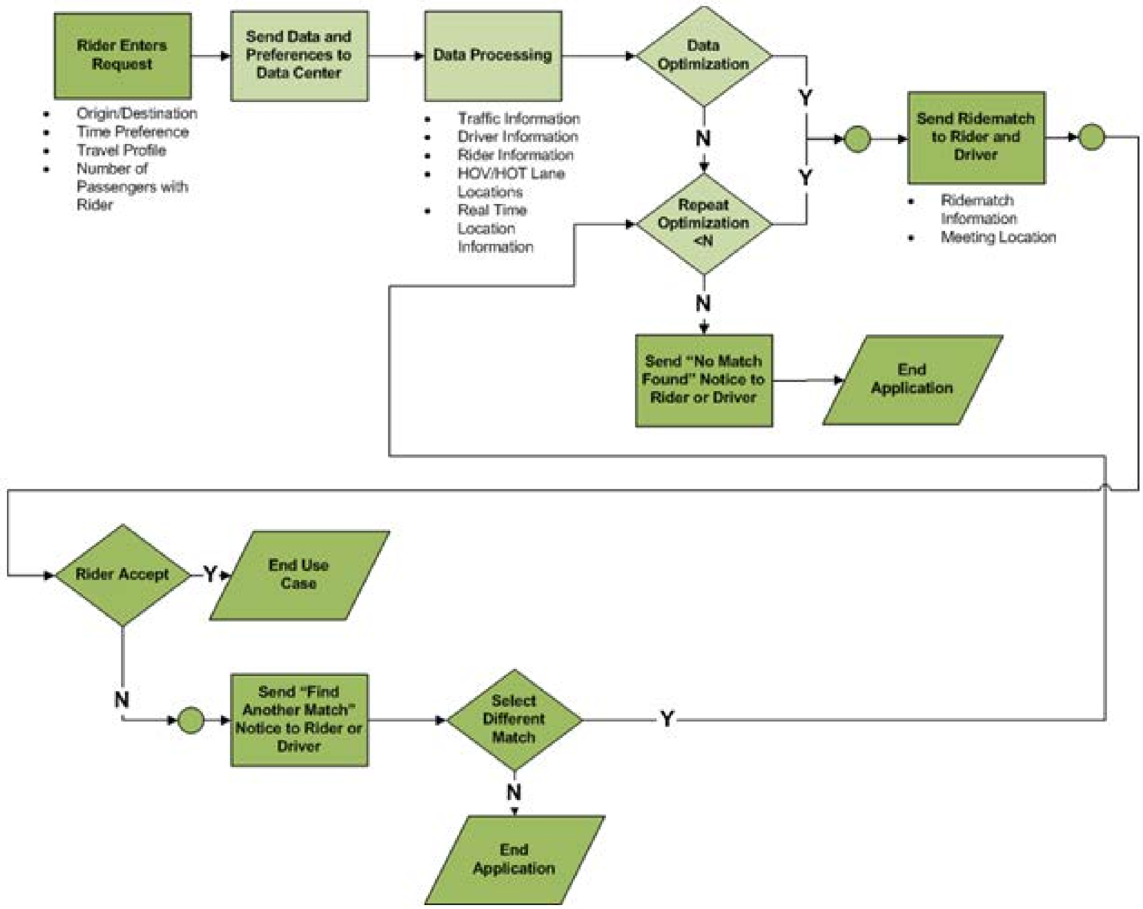


**Figure 6-9. D-RIDE Process and Data Flow for Passenger**

### Steps:

The steps described below follow the process diagram shown in Figure 6-9.

1. The passenger uses their personal device or the automated ridematch system to request a ride. The passenger enters the following information about their requested ridematch: origin/destination, time preference, travel profile, number of riders with the passenger.
2. The information is transmitted after the user clicks "Submit Information" and is sent to the data center for processing (shown in lighter shade of green).
3. The data center processes the information submitted by the passenger, optimizes to find a potential ridematch, and sends that information to the passenger for approval.
4. If no match can be found, the application ends after N tries.

5. If the passenger does not accept the ridematch, then the application sends the notice “find another match” to the passenger, and gives the passenger the option of finding another match or ending the use of the application.

**Service/Software Needed**

- Personal Device;
- Automated rideshare system;
- data center with optimization software;
- Communications protocols between devices; and
- Usable cellular/landline/data network for communication between passengers and data center.

#### *6.3.1.3 Process 3: Driver Requests a Ridematch*

In this process a driver needs a ridematch from their origin (where they are now) to their destination. The driver uses the D-RIDE application installed in their vehicle to request the ridematch and receive information on the upcoming ridematch, including information on the time/place to meet their passenger.

**Users Involved (Actors)**

User Class: Drivers, specifically drive-alone commuters

User Class: Implementers, specifically developers (in an operations/maintenance function only)

**Pre-Condition**

Driver has already registered for the D-RIDE application and has the application installed on their in-vehicle system (e.g., connected vehicle). Vehicle knows the current location. The driver knows their destination information. The process and data flow is shown in Figure 6-10 (light green reflects data processing outside of passenger’s field of vision).

**Steps**

The steps described below follow the process diagram shown in Figure 6-10.

1. The driver uses their in-vehicle D-RIDE application to request a ridematch passenger. The vehicle prompts the driver for the following information about their requested ridematch: origin/destination, time preference, travel profile, number of passengers in vehicle.
2. The information is transmitted after the driver agrees to “Submit Information” and is sent to the data center for processing (shown in lighter shade of green).
3. The data center processes the information submitted by the driver, optimizes to find a potential ridematch, and sends that information to the driver for review and approval (recounted to the driver verbally by the in-vehicle system).
4. If no match can be found, the application ends after N tries.

5. If the driver chooses to not accept the ridematch, then the application sends the notice "find another match" to the driver audibly, and gives the driver the option of finding another match or ending the use of the application.

