

***Concept of Operations for
Development and Demonstration for Dynamic Transit
Operations System
Using Connected Vehicle Technologies***

Version 1.0

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1 Introduction

Transit service has been very cost ineffective and the level of service, when measured by connectivity and service frequency, has been generally undesirable in the majority of suburban regions in California. The recent development of Connected Vehicle technologies (broadly defined as communication and positioning technologies) and real-time information about the overall transportation systems (both transit and highway networks) has begun to make dynamic transit operation feasible. Dynamic transit operations, including Dynamic Dispatch (T-DISP), Connection Protection (T-CONNECT) and Dynamic Ridesharing (D-RIDE) can substantially improve transit service quality by providing faster, more convenient, and cost effective trips to the traveling public. T-CONNECT application scenarios are intended to improve the successful transfer between mode (from car to bus, train to bus) and between different bus routes of an individual agency. T-DISP application scenarios are intended to adjust transit operation to be more responsive to travelers demand and traffic conditions. D-RIDE offers travelers to share their rides to connect to/from public transportation.

UC Berkeley California Partners for Advanced Transportation Technologies (PATH) in partnership with Tri Delta Transit (TDT), Contra Costa County Transportation Authority (CCCTA) and California Department of Transportation (Caltrans) to develop an Integrated Dynamic Transit Operation (IDTO) prototype system that enables T-DISP and T-CONNECT services as well as real-time information for transit operations and travelers. This prototype IDTO will be tested and demonstrated for at Tri Delta Transit. IDTO will eventually allow transit agencies to become a faster and better transportation option that attracts more travelers, reducing the transit operation costs, and allow public transit to assume a greater role in the overall solution to reduce transportation congestion, increase safety, and improve air quality. This development efforts of IDTO can lead to transforming some of the current fixed route operation into dynamically focused transit services in suburban regions across California.

1.1 Statement of Problem

In the majority of the suburban regions in the United States, transit service has been very cost ineffective and the level of service, when measured by connectivity and service frequency, has been generally undesirable. There are many barriers that prevent commuters from choosing transit as an alternative travel mode.

First mile and last mile connectivity

As transit riders are spread over a larger low population areas and are served with small number of buses, transit stops must locate in what are believed to be central locations based concentration of transit travelers identified using the census data and from the historical passenger count data and prior experience. As a result, bus stops are typically not reachable by foot for majority of suburban travelers.

Service routes

Except for a small number of commute oriented express services (but may account for relative large percentage of riders), majority of the suburban transit routes are designed to stop by larger

set of stations to increase coverage areas therefore they are not designed for typical commute purposes. As a result, trips on these routes takes too long for a commuter to reach ones destination.

Service frequent

The suburb transit operation usually use fixed route scheduled based operations with service interval spaced out at 20 min to 30 min and sometimes 60 min apart. Commuters would have to work with transit schedule and once missing a bus, they would have to wait for the next bus that is many minutes away. Transit on-time performance is also an important factor. Furthermore, even when provided all options, travelers are concerned about the reliability of the services, particularly when it involves transfers between modes or between buses. Frustration over missing scheduled transit connections or significant delays of the buses can cause “occasional” riders to use transit less often.

Lack of real-time information

Real-time information has become a great tool for transit riders. However, for non-traditional transit riders, lack of knowledge about transit options still present a big challenge. Travelers usually do not know the full range options available to them for making an alternative trip decision.

Enabling innovative means to link travelers’ needs (demand) with transit capacity and to dynamically make operational adjustments to meet travelers needs has great potential to enhance the quality of transit service, improve customers’ satisfaction level, and to attract “occasional” riders or “choice” drivers to use transit more often.

1.2 Overview of this Research Project

This project is to develop a fully functional Integrated Dynamic Transit Operation (IDTO) prototype system that enables T-DISP, T-CONNECT and D-RIDE services as well as real-time information for transit operations and travelers. This prototype IDTO will be tested and demonstrated with limited scale at Tri Delta Transit agency in this phase of the project. The field testing will collect rich set of data to evaluate the benefits and impacts and IDTO. Should the results are promising, additional test sites including bus stops, routes and connecting points within the transit agency will be further implemented and tested in full scale in the following phase.

