Report on Functional Requirements and Software Architecture for the IDTO Prototype

Phase I Demonstration Site (Columbus)

www.its.dot.gov/index.htm

Final Report — August 30, 2013
FHWA-JPO-14-166

U.S. Department of Transportation

Produced by Battelle Memorial Institute
U.S. Department of Transportation
Research and Innovative Technology Administration
Federal Transit Administration

Cover Photo: The Ohio State University

Notice

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-JPO-14-166		

4. Title and Subtitle	5. Report Date
Report on Functional Requirements and Software Architecture for the IDTO Prototype – Phase I Demonstration Site (Columbus)	August 30, 2013
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Thomas Timcho, Matthew Burns, Santosh Mishra, Carol Schweiger, Jodi Rizek, Gregory Zink	100026848-200

9. Performing Organization Name And Address	10. Work Unit No. (TRAIS)
Battelle 505 King Avenue Columbus, Ohio 43201	11. Contract or Grant No. DTFH61-12-D-00040 / O&ITS-13-02

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
United States Department of Transportation ITS Joint Program Office Research And Innovative Technology Administration (RITA) 1200 New Jersey Avenue, SE Washington, DC 20590	Final Report 14. Sponsoring Agency Code HOIT-1

15. Supplementary Notes
Mr. Ron Boenau, COTM

16. Abstract

This report documents the System Requirements and Architecture for the Phase I implementation of the Integrated Dynamic Transit Operations (IDTO) Prototype bundle within the Dynamic Mobility Applications (DMA) portion of the Connected Vehicle Program. It builds off of the previous system requirements report and adds site-specific requirements.

17. Key Words	18. Distribution Statement
Integrated Dynamic Transit Operations, IDTO, T-CONNECT, T-DISP, D-RIDE, Dynamic Mobility Applications, DMA	Final document. Limited Distribution. Has not been checked for Section 508 compliance.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	82	

Acknowledgements

This report builds on the previous work captured in the Report on *Functional and Performance Requirements and High-Level Data and Communication Needs for Integrated Dynamic Transit Operations (IDTO)*, ITS JPO Publication Number FHWA-JPO-12-085, and as such, directly copies the system requirements and associated definitions as the bases for the tailored requirements associated with this next phase of the IDTO project.

Table of Contents

List of Tables

List of Figures

Chapter 1 Scope

Identification of System

This report documents the System Requirements and Software Architecture for the Phase 1 Prototype development and Prototype demonstration of the Integrated Dynamic Transit Operations (IDTO). This is a key bundle within the Dynamic Mobility Applications (DMA) portion of the Connected Vehicle initiative. The Phase 1 site is located in Columbus, OH.

Terminology

The meanings of the auxiliary verbs used in this document are defined as follows:

- Shall — Compliance with a requirement, specification or a test is mandatory
- Should — Compliance with a requirement, specification, or a test is recommended
- May — Expresses a permissible way to achieve compliance

The meanings of the verification methods are as follows:

- Inspection — *Inspection is observation using one or more of the five senses, simple physical manipulation, and mechanical and electrical gauging and measurement to verify that the item conforms to its specified requirements*
- Demonstration — *Demonstration is the actual operation of an item to provide evidence that it accomplishes the required functions under specific scenarios*
- Test — *Test is the application of scientific principles and procedures to determine the properties or functional capabilities of items*
- Analysis — *Analysis is the use of established technical or mathematical models or simulations, algorithms, or other scientific principles and procedures to provide evidence that the item meets its stated requirements*

Introduction

Task 2 of the IDTO Prototype Development and Prototype Deployment Project calls for an assessment of the prior systems engineering work as it relates to the tailoring of the system requirements specific to the IDTO Prototype demonstration that will be conducted under Phase 1, in Columbus, OH. Furthermore, this same task also encompasses the development of a software architecture that reflects these site-specific requirements and is the first step in the design process.

While these activities are usually documented under separate cover, the original government scope of work identified a single deliverable item associated with this specific subtask, and as such, this single-report format will be retained.

Approach

The content of this document was generated both through the incorporation of previously documented information related to the IDTO Prototype, as well as the results of additional requirements analysis and design work performed specific to the Phase 1 IDTO Prototype demonstration site in Columbus, OH. While it is not intended to duplicate the previous efforts, this document has been prepared to be standalone in its content, but assumes the reader has familiarity with IDTO, the DMA program, and the overall Connected Vehicle initiative.

While this document focuses on a specific demonstration site that includes specific partners, the document will focus on the roles of the associated partners and discuss it in terms of these roles.

Document Organization

As previously noted, this document comprises a single report which identifies the site-specific system requirements and accompanying software architecture, as defined for Phase 1 of the IDTO Prototype development and demonstration. This report is comprised of the following major sections:

- A brief concept of operations discussion for the Phase 1 site
- An evaluation of the applicability of previous IDTO requirements to the Phase 1 demonstration
- Development of site-specific requirements
- Documentation of the software architecture.

The structure of this document is consistent with the Institute of Electrical and Electronics Engineers (IEEE) Standard 1233-1998 IEEE Guide for Developing System Requirements Specifications and Federal Highway Administration's (FHWA) System Engineering Guidebook (SEGB) that adapted IEEE-1233. It has been tailored to include the relationship to the previous IDTO requirements development work, as well as to accommodate the addition of the Software Architecture, as indicated by the government task order.

Chapter 2.0 – Phase 1 Demonstration Site offers a brief summary of the partners and modes of transportation that will be supporting the IDTO Prototype Demonstration as demonstrated by Battelle and the Battelle partners in Columbus, OH.

Chapter 3.0 documents the high level concept of operations and represents an adaptation of the System Overview section of the previously published *Report on Functional and Performance Requirements and High-Level Data and Communication Needs for Integrated Dynamic Transit Operations (IDTO)*[1] as tailored to represent the Phase 1 demonstration scenario.

[1] August 13, 2013, US DOT Publication FHWA-JPO-12-085, Produced by Science Applications International Corporation (SAIC) for the U.S. Department of Transportation under DTFH61-06-D-00005, Task No. T-11-018.

Chapter 4.0 documents the assessment of the applicability to the Phase 1 site demonstration for each of the previously defined IDTO requirements, as also published in publication # FHWA-JPO-12-085.

Chapter 5.0 captures the new functional and performance requirements that were specific to the government scope of work related to this project, and as necessitated by both the site-specific partner's needs, as well as the ability to support the prototype demonstration and evaluation.

Chapter 6.0 documents the initial, high-level software architecture specific to the Phase 1 demonstration.

Chapter 7.0 provides definitions and abbreviations used within this document.

Chapter 2 Phase 1 Demonstration Site

The IDTO Phase 1 demonstration site will be conducted in Columbus, OH. The Battelle Team that will be conducting this demonstration include the Central Ohio Transit Agency (COTA) and the Ohio State University (OSU) Transportation and Traffic Management Department, which operates the Campus Area Bus System (CABS) and will soon be deploying TaxiCABS, the on-campus demand-response capability. Additionally, Zimride, a nationally recognized service provider for rideshare capabilities, will roll out their dynamic rideshare service in the Columbus area. Finally, Capital Transportation, a Columbus-based private-sector transportation provider that operates a demand/response shuttle service at the Defense Supply Center Columbus (DSCC) military base will also be incorporated. TranSystems and the Transit Lab at OSU augment the Battelle development efforts by providing subject matter expertise both in terms of IDTO and transit deployment and research in general.

Battelle's role includes the development and operation of the IDTO Prototype. The IDTO Prototype, which encompasses the Travel Management Coordination Center (TMCC), as described herein, as well as the mobile applications and data collection associated with the various evaluation efforts associated with this effort. COTA's participation includes support of the T-CONNECT application by allowing for onboard equipment upgrades, as well as integration with their dispatching operations. The OSU-operated CABS, with its available AVL systems, will provide incoming connections to allow for protected transfers with the connecting COTA service. TaxiCABS will provide the demand/response component of T-DISP capability, and Capital Transportation, like CABS, will support the demonstration of T-CONNECT at a separate, high demand location in Columbus. Finally, Zimride will provide the D-RIDE capability. Table 2-1 summarizes these partners, their role and the associated applications. Detailed descriptions of each follow as well.

Battelle

Battelle will serve as the system integrator and software developer for the IDTO Prototype application, including interfacing will all of the various partner systems, developing the SmartPhone application, and support for the evaluation components of this project. Additionally, Battelle will be responsible for managing the rideshare partner that is part of this demonstration.

Central Ohio Transit Agency

COTA operates a fixed-route service in the Columbus and the surrounding central Ohio community. Under the scenario described herein, the COTA fixed-service routes, particularly those that serve the OSU campus area and DSCC will be expanded to support the T-CONNECT application and will allow for these requests to be made to the various buses serving the demonstration area.

The Ohio State University Transportation and Traffic Management Department

OSU operates a fixed-route / fixed-schedule transit system known as CABS which serves the Central Campus academic core as well as remote residential, parking, and off-campus locations. The current fleet of buses is equipped with real-time AVL capabilities, which will be leveraged for this demonstration. In addition to this fixed-route CABS service, OSU is in the final stages of deploying a new demand-response service called TaxiCABS. Scheduled to be operational in late-2013, TaxiCABS will provide service to the Central Campus area, as well as neighborhoods adjacent to the campus. The IDTO Prototype will integrate with both the fixed-route CABS system, as well as the new TaxiCABS service as part of the IDTO Prototype demonstration.

Capital Transportation

Capital Transportation is a Columbus-based private-sector transportation provider that performs contract demand-response services at various locations including the Defense Supply Center Columbus (DSCC). Capital Transportation performs several runs daily at the DSCC location, carrying passengers between the base's three main entrances and various locations on the base. Capital Transportation will be provided with an on-board capability to request and confirm T-CONNECT connections with adjacent COTA fixed routes.

Zimride

Zimride will serve as the D-RIDE provider, a capability that they presently offer in a number campus and urbanized areas throughout the country. Through the use of social-networking tools, Zimride enables the matching of drivers and riders for both ad-hoc and pre-planned trips.

Table 2-1. Columbus Demonstration Site Partner Roles

Partner	Service	Role	Application Area		
			T-CONNECT	T-DISP	D-RIDE
COTA	Fixed Route / Schedule	T-CONNECT Provider	X		
OSU CABS	Fixed Route / Schedule	T-CONNECT Feeder	X		
OSU TaxiCABS	Demand / Response	T-DISP Provider		X	
Capital Transportation	Private Demand / Response Provider	T-CONNECT Feeder	X		
Zimride	Rideshare Enabler	Rideshare Provider			X
Battelle	IDTO Prototype	System Integrator	X	X	X

Source: Battelle

Chapter 3 High-Level Concept of Operations for Phase 1 Demonstration

This section contains the description of the proposed applications within the IDTO bundle as originally documented in the IDTO Report on Functional and System Requirements and as adapted to reflect the specific demonstration that will be conducted as part of Phase 1. This information is included in order to allow this document to be standalone in its understanding.

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.

For the Phase 1 demonstration site, two different basic scenarios are planned. In the first scenario, travelers on the University's local fix-route service (T-CONNECT feeder) may request a transfer to the corresponding county-wide fixed-route/fixed-schedule service (T-CONNECT provider) that services

the campus area. A traveler will make the transfer request directly using an IDTO-enabled device. As part of the trip planning component under the same scenario, the T-DISP and D-RIDE functions will also be made available to the traveler in order to provide trip alternatives in cases where a connection protection cannot be made.

The second scenario in Columbus related to T-CONNECT again involves the T-CONNECT Provider as the outgoing bus, but in this scenario, also includes the private-transportation partner, as the incoming bus from which a T-CONNECT will be requested. In this scenario, the incoming bus driver, not the traveler, will make the transfer request.

T-DISP

The T-DISP application is expected to advance the concept of demand-responsive transportation services utilizing the global positioning system (GPS) and mapping capabilities of personal mobile devices to enable a traveler to input a desired destination and time of departure tagged with their current location. A central system, such as a Travel Management Coordination Center (TMCC) 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. For example, if a paratransit vehicle is not available, a traveler would be given information on fixed-route service or connected to a private service.

The proposed application may consider a common platform that allows people to effectively communicate and access shared transportation resources more readily than currently occurs. The platform would provide a transit exchange that allows prospective travelers and vehicle operators to trade in a transparent market on demand for optimal mobility solutions without advanced notice.

The application may consider real-time traffic conditions to dynamically route vehicles as necessary (i.e., to select the optimum route), and real-time vehicle capacity to dynamically assign or remove vehicles from service as necessary. It would accommodate dispersed origin-destination trips and trips in low density, low ridership areas, and may replace some late night or mid-day fixed-route service.

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

a) Voice radio communications to facilitate interactions between drivers and dispatchers, and to serve as a back-up if data communication fails;
b) Data communication to exchange data and trip information between the Control Center and vehicles
c) Computer aided dispatch/automatic vehicle location (CAD/AVL) systems to track vehicle locations and assist in messaging between drivers and dispatchers;
d) A common interface between CAD/AVL and messaging systems, especially in the case of a multiple agency/multiple transportation provider environment;
e) 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;
f) 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

g) 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.

For the Phase 1 demonstration site, T-DISP is fulfilled at two different levels. As part of the high-level IDTO Prototype application, a centralized service, similar to the TMCC concept introduced above will be implemented to serve as the conduit thru which a traveler can access information about all of the Columbus-area partners. This includes the two different fix-routed offerings, the two distinct demand/response services, and a ride-share offering. Thru this high-level 'TMCC' layer of the IDTO Prototype, many of the integration features as noted in the list above are satisfied. This includes items b thru g. Item f is further fulfilled by the specific implementation of the University-operated demand/response service.

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 facilitates this process by analyzing inputs from both passengers and drivers pre-trip, during the trip, and post-trip. These inputs are 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.

For the Phase 1 demonstration, Battelle will deploy and subsequently integrated the IDTO Prototype with the D-RIDE provider. By doing such, both pre-planned and dynamic ride-share connections will be available via a social-networking based paradigm. Thru a combination of the IDTO Prototype software, and the existing provider offering, most of the needs of D-RIDE will be fulfilled, however, only a semi-automated ridematch feature will be enabled. The traveler will ultimately need to decide which of the available options (if more than one) are chosen, and similarly, a driver will have the ability to accept or deny a rider.