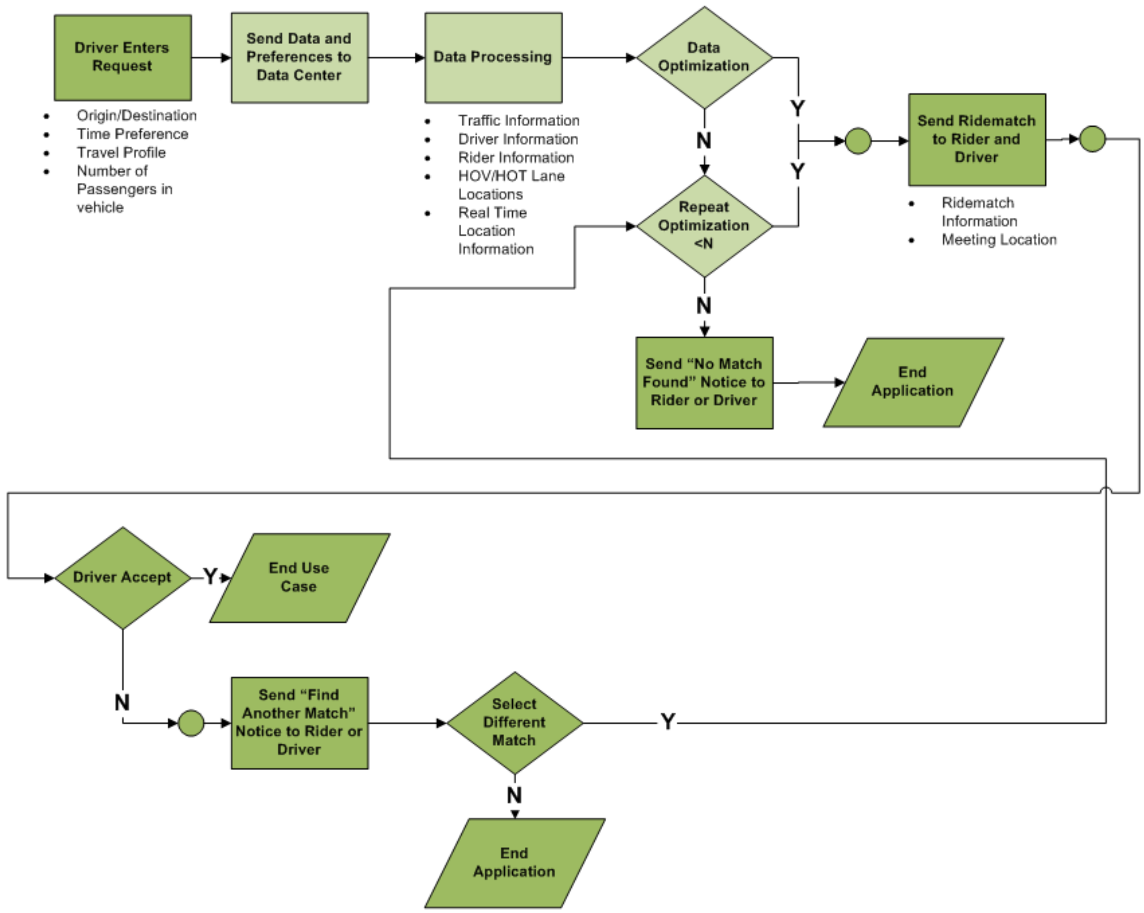


**Figure 6-10. D-RIDE Process and Data Flow for Driver**

**Service/Software Needed**

- In-vehicle system,
- Data center with optimization software,
- Communications protocols between devices, and
- Usable data network for communication between vehicles and data center.

#### *6.3.1.4 Process 4: D-RIDE Notifies Travelers of Ridematch*

In this process the driver receives a ridematch request via their in-vehicle system and agrees or disagrees to accepting the passenger. Similarly, the passenger receives a ridematch request via communication system and agrees or disagrees to accepting the match. If both travelers agree then the information is then sent to both travelers to meet and begin the ridematch trip.

**Users Involved (Actors)**

User Class: Passengers, specifically:

- Persons without access to reliable transit
- Carpool riders
- Transit commuters

User Class: Drivers, specifically drive-alone commuters

User Class: Implementers, specifically developers (in an operations/maintenance function only)

**Pre-Condition**

Driver has already registered for the D-RIDE application and has the application installed on their in-vehicle system (e.g., connected vehicle). Vehicle knows the current location. The driver knows their destination information.

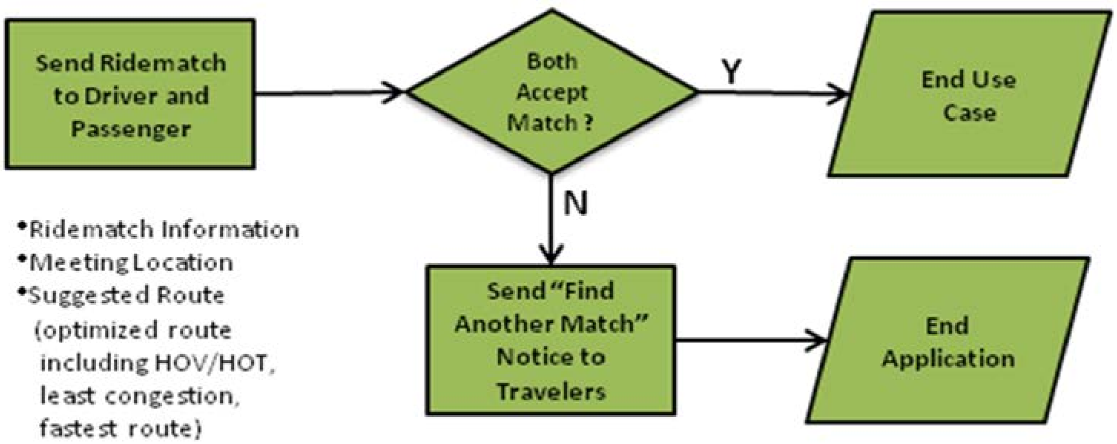


**Figure 6-11. D-RIDE Process and Data Flow for Travelers Receiving Request for Ridematch**

**Steps:**

The steps described below follow the process diagram shown in Figure 6-11.

1. The driver receives a ridematch request audibly from their in-vehicle D-RIDE application. The vehicle tells the driver about the potential ridematch, including: ridematch information, meeting location, suggested optimized route information.
2. The in-vehicle system sends the information to the driver for review and approval (recounted to the driver verbally by the in-vehicle system).
3. The passenger receives a ridematch request for review and approval.
4. If either the driver or passenger chooses to not accept the ridematch, then the application sends the notice "find another match" to the driver (audibly) and the passenger, and the application ends.

5. If both travelers accept the ridematch, the use case ends.

**Service/Software Needed**

- In-vehicle system,
- Data center with optimization software,
- Communications protocols between devices, and
- Usable data network for communication between vehicles and data center.

#### *6.3.1.5 Process 5: D-RIDE Monitors Ridematch Trip to Completion*

In this process, the rider and driver have accepted their ridematch, formulated using data on the number of travelers provided in the initial request submittal. By accepting the ridematch, the users accept the suggested route, which may include the use of HOV/HOT lanes. The data center sends a final ridematch trip plan including route information. As the trip is conducted, real-time location is tracked by the application and confirms trip plan adherence, aiding implementers monitoring HOT/HOV lane occupancy and use by D-RIDE users.

**Users Involved (Actors)**

User Class: Passengers, specifically:

- Persons without access to reliable transit
- Carpool riders
- Transit commuters

User Class: Drivers, specifically drive-alone commuters

User Class: Implementers, specifically:

- Tolling Authorities
- State and Local Agencies
- Developers (in operations and maintenance function)

**Pre-Condition**

- Passenger has already registered and has the application installed on their personal device. Driver has already registered for the D-RIDE application and has the application installed on their in-vehicle system (e.g., connected vehicle).
- Passenger and/or driver have entered number of passengers with the requesting user.
- The ridematch sent by the data center includes suggested optimized route information to be converted to a final trip plan.
- Driver deems the suggested route to be acceptable.

- Data center knows the location of HOV/HOT lanes.
- Vehicle knows its current location.

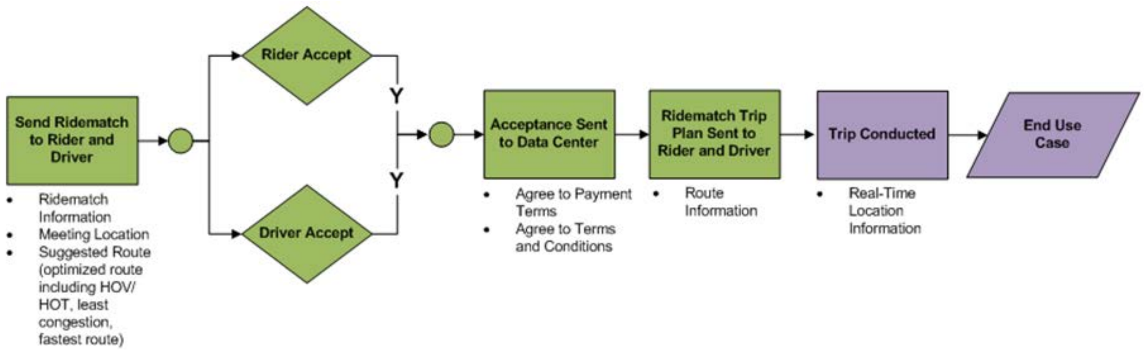


**Figure 6-12. D-RIDE Process and Data Flow for Ridematch Tracking**

**Steps**

1. The steps described below follow the process diagram shown in Figure 6-12.
2. The rider and driver review the ridematch information, including suggested optimized route information.
3. Both users accept the ridematch and terms and conditions.
4. The data center sends the accepted ridematch trip plan to the rider and driver, which includes the optimized route. The route includes HOV/HOT lane use information.
5. In-vehicle systems' monitoring real time location combined with information on the accepted trip plan notify implementers of HOV/HOT lane occupancy.

**Service/Software Needed**

- Personal Device,
- Automated rideshare system,
- In-vehicle system,
- Data center with route optimization software,
- Communications protocols between devices,
- Real time location tracking capability in vehicle, and
- Usable data network for communication between vehicles and data center.

# Chapter 7. Summary of Impacts

Section 7 presents the potential operational, organizational, procurement, and developmental impacts of the family of systems for users, developers, support and maintenance organizations and the sponsoring institutions. Also considered are training, documentation, maintenance and support, primary/secondary impacts, and qualitative and quantitative targets for transformative impacts.