In this project, we will stress using a combination of innovative real-time data capture and data management methodologies to enable improved dynamic transit applications. IDTO provides improved level of service to passengers and supports enhanced transit operations by enabling travelers to *interact* with transit systems on trip options and real-time needs. This results in better passenger service and will expand the horizon for public transit management, offering the opportunity to both improve service level and facilitate better operational and planning decisions.

The IDTO system will be field tested at at least two test routes and multiple bus stops within Tri Delta Transit service areas.

1.3 Document Overview

This document describes the Concept of Operation (ConOps) for a **Dynamic Transit Operations System to be implemented and tested at Tri Delta Transit**.

The ConOps describes the goals, functions, key concepts, architecture, operational scenarios, operational policies, and impacts of interactive transit station information systems. A summary of benefits and costs follows the ConOps description. This document follows the outline provided by IEEE Standard 1362-1998, with small variations to reflect the nature of the specific system under study.

The ConOps will be a basis for the research, development and field testing of IDTO. It is expected that this ConOps will be updated while progress is made under this project. The updated ConOps will serve as a tool for transit technology developers to develop IDTO related technologies and for transit agencies to implement IDTO.

This document is organized as follows:

Section 1, Introduction provides the context for developing a concept of operations for IDTO.

Section 2 Reference provides acronyms and cited references.

Section 3, Current Situation reviews state-of-the-practice of bus stop operations and existing deployments of traveler information systems.

Section 4, Motivation for IDTO describes the needs for IDTO and how IDTO addresses these needs.

Section 5, Concept of Proposed IDTO summarizes the goals, functionalities and the key concepts of IDTO and provides a proposed system architecture.

Section 6, Operational Scenarios summarizes the operational scenarios, information needs, and functionality associated with the IDTO.

Section 7, Summary of Impacts analyzes the operational policies, the operational and organizational impacts, and benefits and costs of the IDTO.

Section 8, Analysis of the Proposed IDTO provides a summary of IDTO and disadvantages/limitations of this system.

2 References

2.1 Acronyms and Definitions

APC	Automated Passenger Counting
AVL	Automatic Vehicle Location
BART	Bay Area Rapid Transit
Caltrans	California Department of Transportation
ConOps	Concept of Operations
CPUC	California Public Utilities Commission
D-RIDE	Dynamic Ridesharing
FOT	Field Operational Test
FTA	Federal Transit Administration
GPS	Global Positioning System
DTO	Dynamic Transit Operation
IDTO	Integrated Dynamic Transit Operation
ITS	Intelligent Transportation System
O-D	Origin-Destination
PATH	California Partners for Advanced Transportation Technology
PeMs	Caltrans Performance Measurement System
T-CONNECT	Connection Protection
T-DISP	Dynamic Transit Operations

2.2 References

[1] “IEEE Guide for Information Technology --- System Definition --- Concept of Operations (ConOps) Document”, IEEE Standard 1362-1998.

3 Current Situation

3.1 Commute Profile within the Test Site Region

82% of all Contra Costa County commuters travel by car (64% drive alone and 18% carpool) and 15% use public transportation; the average one-way commute time is 35 minutes for an average commute distance of 22 miles¹. Although the commute patterns vary among the regions of East and Central Contra Costa and Tri-Valley, there are several common characteristics.

- 45% of Tri Delta Transit customers are frequent users who ride a bus 5+ days per week². Of those frequent users, many are “transit dependent” (i.e., lacking access to a car).
- 40% Tri Delta Transit need to make at least one transfer during their trip.
- 10% of all Tri Delta Transit trips transferring to/from BART accounts for the most frequent inter-system transfers.

3.2 Overview of Transit Operation at Tri Delta Transit

The proposed demonstration site is in the Eastern Area of Contra Costa County in the San Francisco Bay Area, including the communities of Bay Point, Pittsburg, Antioch, Oakley, Brentwood, Discovery Bay and Byron (see Figure 1). Tri Delta Transit, also known as Eastern Contra Costa Transit Authority (ECCTA), is the local public transit transportation provider for the proposed demonstration site with a population of about 280,000 residents in the 225 square miles of Eastern Contra Costa County. Tri Delta owns a total of 96 revenue vehicles, including 67 fixed-route buses, 23 Dial-a-Ride buses and 6 med-vans. All buses are wheelchair accessible. Tri Delta Transit operates 13 weekday local bus routes (including express route 300) and four local bus routes on weekends and holidays to serve more than 650 bus stops, and door-to-door bus service (Dial-a-Ride) for senior citizens and people with disabilities. Tri Delta Transit provides nearly 10,000 rides per day on fixed-route service and over 300 rides per day on Dial-a-Ride.