Chapter 4 Assessment of Existing Requirements

This section identifies the subset of the originally defined IDTO Functional and Performance requirements that are expected to be fulfilled as part of Phase 1 of the IDTO Prototype demonstration. These requirements are organized in the same manner and include the same cross-references as the original requirements, but include additional columns to capture the applicability to the specific site and partners. In order, the columns and a brief description are as follows:

- Rqmt. No – Requirement Number as defined for each applications area.
- Section – Used to convey hierarchical organization of the requirements.
- Requirements – Text of the requirement.
- Operational Mode – Mode of operation as defined in the original system requirement document
  - Normal Mode [N]
  - Overloaded Mode [O]
  - Premium Mode [P]
  - Failure Mode [F]
  - Test/Training [T]
- Verification Method – One of four techniques, Demonstrate, Inspect, Test or Analyze. (See Section 1.0)
- User Need ID – References ID of User Need captured in the original system requirement documentation.
- Included in Phase 1? (Y/N) – Indicates whether or not these previously developed IDTO requirements will or will not be included. NOTE: A few TBD entries also remain in this draft as further clarification with partners remain.
- Notes / Comments – Documents specific conditions on meeting a requirement or justification for those requirements which cannot be fulfilled under this effort.

In addition to these carry over elements, additional information is included for each of the three applications, as noted below.

T-CONNECT Functional and Performance Requirements

T-CONNECT serves to preserve or 'protect' traveler transfer by holding an outgoing vehicle to allow travelers to complete a transfer. As previously discussed, the Phase 1 demonstration will include two different scenarios to demonstration T-CONNECT. In both scenarios, the county-wide local public transit agency will serve as the T-CONNECT provider, allowing buses to be delayed in order to support demonstration and data gathering associated with this application. Specific stops on a select

set of routes will be provisioned to support T-CONNECT. Two other transportation providers will serve as the incoming 'feeder' vehicle in these T-CONNECT scenarios.

In the first scenario, the University-operated fixed routes service will be coordinated with the T-CONNECT provider. Under this scenario, the transfer requests will be traveler initiated. In the second scenario, the private transportation provider will also service to initiate the T-CONNECT request in association with its on-base demand/response service.

As annotated below, the planned scenarios in Phase 1 are expected to satisfy most of the defined requirements; however there are a few notable exceptions. In particular, because the travelers in the first scenario are expected to include a large portion of OSU students, who pay a single quarterly price to access the local public fixed-route service, and as the University-operated service is not a revenue generating service, the fare-related components are mostly considered out of scope. Any other exceptions and the specific tailoring of requirements are included in the table below as well.

Table 4-1. T-CONNECT Functional and Performance Requirements

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
Functional Requirements							
	3.1.1.1	**In-Vehicle System**					
	3.1.1.1.1	**Incoming Vehicle**					
	3.1.1.1.1.1	**Transfer Request Issuance**					
RC-1		The application shall allow drivers to request transfers on customers' behalf using their mobile data terminals (MDTs).	N,O,P, T	Demonstrate	TC-2	Y	Demonstrated using private demand/response provider at the Defense Supply Construction Center in Columbus, OH.
RC-2		The application shall allow drivers to specify if the requesting passenger is using a mobility aid or requires special services.	N,O,P, T	Demonstrate	TC-2	Y	Will be an option in the traveler profile but dependent on the content of the data fed by the associated providers.
RC-3		The application shall notify drivers about any required fare payment for customers requesting the transfer.	N,O,P, T	Test	TC-2, TC-7	Y	Demonstration will use a simplified model to indicate approx. fare amount as actual fare payment will not be demonstrated in Phase 1.
RC-4		The application shall provide alternate provisions to avoid manual input of transfer requests by drivers on MDTs or other in-vehicle equipment.	N, O, P	Test	TC-2	Y	Demonstration of private demand/response to public fixed-route will include driver-initiated T-CONNECT request.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
	3.1.1.1.1.2	**Transfer Request Status Monitoring**					
RC-5		The MDT shall retry the delivery of transfer requests for a configurable amount of time. The application shall notify drivers about the acceptance and failed delivery of transfer requests.	N,O,P,T	Demonstrate	TC-2	Y	
RC-6		Once the confirmation has been received and processed by the T-CONNECT Request Broker, the MDTs shall notify if the Transfer has been accepted or denied.	N,O,P,T	Demonstrate	TC-2, TC-4	Y	
RC-7		The central T-CONNECT subsystem shall continue to monitor the status of transfer requests and notify the driver if a requested transfer cannot be protected.	N,O,P,T	Demonstrate	TC-3,	Y	
	3.1.1.1.2	**Outgoing Vehicle**					
	3.1.1.1.2.1	**TCP Request and Monitoring**					
RC-8		The application shall notify drivers about an upcoming transfer on their MDTs.	N,O,P,T	Demonstrate	TC-2	TBD	Discussions with local agency and their software provider have not yet determined if this requirement can be fulfilled. This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
RC-9		The drivers shall be able to view a list of the current list of transfer requests and any changes in the upcoming transfer requests for the outgoing vehicle.	N,O,P, T	Test	TC-2	N	Constrained by current system and operational policies of the provider.
RC-10		The application shall require that drivers confirm the completion of a transfer once the customer is on-board the outgoing vehicles.	N,O,P	Demonstrate	TC-2	N	This will not be a part of the Outgoing Vehicle, but will be implemented as part of the mobile device capability or by post-processing match of rider farecard/ID data.
	3.1.1.1.2.2	**Fare Payment**					
RC-11		The MDT shall display the driver the amount a transferring customer is required to pay.	N,O,P	Demonstrate	TC-2, TC-7	N	The nature of the relationship between the phase 1 partners, and PII / SPII concerns related do not allow for reasonable demonstration of this feature.
RC-12		The application shall allow customers to pay for the trip using approved fare media.	N,O,P	Demonstrate	TC-2	N	The nature of the relationship between the phase 1 partners, and PII / SPII concerns related do not allow for reasonable demonstration of this feature.
RC-13		The application shall validate the payment and notify the driver if the paid amount is not as expected or the payment is not successful.	N,O,P	Test	TC-2 TC-7	N	The nature of the relationship between the phase 1 partners, and PII / SPII concerns related do not allow for reasonable demonstration of this feature.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
	3.1.1.2	**Central System**					
	3.1.1.2.1	**Transfer Request Brokerage and Processing**					
RC-14		T-CONNECT shall include a central transfer request brokerage subsystem capable of processing transfer requests from customers in a mixed-mode (e.g., fixed-route bus, demand response bus, and rail) environment to determine the feasibility of a connection protection request. The application shall automatically group transfers when multiple customers are requesting for transfers at the same location for a route within a preconfigured timeframe (e.g., within 15 minutes).	N,O,P, T	Test	TC-3, TC-4	Y	Due to frequency of routes, timeframe of less than 5 minutes is a more realistic constraint for demonstration purposes.
RC-15		The brokerage subsystem shall have the capability to process transfer requests involving modes owned and operated by multiple public transit agencies and private operators	N,O,P, T	Test	TC-3, TC-4	Y	
RC-16		Based on the availability of real-time coordination between various transportation management systems (e.g., ridesharing systems, taxi dispatch systems), the brokerage subsystem shall be able to determine (e.g., with the help of T-DISP and D-RIDE) non-transit connection alternatives when needed.	N, P	Test	TC-3, TC-4	Y	

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
RC-17		The brokerage subsystem shall determine the transfer feasibility based on preconfigured policies and procedures (e.g., maximum allowable hold time).	N,O,P	Test	TC-4	Y	
RC-18		The brokerage subsystem shall determine the feasibility of transfers based on customer preferences.	N,P	Test	TC-4	Y	The preferences will limited to the following: Arrival Time Maximum number of transfers Preferred modes (fixed-route, demand response, ride share) Wait time at a stop On-board time on a vehicle Fare (est.)
	3.1.1.2.2	**Dynamic Management of Transfer Requests**					
RC-19		The application shall be capable of creating and managing a dynamic list of feasible transfer requests for various modes in a single or multiple agency environments.	N,O,P	Demonstrate	TC-4	Y	

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
RC-20		For connections involving fixed-route modes, the application shall 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) for determine the updated feasibility of transfer requests.	N,O,P	Test	TC-2, TC-3, TC-4, TC-6, TC-9	Y	
		The application shall dynamically update the list of transfer requests based on the following information:					
RC-21		a.) Current location of incoming and outgoing vehicles.	N,O,P	Test	TC-3, TC-4	Y	
RC-22		b.) Route and schedule adherence (RSA) of incoming and outgoing vehicles.	N,O,P	Test	TC-3, TC-4	TBD	RSA for outgoing vehicles may not be available in sufficient time to support T-CONNECT needs. Discussions with partner vendor will determine final result.
RC-23		c.) Predicted arrival of incoming and outgoing vehicles at transfer locations.	N,O,P	Test	TC-3, TC-4	Y	
RC-24		d.) Current passenger capacity of the outgoing vehicle for wheelchair and non-wheelchair passengers.	N,O,P	Test	TC-3, TC-4	Y	Dependent on availability of the information from provider.
RC-25		e.) Dynamic changes in operations to incorporate operational situations such as short-turn of buses and addition of runs/vehicles by agencies.	N,O,P	Test	TC-3, TC-4	N	Demonstration limited to regularly scheduled service. Short-turn / additions are not expected to be reflected in data streams.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
RC-26		f) Impact of dwell time of outgoing vehicles at transfer points on schedule adherence at downstream stops.	N,O,P	Test	TC-3, TC-4	Y	Operationally, a T-CONNECT won't be issued if already 3 min behind schedule.
RC-27		g.) Preconfigured customer preference and agency policies and procedures.	N,P	Test	TC-3, TC-4	Y	See RC-18
RC-28		h) Changes in transfer requests by customers.	N,P	Test	TC-3, TC-4	Y	Two types of changes will be supported: Aborted – when the user does not board either the incoming or outgoing vehicle; or user-canceled trip.
RC-29		In the event the system determines that a transfer is in jeopardy, the application shall notify the individuals as per system configurations. These configurations shall depend on an agency's standard operating procedures.	N,P	Test	TC-2, TC-9	Y	
RC-30		The application shall allow manual intervention of dispatchers and operational supervisors to override the system-determined feasibility of transfer requests.	N,O,P, T,F	Test	TC-3, TC-6	Y	