## 7.1 Operational Impacts

### 7.1.1 T-CONNECT

The implementation of T-CONNECT will require several operational changes ranging from changes in operational policies and procedures to the existing performance measures. A summary of these operational changes is as follows:

**Changes in Operational Procedures**
Currently, agency operational procedures strive to meet on-time performance and other critical measures with limited focus on TCP, except for stops/stations that have a large number of passengers. Operational procedures will need to be revisited by agencies to accommodate intermodal, interagency or interagency transfers. These procedures will require new guidelines for all system users including, drivers, dispatchers and operations managers.

**Need for Continuous Capacity Analysis**
T-CONNECT may potentially attract more riders. Thus, agencies must perform a continuous assessment of their capacity and deploy additional resources, as necessary, in order to maintain the desired quality of service for their riders

**Fare Structure and Payment/Collection Options**
Fare payment may not be impacted in most situations unless interagency or intermodal services are involved. Partner agencies may agree upon a “flat fare” for timely transfers or determine other revenue collection and sharing mechanisms. In some situations, a premium fare may be charged for transfers when travelers are willing to pay for premium services (e.g., when outgoing vehicle is a flexible door-to-door service). Agencies should consider these alternatives in making any necessary operational decisions.

**Review of Existing Route/Vehicle and Operator Schedules**
Agencies will need to revisit their schedules and revise them if necessary based on input from operational field data (e.g., historic data from a CAD/AVL system). The schedules may need to be revisited to provide sufficient running times between stops and sufficient dwell times at stops, particularly at transfer points. Sometimes schedules may need to be adjusted to coordinate with regional transit providers where an interagency T-CONNECT application would need to be

established. Some of these decisions will be influenced by factors such as the operational priority of agency modes (e.g., higher priority for a bus rapid transit [BRT] vehicle than a regular fixed-route bus).

**Review of Current Performance Measures**
Current performance measures should be revisited to measure T-CONNECT outcomes. Particularly, on-time performance criteria will require detailed analyses to ensure that agency goals related to on-time performance do not compete with T-CONNECT goals.

**Review of Transfer Locations**
Given that T-CONNECT will offer additional capabilities for transfer connection (e.g., intermodal and interagency transfers), agencies may have to examine existing transfer points which may be constrained by the existing capabilities of the system.

**Periodic Accuracy Analysis of Real-time Data**
As discussed later, T-CONNECT will make decisions based on the real-time data available from participating agencies. Thus, agencies will be required to ensure that provisions are established for ensuring that real-time data available from vehicles (e.g., location, passenger counts) is current and accurate. Also, agencies must ensure that real-time information disseminated to travelers is accurate to achieve rider satisfaction goals.

### 7.1.2 T-DISP

The impacts and changes to operations would occur after the changes to business processes and the organizational impacts had been agreed to (see Section 7.2.2) If after the organizational issues would be resolved, the most significant anticipated impact would be that that transportation providers could be providing more service than they are currently. If there is a net increase in service, then there would be increased operations and maintenance costs. There would also be an increase in costs to operate the TMCC if one does not currently exist. This would include staffing needs, ongoing operational costs, and any upfront capital cost. There would potentially be changes in how Travelers make trip requests as well. Additional operational impacts would include:

**Changes in Operational Procedures**
Agency operational procedures will need to be revisited by agencies to accommodate intermodal, interagency or interagency operations and possibly transfers. These procedures will require new, modified or eliminated guidelines for all system users including, drivers, dispatchers and operations managers.

**Develop Integrations**
Integrations will need to be developed so that real-time vehicle location and availability of service can be shared between participating agencies that may be using different, and/or proprietary systems from different vendors.

**Fare Structure and Payment/Collection Options**
Depending on the organizational structure, there could be impacts to the fare payment or collection system. There could be integrations between multiple agencies fare collection systems or these could remain independent. How fare revenue is distributed amongst the involved agencies is another consideration that would impact operations, but would be developed within the organizational structure.

**Review of Dynamic Schedules**

The agencies involved in T-DISP will need to revisit the results from the dynamic scheduling (i.e., historic data from a CAD/AVL system) and review the schedules and options that had been created. This review will create feedback on the effectiveness of the multi-agency operations and could inform how the organizational structure could be modified over time (i.e. replace demand-response service with fixed routes if passenger trips warrant it).

**Review of Current Performance Measures**

Current performance measures should be revisited to measure T-CONNECT outcomes. Particularly, on-time performance criteria will require detailed analyses to ensure that agency goals related to on-time performance do not compete with T-CONNECT goals.

**Periodic Accuracy Analysis of Real-time Data**

T-DISP systems will rely heavily on real time data from multiple transportation providers, and possibly multiple systems. Agencies will be required to ensure that provisions are established for ensuring that real-time data available from vehicles (e.g., location, vehicle capacity) is current and accurate. Also, agencies must ensure that real-time information disseminated to travelers is accurate to achieve rider satisfaction goals.

## 7.1.3 D-RIDE

New D-RIDE services will impact how travelers and drivers seek shared rides when compared to existing ad-hoc carpooling systems. Implementation of a D-RIDE application may also result in new operational needs and capabilities for public agencies and private organizations interested in offering and managing new or expanded ride sharing services. Key operational impacts for system users and operators are described below.

**Management of D-RIDE user accounts**

Drivers and travelers wishing to provide carpool rides will have to register with the organization or agency managing the D-RIDE services. This information may be used to track system usage, enhance system safety, support financial transactions, or personalize ride match searches. This will create a need for D-RIDE users to manage the information contained in their user account. On the other hand, system operators will be required to maintain the hardware and software implementing the database and to manage access to the information contained within it.

**Individual and Vehicle Tracking**

To optimize ride-matching capabilities, estimate pick-up times, provide real-time status updates and enhance user safety, individuals providing carpool rides may be required to have their vehicle tracked. Since vehicles do not necessary have onboard GPS devices, participating drivers may be required to install a small tracking device inside their vehicle that they would activate each time they become available to pick up riders or are carrying D-RIDE passengers. Alternatively, a method for using GPS signals from a driver's mobile phone or portable device could be devised. For vehicles equipped with an Automated Vehicle Location (AVL) system, the solution may simply be to enable D-RIDE to use the data collected by the system.

Riders may also be asked to allow D-RIDE to read GPS data from their mobile phone or portable device. This may be done for implementing automated localization, tracking how long an individual has been waiting for a ride, compiling information about trips being made, or provide travelers with enhanced security.

**Accessing D-RIDE Services**

Travelers may be provided access to D-RIDE services by using an application installed on their desktop computer, smartphone or other mobile device. Access from mobile devices may further require that travelers have internet-capable devices supported by adequate data communication plan from their wireless provider. The possibility to call in requests may also be provided to enable individuals without mobile or computer-based access to use the D-RIDE services. Drivers are further expected to receive ride requests while driving. This will require them to have onboard equipment capable of receiving the requests and allowing them to review and accept/reject requests while driving without affecting their safety or that of surrounding vehicles.

**Management of ride requests**

Ride seekers will have the responsibility to create requests for the day/time they need a ride and to update existing requests within a reasonable amount of time following a change in travel plans. Timely updates will be important to avoid scheduling unnecessary pick-up trips, ensure system efficiency maintaining high confidence in the system and promote high repeat uses.

**Availability Notification**

Drivers interested in offering carpooling rides will have to notify the D-RIDE system when they become available for picking up trips, and conversely, when their availability ends. This could be done by requesting drivers to “check in” and “check out” whenever their status changes. It would not be sufficient to simply track vehicles, since participating drivers may not always be available.

**Financial Transactions**

Unless a sufficient independent revenue stream is developed, riders may be required to pay a small fee for the rides offered. Drivers may also be required to pay a small monthly fee for equipment leased to them or installed onboard their vehicle. Depending on system configuration, transactions can either be done in cash at the time a service is rendered or through automated debits from a D-RIDE or bank account linked to a user profile. If used, automated debiting will require system users to continuously ensure there are sufficient funds in their account to pay for the services they plan to use.