¹ MTC. Commute Profile 2005, Region Report.

² Tri Delta Transit. 2012 Passenger Survey Report.

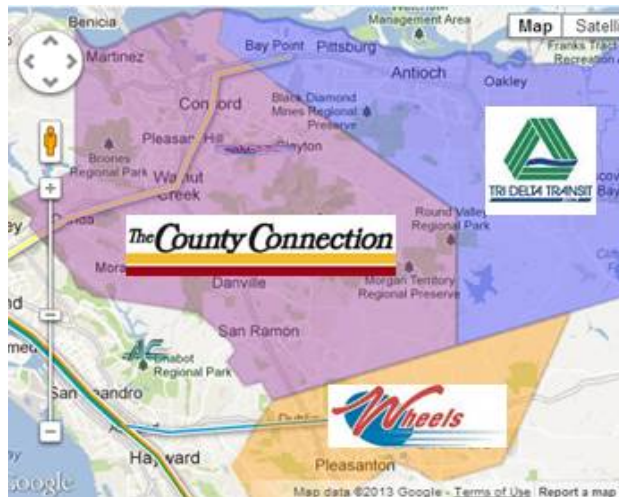


Figure 1 Bus Transit Map of Proposed Demonstration Site



Figure 2 Rail Map of Proposed Demonstration Site

Tri Delta Transit provides, in addition to serving patrons who travel within the service area, transit connection service to adjacent areas and other public transit transportation providers to move travelers to other regions in the San Francisco Bay Area (see Figure 2). Tri Delta Transit local buses connect to the Bay Area Rapid Transit (BART) system at Pittsburg/Bay Point and Concord, Amtrak Capitol Corridor trains at Martinez, and with transit agencies County Connection at shared bus stops.

Tri Delta Transit operates along State Highway 4 corridor, which suffers recurrent congestions during the peak periods. The Caltrans Performance Measurement System³ (PeMS) collects loop detector data and estimates real-time traffic conditions. In addition, a number of FasTrak readers⁴ are installed along the major freeways to collect point-to-point travel time. The archived loop data and point-to-point detector data are being used to forecast driving times for about 90% of the Bay Area freeway network⁵. Real-time traffic conditions, incidents, and travel time forecasts are currently available to the public through '511 SF Bay' Web APIs⁶. Figures 3 and Figure 4 illustrate typical midweek (Tuesday to Thursday) morning and afternoon peak freeway conditions.