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
	3.1.1.2.3	**Real-time Traveler Information**					
RC-31a		The application shall notify customers about the feasibility of requested transfers immediately when determined by the system.	N,O,P, T	Demonstrate	TC-2, TC-4, TC-6, TC-9	Y	RC-31 was split into two distinct requirements. They are both intended to be demonstrated in Phase 1.
RC-31b		The application shall continuously monitor and provide customers updates on the current status of the feasibility as per their preferences.	N,O,P, T	Demonstrate	TC-2, TC-4, TC-6, TC-9	Y	
RC-32		The application shall provide real-time status of requested transfers to travelers via a variety of media (e.g., Dynamic Message Signs (DMS) at Transfer Points, text alerts, Internet, interactive voice response (IVR))	N,O,P, T	Demonstrate	TC-9	Y	Phase 1 will include alerts as provided to the mobile device only.
RC-33		If the system does not have the access to real-time data such as real-time vehicle location and RSA information, the application shall calculate transfer feasibility based on schedule data.	F	Demonstrate	TC-3, TC-4	N	Design intent will leverage any available capabilities of selected tools, but is not intended to build a new scheduling software package.
RC-34		The system shall provide the capability to manually override the transfer alternatives suggested by the system.	N,O,P, T	Demonstrate	TC-3, TC-6	N	Design intent will leverage any available capabilities of selected tools, but is not intended to build a new scheduling software package.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
	3.1.1.2.4	**Interfaces (managed by T-CONNECT Integrator)**					
	3.1.1.2.4.1	**Data Communication System**					
RC-35		The T-CONNECT central servers shall be connected with relevant servers (e.g., computer aided dispatch/automatic vehicle location [CAD/AVL], Real-time Information) via local area network and wide area network connectivity for real-time data exchange.	N,O,P, T	Demonstrate	TC-3, TC-11, TC12	Y	This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.
RC-36		The application shall be connected with vehicles via wireless data communication system directly or indirectly (e.g., via a CAD/AVL system) for real-time data exchange.	N,O,P, T	Demonstrate	TC-1	Y	This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.
	3.1.1.2.4.2	**CAD/AVL System**					
RC-37		T-CONNECT shall be connected with the CAD/AVL system used for managing incoming and outgoing vehicles for obtaining information on the current locations of vehicles and the most recent route and schedule adherence information.	N,O,P, T	Demonstrate	TC-3, TC-4, TC-5, TC-12	Y	Current plan is for both incoming and outgoing services to provide this information. This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
RC-38		T-CONNECT shall have the capability to interface with and process information from multiple CAD/AVL systems, representing real-time operations management system for participating agencies and private operators.	N,O,P, T	Demonstrate	TC-3, TC-4, TC-5, TC-12	Y	This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.
	3.1.1.2.4.3	**Automated Passenger Counting (APC)Systems**					
RC-39		The application shall obtain real-time passenger count information from outgoing vehicles to determine current vehicle capacity.	N,O,P, T	Demonstrate	TC-3, TC-4, TC-5, TC-12	N	APC data is not available in real-time for the T-CONNECT provider.
	3.1.1.2.4.4	**Vehicle Arrival Prediction System**					
RC-40		The application shall be interfaced with vehicle arrival prediction system(s) to obtain information on expected time of arrival (ETA) of incoming and outgoing vehicles at transfer points.	N,O,P, T	Demonstrate	TC-2, TC-3, TC-4, TC-5, TC-9, TC-12	Y	This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.
RC-41		When vehicle arrival prediction information is not readily available, T-CONNECT shall be equipped to determine predicted arrival information based on current vehicle location, RSA information obtained from vehicles and predicted arrival of the passenger at the outgoing vehicle stop, including the walking time between the two stops.	N,O,P, T	Test	TC-2, TC-3, TC-4, TC-5, TC-9, TC-12	N	Design intent will leverage any available capabilities of selected tools, but is not intended to build a new scheduling software package.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
	3.1.1.2.4.5	**Fare Payment System**					
RC-42		The application shall be interfaced with the fare payment system to determine required amount of fare to be paid by the customers requesting for a transfer based on agency fare rules.	N,O,P, T	Demonstrate	TC-2, TC-7	N	The nature of the relationship between the phase 1 partners, and PII / SPII concerns related do not allow for reasonable demonstration of this feature.
RC-43		The application shall update the fare payment system with amount paid, date and time of fare transaction, and location of fare transaction based on information obtained from outgoing vehicles.	N,O,P, T	Demonstrate	TC-2, TC-7	N	The nature of the relationship between the phase 1 partners, and PII / SPII concerns related do not allow for reasonable demonstration of this feature.
	3.1.1.2.4.6	**Traffic Management Center**					
RC-44		The application shall be interfaced with the regional or local traffic management center to obtain information on and prediction traffic conditions to update the vehicle arrival prediction information.	N,P	Test	TC-2, TC-3, TC-4, TC-9, TC-12, TC-13	N	Phase 1 does not included integration with local or regional TMC. Historical data from current partners and their current practices will be the foundation for vehicle arrival prediction.
	3.1.1.2.4.7	**T-DISP Application**					
RC-45		The application shall be interfaced with T-DISP applications to provide other trip alternatives to customers when transfer requests cannot be completed using available operational resources.	P	Test	TC-4	Y	Demonstrated as part of initial trip planning, but dynamic changes mid-trip are not anticipated to be included.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
	3.1.1.2.4.8	**D-RIDE Application**					
RC-46		The application shall be interfaced with D-RIDE applications to provide public or private shared ride trip alternatives to customers when transfer requests cannot be completed using available operational resources.	P	Test	TC-4	Y	Demonstrated as part of initial trip planning, but dynamic changes mid-trip is not anticipated to be included.
	3.1.1.2.5	**System Administration**					
RC-47		The application shall allow agencies to create and modify transfer points. These configurations shall be by mode (e.g., fixed-route and demand response), time of day (e.g., AM and PM peaks and mid-day) and type of operation (e.g., public or private).	N,O,P	Demonstrate	TC-4	Y	Demonstration is expected to include two, possibly more, schedule changes, based on weekday, weekend, and University sessions. This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.
RC-48		The application shall allow agencies to modify the following parameters:	N,O,P	Demonstrate	TC-4		
RC-49		a.) Maximum hold-until time for outgoing vehicles	N,O,P	Demonstrate	TC-4	Y	This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.
RC-50		b.) Maximum wait time for customers transferring from incoming to outgoing vehicles	N,O,P	Demonstrate	TC-4	Y	This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.
RC-51		c.) Maximum number of transfers allowed to each customer for a defined time period (e.g., within a month)	N,O,P	Demonstrate	TC-4	Y	This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
RC-52		d.) Number of minutes prior to the connection when the system notifies the drivers of outgoing vehicles about the upcoming transfers	N,O,P	Demonstrate	TC-4	Y	This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.
RC-53		e.) Whether or not to seek alternatives with the help of T-DISP and D-RIDE when requests cannot be completed.	N,P	Demonstrate	TC-4	N	Consistent with RC-45 and RC-46.
	3.1.1.3	**Customer-end Systems**					
	3.1.1.3.1	**Profile Management**					
RC-54		The application shall provide a web-based interface to agency customers to create, modify and delete their profiles and enter preferences for travel and real-time information.	N,O,P, T	Demonstrate	TC-10	Y	
RC-55		The process of customer information intake, storage and retrieval must be compliant with Health Insurance Portability and Accountability Act (HIPAA) requirements.	N,O,P, T	Demonstrate	TC-10	Y	Will follow informed consent as defined by IRB.
RC-56		In the event customers have registered with the agency for other services (e.g., fare payment system), the application shall have the ability to link customer databases to avoid duplication of information and maintain data integrity.	N,O,P, T	Demonstrate	TC-8, TC-9, TC-10	N	Scope of current partners does not permit demonstration of this feature.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
	3.1.1.3.2	**Transfer Request Issuance**					
RC-57		The application shall provide customers a web-based interface for requesting transfers in advance or in real-time.	N,O,P, T	Demonstrate	TC-8, TC-9, TC-10	Y	
RC-58		The application shall allow customers to modify or cancel their requests in real-time.	N,O,P, T	Test	TC-8, TC-9, TC-10	Y	
	3.1.1.3.3	**Fare Payment System**					
RC-59		The application shall allow customers to pay for transfer trips using a web-based interface and provide an electronic or paper-based proof of payment.	N,O,P, T	Test	TC-8, TC-9, TC-10	N	The nature of the relationship between the phase 1 partners, and PII / SPII concerns related do not allow for reasonable demonstration of this feature.
	3.1.1.3.4	**Real-time Traveler Information**					
	3.1.1.3.4.1	**Transfer Location Signage**					
RC-60		The application shall notify customers about the predicted arrival of incoming vehicles at transfer locations using DMS installed at those transfer locations.	N,O,P, T	Test	TC-8, TC-9, TC-10	N	Capability doesn't currently exist for outgoing vehicle stops.
	3.1.1.3.4.2	**Web-enabled Devices**					
RC-61		The application shall notify customers about the status of their transfer requests via a web-based interface.	N,O,P, T	Test	TC-8, TC-9, TC-10	Y	

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
RC-62		The application shall notify customers about the predicted arrival time of incoming vehicles via a web-based interface.	N,O,P, T	Test	TC-8, TC-9, TC-10	Y	
	3.1.1.3.4.3	**Interactive Voice Response**					
RC-63		The application shall notify customers about the status of their transfer requests via an IVR-based interface.	N,O,P, T	Test	TC-8, TC-9, TC-10	N	IVR is not planned for the Phase 1 demonstration given the complexity of its implementation and the target ridership.
RC-64		The application shall notify customers about the predicted arrival time of incoming vehicles via an IVR-based interface.	N,O,P, T	Test	TC-8, TC-9, TC-10	N	IVR is not planned for the Phase 1 demonstration given the complexity of its implementation and the target ridership.
	3.1.1.3.4.4	**Alerts**					
RC-65		The application shall send alerts to customers based on their subscription preferences.	N,O,P, T	Demonstrate	TC-8, TC-9, TC-10	Y	
RC-66		The application shall allow customers to subscribe and unsubscribe to alerts via web and IVR-based interfaces.	N,O,P, T	Demonstrate	TC-8, TC-9, TC-10	Y	Only web alerts will be supported. IVR is not planned for the Phase 1 demonstration given the complexity of its implementation and the target ridership.
RC-67		The application shall allow customers to provide preferences for alerts via a web-based interface. These preferences shall be stored in customer profiles.	N,O,P, T	Test	TC-8, TC-9, TC-10	Y	

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
Performance Requirements							
	3.2.1.1	**In-Vehicle System**					
	3.2.1.1.1	**Incoming Vehicle**					
	3.2.1.1.1.1	**Transfer Request Issuance**					
RC-68		The data entry interface shall allow drivers to complete the entry of transfer requests for each customer or a group of customers within a configurable number of seconds.	N,O,P	Demonstrate	TC-2	Y	Revise requirement to demonstrate maximum of 4 steps to completed transfer request issuance, as opposed to number of seconds.
RC-69		The application shall immediately pre-process driver request to determine the feasibility of a transfer based on a preconfigured matrix of transfer points within MDTs (e.g., combination of fixed-routes) and notify the driver about any exceptions prior to sending the request to the T-CONNECT Request Broker.	N,O,P	Demonstrate	TC-2	N	Phase 1 demonstration limited to centrally processed transfer requests.
	3.2.1.1.1.2	**Transfer Request Status Monitoring**					
RC-70		The application shall resend the transfer request to the T-CONNECT Request Broker unless the acknowledgement is received. The application shall try at least three (3) times prior to notifying the driver of the failed delivery of a transfer request.	N,O,P	Demonstrate	TC-2, TC-4	Y	

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
RC-71		The central application shall monitor the status of a transfer request for every configurable number of seconds to notify drivers of any changes in the status of the feasibility of the request, when the transfer is expected to occur within the next configurable number of minutes.	N,O,P	Demonstrate	TC-1, TC-2, TC-4, TC-11, TC-12	Y	
	3.2.1.1.2	**Outgoing Vehicle**					
	3.2.1.1.2.1	**TCP Request Receipt**					
RC-72		The outgoing vehicles shall receive the transfer request a configurable number of minutes prior to the expected time of arrival of those vehicles at transfer points. Once the transfer is a configurable number of minutes away, the application shall check the status of transfer feasibility every sixty (60) seconds.	N,P	Demonstrate	TC-1, TC-2, TC-11	Y	IDTO prototype will queue a request until which time it would be issued to the outgoing vehicle. This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.
RC-73		If the transfer requests are submitted after a configurable number of minutes, the application shall either deny the transfer request or suggest an alternative based on available resources.	N,P	Demonstrate	TC-1, TC-2, TC-11	Y	Interpretation of this requirement is that there is a point at which it is too late to request the protected transfer. This rule will be implemented.
	3.2.1.1.2.2	**Fare Payment**					
RC-74		In the event fare payment is required, the processing time shall be less than a configurable number of seconds per customer.	N,P	Demonstrate	TC-1, TC-7, TC-11	N	As previously identified, demonstration will not include a fare component.

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
	3.2.1.2	**Central System**					
	3.2.1.2.1	**Transfer Request Brokerage and Processing**					
RC-75		The application shall obtain the transfer request from the vehicles within sixty (60) seconds from the time a request is entered on the MDT or other media.	N,O,P, T	Analyze	TC-1, TC-2, TC-11	Y	
RC-76		The application shall receive AVL information every thirty (30) seconds.	N,P	Analyze	TC-1, TC-3, TC-4, TC-11, TC-12	Y	30 Sec rate may not be achievable on the part of the partners. Target 60 seconds.
RC-77		The application shall obtain RSA information at least at a time interval equivalent to 20% of the total trip length (e.g., every five minutes on a twenty minute trip).	N,O,P	Analyze	TC-1, TC-3, TC-4, TC-11, TC-12	Y	Dependent on provider being capable of matching this rate.
RC-78		When more than one system (single or multiple agency environments) are involved in determining the transfer feasibility, required information shall be synchronized between systems every thirty (30) seconds.	N,P	Analyze	TC-3, TC-4, TC-12	Y	

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
RC-79		When determining the transfer feasibility, the application shall ensure that the average wait time for passengers waiting for the outgoing vehicles at transfers point is not more than a configurable number of minutes.	N,P	Analyze	TC-3, TC-4	Y	
	3.2.1.2.2	**Dynamic Management of Transfer Requests**					
RC-80		The application shall be able to determine the real-time feasibility of a transfer request at least five (5) minutes prior to the actual transfer.	N,O,P	Demonstrate	TC-3, TC-4	Y	Given the operational scenario, a three (3) minute constraint is more feasible.
RC-81		The application shall automatically monitor the status of each transfer request every sixty (60) seconds when the transfer is due within the next five (5) minutes.	N,O,P	Demonstrate	TC-2, TC-3, TC-4, TC-9	Y	
RC-82		In the event a transfer is in jeopardy, the application shall notify the affected parties within thirty (30) seconds.	N,O,P	Demonstrate	TC-2, TC-3, TC-4, TC-9	Y	

Rqmt No.	Section	T-CONNECT Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)	Notes/Comments
	3.2.1.3	**Customer-end Systems-Real-time Information**					
RC-83		The application shall provide real-time information on the status of transfer feasibility and the ETA of incoming and outgoing vehicles at a transfer point to customers with an accuracy of at least 95% when the transfer is due within five (5) minutes.	N,O,P	Analyze	TC-9	Y	This Requirement will be satisfied using existing in-place vendor software, either modified, or as-is.

Source: USDOT publication as annotated by Battelle

T-DISP Functional and Performance Requirements

The T-DISP application serves two major roles in IDTO. First, it allows for a traveler to perform travel planning, via internet enabled devices, using inputs from multiple agencies. Second, the T-DISP application serves to dynamically schedule and/or route in-service vehicles by matching compatible trips together. The first role will be performed by the IDTO Prototype Application software. The term TMCC was used in much of the previous documentation to identify this capability. The TMCC will be the conduit through which a traveler can request and book trips. The TMCC aka IDTO Prototype will be hosted in a centralized manner on cloud-services and interfaces with, but is independent of, the specific agency's existing systems.

The second component of the T-DISP application will be fulfilled through the demand/response service offered by OSU. It will leverage their existing demand / response software to support dynamic scheduling and routing.

Similar to the analysis of the previous T-CONNECT requirements, additional information has been added to the previous requirements information. In this case, there are three added columns. Two of the columns are included to indicate if the requirement will be satisfied by the TMCC or via the demand/response component of T-DISP, and the third added column again has notes or annotations. All other columns are identical to the definitions found earlier in Section 3.1. It should be noted that those requirements satisfied by the demand/response provider indicates the use of that provider's in-place software system, either as-is or modified to support IDTO. Those requirements satisfied by the TMCC will be included as part of the software components to be developed under the auspices of this project.

Table 4-2. T-DISP Functional and Performance Requirements

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
Functional Requirements								
	3.1.2.1	**In-Vehicle System Integration with Mobile Data Terminals (MDTs)**						
RD-1		The T-DISP application shall utilize the capabilities of an existing MDT, integrated with central CAD/AVL software, to accomplish the following:	N, O, P, T	Inspect	TD-8, TD-10, TD-11, TD-19	N/A	Y	
RD-2		Automated vehicle location tracking	N, O, P, T	Demonstrate	TD-8	Y	Y	
RD-3		Monitoring of route and schedule adherence	N, O, P, T	Demonstrate	TD-8	Y	Y	
RD-4		Wireless voice communications between drivers and the dispatcher	N, O, P, T	Demonstrate	TD-15	N/A	Y	
RD-4b		Wireless data communications between drivers and the dispatcher				N/A	Y	
RD-5		Management of manifest data	N, O, P, T	Demonstrate	TD-8, TD-9, TD-17	N	Y	Manifest data to be consistent with current demand/response partner's practices.

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-6		Fare payment	N, O, P, T	Demonstrate	TD-8, TD-15	N	N	The nature of the relationship between the phase 1 partners, and PII / SPII concerns related do not allow for reasonable demonstration of this feature.
RD-7		Automated vehicle announcements	N, O, P, T	Demonstrate	TD-8, TD-15	N	N	Demonstration partners do not possess the capability to demonstrate this feature.
	3.1.2.2	**Central System**						
	3.1.2.2.1	**Multi-Modal Scheduling System**						
RD-8		The application shall accept trip origin and destination requests from travelers.	N, O, P, T	Demonstrate	TD-5, TD-21	Y	Y	
RD-9		The application shall schedule trip requests based on configurable settings for: - Traveler trip time and location request - Cost of trip to provider - Traveler presence - Vehicle characteristics.	N, O, P, T	Analyze, Demonstrate	TD-5 Y		N/A	

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-10		The application shall allow for trips to be scheduled based on configurable settings related to the cost of the mode of service[2].	N, O, P, T	Demonstrate	TD-5, TD-8	Y	Y	Demonstration will use a simple static fare model to show how it could be used in trip selection.
RD-11		The application shall provide alternative trip options[3] availability.	N, O, P, T	Demonstrate	TD-3, TD-4, TD-12	Y	N/A	
RD-11b		The application shall provide parking availability.				N	N/A	Parking availability is not readily available within the current scope of this effort.
RD-12		The application shall track all vehicles and their characteristics in the application.	N, O, P, T	Demonstrate	TD-5	N/A	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-13		The application shall calculate time and distance between origins and destinations.	N, O, P, T	Analyze, Demonstrate	TD-5	N/A	Y	Assumed feature of demand/response provider's current CAD/AVL software.