**Automated ride-matching process**

Agencies that currently offer dynamic ride services typically rely on human operators to schedule trips, often as a consequence of a low volume of requests. This may not be possible for D-RIDE services if high volumes of requests are expected to be processed with relatively short response times. Algorithms capable of automatically determining the best suitable matches between issued ride requests and available drivers will likely need to be used. While this may relieve agency staff from some tasks, it may also create additional needs regarding the operation and maintenance of the hardware and software implementing the ride matching system.

**Management of D-RIDE software and devices**

D-RIDE users may be required to install an application on their computer or mobile devices. Drivers may further be required to install custom devices onboard their vehicle. These needs will require agencies or organizations offering D-RIDE services to implement processes for managing and periodically upgrading software and equipment used to support the D-RIDE application. Users may further be periodically asked to upgrade equipment and software they use.

**Operation of customer service center**
While a general objective may be to employ an automated ride matching system, customer service representatives may be needed to help fulfill particular requests, answer inquiries about D-RIDE, help new customer set up an account, and resolve various unusual situations.

**Vehicle fleet**
Public agencies and private organizations interested in offering D-RIDE services may be required to assign specific vehicles from within their existing fleet to support carpooling activities or to purchase new vehicles. In particular, vehicles with special equipment may be required to provide services to individuals with special needs, such as individuals in wheelchairs, if such services are sought to be offered.

**Outreach and marketing**
Outreach and marketing activities may be required to increase awareness in D-RIDE services and increase system utilization, particularly in early deployment stages. Marketing activities may also be required if revenues to support D-RIDE services are to be generated from advertising and sponsorships.

## 7.2 Organizational Impacts

### 7.2.1 T-CONNECT

T-CONNECT will require organizational changes in order to comply with new regional agreements and redefined roles and responsible for agencies. The changes can be summarized as follows:

**Regional Agreements**
In order to accomplish the regional goals for T-CONNECT, agencies will have to coordinate to develop agreements (which should also be compliant with the Regional ITS Architecture). These discussions may involve several consensus building sessions and negotiations to arrive at agreements that meet the needs of the individual organizations as well as facilitate reaching the regional goals for T-CONNECT. Further, roles and responsibilities relevant to regional partners should be developed, documented and implemented.

**Data Collection and Sharing**
In order to ensure coordination among regional partners, agencies will be required to collect and share real-time data with their partners. Data collection and sharing needs will depend on agency characteristics and any relevant system configurations must be determined prior to system implementations.

**Organizational Restructuring**
Due to changes in operational procedures, an agency may have to re-evaluate their staffing and management structure to ensure smooth coordination across departments within an agency, and across agencies in the region. There may be a need for additional staff but in most cases new roles and responsibilities may be created for existing personnel. Staffing and training needs necessary as per new roles and responsibilities should be developed by deploying agencies at the time of system design.

**Highly Efficient Support and Maintenance**
T-CONNECT will be a highly critical system, dependent on the availability of the underlying technologies (e.g., vehicles, systems/subsystems). Thus, maintenance should conduct scheduled preventive maintenance of the underlying elements. Also, agencies should establish readily available support (internal or external) to quickly recover from any T-CONNECT failures. Thus, agencies must determine system maintenance and support cost prior to the system implementation and plan ahead to recover from maintenance failures, should those occur.

### 7.2.2 T-DISP

There are potentially significant impacts to organizational structure for a deployment of the T-DISP application. These impacts would be more complex based on the size and number of operators (and existing systems) in the geographic area looking to implement T-DISP. There are two categories of organizational impacts for T-DISP. One category includes the overall organizational structure and the method by which multiple entities (public and private transportation providers) coordinate and operate as one organization to most effectively provide service to the community. The second category is the organizational change that will occur on a daily basis to make the T-DISP application work. There will be technical and regulatory impacts of operating T-DISP, particularly if entities began to provide service in a more coordinated model.

**Organizational and Regulatory Impacts**
The organizational impacts for T-DISP are significant depending on the number of entities and complexity of service in a region. The relationship between public and private transportation providers is critical. The method by which the entities (public and private transportation providers) are willing to develop and structure their organization is likely to vary between different regions due to size of region, number of modes, previous attempts at coordination of service, prior relationships and agreements, and ultimately the perceived benefits (or costs) of participating in the T-DISP application.

The tension that often exists when entities attempt to coordinate service is balancing cooperation and competition, with public transportation providers operating under more of a cooperative model. Public transportation agencies provide service to the community using primarily public funds. They will provide service based on where service is needed or requested in their community. Private transportation providers (most frequently taxi companies, shuttle operators, medical transportation providers) are looking to provide service where they can maximize their revenue (i.e., make a profit.) However, public and private transportation providers often work together to provide service, quite commonly when public transit agency contracts out a portion of their service (e.g., demand-response paratransit service operated by a private provider).

In this arrangement, the private company can provide the trips at a lower cost than the public agency. It is typical that the contractual relationship between the two entities specifies the total dollar amount and/or a number of trips with a per-trip compensation. These amounts are pre-determined before any service is provided (e.g., as part of a competitively bid procurement and subsequent contractual agreement).

Along these lines, this model could be expanded to the T-DISP application. The concept is the same - the entity that can provide the service the most efficiently and effectively should provide that trip. The impacts of T-DISP would be to structure organizational and business relationships to take advantage of providing service more effectively to the overall community.

In one model, the arrangement would be more cooperative. Entities would agree to what amount and level of service they are willing to provide, and at what level of compensation. As an example, there are 100 trips to be provided, five entities are participating, and each entity would provide 20 trips. Another arrangement would include a more competitive business arrangement. Transportation providers would compete by offering to provide service at different trip rates. This model is more complex and would likely have to include some combination of guarantees, constraints and incentives in order to maximize participation.

**Technology Impacts**
From a technical and regulatory standpoint, there would be a number of impacts. Entities would need to have the ability to integrate existing systems or purchase new systems in order to be able to communicate with the TMCC. Each entity participating in the arrangement would need to be subject to the appropriate safety regulations. For smaller, private transportation providers, these regulations may be a barrier to participating. Another barrier could be having to purchase and use on-board and central systems to participate in the T-DISP application.

**Training and Staffing Impacts**
With the implementation of new, or modified technology, there will be training needs in order to ensure that staff are able to properly use the new systems. This training may be especially important for users who are new to the system, and/ or new to computers and technology in general. Vehicle operators, especially in smaller operating environments, may have additional training needs. Another impact related to training is that there may be changes in staff job descriptions and daily tasks with the deployment of new systems.

## 7.2.3 D-RIDE

Organizational impacts primarily affect agencies and organizations that would be managing D-RIDE applications. To a large extent, the magnitude of these impacts will be function of whether the agency or organization is already managing a carpool program or offering a dynamic ride service. As described below, the main anticipated organization impacts are related to staffing, training, and cooperation issues.

**Staffing**
New employees may be needed to operate and manage D-RIDE. Depending on the case, public agencies may be able to handle the added workload with their existing staff or may need to hire additional representatives. In particular, customer representatives will be needed to handle inquiries, requests and complaints from existing and potential D-RIDE users. In early system development stage, an outreach coordinator may also be required to help promote system awareness and utilization. Depending on the adopted operational model, marketing staff may further be required to help develop advertisement revenues and sponsorships. Legal and IT staff will also likely have to be expanded.

**Training**
Employees operating the D-RIDE application will need to be trained on how to handle customer requests and inquiries, as well as various situations, such as drivers or riders showing late, no-shows, unusual high volumes of requests, etc. Training will also be required for individuals to operate software implementing D-RIDE functionalities, and possibly managing the hardware supporting the application.

**Cooperation agreements among transportation providers**
D-RIDE systems considering ride matching opportunities across multiple transportation providers will require the development of cooperation agreements between all participants to define what might be expected from each one of them.

**Cooperation agreements with tolling agencies**
Systems allowing drivers to pay tolls from their D-RIDE customer account as a way to promote carpooling may require the development of agreements with tolling agencies.