³ <http://pems.dot.ca.gov>

⁴ <http://traffic.511.org/index#TRIP>

⁵ <http://www.mtc.ca.gov/news/transactions/ta02-0307/predict-a-trip.htm>

⁶ <http://511.org/developer-resources.asp>

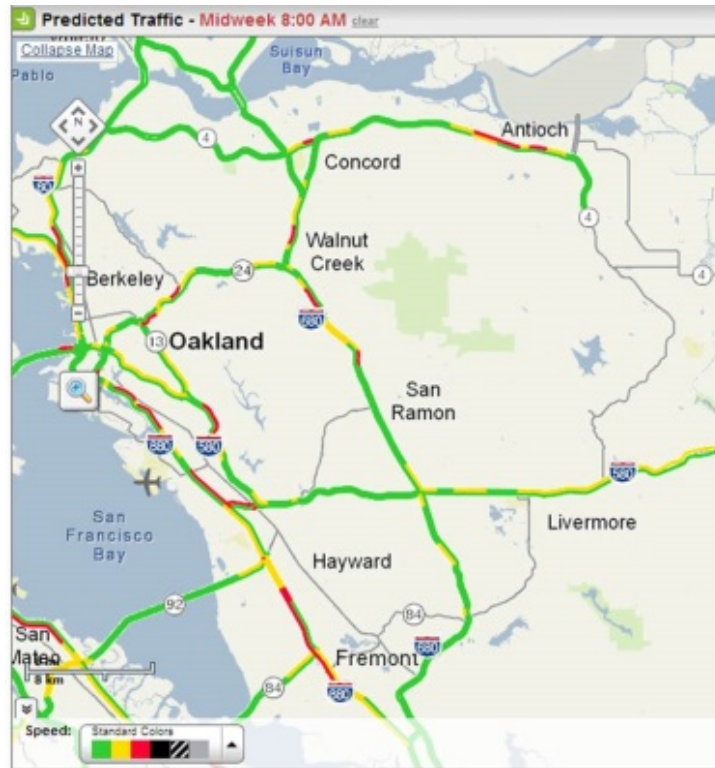


Figure 3 Typical Midweek Freeway Conditions at 8AM

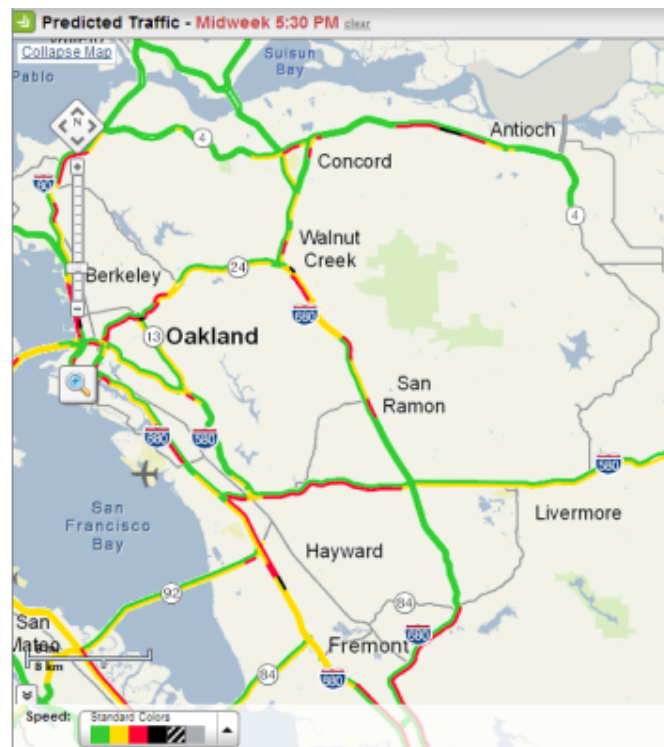


Figure 4 Typical Midweek Freeway Conditions at 5:30PM

Tri Delta Transit is equipped with a transit management system developed by Connexionz. The transit management system is capable of providing real-time bus AVL/APC data⁷ and predicted arrival time data. However, Tri Delta Transit management system does not have an onboard data terminal. The communication between a bus operator and the dispatch center (including holding bus requests) is via voice over radio. Real-time bus arrival information have become available on the Internet and through mobile applications.

There are four Park-N-Ride lots within the Tri Delta Transit service area that offer free parking and connections to BART and Tri Delta Transit, namely, the eBART Station at Antioch (with 312 parking spaces), the Brentwood Park-N-Ride (with 78 parking spaces), the Pittsburg Park-N-Ride (with 125 parking spaces), and the Discovery Bay Park-N-Ride (with 41 parking spaces). Most of the Park-N-Ride lots are not being fully utilized. Parking is also available at BART Stations at Pittsburg/Bay Point and Concord, however they are usually filled before 8 AM. Tri Delta Transit service honors free inter-agency transfers among the connecting transit agencies at shared bus stops and offer reduced fares for transferring from BART.

Tri Delta Transit has already deployed operations of connection protection in response to phone calls from passengers. Bus operators also hold the buses at BART station based on train arrival indication lights. Tri Delta Transit buses also perform route deviation for congestion avoidance. Bus operators report to dispatch about the congestion, and dispatch assigns the detour route.

3.3 Status of Development of Dynamic Transit Operation

Dynamic Transit Operation (DTO) is a desirable mode of public transportation. DTO has been implemented for few paratransit services but has not been deployed for regular transit service routes in the United States. United State Department of Transportation sponsored field operation tests of IDTO between 2013 and 2014. Only Connection protection has been tested in the full scale transit operation environment. Because of the one minute longest wait time limitation, the success rate for connection protection has been low. Table 1 provides a summary of these field operational tests.