[2] For example, the application shall assign a cost to each available mode or type of service in the system (e.g., fixed rail, route, paratransit)

[3] For example, over the telephone (landline or mobile) or the internet.

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-14		The application shall assign available vehicles based on how soon a vehicle can meet a trip origin request.	N, O, P, T	Demonstrate	TD-5	N/A	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-15		The application shall calculate the earliest pick-up time availability.	N, O, P, T	Analyze, Demonstrate	TD-5	N/A	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-16		The application shall track existing vehicle availability in real-time to determine solutions for each trip request.	N, O, P, T	Analyze, Demonstrate	TD-5	N/A	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-17		The application shall track and confirm the status of trip requests (e.g., requests that are not completed, trips underway, and completed trips).	N, O, P, T	Analyze, Demonstrate	TD-5, TD-6, TD-8	N	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-18		The application shall dynamically reflect the changing availability of vehicles in terms of geographic and temporal location, and capacity.	N, O, P, T	Analyze, Demonstrate	TD-5, TD-6, TD-8	N	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-19		The application shall automatically move trips to another manifest if a vehicle falls behind schedule. Additionally, the application shall allow the manual reassignments and adjustments of trips to manifests and vehicles in such situations.	N, O, P, T	Demonstrate	TD-5, TD-6, TD-8	N	Y	Assumed feature of demand/response provider's current CAD/AVL software.

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-20		The application shall be capable of scheduling, in batch mode, all bookings for the next travel day, using parameters associated with street network segments as established in the GIS system (e.g., physical barriers, running speed by time of day, and appropriate dwell times for the boarding and alighting of passengers).	N, O, P, T	Analyze, Demonstrate	TD-5, TD-6, TD-8	N	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-21		The application shall calculate available trip options based on configurable settings, including: 1 – Origin and destination times based on vehicle locations relative to pick-up and drop-off locations 2 – Vehicle locations relative to pick-up and drop-off locations 3 – Available modes of services (i.e., fixed-route bus, express bus, demand response).	N, O, P, T	Analyze, Demonstrate	TD-5, TD-6, TD-8	1 – Y 2 – N 3 – Y	1 – Y 2 – Y 3 – N	The TMCC will not track demand/response vehicle locations directly. The demand/response CAD/AVL will only be aware of its vehicles. The TMCC will handle the multi-modal aspects.
RD-22		The application shall include a geographic information system (GIS) module to provide and display map data.	N, O, P, T	Inspect	TD-5, TD-6, TD-8	Y	Y	
RD-23		The application shall be capable of processing trip origin and destination using latitude and longitude coordinates, in order to maximize the possible set of trip patterns.	N, O, P, T	Analyze, Demonstrate	TD-5, TD-6, TD-8	Y	Y	

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-24		The application bundle shall include a GIS module that will calculate travel times between origins and destinations.	N, O, P, T	Analyze, Demonstrate	TD-5, TD-6, TD-8	Y	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-25		The application shall calculate the possible vehicle trip assignments for each request and searches for solutions based on predetermined weighted factors, including: travel time, distance, impact on other passengers, and impact on allowable maximum travel and wait times.	N, O, P, T	Analyze, Demonstrate	TD-5, TD-6, TD-8	Y	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-26		The application shall produce a daily manifest for each driver/vehicle.	N, O, P, T	Demonstrate	TD-5, TD-6, TD-8	N	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-27		The application shall be able to display all manifests generated for a given day. The application shall provide tools to allow manual adjustments to the run manifests, including manually moving trips between manifests.	N, O, P, T	Analyze, Demonstrate	TD-5, TD-6, TD-8	N	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-28		The application shall allow trips to be added to an existing manifest on the same day.	N, O, P, T	Demonstrate	TD-5, TD-6, TD-8	N	Y	Assumed feature of demand/response provider's current CAD/AVL software.

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-29		The application shall identify a range of alternatives for assigning the trip to existing manifests for that day so as to best satisfy the requirements of the trip request while minimizing any impact on existing trips.	N, O, P, T	Analyze, Demonstrate	TD-5, TD-6, TD-7, TD-8	N	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-30		The application shall present these alternatives in rank order (or another scheme) with a numerical "score" to indicate the degree of difference between choices presented to a reservations agent.	N, O, P, T	Analyze, Demonstrate	TD-5, TD-6, TD-7, TD-8	N	Y	Assumed feature of demand/response provider's current CAD/AVL software.
	3.1.2.2.2	**Integration with External Systems**						
	3.1.2.2.2.1	**Computer-Aided Dispatch/Automatic Vehicle Location System**						
RD-31		The application shall be integrated with a CAD/AVL system (or multiple CAD/AVL systems in a multi-agency environment) to accomplish the following;	N, O, P, T	Inspect	TD-5, TD-15, TD-16, TD-17, TD-18	Y	Y	TMCC is not a CAD/AVL system, but will link to corresponding provider CAD/AVL systems.
RD-32		Obtain vehicle location information at every configurable number of seconds.	N, O, P, T	Analyze, Demonstrate	TD-8	Y	Y	
RD-33		Communicate with drivers wirelessly via canned messages, free-form text messages, and one-way or two-way voice calls.	N, O, P, T	Demonstrate	TD-15	N/A	Y	Via available commercial device (MDT), where applicable.

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-34		Electronically transmit and manage driver manifest data (e.g., pick-ups, drop-offs and no-shows).	N, O, P, T	Demonstrate	TD-5, TD-8, TD-9, TD-17	N/A	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-35		Track on-board passenger counts.	N, O, P, T	Demonstrate	TD-15	N	N	Capability for real-time APC not present in Phase 1 partner's systems.
	3.1.2.2.2.2	**Customer Information System**						
RD-36		The application shall be integrated with a Customer Information System to obtain customer input and provide real-time information on the status of their trips.	N, O, P, T	Demonstrate	TD-1, TD-2, TD-5, TD-6, TD-20	N	N	Feature not available thru current demand/response partner.
	3.1.2.2.2.3	**T-CONNECT**						
RD-37		The application shall be integrated with T-CONNECT to determine transfer opportunities for multi-modal trips.	N, O, P, T	Demonstrate	TD-5	Y	Y	
	3.1.2.2.2.4	**D-RIDE**						
RD-38		The application shall be integrated with D-RIDE to determine ridematch opportunities.	N, O, P, T	Demonstrate	TD-5, TD-13	Y	Y	

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
	3.1.2.2.2.5	**Revenue Management System**						
RD-39		The application shall be integrated with a revenue management system to determine the fare paid by customers for trips scheduled by T-DISP.	N, O, P, T	Inspect	TD-8, TD-15	N	N	The nature of the relationship between the phase 1 partners, and PII / SPII concerns related do not allow for reasonable demonstration of this feature.
	3.1.2.2.2.6	**Vehicle Arrival Prediction System**						
RD-40		The application shall be interfaced with a vehicle arrival prediction system(s) to obtain information on the expected time of arrival (ETA) for vehicles conducting customer-requested pick-ups and drop-offs.	N, O, P, T	Analyze, Demonstrate	TD-5, TD-8	N/A	TBD	Assumed feature of demand/response provider's current CAD/AVL software.

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
	3.1.2.2.2.7	**Traffic Management Center**						
RD-41		The application shall be interfaced with the regional or local traffic management center to obtain information on current and prediction traffic conditions to update the vehicle arrival prediction information.	N, P	Inspect, Demonstrate	TD-5	N	N	Phase 1 does not included integration with local or regional TMC. Historical data from current partners and their current practices will be the foundation for vehicle arrival prediction.
	3.1.2.3	**Customer-end System**						
	3.1.2.3.1	**Customer Profile Management and Trip Booking**						
RD-42		The application shall enable requests for trips to be made via multiple media.	N, O, P, T	Test	TD-3, TD-21	Y	Y	An Internet enabled device will allow access to the TMCC, both internet and phone for demand/response provider.
RD-43		The application shall allow travelers to request trips including origin, destination, time and a return trip.	N, O, P, T	Demonstrate	TD-3, TD-20, TD-21	Y	Y	

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-44		The application shall allow automated trip reservations for preferred locations and/or common trips for customers.	N, O, P, T	Demonstrate	TD-1, TD-2	N	Y	Limited to features of demand/response partner's system.
RD-45		The application shall include a user profile for all trip requests. The process of customer information intake, storage and retrieval must be compliant with Health Insurance Portability and Accountability Act (HIPAA) requirements.	N, O, P, T	Demonstrate	TD-1, TD-2	Y	Y	Yes, for now pending further HIPAA review.
RD-46		The user profile shall include configurable traveler preferences and requirements for use during trip requests.	N, O, P, T	Analyze, Demonstrate	TD-1, TD-2	Y	Y	
RD-47		The application shall include in the user profile additional information necessary for the provision of Medicaid or ADA complementary paratransit service.	N, O, P, T	Demonstrate	TD-1, TD-2	Y	N	Profile will support in TMCC, if data is also available in GTFS feed. OSU Paratransit would be used in case for D/R, but that service is not part of the demonstration.

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-48		The application shall permit trip booking while the call taker is on the phone with the client.	N, O, P, T	Demonstrate	TD-1, TD-2, TD-7, TD-20, TD-21	N	Y	Assumed feature of demand/response provider's CAD/AVL system, although this is outside of the scope of our intended demonstration.
RD-49		The application shall be capable of booking both subscription (standing-order) and demand response trips while the call taker is on the phone with the client.	N, O, P, T	Demonstrate	TD-2	N	Y	Assumed feature of demand/response provider's CAD/AVL system, although this is outside of the scope of our intended demonstration.
RD-50		The application shall be capable of booking same day trips.	N, O, P, T	Demonstrate	TD-7	Y	Y	
RD-51		The application shall have the ability to place the automated trip in a pending reservations list, until it is confirmed through the reservations software/staff.	N, O, P, T	Demonstrate	TD-7	N	Y	Assumed feature of demand/response provider's CAD/AVL system, although this is outside of the scope of our intended demonstration.

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-52		The application shall allow the caller user to enter the origin and destination utilizing frequently used addresses available.	N, O, P, T	Demonstrate	TD-7	Y	N/A	
RD-53		The application shall be capable of accepting trip requests up to a configurable number of days in advance of the requested trip date.	N, O, P, T	Demonstrate	TD-7	Y	Y	
RD-54		The application shall provide a confirmation or trip number for the traveler to have for reference.	N, O, P, T	Demonstrate	TD-7	Y	Y	
RD-55		a) The application shall identify and automatically geocode the location associated with each entered address. b) If the automatic geocoding fails, the application shall provide alternative methods of establishing x- and y- map coordinates for the address. c) One of the alternative methods supported shall be clicking on a map location with the mouse.	N, O, P, T	Analyze, Demonstrate	TD-7	a – Y b - Y c - N	a – Y b - TBD c - N	Assumes feature available within respective partner tools. Mapping is outside of the scope of this demonstration.
RD-56		The application shall transmit trip choices to the traveler.	N, O, P, T	Demonstrate	TD-7	Y	Y	

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-57		The application shall receive a trip confirmation back from the traveler.	N, O, P, T	Demonstrate	TD-7	Y	N	Necessary only to book T-CONNECT protected trip. Integration with demand/response software is still TBD, but is not assumed to be available at present.
RD-58	3.1.2.3.2	Real-time Traveler Information						
RD-59		The application shall send real-time service status to travelers per their request in real-time or per their subscription preferences (e.g., five minutes before vehicle arrival).	N, O, P, T	Demonstrate	TD-7	Y	N	Dependent on features of TMCC software.
RD-60		The application shall provide trip details to the traveler when requested.	N, O, P, T	Demonstrate	TD-7	Y	N	Dependent on features of TMCC software.
Performance Requirements								
	3.2.1	**Central System – Multi-Modal Scheduling System**						
RD-61		The application shall process trip origin and destination requests from travelers in less than two (2) minutes.	N,O, P	Analyze, Demonstrate	TD-1, TD-2, TD-6	Y	Y	

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
RD-62		The application shall prompt the user to accept the suggested trip within 15 to 30 seconds.	N,O, P	Analyze, Demonstrate	TD-1, TD-2, TD-6	Y	Y	Assumed feature of demand/response provider's current CAD/AVL software.
RD-63		The application shall display a timer and a warning of a 'system time out' when the suggested trips are within five (5) seconds of expiring.	N,O, P	Demonstrate	TD-1, TD-2, TD-6	Y	N	
RD-64		The application shall develop trip suggestions to keep traveler wait time at the boarding location under configurable number of minutes.	N,O, P	Demonstrate	TD-1, TD-2	Y	N	
RD-65		The application shall not allow trip additions to manifests that increase the time on-board for existing passengers to be more than a configurable number of minutes.	N,O, P	Analyze, Demonstrate	TD-7, TD-9, TD-14	N/A	TBD	Assumed feature of demand/response provider's current CAD/AVL software.
RD-66		When more than one (1) system (single or multiple agency environments) is involved in determining trip feasibility, required information shall be synchronized between systems every thirty (30) seconds.	N,O, P	Analyze, Demonstrate	TD-7, TD-9	Y	N	Frequency may be different depending on partner's system capabilities.
RD-67		The application shall post trips to the vehicle's electronic manifest on the vehicle MDT within 30 seconds of receiving a confirmed trip from the traveler.	N, O, P	Analyze, Demonstrate	TD-14	N	TBD	Assumed feature of demand/response provider's current CAD/AVL software.