# 7.3 Procurement/Development Impacts

## 7.3.1 T-CONNECT

T-CONNECT procurement and Implementation process will be complex and will require agencies to follow systems engineering steps for an effective deployment. Some of the impacts of the procurement and implementation of T-Connect are as follows:

**Planning Studies**
As discussed above, several changes will be required at the operational and organizational levels to successfully implement T-CONNECT. Agencies may need to conduct assessments to determine the best possible options for changes. Results of these studies should be documented and used in specifying the T-CONNECT application as part of the procurement process. Further, agencies should conduct cost-benefit analyses of available alternatives to ensure that the selected alternatives are not cost-prohibitive. Also, they should ensure that the selected alternatives do not compete with the T-CONNECT or overall system goals and objectives.

**Technical Design**
Technical design will be a very important component of the system implementation process. Agencies will need to ensure that all participants are invited to meetings to reach consensus on critical implementation issues.

**Installation and Testing**
Systems will be developed and installed based on the agreed upon technical design. However, field deployments will require detailed testing of every system component. Appropriate testing stages must be specified depending on the complexity of the implementation (e.g., factory acceptance testing, pilot testing, system testing, and burn-in testing). Test results must be documented to ensure traceability of all functional requirements back to T-CONNECT goals and objectives, and forward to successful deployment of each requirement. The installation and testing will require heavy involvement of various system participants. While travelers are not usually involved in implementations of this type, in this case, it may be prudent to enlist volunteers in the pilot implementation in certain scenarios.

**Change Management**
In most cases, agencies will have a parallel system available to meet the current needs of existing TCP procedures. Agencies will need to ensure a smooth transition from an TCP existing system (or no existing system) to T-CONNECT. Any training and retraining needs must be identified. Further, any potential conflicts among internal staff should be assessed in addressing changes that will be required to deploy T-CONNECT.

**Training and Documentation**
As discussed above, maintenance and support will be critical to the success of T-CONNECT. Training needs will be articulated to ensure that the most appropriate staff are assigned to support T-CONNECT. Also, there will be documentation requirements levied on technology vendors to ensure that each participating agency has what they need to operate and maintain the systems/subsystems underlying T-CONNECT.

### 7.3.2 T-DISP

There are a number of development impacts for T-DISP which impact transportation providers and system integrators. Key development impacts include the following:

**Multimodal Scheduling Systems**

Development of new or enhanced systems in order to meet the functionality necessary for multi-modal scheduling systems will be needed. These systems are likely to be enhancements to existing reservations and scheduling systems.

**Legacy and Inter-Agency System Interfaces**
Development of integrations and interfaces between CAD/AVL systems and/or legacy systems already in use at transportation agencies will be needed. These integrations are necessary to be able to share information on vehicle location and availability in order to dynamically schedule service.

There is also a need to develop integrations or provide interfaces among technology systems, especially when there are multiple transportation providers who already have proprietary systems in-place.

**Customer Communication Systems**
Development of new customer communication systems is needed. These enhanced customer communications systems must also be accessible by all types of travelers, including people with disabilities, or those that may not have direct access to mobile devices. The customer communication system will need to be able to receive and send messages to travelers.

**Procurement**
There are procurement impacts as well. The entities involved will have to purchase these new or enhanced systems. And while not specifically a procurement or development impact, the entities involved in T-DISP will have to develop business and organizational agreements to work together.

### 7.3.3 D-RIDE

Most of the application development needs can be expected to fall onto the agency or organization seeking to provide D-RIDE services. In most cases, D-RIDE will provide new features that could be developed in parallel to existing activities without significant disruptions to them. Key technical issues that will need to be addressed before a system launched are discussed below.

**Data Management**
Data management development impacts will include the following components: the development of a secure database containing user profiles for each registered driver and rider; a system for managing ride requests, particularly for systems that may allow requests to be made several hours and/or days in advance; and a system for monitoring the location and availability of drivers to pick up riders.

**Complex Algorithms**
Algorithms will be used to match available drivers with individuals seeking riders; and analyze information linked from an existing database containing information about the road network and traffic conditions in the service area that will be used to predict the time required by drivers to reach specific pick-up locations.

**User Interfaces**
User interfaces will be required to allow drivers and rider to issue and accept ride requests.

**Wireless Communication Network Systems**

These are required to enable wireless communication between moving vehicles and infrastructure (V2I).

**Integration with Other Systems**
The D-RIDE application could also possibly be integrated with existing regional ITS architecture systems; be linked to other IDTO applications, be integrated with other legacy systems used by participating organizations; and be developed to handle carpool fees and incentives, if such items are to be used.

**Revenue Stream**
The development of adequate revenue streams is critical to support D-RIDE operations if services are to be provided free of charge to D-RIDE users.

**Ease of Use**
An important component of D-RIDE should be ease of use. Inconveniences or difficulties created by non-convivial interfaces can reduce interest in D-RIDE. Similarly, system operators will need to be provided with efficient system management tools that can allow them to address a wide range of issues, particularly in systems in which short resolution time may be expected. To ensure that both traveler's and operator's needs are adequately fulfilled a staged development approach may be best suited. Key development phases may involve the following:

- **Phase 1**: Development of basic operational principles of the D-RIDE application.
- **Phase 2:** Development and testing of individual system functionalities.
- **Phase 3:** Integration of various system elements.
- **Phase 4:** Offline system operation testing and training of agency/organization staff.
- **Phase 5:** Online system operational testing with candidate drivers and riders.
- **Phase 6**: System launch.

A major expected D-RIDE component is the ability to establish a reliable and standardized method for communicating with D-RIDE drivers while they are driving. Continuous communication capabilities will be required to support vehicle tracking and the exchange of information regarding ride requests. Agencies or organizations operating Automated Vehicle Location (AVL) systems may have the capability of adapting existing onboard vehicle tracking and communication systems to meet D-RIDE's operational needs. However, desired capabilities are likely to be absent from vehicles operated by individuals. Some vehicles may already have built-in onboard wireless communication devices (such as vehicles equipped with General Motor's On-Star system) or devices enabling to connect a cellular phone to onboard systems. However, owners of such vehicles may only represent a fraction of the pool of potential drivers. Some onboard systems may also be inaccessible for use by a D-RIDE application. A communication solution applicable to a wide array of situations will therefore need to be developed. Due to potential impacts on other ITS applications, the design of this solution is likely to require involvement from USDOT.

**Safely Communicating Information to Drivers**

Developing a safe method for communicating information to drivers is another major requirement. A method must be found that would allow drivers to safety change availability status, review ride requests and send request acceptance notices while driving. Drivers cannot be expected to use complicated interfaces that would take their attention away from the road ahead. They may also not be willing, or able, to pull over to review and accept requests. Satisfying these requirements will require the development and testing of easy-to-use interfaces suitable for driving environments.

Individual currently using carpool services, either as driver or rider, would only be minimally impacted by D-RIDE development activities. Most existing carpoolers may become aware of D-RIDE services when a pre-launch marketing campaign is initiated or after the application has been deployed. However, active participation from potential D-RIDE users may be sought during system development to help ensure that the resulting system functions and interfaces adequately meet their need and will contribute to the long-term success of the application. Examples of activities from which active participation from potential system users may be sought include:

- ***Public design reviews* -** Public meetings organized at key development stages to allow potential D-RIDE drivers and riders to provide comments on proposed system features.
- ***Operational tests* -** Prior to an official application launch, individuals interested in participating in a test D-RIDE operation may be sought to help identify and correct any remaining issue with the developed system.

# Chapter 8. Analysis of Proposed System

Section 8 presents analysis of the benefits, limitations, advantages, disadvantages, alternatives and trade-offs considered for the proposed family of systems/applications.

## 8.1 Summary of Improvements

### 8.1.1 T-CONNECT

Improved Agency Operations

T-CONNECT will require several improvements to existing technology so that the system is able to provide travelers with the ability to successfully transfer between routes, vehicles and modes. Some of these improvements include:

- Improved frequency and accuracy of real-time vehicle location, passenger count and event data;
- More efficient management of real-time operational data;
- Improved accuracy of predicted arrival/departure times; and
- Improved success rate for transfers.

**Increased Interagency and Intermodal Coordination**
One of the biggest advantages of T-CONNECT would be that multiple agencies will be able to provide connecting services. In order to achieve this, agencies will need to rely on the capabilities of T-DISP, especially where multiple agencies are involved.