Table 1 Summary of USDOT IDTO Field Operational Tests

IDTO Applications	Columbus, OH	Orlando, FL
T-CONNECT	<p>Agencies:</p> <ul style="list-style-type: none"> Central Ohio Transit Authority (COTA) Fixed-Bus-Routes OSU Campus Area Bus System (CABS) Free On-Campus bus service <p>Scenarios:</p> <ul style="list-style-type: none"> T-CONNECT on selected COTA routes (transfer within COTA) and at selected OSU 	<p>Agencies:</p> <ul style="list-style-type: none"> Central Florida Regional Transportation Authority (LYNX) UCF on-campus shuttle service SunRail – commuter rail, 31 miles with 12 station <p>Scenarios:</p> <ul style="list-style-type: none"> T-CONNECT on selected LYNX routes (transfer within LYNX), at selected UCF campus (UCF

⁷⁷⁷ Currently APC is not provided in real-time

	campus locations (CABS to COTA transfer)	shuttle to LYNX transfer), and potentially at selected SunRail stations (SunRail to LYNX transfer)
T-DISP	<ul style="list-style-type: none"> • OSU TaxiCABS (demand responsive shuttle service for faculty and staff) • Service expecting to start in late-May, 2014 	<ul style="list-style-type: none"> • LYNX FlexBus (demand responsive station-to-station service) • Demonstration began on April, 2014

4 Motivation for IDTO

Dynamic transit operations, including T-DISP, T-CONNECT, and D-RIDE, can substantially improve transit service quality by providing faster, more convenient, and cost effective trips to the traveling public. As travelers begin to use dynamic transit operations, both travelers and transit providers will have a more collaborative transit experience. What has been envisioned is that by transforming current fixed route operation into dynamic focused transit services in suburban regions across California, transit service will become faster and better transportation option for significant more travelers, the transit operation costs will be reduced, and transit systems will assume a greater role in the total solution to transportation congestion, safety, and improved air quality. The recent development of communication and positioning technologies and real-time information about the overall transportation systems (both transit and highway networks) has begun to make dynamic transit operation feasible.

4.1 How IDTO Addresses the Stakeholders' Needs

Dynamic transit operations, including T-DISP, T-CONNECT, and D-RIDE can substantially improve transit service quality by providing faster, more convenient, and cost effective trips to the traveling public. When travelers begin to use dynamic transit operations, both travelers and transit providers will have a more collaborative transit experience. What has been envisioned is that by transforming current fixed route operation into dynamic focused transit services in suburban regions across California, transit service will become faster and better transportation option for significant more travelers, the transit operation costs will be reduced, and transit systems will assume a greater role in the total solution to transportation congestion, safety, and improved air quality.

4.2 Assumptions and Constraints

Our hypothesis is that IDTO functions will be built upon on the existing ITS applications. The assumptions used for project planning are (1) IDTO will directly interface with transit management system, thorough which real-time transit operation information can be directly inputted to IDTO system with minimum delays (<1 sec); (2) D-RIDE will be built upon an existing ridesharing application. The arrangement with the ridesharing provider will be facilitated by CCCT; (3) Connection protection will be implemented at two BART stations (Pittsburg/Bay Point and Concord) and major TDT transfer points; (4) T-DISP will be designed for two transit routes (route 387 and 388) at this phase of the project; (5) interface with dispatcher center will respond to recommendation generated by IDTO system when predetermined conditions are met.

The lack of on-board driver information terminal presents a constraint for IDTO. The transit dispatcher center will experience increased workload in respond to the dynamic operation recommendations by the IDTO system. It is a nature progression for Tri Delta Transit to upgrade its transit management system with driver information terminals when the level of dynamic operation increases.

4.3 Description of Desired IDTO Operation

When using the multimodal trip planning based IDTO bundle, a traveler would input his/her desired origination (or automatically set to the user's current location using the Smartphone GPS) and destination (O/D), expected departure time, and preference of travel (e.g., drive to BART, take transit, or ridesharing, etc.). The IDTO system, utilizing off-shelf trip planning service which is taking into consideration the real-time transit and traffic conditions and ridesharing service, will plan a trip that best fits the traveler's needs. The planned trip could consist of several segments, with each segment representing a different transportation mode. Once the traveler has confirmed the planned trip, the IDTO system will track the user throughout the planned trip. Naturally, not all trips can go as planned (for example, a train/bus could be running late). The IDTO system will keep an update on the status of the traveler and the corresponding trains/buses, and when needed, automatically place T-CONNECT requests. The traveler will be informed of updates or status changes, preferably through text-to-speech techniques. As a traveler can change their options during a planned trip, a new trip will be planned for the traveler based on the traveler's preference, and the IDTO system will continue to assist the traveler throughout the newly planned trip.