Rqmt No.	Section	T-DISP Requirements	Operational Mode	Verification Method	User Need ID	Included in Ph. 1? (Y/N)		Notes/ Comments
						TMCC	Demand/ Response	
	3.2.2	**Customer-end System**						
RD-68		The application shall provide real-time information on the status of trip feasibility and the estimated time of arrival (ETA) of incoming and outgoing vehicles with an accuracy of at least 95% when the trip request is due within five (5) minutes.	N,O, P	Analyze, Demonstrate	TD-5, TD-15	Y	TBD	Assumed feature of demand/response provider's current CAD/AVL software.
RD-69		The application shall provide trip confirmation details to the traveler within a configurable number of seconds after the trip request submission.	N,O, P	Analyze, Demonstrate	TD-6	Y	Y	

Source: USDOT publication as annotated by Battelle

D-RIDE Functional and Performance Requirements

The D-RIDE application allows for a traveler to select a travel option that include private vehicles in the form of traditional carpooling, but with a dynamic ability to match driver / traveler trips thru the use of smartphone-based enabling technologies. Both riders and drivers alike will be able to create trips using services provided thru the ride-share partner and accessed via the IDTO Prototype application. As with T-CONNECT, the assessment of the D-RIDE Requirements includes both an indication of our inclusion or exclusion (Y/N) and notes or comments related to the decision. It should be noted that those requirements satisfied by the D-RIDE provider indicates the use of that provider's in-place software system, either as-is or modified to support IDTO. Those requirements satisfied by the TMCC will be included as part of the software components to be developed under the auspices of this project.

Table 4-3. D-RIDE Functional and Performance Requirements

Rqmt No.	Section	D-RIDE Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)		Notes/Comments
						TMCC	Ride-Share	
Functional Requirements								
	3.1.3.1	**Application User Interface**						
RR-1		The application shall communicate potential trips with drivers/riders via multiple communication methods (e.g., WiFi, cellular, Ethernet, etc.).	N, O, T	Demonstrate	DR-4, DR-5, DR-6, DR-9	Y	Y	
RR-2		The application shall identify current user location.	N, O, T	Test	DR-3, DR-4	Y	TBD	
RR-3		The application interface and data center shall communicate via a standard protocol relevant to the communication method used.	N, O, T	Inspect	DR-2, DR-4	Y	Y	
RR-4		The application shall provide a user interface to obtain customizable profile information from customers.	N, O, T	Demonstrate	DR-1, DR-3, DR-4, DR-5, DR-6, DR-9, DR-10	Y	Y	

Rqmt No.	Section	D-RIDE Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)		Notes/Comments
						TMCC	Ride-Share	
RR-5		The application shall accept multiple forms of payment.	N, T	Demonstrate	DR-7	N/A	Y	Fare is not a part of the demonstration, however the rideshare partner does support this requirement.
RR-6		The application shall provide a hands-free function-mode for use when driving.	N, O, T	Demonstrate	DR-6	N	N	This feature is not within the scope of the planned demonstration. No additional devices are anticipated for rideshare drivers.
RR-7		The application user interface shall track payment information with a payment system.	N, T	Analyze	DR-4, DR-7, DR-8	N	Y	See comment for RR-5.
RR-8		The application shall accept routing preferences from users.	N, T	Demonstrate	DR-10	Y	Y	
RR-9		The application shall provide an interface for rating ridematches after completion.	N, T	Demonstrate	DR-12	Y	TBD	
RR-10		The application shall provide the capability to push messages to both the rider and driver.	N,O,T	Demonstrate	DR-5	N	Y	TMCC will serve only to advise traveler of option. All trip bookings will occur within provider's system.

Rqmt No.	Section	D-RIDE Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)		Notes/Comments
						TMCC	Ride-Share	
	3.1.3.2	**Data (Control) Center**						
RR-11		The application data center shall optimize stored profile and geographic data to provide optimal ridematches for users.	N, O, T	Analyze	DR-3	N	N	Feature not demonstrated within scope of this project.
RR-12		The application data shall be integrated with a payment system.	N, T	Demonstrate	DR-4, DR-7, DR-8	N	Y	
RR-13		The application data center shall collect profile information from each traveler.	N, O, T	Demonstrate	DR-2, DR-4, DR-5	Y	Y	
RR-14		The application data center shall store profile information from each traveler.	N, O, T	Analyze	DR-2	Y	Y	
RR-15		The application data center shall collect preferred routings from each traveler (e.g., stop/start location, time of day, day of week).	N, T	Demonstrate	DR-2, DR-4	N	TBD	Feature will be demonstrated to the extent the rideshare partner's system supports this capability.
RR-16		The application data center shall store preferred routings from each traveler.	N, T	Analyze	DR-4	N	TBD	Feature will be demonstrated to the extent the rideshare partner's system supports this capability.

Rqmt No.	Section	D-RIDE Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)		Notes/Comments
						TMCC	Ride-Share	
RR-17		The application data center shall communicate with support agencies (e.g., departments of transportation, transit agencies, etc.) to pull information from agencies (e.g., schedules, vehicle locations).	N, O, T	Demonstrate	DR-4	N	N	Feature not demonstrated within scope of this project.
RR-18		The application data center shall have a back-end interface for viewing usage statistics for the application.	N, T	Demonstrate	DR-11	N	Y	Feature will be demonstrated to the extent the rideshare partner's system supports this capability.
Performance Requirements								
	3.2.3.1	**Application User Interface**						
RR-19		The application shall transmit any traveler data to the data center from the application within one (1) minute of receiving the original request.	N, T	Analyze	DR-5	Y	Y	
RR-20		The application shall determine a ridematch or lack thereof within five (5) minutes of the request being sent from the data center.	N, T	Analyze	DR-9	Y	Y	

Rqmt No.	Section	D-RIDE Requirements	Operational Mode	Verification Method	User Need ID	Included in Phase 1? (Y/N)		Notes/Comments
						TMCC	Ride-Share	
	3.2.3.2	**Data (Control) Center**						
RR-21		The data center shall transmit ridematches to ensure that riders are picked-up within a user-identified timeframe for the driver/vehicle to arrive.	N, T	Analyze	DR-9	N	N	Feature not demonstrated within scope of this project.
RR-22		The data center shall communicate the result of the ridematch search within five (5) minutes 99.5% of the time.	N, T	Analyze	DR-9	Y	Y	

Source: USDOT publication as annotated by Battelle

Chapter 5 Phase I Demonstration – Site Specific Requirements

This section identifies the new functional or performance requirements that are necessary as a result of the site-specific demonstration, as well as those needs specific to the IDTO Prototype experimental plan, the data gathering and sanitizing effort, the impacts assessment team needs, and the overall DMA program evaluation needs. These requirements are organized according to the respective demonstration partner and transportation services provided by these partners. Where possible, these requirements will be referenced back to the original user needs, or in the case of derived requirements, any background discussion that supports their existence.

Specific to this Prototype Development and Demonstration, the following new User Needs have been defined. These are based on additional capabilities that the IDTO bundle must exhibit during this prototype phase. The corresponding requirements that support these needs, as well as other derived needs follow.

Table 5-1. Prototype Demonstration Needs

Need ID	Prototype Needs
PD-1	The prototype must support the needs of both the impacts assessment contractor and the DMA evaluation contractor by logging trip information for both requested and fulfilled trips.
PD-2	Travelers and drivers (D-RIDE only) must register as a form of authentication.
PD-3	Any data submitted to US DOT shall not contain any Personally Identifiable Information (PII) or Sensitive Personally Identifiable Information (SPII).
PD-4	The IDTO application shall provide a traveler with all tools to support travel planning, booking and transfer using a mobile device.
PD-5	Partnering agencies must enable or extend current in-house tools to support integration with the IDTO application.
PD-6	The IDTO Prototype must be transferrable with minimal changes to a second location.

Source: Battelle

Table 5-2. Phase 1 Demonstration – System Requirements

Rqmt No.	Section	IDTO Prototype Requirements	Operational Mode	Verification Method	User Need ID	Notes/Comments
Functional Requirements						
	5.1	**IDTO Prototype System**				
	5.1.1	**Traveler Mobile Device**				
RP-100		The IDTO Prototype shall enable travelers to request trips using personal portable devices such as smart phones and tablet computers.	N,O,P,T	Demonstrate	PD-4	
RP-101		The IDTO Prototype shall support travel planning via other internet enabled devices.	N,O,P,T	Demonstrate	PD-4	T-CONNECT not supported in instances of non-mobile access.
RP-102		The IDTO Prototype shall allow the selection of a trip by the traveler.	N,O,P,T	Demonstrate	PD-4	
RP-103		The IDTO Prototype shall support registration of travelers.	N,O,P,T	Demonstrate	PD-2	
RP-104		The IDTO Prototype shall use location services to determine current location of traveler.	N,O,P,T	Demonstrate	PD-4	
RP-105		The IDTO Prototype shall determine if a traveler is on the expected mode of transportation for itineraries that include T-CONNECT options.	N,O,P,T	Demonstrate	PD-4	
RP-106		The IDTO Prototype shall receive status updates from the TMCC.	N,O,P,T	Demonstrate	PD-4	

Rqmt No.	Section	IDTO Prototype Requirements	Operational Mode	Verification Method	User Need ID	Notes/Comments
RP-107		The IDTO Prototype system shall require participant to read and acknowledge the risks and ramifications of participation in the study, i.e., the system shall require an informed consent from every participant)	N,O,P,T	Analysis	PD-3	
	5.1.2	**Travel Management Coordination Center**				
RP-107		The IDTO Prototype System shall obtain route and schedule information from each transportation provider.	N,O,P,T	Demonstrate	PD-5	
RP-108		The IDTO Prototype System shall obtain ETA data from each partner associated with a T-CONNECT protected transfer.	N,O,P,T	Demonstrate	PD-5	
RP-109		The IDTO Prototype System shall determine, through the application of a series of rules, when a T-CONNECT shall be issued to COTA.	N,O,P,T	Demonstrate	PD-4	
RP-110		The IDTO Prototype System shall identify and present in the order specified in traveler's profile, available trips that satisfy the travelers' request.	N,O,P,T	Demonstrate	PD-4	
RP-111		The IDTO Prototype System shall determine, through the application of a series of rules, when a T-CONNECT shall be issued to COTA.	N,O,P,T	Demonstrate	PD-4	
RP-112		The IDTO Prototype System shall log all traveler transactions.	N,O,P,T	Demonstrate	PD-1	
RP-113		The system shall encrypt at rest any and all PII subscriber data in the system.	N,O,P,T	Analysis	PD-3	

Rqmt No.	Section	IDTO Prototype Requirements	Operational Mode	Verification Method	User Need ID	Notes/Comments
		Administrative Portal				
RP-113 **5.1.3**		The IDTO Prototype System shall allow for the creation, modification and deletion of participants.	N,O,P,T	Demonstrate	PD-2	Participants include both travelers, and in the case of D-RIDE, it also includes drivers.
RP-114		The IDTO Prototype System shall allow for the creation of reports of the data collected.	N,O,P,T	Demonstrate	PD-1	
RP-115		The IDTO Prototype System shall export data in a de-identified manner for delivery to the RDE.	N,O,P,T	Demonstrate	PD-1	
RP-116		The IDTO Prototype System shall be capable of identifying traveler role (i.e. student, staff, and faculty).	N,O,P,T	Demonstrate	PD-1	TaxiCABS restriction to only OSU faculty.
RP-117		The IDTO Prototype System shall filter and/or obfuscate the origin of all subscriber data included in any report,	N,O,P,T	Demonstrate	PD-3	
	5.2	**T-CONNECT Provider (COTA Fixed-Route Service)**				
RP-200		The T-CONNECT Provider's system shall support the generation of the general transit feed specification (GTFS) data file.	N,O,P,T	Demonstrate	PD-5	
RP-201		The T-CONNECT Provider's system shall support the generation of the GTFS-Realtime data file.	N,O,P,T	Demonstrate	PD-5	
RP-202		The T-CONNECT Provider's system shall accept a T-CONNECT request from the TMCC.	N,O,P,T	Demonstrate	PD-5	
RP-203		The T-CONNECT Provider's system shall automatically process a T-CONNECT request for those that meet all agreed to conditions.	N,O,P,T	Demonstrate	PD-5	

Rqmt No.	Section	IDTO Prototype Requirements	Operational Mode	Verification Method	User Need ID	Notes/Comments
RP-204		The T-CONNECT Provider's system shall support the monitoring and/or cancelling of a T-CONNECT request by a dispatcher.	N,O,P,T	Demonstrate	PD-5	
RP-205		The T-CONNECT Provider's system shall provide an indication to the TMCC that a T-CONNECT was not accepted.	N,O,P,T	Demonstrate	PD-5	
RP-206		The T-CONNECT Provider's system shall incorporate the T-CONNECT duration into the current interface with the bus driver.	N,O,P,T	Demonstrate	PD-5	
RP-207		The GTFS –Realtime shall be provided at a rate of once (1) per minute.	N,O,P,T	Demonstrate	PD-5	
RP-208		The notification of a canceled T-CONNECT shall be sent to the TMCC within 30 seconds of the cancelation event.	N,O,P,T	Demonstrate	PD-5	
RP-208		The notification of a canceled T-CONNECT shall be sent to the TMCC within 30 seconds of the cancelation event.	N,O,P,T	Demonstrate	PD-5	
	5.3	**Fixed Route T-CONNECT 'Feeder' (OSU CABS)**				
PD-300		The incoming vehicle system shall support the generation of the general transit feed specification (GTFS) data file.	N,O,P,T	Demonstrate	PD-5	
PD-301		The incoming vehicle system shall support access to their BUS Time API to obtain vehicle position and ETA data.	N,O,P,T	Demonstrate	PD-5	
RP-302		The GTFS –Realtime shall be provided at a rate of once (1) per minute.	N,O,P,T	Demonstrate	PD-5	
	5.4	**Demand / Response Service (OSU TaxiCABS)**				
PD-400		The demand/response system shall provide availability information when requested by the TMCC.	N,O,P,T	Demonstrate	PD-5	

Rqmt No.	Section	IDTO Prototype Requirements	Operational Mode	Verification Method	User Need ID	Notes/Comments
PD-401		The demand/response system should accept a booking from the TMCC.	N,O,P,T	Demonstrate	PD-5	
	5.5	**Private D/R T-CONNECT 'Feeder' (Capital Trans.)**				
PD-500		An in-vehicle device, based on a wireless tablet device, shall be configured to serve as an MDT and AVL system for the fleet of buses.	N,O,P,T	Demonstrate	PD-5	
PD-501		The private demand/response MDT shall support the generation of vehicle position data that is provided to the TMCC at a configurable rate..	N,O,P,T	Demonstrate	PD-5	
RP-502		The private demand/response driver shall request T-CONNECT protection on behalf of the ridership.	N,O,P,T	Demonstrate	PD-5	
RP-503		The private demand/response system shall report status of transfer to the driver.	N,O,P,T	Demonstrate	PD-5	
	5.6	**Rideshare Provider (Zimride)**				
PD-600		The rideshare system shall provide availability information when requested by the TMCC.	N,O,P,T	Demonstrate	PD-5	
PD-601		The rideshare system should accept a booking from the TMCC.	N,O,P,T	Demonstrate	PD-5	
PD-602		The rideshare system shall provide a means to authenticate riders and drivers.	N,O,P,T	Demonstrate	PD-2	

Source: Battelle

Chapter 6 Software Architecture

Building on the Requirements that have been expressed for the Phase 1 Prototype demonstration, this chapter documents a software architecture that defines the functions included for the IDTO Prototype and each partner; the interfaces between the traveler, the various partner systems, and the evaluation teams; as well as the interfaces and components internal to the core IDTO Prototype component (aka the TMCC). This section is organized to first show the high level interfaces between the various entities. Next, the details of the functions embodied in the prototype application will be discussed. And finally, the detailed representation and discussion of specific dialogs that exist between the various entities are detailed.