Further, T-CONNECT can enable intermodal transfers for transit and non-transit modes. For connections involving non-transit modes, the capabilities of D-RIDE will be required to schedule trips that include ridesharing.

Increased connection opportunities for travelers will help transit agencies gain operational efficiencies. Also, by enabling coordination among transit and non-transit modes, T-CONNECT will greatly benefit congestion mitigation initiatives. For example, travelers would like to reduce the cost of travel and may prefer to travel by utilizing a combination of transit and non-transit connections when traveling to downtown areas, where congestion pricing is in effect.

**Efficient Utilization of Resources**
Efficient service coordination through T-CONNECT (with assistance from T-DISP) will allow agencies to assess their priorities relative to providing service on certain routes or to certain locations (e.g.,

routes serving as feeder routes to a commuter rail station). Since travelers can connect to routes from regional partners with T-CONNECT, agencies may consider allocating resources to other routes (e.g., for communities that are currently underserved) from traditionally more utilized routes.

**Flexible Transfer Locations**
Currently, agencies often define a fixed number of transfer points since existing CAD/AVL systems are designed to handle transfer requests for a limited number of transfer points. T-CONNECT will allow agencies to offer transfers at a larger number of locations, potentially in partnership with other regional providers.

**Increased Travel Options for Captive Riders**
Sometimes travelers are forced to drive to a destination due to the lack of reliable transfer opportunities. T-CONNECT will provide additional transit alternatives to these travelers.

**Improved Traveler Satisfaction**
T-CONNECT will allow seamless and reliable connectivity between transit and non-transit modes. This capability will help travelers rely on transit for their trips, especially in circumstances when non-transit modes compete with transit modes (e.g., trips to downtown with high parking rates). Further, the efficient management of travel times and wait times within T-CONNECT and supporting systems will reduce the overall trip time for transit modes.

With the assistance of T-DISP and D-RIDE, T-CONNECT may be able to offer alternatives when a traveler faces a missed connection. Also, T-CONNECT will make decisions based on traveler preferences (e.g., choice of modes/routes) which will result in improved satisfaction regarding the transit operations among travelers.

Finally, T-CONNECT will be designed to provide real-time information related to scheduled connections for travelers. Real-time information will be available on demand via the Internet on web-enabled devices. Additionally, travelers will be able to obtain real-time information via conventional phones either from customer service representatives or interactive voice response systems. Travelers will also be able to subscribe to timely alerts to indicate if the status of their connection has changed. Further, travelers on the “outgoing” vehicles will be provided in-vehicle audio-visual information on the wait-time/hold-time until the transfer is complete and the outgoing vehicle departs. Timely dissemination of real-time information will result in improved traveler satisfaction.

### 8.1.2 T-DISP

The T-DISP application has tremendous potential to address many of the current limitations of coordinated public transportation service:

**Ability to meet demand for flexible trip-making**
Transit is often limited by service coverage, spatially, temporally and politically. The possibility for additional services provided through a more coordinated service delivery could help meet the demand for more flexible trip-making.

**Improved customer perception of transit**
From a customer standpoint, the ability to customize trips could improve the perception of transit and encourage ridership.

**High anticipated rates of T-DISP related technology adoption**
An advantage for T-DISP is that many of the systems that would be needed for full deployment already exist in some fashion. Many transit agencies are already using CAD/AVL systems as well as scheduling software for fixed-route and demand-response service. The enhancements necessary for multi-modal scheduling would be beneficial for agencies whether or not they participate in a T-DISP application since customer trip requests could be accommodated by other entities, thus reducing agency costs. Therefore, there is an incentive to develop (or expand on) scheduling systems to improve multi-modal service scheduling.

**Improved trip options and traveler information**
Improving trip options and information to customers may be another incentive for transit agencies to participate. If agencies are able to provide more trip options to their customers, it could increase customer satisfaction, and ultimately may increase ridership. One limitation for customers of transit agencies now is in the uncertainty of knowing when and if the transit vehicle will arrive. Improvements to customer information systems can improve the perception of quality of service by adding a degree of certainty that the service will be available when needed.

### 8.1.3 D-RIDE

D-RIDE seeks to provide carpool drivers and riders with a convenient, flexible way of organizing carpool trips. Unlike traditional carpools, where both drivers and riders are bound to specific meeting locations and times, D-RIDE aim to allow riders to issue requests when needed and drivers to offer and accept rides when convenient to them. Specific improvements offered by this ridesharing model over traditional carpool systems are described below.

**Increased trip planning convenience for ride seekers**
The ability to issue ride requests from mobile devices will allow travelers to plan carpool rides wherever they are and whenever they need a ride. Ubiquitous access to the D-RIDE application will also allow individuals to modify existing requests to accommodate unforeseen delays due to congestion, meetings running late, or other unforeseen events.

A particularly significant convenience will be the ability to accommodate “last-minute” travel needs. In the traditional carpool model, individual seeking rides often only have the option to go to a specific location and wait there for a driver traveling towards their intended destination to show up. For individuals seeking to reach less-traveled destinations, this model creates the potential for long wait times and even the possibility that no suitable ride be offered. Constraints also exist in areas where transit agencies already offer dial-in ride services, as many agencies require that requests be made sufficiently in advance, often with at least 24-hour notice. The ability to generate ride requests at any time from any location should greatly improve the ability of travelers of finding suitable rides on short notices.

**Increased ride sharing convenience for drivers**
The ability to review desired pick up locations from ride seekers will provide drivers with more flexibility to offer carpool rides. First, there will be no need for drivers to go to specific pick-up locations to see if individuals are waiting for a ride and thus risk making the trip for nothing. Drivers will know at any given time whether individuals are looking for rides. The ability to receive ride requests while driving will notably enable drivers to become aware of ride sharing opportunities that may not have existed when they started their trip and may have been otherwise missed. Finally, drivers will have the

opportunity to only accept carpool requests from individuals wishing to be picked up at convenient locations along their path.

**Increased travel options for rural travelers**

Residents of rural areas where few transit services are offered, if any, may be able to plan some of their travel needs using D-RIDE services, and thus increase their mobility, provided that there is a sufficient local pool of participating drivers.

**Increased viability of carpool as travel option**

The ability to schedule convenient pick-up and drop-off locations, as well as convenient times, will provide more opportunities for individuals to consider carpooling as a travel option. This may entice more drivers and travelers to seek carpooling arrangements.

**Personalization of carpooling experience**

Data stored in user profiles may be used to match riders and drivers sharing specific preferences or interests. For instance, a traveler frequently carrying large boxes or luggage could indicate an interest only in rides for which adequate carrying capacity would be available onboard. Similarly, a female driver worrying about her safety could specify her availability only for picking up female travelers. The personalization can go as far as the willingness of drivers and travelers to provide detailed preference information in their user profile, subject to the ability of the ride matching algorithms to consider these preferences.

**Ability to attract more carpool drivers**

The ability to pick-up additional passengers with minimum detour may entice more drivers to open their vehicle for carpool rides, particularly if these additional passengers help pay fuel costs, enable them to travel on HOV lanes, provide toll reductions on HOT lanes, or provide them with other incentives.

**Increased Utilization of HOV/HOT Lanes**

Drivers who would not otherwise be eligible for using HOV lanes may gain the ability to use them by picking up additional passengers. This may not only lead to an increase in the utilization of HOV/HOT lanes, but may also reduce congestion on general purpose traffic lanes, leading to a more efficient overall utilization of existing roadway infrastructures.

**Reduced Congestion and Pollution**

Increases in carpooling activities can result in an overall reduction in the number of vehicles traveling on roadways and allow more vehicles to use underutilized HOV/HOT lanes. These changes can lead to reductions in congestion, particularly during peak travel periods, and further contribute to reducing fuel consumption and vehicle emissions.

# 8.2 Disadvantages and Limitations

## 8.2.1 T-CONNECT

While T-CONNECT is expected to offer several improvements in the existing transfer procedures and assist in interagency coordination, there are several disadvantages and limitations tied to this application as follows:

**Changes in Existing Operational Procedures**
As stated earlier, agencies will need to reassess their existing operating procedures in order to meet T-CONNECT goals and objectives, particularly when regional partners are involved. Consensus building to adopt common minimum guidelines for coordination will be a highly demanding task for the initial configuration of T-CONNECT. Sometimes, these changes may require negotiations with employee unions (e.g., for drivers).