System of Interest for Phase 1

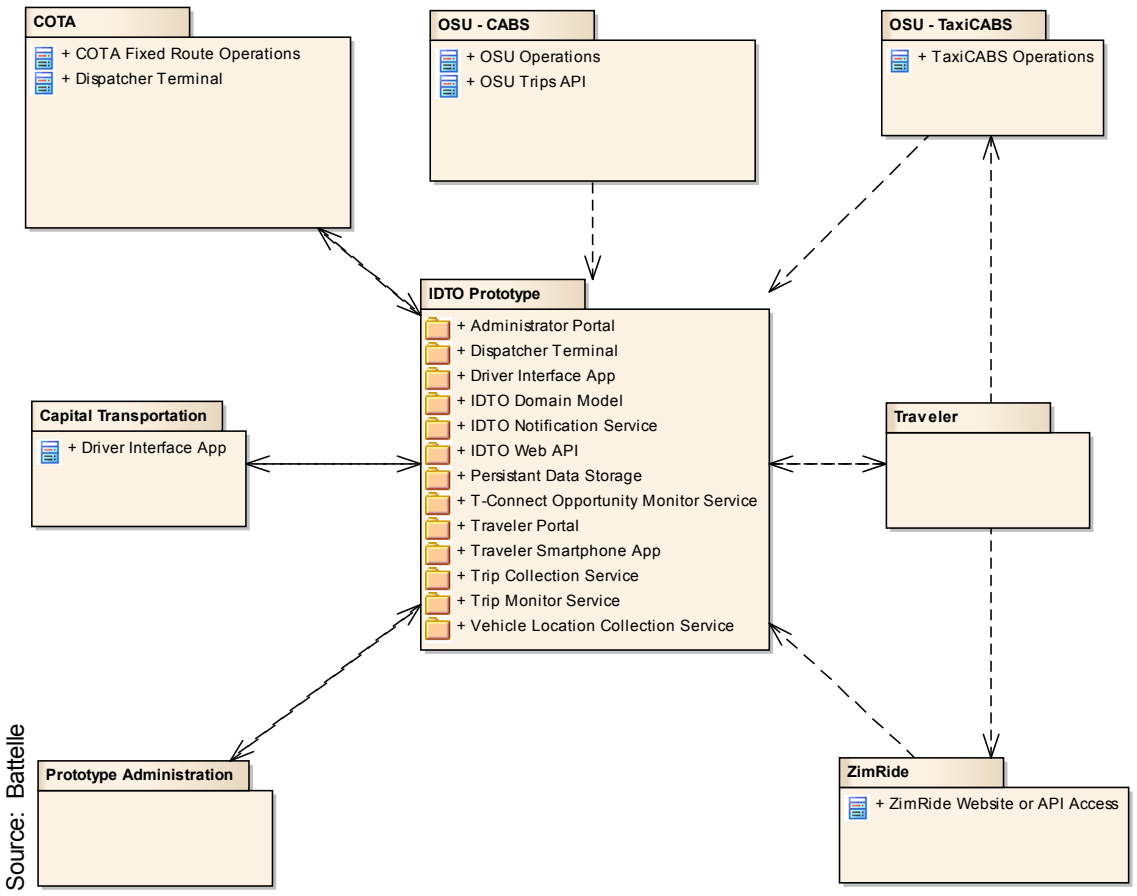


Figure 6-1. System of Interest for Phase 1

Figure 6-1 represents the high-level relationship between each of the entities (partners) that will be integrated in the Phase 1 demonstration. In the center is located the 'IDTO Prototype', or as also identified, the TMCC. The IDTO Prototype serves as the conduit through which nearly all traveler interactions take place. As can be seen in this same figure, with the exception of the relationship of the traveler with both TaxiCABS and Zimride, all other interfaces exist only thru the IDTO Prototype. Notice too that some of the interface arrows are bi-directional, while others are uni-directional. This directionality represents the type of dialog the underlying systems of the two respective parties are expected to maintain. Table 6-1 summarizes each of the interfaces. Note: The interface description marked with an asterisk (*) indicate a proprietary interface that will be developed in order to enable the IDTO Prototype. All others interfaces are intended to be open and when possible, industry standard interfaces.

Table 6-1. Level 1 Entities

Provider	Role	S/W Vendor	Notes
COTA	T-CONNECT Provider	Trapeze	Trapeze will be responsible for modifying their CAD/AVL system, as currently operated by COTA, to support generation of GTFS-Realtime as well as T-CONNECT interfaces.
OSU CABS	T-CONNECT Feeder	Clever Devices & In-House	Battelle/OSU will work collaboratively to obtain the necessary vehicle location data from OSU.
OSU TaxiCABS	Demand / Response	Trapeze	Trapeze will be responsible for modifying their CAD/AVL system, as currently operated by OSU, to support interface to schedule availability and possibly booking.
Traveler	System User	IDTO-Provided	Android, iPhone or web-enabled application built as part of the IDTO Prototype.
Zimride (Ridesahre)	Rideshare	In-House	No changes necessary to their current in-house software. Interface with IDTO will be minimal, and re-direct to their system.
Prototype Administration	System User	IDTO-Provided	Part of the TMCC built under this project.
Capital Transportation	Private Demand/Response	IDTO-Provided	Part of the IDTO prototype software to be built under this software.

Source: Battelle

Table 6-2. Level 1 Interfaces

Source	Destination	Type	Description
COTA (T-CONNECT Provider)	IDTO Prototype	Bi-directional	GTFS Data, T-Connect dialog*
OSU CABS (T-CONNECT Feeder)	IDTO Prototype	Uni-directional	GTFS Data
OSU TaxiCABS (Demand / Response)	IDTO Prototype	Uni-directional	Dispatch Data*
Traveler	IDTO Prototype	Bi-directional	Trip Planning data, T-CONNECT status, etc.
Zimride (Ridesahre)	IDTO Prototype	Uni-directional	Ride availability*
Prototype Administration	IDTO Prototype	Bi-directional	Traveler accounts, reports, data capture, log management
Capital Transportation	IDTO Prototype	Bi-directional	AVL Data
Traveler	OSU TaxiCABS	Uni-directional	Trip Planning
Traveler	Zimride	Uni-directional	Trip Planning

Source: Battelle

Detailed Architecture of the IDTO Prototype Application

As can be inferred from the previous section, the focus of the software development effort to be performed for the IDTO Prototype lies with the IDTO Prototype entity. The IDTO Prototype serves to manage all interfaces between the various partners and the user, provide trip planning capability, house the T-Connect logic, and support logging needs associated with the evaluation. As Figure 6-2 illustrates, the software of the IDTO Prototype will be composed of multiple components. Each component can be further categorized into one of three system layers: "Presentation," "Logic," or a "Data," as described below. Collectively, as illustrated in Figure 6-2, these three layers will comprise the IDTO Prototype Application system.

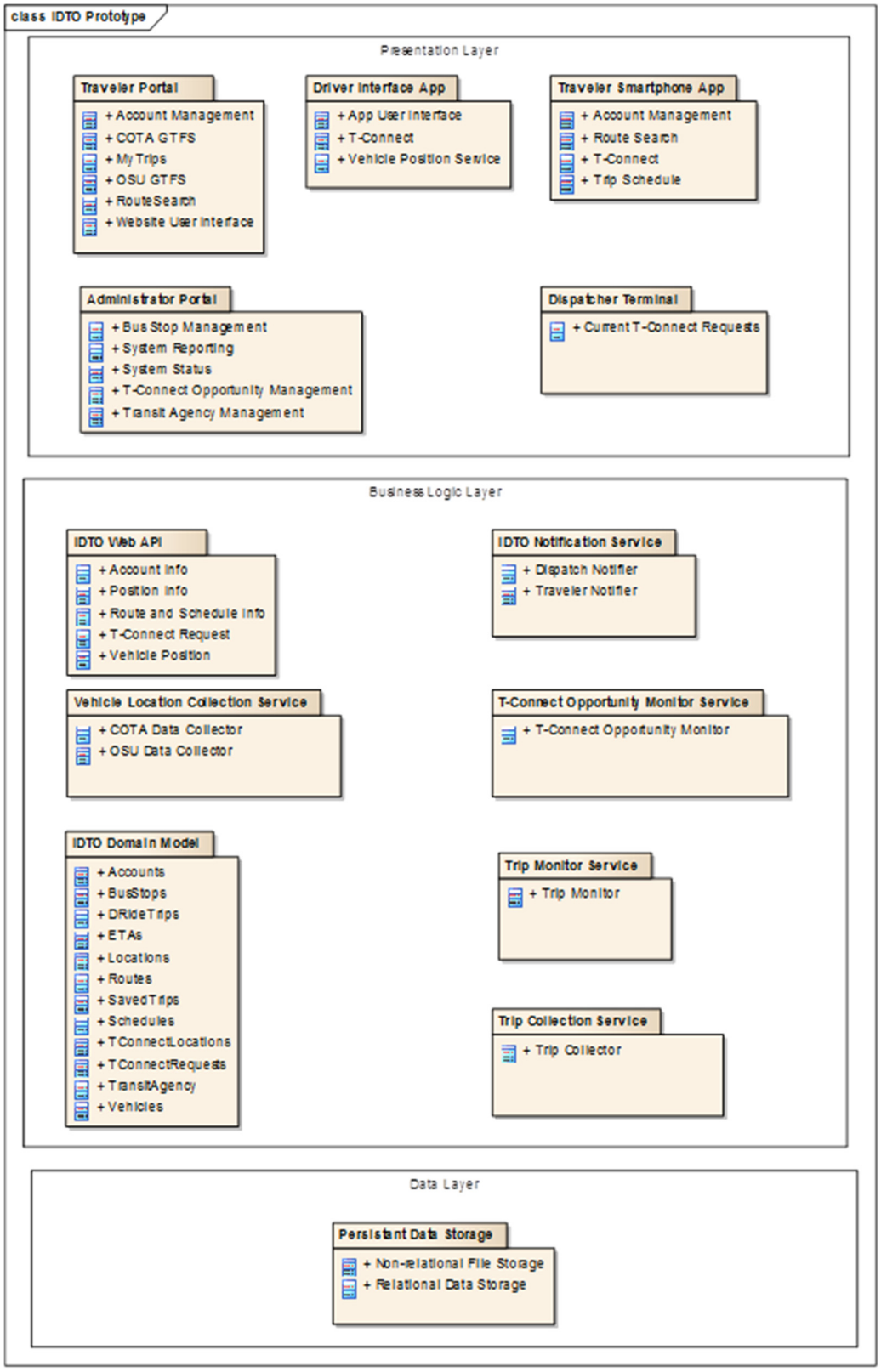
The **Presentation Layer** will be responsible for the portion of the IDTO Prototype that is visible to participants and transit operators. The software components envisioned in the presentation layer allow travelers to have a choice of accessing the IDTO Prototype Application system either from a fixed internet access device such as a laptop or desktop or the presumed more common method via a smartphone or tablet. Direct access by the traveler or administrator will be through a website portal. Users making travel requests from their mobile phone will be presented with a user interface and user experience consistent with the selected mobile device platform. Common functionality and data access methods between the multiple mobile experiences will be consolidated into an Application Programming Interface (API) implemented as a web service.

The **Logic Layer** components make the decisions and act upon the requests and messages received by the Presentation Layer. Separating the Logic Layer components from the components of the Presentation Layer allows for modification or expansion to other platforms with minimal effect on the code that performs the core functionality of the system. For the IDTO Prototype Application, the software components that will perform the route management, trip route selection, traveler account management, and data logging will be key features of the Logic Layer.

A key element to be incorporated into the Logic Layer is to leverage existing open-source trip planning solutions. Both Google Transit and OpenTripPlanner (OTP) are potential options to satisfy this need. When the solutions and extended by the Battelle team, and combined with customized mobile applications developed under this project, the combination will fulfill the needs expressed for the IDTO Prototype (aka TMCC).

The **Data Layer** components will serve as the location where all IDTO Prototype data will be persisted. Traditional relational databases will be used to provide the majority of the data storage load, but newer, more efficient and less expensive storage methods found in cloud-based data warehouses such as "blobs" and "queues" will be used to the extent possible.

Associated with each of these layers are a series of 'packages'. These packages represent the different organization of functions that each subcomponent of the system must provide. Details of these packages will emerge as the design of the system is further matured in the next phases of this project.



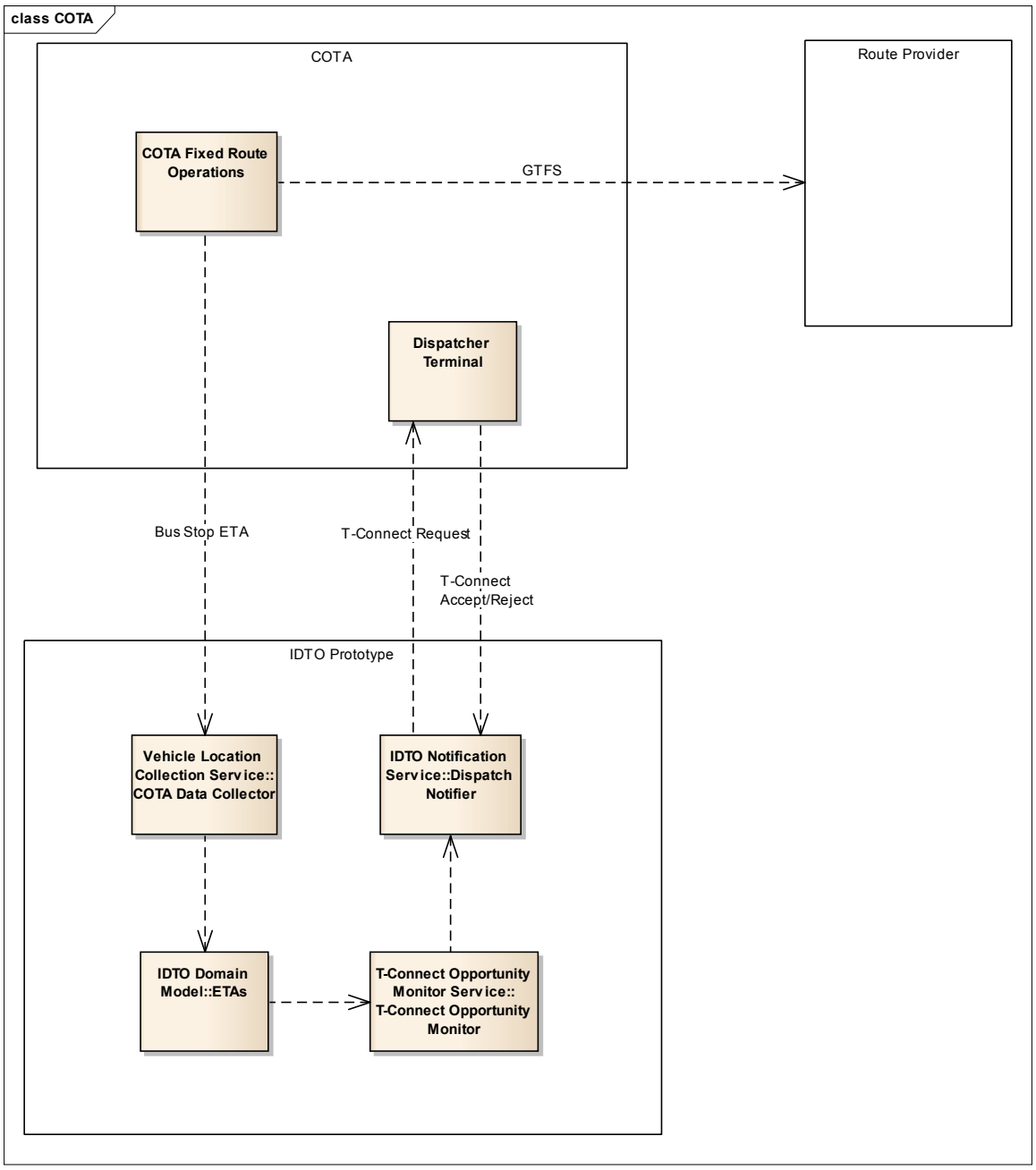
Source: Battelle

Figure 6-2. Detailed IDTO Prototype Multi-Layer Architecture

Interface with the T-CONNECT Provider (COTA)

The IDTO Prototype Application will interface with COTA via several distinct dialogs. Figure 6-3 identifies the specific interfaces and the functionality associated with these interfaces. As shown, Bus Stop ETA from COTA's Fixed Route Operations software (aka Trapeze Novus ITS product) is provided to the IDTO Prototype in the form of GTFS-Realtime. The Vehicle Locations Collection Service within the Prototype then persists this information in the ETA database. The T-CONNECT Opportunity Monitor Service, which serves to monitor traveler transfer requests along with incoming and outgoing buses, uses this ETA data to formulate any necessary T-CONNECT. If a T-CONNECT is warranted, the IDTO Notification Service communicates the T-CONNECT request to the Dispatcher Terminal, where the T-CONNECT is either accepted or denied. A return notification from the Dispatcher Terminal to the IDTO Notification Service completes this transaction.

In parallel with these exchanges, GTFS data is also being made available to the Route Provider (aka Open Trip Planner) to support traveler's trip planning needs.



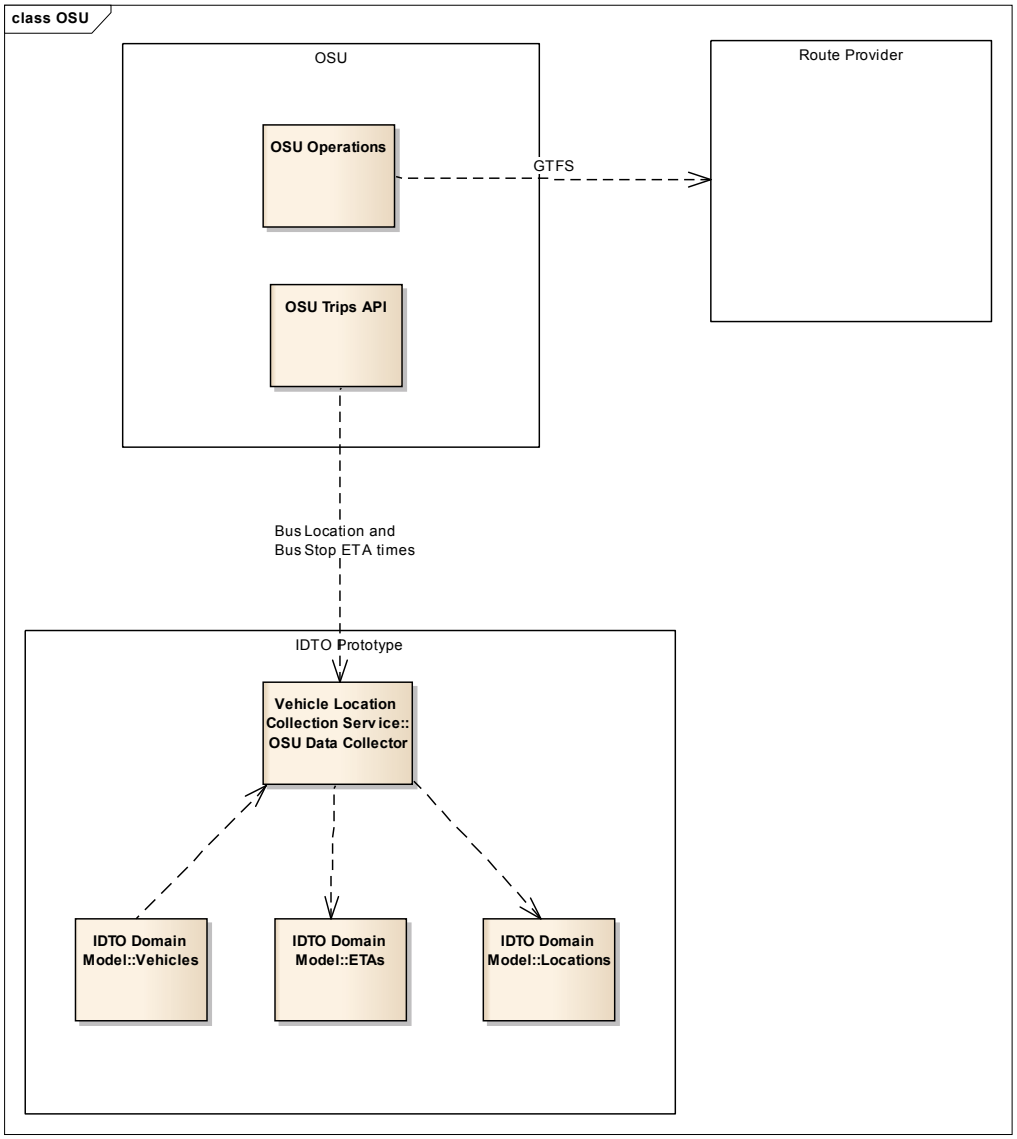
Source: Battelle

Figure 6-3. Interface with COTA

Interface with Incoming Fixed-route Service (OSU CABS)

The IDTO Prototype Application will interface with CABS via several distinct dialogs. Figure 6-4 identifies the specific interfaces, and the functionality associated with these interfaces. As shown, Bus Location and Bus Stop ETA from OSU's TRIPS API (as provided by Clever Devices) are provided to the IDTO Prototype in the form of RESTful Web service calls. The Vehicle Locations Collection Service within the Prototype then persists this information in the underlying database where it will be used by other services within the IDTO Prototype. These services include the T-CONNECT Opportunity Monitor Service, which serves to monitor traveler transfer requests along with incoming and outgoing buses and issues any necessary transfer protection request.

In parallel with the exchange from TRIPS to the IDTO Prototype, GTFS data is also being made available to the Route Provider (aka Open Trip Planner) to support traveler's trip planning needs.



Source: Battelle

Figure 6-4. Interface with OSU CABS

Interface with Demand / Response (OSU Taxi CABS)

The IDTO Prototype Application will implement a single interface with the OSU TaxiCABS provider. Figure 6-5 identifies the specific interface, and the functionality associated with this interface. As shown, Schedule data from OSU's TaxiCABS operations (as provided by Trapeze) is provided to the IDTO Prototype in an as yet unspecified format. The Trip Collection Service within the Prototype then transforms this information to provide the traveler with possible trip options.

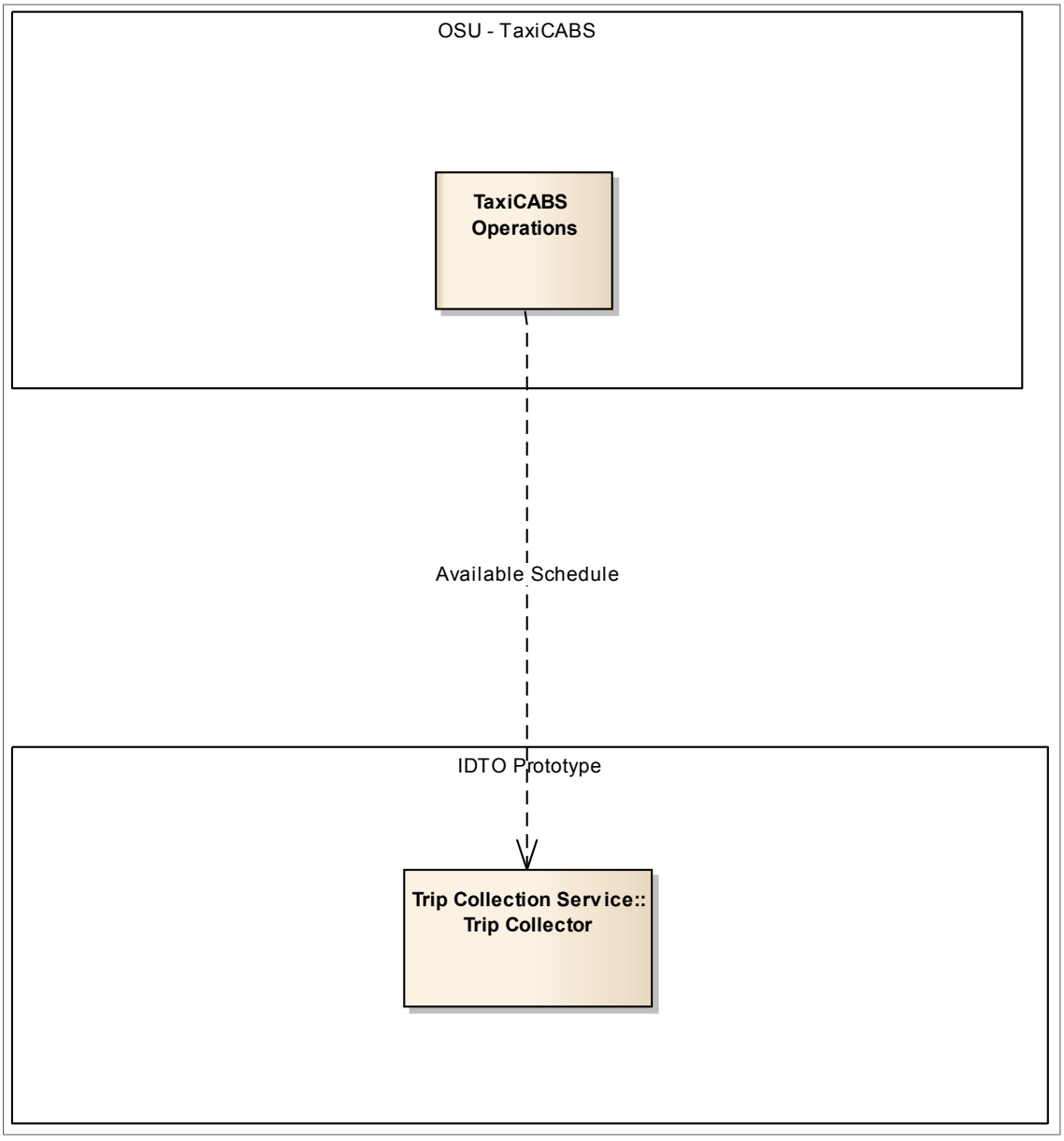
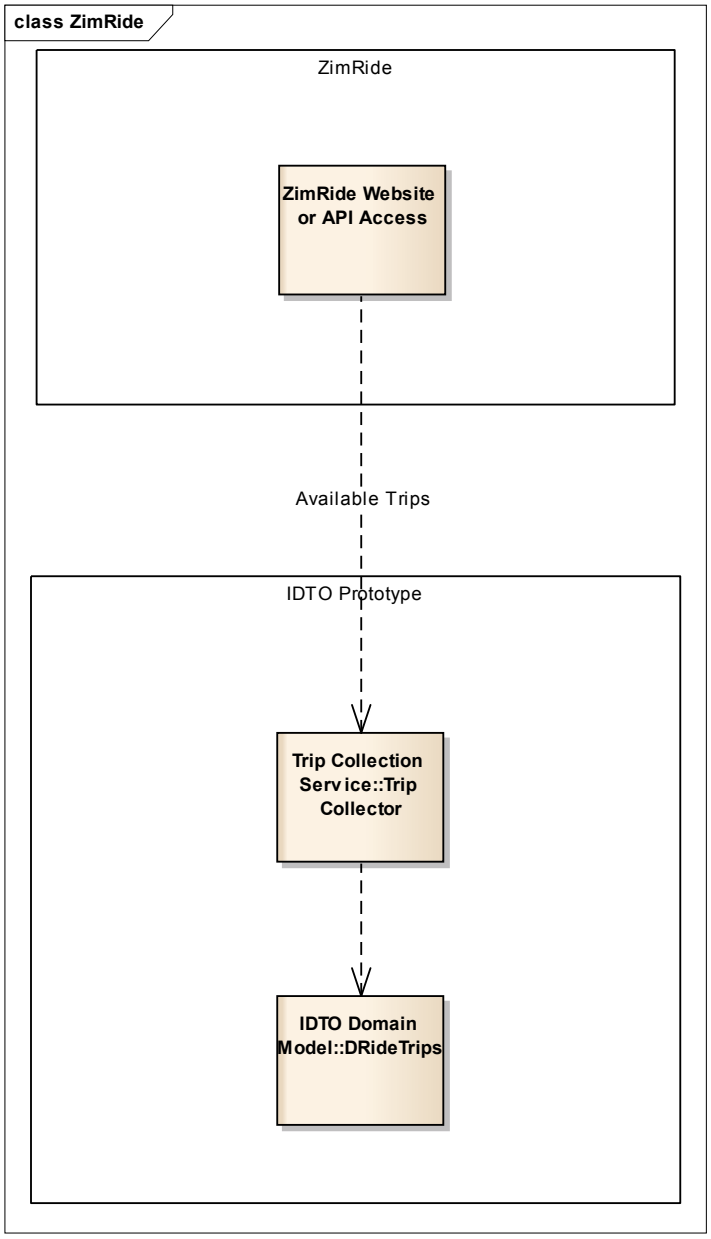


Figure 6-5. Interface with OSU TaxiCABS

Interface with Rideshare System (Zimride)

The IDTO Prototype Application will implement a single interface with Zimride. Figure 6-6 identifies the specific interface, and the functionality associated with this interface. As shown, Trip data from Zimride Website is provided to the IDTO Prototype in a TBD format. The Trip Collection Service within the Prototype then persist this data in the underlying Data Layers. Available trips will then be made available for travelers to select as possible route alternatives.