**Increased Need for Coordination and Operational Monitoring in Real-time**
As discussed earlier, one of the most important aspects of T-CONNECT is the need for interagency and intra-agency coordination. While inter-departmental communication procedures may be easily established and followed, additional efforts will be required when regional partners are involved. In regional coordination scenarios, technical and institutional issues will need to be resolved, which could be cost-prohibitive (e.g., cost of purchasing new systems). Further, once policies and procedures are established and inter-system communication is established, agencies likely will need constant contact in order to ensure successful T-CONNECT operations and positive rider satisfaction.

**Additional Demand for Real-time Data**
T-CONNECT will be a completely data driven system. Some agencies may not have the required data readily available (e.g., real-time traffic data for accurate arrival prediction). In these situations, either new systems will need to be purchased (e.g., upgrade of an on-board system to provide additional information) or interfaces with external data providers may need to be established (e.g., regional traffic management centers [TMCs]).

**Training/Retraining Expenses**
Training is key to the success of any operational system and will be even more important because increased coordination is required. In some situations due to changes in existing operational procedures or systems, training expenses may be even higher due to the number of personnel that need to be trained or retrained.

**Travelers' Unwillingness to Make Connections**
Investment into T-CONNECT may not be rewarding if travelers are not interested in making transfers, at least in the situations when more than one connection is required. Also, when travelers' preferences regarding mode choice and service providers are accommodated by T-CONNECT, the system may not be able to offer connection protection due to certain constraints set forth by these preferences.

**Drivers' Willingness to Follow Hold-until Rules**
Vehicle operators may not be supportive of extended vehicle hold times, especially in situations where they expect to have a negative operational impact on downstream stops due to their own experience.

In these circumstances, drivers may leave without the connecting passenger. This type of issue will have to be considered in the development of staff procedures.

**Provision of Trip Alternatives**

T-CONNECT will be designed as a “broker” system in order to accept transfer requests from travelers and complete transfer requests according to traveler preferences and agency policies and procedures. However, if requests cannot be completed or if there is a missed connection, T-CONNECT may not be able to provide alternatives to travelers on its own without significant wait time (e.g., particularly when a transfer point is served by a low frequency route). In these situations, T-CONNECT will rely on T-DISP and D-RIDE to provide alternatives to travelers.

**Connection Protection Limitations in a Multi-agency T-CONNECT Environment**

T-CONNECT will be designed to accommodate policies and procedures of all participating agencies. Even though agreements will be in place, in rare operational circumstances, a transfer may not be protected due to operational anomalies for the outgoing route/vehicle associated with the partner agency (e.g., missed trip or short turning a vehicle). Also, in some situations, the outgoing vehicle may have to leave without completing the transfer due to operational procedures (e.g., to ensure schedule adherence at the downstream stops. If this is a multi-agency environment, decisions related to hold-times at transfer points will be handled solely at the discretion of the agency operating the outgoing vehicle. Thus, these situations may result in a missed connection. Also, there may be rare circumstances when drivers from partner agencies may not be willing to wait longer than what is allowed by their union rules.

**Highly Dependent on Real-time Data Accuracy**

As discussed earlier, T-CONNECT will be entirely dependent on the accuracy of real-time operational data for making reliable decisions. If data are being used for determining whether or not a connection can be protected, system users may be provided incorrect information. The system must be designed to handle real-time data in an efficient manner and any possible delays or other issues in data transmission due to network latency or communication between individual systems should be considered when designing the system. As mentioned earlier, if possible, real-time data transmission standards such as Service Interface for Real Time Information (SIRI) should be considered.

**Handling of Missed Connections**

Missed connections can deeply influence traveler satisfaction regarding T-CONNECT. However, sometimes, agencies may not have any alternatives even with the help of T-DISP and D-RIDE, to meet traveler’s needs and preferences. Agencies will have to develop detailed guidelines on the handling of missed connections to reduce the number of customer complaints.

**Handling of No-Shows**

T-CONNECT expects that travelers will make the connection as scheduled. However, in some situations travelers may not make the connection due to an unexpected situation and may seek an alternate connection on their own (e.g., hire a taxi even before reaching the transfer point). This situation could be an issue if travelers do not notify the T-CONNECT system about their changed plans.

**Managing Preferences of Travelers On-board Outgoing Vehicles**

Travelers on the outgoing vehicles may not be always supportive of an extended hold-time (e.g., longer than five minutes). This traveler behavior may compete with agencies’ goals of offering guaranteed connection protection, especially in the situation when the number of transferring passengers is high (e.g., ten passengers transferring from an incoming train, while there are only three passengers waiting in the outgoing vehicle).

### 8.2.2 T-DISP

While T-DISP is expected to offer improved transportation options to the riding public, there are several disadvantages and limitations associated with the application:

**Developing Business Model and Rules**
The most significant limitation to T-DISP is in developing the business model and rules and organizational structure to encourage entities to participate. There is an inherent need to design the overall structure to incentivize participation from transportation providers.

**Encouraging Service Provider Participation**
Public transportation providers have some incentive to participate in a T-DISP application because their agency mission is likely to center around providing service to their community. T-DISP may offer them a method to expand their range of service either geographically (to include more rural or exurban areas that are not effectively served by fixed route service) or temporally (to provide service late in the evening or early in the morning). However, the limitations include whether or not this service can be provided by another entity at a lower cost, or the availability of resources to pay for this service, regardless of who is operating the service. As an example, if a transit agency operates a fixed-route service into a low density residential area, some resources are already allocated to the service. By partnering with other agencies and utilizing new systems, the service might be provided more efficiently and effectively.

**Availability of Services in Low Density Areas**
But it may be that there is currently no service available in the more rural or low density areas, so there may not be additional resources available. In this case, the incentives for participation by the transit agency may be lower, but the incentive for a private transportation provider may be higher, since this is essentially a new market for service. Of course this example is dependent on the willingness of Travelers in these areas to pay for private transportation services, or for additional resources to be made available to pay for this service.

### 8.2.3 D-RIDE

Specific disadvantages associated with the proposed D-RIDE application concept include the following:

**Required communication capability with vehicles**
A key feature of the D-RIDE concept is the ability to communicate with drivers in their vehicles. While wireless communication capability may already exist for fleets of vehicles operated by transit agencies or commercial organizations, vehicles operated by individuals often do not have such a capability. Establishing communication with a fleet of privately-owned vehicles will require providing drivers with suitable equipment to install onboard their vehicle or innovative methods to establish wireless communication that have not yet been used on a large scale.

**Reliance on accurate and timely data**

System performance will depend on the ability to obtain accurate information regarding the location of vehicles operated by D-RIDE drivers, and possibly ride seekers. Inaccurate tracking data may make it difficult to estimate reliable travel times and provide narrow pick-up windows, as well as result in missed matching opportunities or assignment of non-optimal matches, particularly in system with few participants.

**Complexity of matching rides in real time**
The process of matching rides for near-term trips with vehicles moving around a road network while factoring traffic conditions and potentially other parameters is an inherently complex task. Developing suitable ride matching algorithms may require various trade-offs to be considered.

Factors that may further limit the deployment or acceptance of the D-RIDE application include:

**Low initial participation rate**
Low participation rates may affect early system deployments and create difficulties for drivers to find suitable riders, and conversely, riders to find suitable drivers. For riders, this limiting factor is amplified by the fact they may have to find rides to both reach a specific destination and come back from it. If only few drivers are offering rides, there may be a low probability of finding rides for both directions. Such problems could reduce interest in D-RIDE and slow participation growth.

**Willingness of drivers to offer rides**
No pick-up possibility will exist if drivers are not offering rides. Without proper incentives, financial or otherwise, there may be limited participation in dynamic ride sharing services. This may be a significant limiting factor in early system deployment, when the system operator may be under pressure to demonstrate service viability before rolling out additional features or expanding services.

**Servicing low-density areas**
Lower population density in rural areas may make it difficult to develop a suitable pool of drivers. While there may be interested riders, interested participants may have difficulties finding suitable rides on a regular basis.