Source: Battelle

Figure 6-6. Interface with Zimride

Interface with Private Incoming Service (Capital Transportation)

The interface between Capital Transportation and the IDTO Prototype represents the most complex of the interfaces included in the Phase 1 Demonstration. It not only provides incoming vehicle data similar to that from an OSU CABS bus, but the Capital Transportation interface also implements the T-CONNECT request services from a mobile device which will be mounted in the shuttle.

As such, the IDTO Prototype Application will interface with Capital Transportation via several distinct interface and dialogs. Figure 6-7 identifies the specific interfaces, and the functionality associated with these interfaces.

Starting from the left, Vehicle Position data is provided to the IDTO Web API, where it is then persisted in the underlying data layer. The Vehicle Position Data is acquired from the in-vehicle mobile device (aka MDT) that will be provided to Capital Transportation as a part of this effort.

Moving right, the second set of interfaces and corresponding dialogs involves the request and notification of T-CONNECTs. As shown, a T-CONNECT request is made by the Driver Interface Application housed in the Capital Transportation shuttle. This request is handled by the IDTO Web API, which forwards the request to the underlying database. The T-CONNECT Opportunity Monitor (TOM) (not shown) then uses this data, along with vehicle position data, etc., to formulate T-CONNECT request to COTA. The IDTO Web API monitors the results of the TOM, and reports the status of the T-CONNECT back to the Driver Interface App.

At the far right, two additional interfaces necessary to support the in-vehicle MDT application are provided. These consist of the Bus Schedule and the Supported Bus Stops. Both of these message flows are generated by the IDTO Web API: Route and Schedule Info service, which obtains data form the underlying database.

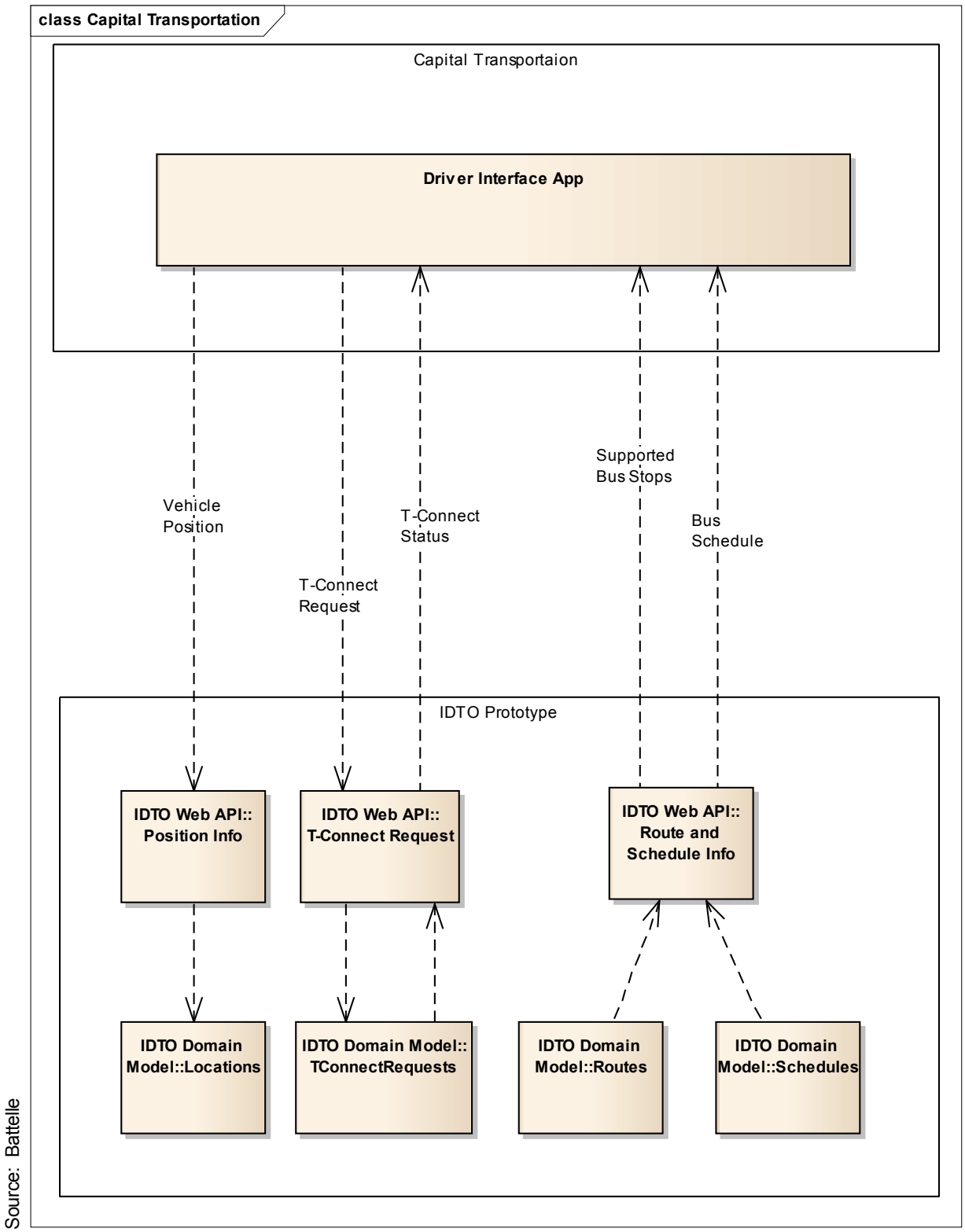


Figure 6-7. Interface with Capital Transportation

Interface with Traveler

The interface between a traveler and the IDTO Prototype and supporting services takes many shapes, but it consists primarily of four (4) distinct information exchanges.

The traveler must first create a profile which establishes trip preferences and provides a mechanism by which the T-CONNECT can be implemented for the traveler. This capability is referred to as Account Management and is supported via both the Traveler Smartphone APP and the Traveler Portal.

Upon establishing an account, the Traveler would next perform route searches. This again is enabled via both the Smartphone App and the Web Portal. Route Searches would access the Route Provider (not shown) to query and present available options.

A Traveler then may 'book' or save a trip, in which case, the trip is saved and subsequently monitored for adherence to the schedule. A critical design outcome is such that a traveler must be validated as being on the designated incoming bus in order for T-CONNECT transfers to be protected.

Finally, complimenting the certainty of a traveler being on the associated carrier, the system will provide trip status information to the traveler. In particular, this will focus on the status of T-CONNECT request.

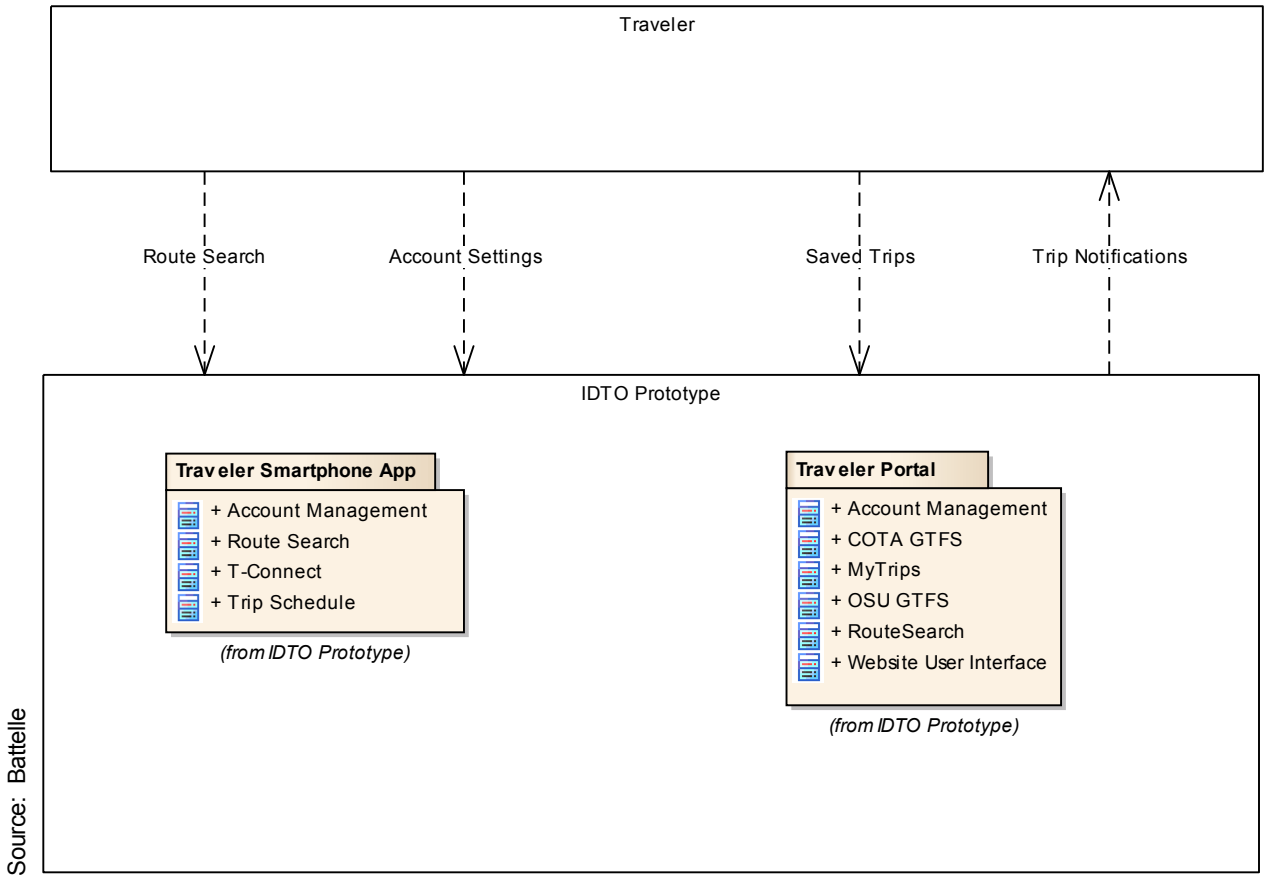


Figure 6-8. Traveler Interfaces

Chapter 7 Glossary and List of Abbreviations

ConOps: The Concept of Operations document results from a stakeholder view of the operations of the system being developed. This document will present each of the multiple views of the system corresponding to the various stakeholders. These stakeholders include operators, users, owners, developers, maintenance, and management. This document can be easily reviewed by the stakeholders to get their agreement on the system description. It also provides the basis for user requirements.

IDTO: A collection of high-priority transformative applications identified by the USDOT's Dynamic Mobility Program. The IDTO bundle of applications consists of the T-CONNECT, T-DISP and D-RIDE applications, as described below.

T-CONNECT: The 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. The system will take into account the overall state of the system, including connection protection requests made by others as well as real-time and historical travel conditions for the services affected, and pre-determined connection protection rules agreed upon by participating agencies and transit modes. The system will then continue to monitor the situation and provide connection protection status updates to the travelers as appropriate.

In addition, travelers onboard of affected 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, indicating the vehicle is holding for an additional x minutes for other travelers.

T-DISP: The application will advance the concept of demand-responsive transportation services utilizing the global positioning system (GPS) and mapping capabilities of personal mobile devices to enable a traveler to input a desired destination and time of departure tagged with their current location. 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. For example, if a paratransit vehicle is not available, a traveler would be given information on fixed-route service or connected to a private service.

The application may consider a common platform that allows people to effectively communicate and access shared transportation resources more readily than currently occurs. The platform would provide a transit exchange that allows prospective travelers and vehicle operators to trade in a transparent market on demand for optimal mobility solutions without advanced notice.

The application may consider real-time traffic conditions to dynamically route vehicles as necessary (i.e., to select the optimum route), and real-time vehicle capacity to dynamically assign or remove vehicles from service as necessary. It would accommodate dispersed origin-destination trips and trips in low density, low ridership areas, and may replace some late night or mid-day fixed-route service. The application would apply the best practices learned from the USDOT Mobility Services for All Americans (MSAA) initiative.

D-RIDE: This application will make use of 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. Dynamic ridematching technology already exists for hand-held mobile applications (iPhone, SMS text enabled phones, etc.) but that technology has yet to find widespread use. Using a hand-held device for communicating one's ridesharing needs is fine for passengers but is not ideal for drivers due to the devices' hands-on nature that can lead to distracted driving. By integrating carpooling functions into a vehicle computer, voice activated ridesharing technology can be built into the vehicle's interface enabling the driver to find and accept potential ridematches along his/her route without having to divert concentration from the roadway. By combining existing mobile ridesharing applications with in-vehicle and roadway based technology, a number of problems associated with carpooling can be solved.

Although vehicles can currently sense the weight of passengers so as to activate or deactivate air bags, it is difficult to accurately verify the true load of a vehicle. Variations of the proposed application can be used by HOV/HOT enforcement agencies to verify vehicle occupancy. Additionally, it may be possible to reduce a toll for each additional passenger in the vehicle instead of a single-preset discount whether the vehicle is carrying two, three, or four passengers.

List of Abbreviations and 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
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
US DOT	United States Department of Transportation

U.S. Department of Transportation
ITS Joint Program Office-HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free “Help Line” 866-367-7487
www.its.dot.gov

FHWA-JPO-14-166

U.S. Department of Transportation