**Limited parking opportunities at key pick-up locations**
The inability to find long-term parking near potential pick-up sites may make it difficult to entice drivers to drop their vehicle and seek a carpool ride for a portion of their trip.

**Difficulty of accurately predicting vehicle travel times**
The algorithms used to predict the time at which drivers should arrive at a pick-up location may not be able to provide arrival windows as short as desired due to the inherent variability of traffic conditions or inaccurate data. Relatively large arrival windows may reduce system attractiveness and lead to lower than expected system utilization rates.

**Unrealistic expectations regarding request response time**
Travelers requesting rides may have unrealistic expectations regarding how fast a ride request should be resolved. While these expectations may be based on comparisons with information services operating on a different premise, they may affect how D-RIDE is perceived and reduce interest in it.

**Ability to handle high volumes of requests**
While D-RIDE services may be expected to start with a low volume of requests, successful applications will likely lead to higher volumes. In such a situation, data processing systems unable to

handle the resulting higher processing load may become a limiting factor for the growth of the application.

**Perceived safety of carpooling experience**
While this may not be a major issue for dynamic ride services provided by transit agencies, it can be for carpooling services. Many individuals may be wary of carpooling simple because of the need to ride with complete strangers.

**Reliance on drivers and riders respecting agreed-upon commitments.**
Drivers may stop offering rides if individuals to be picked up frequently do not show up on time at the agreed location. Similarly, riders may lose interest in D-RIDE if drivers do not show up or arrive much later than anticipated. Mechanisms may thus be needed to ensure that all agreed travel arrangements are respected.

## 8.3 Alternatives and Trade-Offs Considered

### 8.3.1 T-CONNECT

There are several parameters that may impact how transfers requests are received, completed and travelers are notified of the request's outcome. Some of these parameters include:

- When and how travelers request a transfer
- Who receives these transfer requests
- How these requests are queued and processed
- Are there any special provisions for processing requests (e.g., traveler preferences, premium transfer)?
- Which modes and agency jurisdictions are involved
- What data is required to complete the request
- How and when travelers are notified of the request's outcome
- How exceptions are handled

The T-CONNECT concept can be implemented using different approaches, especially when dealing with interagency and intermodal scenarios, which often have individual and proprietary operations management systems (e.g., CAD/AVL). Some of these alternatives include:

- Capitalize on existing systems and configurations, and establish data sharing arrangements among agencies' systems to forward transfer requests from travelers and monitor the status of the requests to provide real-time information to travelers
- Establish a centralized brokerage system which would handle transfer requests based on real-time data available from regional agencies, and also connect with T-DISP and D-RIDE

Either of these approaches will be able to ensure TCP but in some cases, the second approach may be cost-prohibitive for smaller agencies. Further investigation will be required as part of the requirements analysis to determine the appropriate approach for T-CONNECT. However, existing CAD/AVL systems may not have been designed to handle transfer connections, at least when a large number of requests are involved. If this is the case, certain enhancements may be required in the first approach as well. As mentioned previously, a detailed gap analysis of the existing system environment will need to be performed before the system requirements are determined for T-CONNECT.

### 8.3.2 T-DISP

One alternative to the T-DISP application is that in some areas where the number of trips per day is relatively low, the functionality of multi-modal scheduling could be accomplished by well-trained and active Dispatchers. As long as Dispatchers were made aware of vehicle location and availability, and could communicate directly with the drivers and vehicles, they could be adjusting trips throughout the day.

### 8.3.3 D-RIDE

A variety of system configurations are feasible to implement D-RIDE services. For instance, various approaches may be developed to enable travelers to create ride requests, track the availability of potential drivers, send ride requests and pick-up routes to drivers, and implement various other system functions. To the extent possible, system development should take advantage of already established systems and functions, rely on databases using commonly accepted data formats, and be compatible with defined regional ITS architectures. Existing regional systems may thus significantly influence system design. Regional differences will further likely require the development and evaluation of operational and architecture system alternatives, as well as criteria for evaluating the merits of each alternative considered.

A major alternative considered in early concept development was the need to provide ubiquitous access to ride sharing services. This resulted in a need to establish wireless communication with vehicles participating in D-RIDE. The rationale for this decision was that D-RIDE should provide capabilities beyond current ad-hoc carpooling systems and transit-based dial-in dynamic ride services. However, the specifics of how this capability is to be established have not yet been fixed since the communication landscape is evolving rapidly, particularly the capability of using smartphones connected to onboard systems as mobile internet routers. The communication approaches that may be used for D-RIDE system development will be function of available or emerging viable communication options at the time the system is being designed.

# Appendix A: List of Stakeholders

Michael Abegg (Minnesota Valley Transit Authority)

Andy Alden (Virginia Tech Transportation Institute)

Todd Allen (RouteMatch)

Perrin Badini

Arnd Beatzner (Mobility Cardhering)

Roger Berg (Denso)

Ron Boenau (Federal Transit Administration)

Bill Boston

Johm Braband

David Brandauer (Trapeze)

John Canfield (Network Commuting)

Philip Caruso (ITE)

Robert Clemons (Daimler Buses, N.A.)

Denis Dorsey (Central Maryland Regional Transit)

Kevin Dow (APTA)

Barry Einsg (Hams Corp.)

Brendan Finn (ETTS, Ltd.)

Amanda Griffith (TrueFit)

Mike Harris

Steve Mortensen (Federal Transit Administration)

Siva Narla (ITE)

Steve Novosad (Atkins)

Koorosh Olyai (Dallas Area Rapid Transit)

Stepan Parker (Transportation Research Board)

Gary Ritter (USDOT– Volpe Center)

Prakash Sah (California Dept. of Transportation)

Aneil Samuel (Blacksburg Transit)

Tom Schwetz (Lane Transit)

Suzanne Sloan

Jeffrey Spencer (Federal Transit Administration)

Aaron Steinfeld

Jim Szudy

Ken Thompson (ESPA)

John Toone (King County, Washington)

Gwo-Wei Torng (Noblis)

Derek Toups (Kimley-Horn)

Stu Whitaker (Whitaker Associates)

Charlene Wilder (Federal Transit

Michael Haynes (CTA)

Eric Hesse (TriMet)

Michael Hilliard (Oak Ridge National Laboratory)

Doug Jamison (LYNX)

Edan Kabatchnik (SQLstream)

Gabriel Lopez-Bernal (USDOT – Volpe Center)

Sam Lott (Kimley-Horn and Associates)

Administration)

Tim Witten (Blacksburg Transit)

Gail Yazersky

Wei-Bin Zhang (University of California Berkeley – PATH)

# Appendix B: List of Acronyms

| Acronym | Description |
|---|---|
| AVA | Automatic Vehicle Annunciation |
| AVL | Automatic Vehicle Location |
| CAD | Computer-Aided Dispatch |
| ConOps | Concept of Operations |
| COTM | Contracting Officer's Task Manager |
| DMA | Dynamic Mobility Applications |
| DMS | Dynamic Message Sign |
| DOT | Department of Transportation |
| D-RIDE | Dynamic Ridesharing IDTO application |
| FHWA | Federal Highway Administration |
| GPS | Global Positioning System |
| HOT | High Occupancy Toll |
| HOV | High Occupancy Vehicle |
| IEEE | Institute of Electrical and Electronics Engineers |
| IDTO | Integrated Dynamic Transit Operations |
| ITS | Intelligent Transportation Systems |
| MDT | Mobile Data Terminal |
| MPO | Metropolitan Planning Organization |
| PDT | Project Development Team |
| PMP | Project Management Plan |
| RSA | Route and Schedule Adherence |
| SBCAG | Santa Barbara County Association of Governments |
| SEMP | Systems Engineering Management Plan |
| SEP | Systems Engineering Process |

| | |
|---|---|
| SIRI | Service Interface for Real-time Information |
| SOW | Statement of Work |
| SRS | System Requirements Specifications |
| T-CONNECT | Transfer Connection IDTO application |
| TCP | Transfer Connection Protection |
| T-DISP | Transit Dispatch IDTO application |
| TMO | Transportation Management Organization |
| TRB | Transportation Research Board |
| VPPP | Value Pricing Pilot Program |
| USDOT | United States Department of Transportation |

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