5 Concept of the Proposed System

5.1 IDTO Goals

From traveler perspective, the goal of IDTO is to enable transit to become a viable transportation option that helps people effortlessly transfer from one mode of travel (car, bus, train, etc.) to another for the fastest and most environmentally friendly trip and makes cross modal travel truly possible.

From transit agency perspective, IDTO is to promptly respond to travelers' needs in a cost effective manner thereby attracting more transit riders, reducing the transit operation costs, and enabling public transit to assume a greater role in the overall solution to reduce transportation congestion, increase safety, and improve air quality.

5.2 Functions of IDTO

IDTO will have the following primary functions:

- Enables passengers to receive “personalized” real-time trip information about transit vehicle arrivals at their origin and destination stop on their planned travel route and the ability to ‘interact’ with transit by requesting timely transit services.
- **T-CONNECT** application is intended to improve the successful transfer between mode (from car to bus, train to bus) and between different bus routes of an individual agency.
- **T-DISP** application scenarios are intended to dynamically adjust transit routes and stops to be responsive to travelers demand and traffic conditions. T-DISP may involve:
 - Deviating from the route to avoid traffic congestion (can be detected by real-time traffic conditions and incident information).
 - Deviating from the route to pick up passengers who are either having difficulty gaining access to the transit stop, or prefer to be picked up at familiar and/or alternative locations.
- **D-RIDE** as a service to arrange shared rides in real-time between origin and transit and between transit stop and destination and offers the potential to reduce the number of transit vehicles used for personal travel, leading to significant environmental and economic benefits.

5.3 Key Concepts

IDTO is implemented through dynamic operations supporting tools for automatic connection protection, route deviation decision making and dynamic ridesharing following a set of predesigned operation rules. IDTO dynamic operation advices may be provided through on-board driver communication terminal via transit data communication and management system. IDTO may require minimum involvement of dispatcher center except for cases exceed the pre-configured rules. When direct data communication is not available, IDTO dynamic operation advices is communicated to the bus operators by dispatchers through voice radio communication. In this case, dispatch involvement is central and the timely response to IDTO may affect the performance of dynamic operation.

IDTO functions should be transparent to travelers similar to call a taxi or an elevator, but with a condition that bus may or may not be available. A traveler would input his/her desired origination (or automatically set to the user's current location using the Smartphone GPS) and destination (O/D), expected departure time, and preference of travel (e.g., drive to BART, or take transit, etc.). The IDTO system, taking into consideration the real-time transit and traffic condition information, will plan a trip that best fits the traveler's needs. The planned trip could consist of several segments, with each segment representing a different transportation mode. Once the traveler has confirmed the planned trip, the IDTO system will track the user throughout the planned trip and will request IDTO operation according to condition of the system. IDTO will provide feedback to the traveler and require confirmation when needed.

When a trips originates from a region served by dynamic transit service, a service call is placed. T-DISP evaluates the condition of the in-route transit vehicles and designated an available transit bus to deviate from its routes when necessary to pick up the passenger who made the call.

Naturally, not all trips can go as planned (for example, a train/bus could be running late). The IDTO system will keep an update on the status of the traveler and the corresponding trains/buses, and when needed, automatically place T-CONNECT requests. The traveler will be informed of updates or status changes, preferably through text-to-speech techniques.

After the passenger reaches his/her destination stop, but still distance away from his/her final destination, D-RIDE will evaluate available ridesharing options is so desired by the traveler and match this traveler with a potential ride provider.

As a traveler can change their options during a planned trip, a new trip will be planned for the traveler based on the traveler's preference, and the IDTO system will continue to assist the traveler throughout the newly planned trip.

5.4 Proposed Architecture

The following architecture has been conceptualized for the IDTO system to be developed under this project, as depicted in Figure 5. The IDTO system has a number of functional elements, including:

- Mobile interface that will enable travelers to plan a trip as described in the typical use case.
- An IDTO server that will host Travel Choice (TC) tools and Decision Support (DS) tools. The TC tools interact with travelers to take O/D inputs, calculate travel choices, present the choices to the traveler, take traveler's confirmation and submit specific requests to the IDTO DS tools when this request involves transit buses. The responsibility of the DS tool is to evaluate the feasible strategies (i.e., T-DISP or T-CONNECT) that will accommodate the request from the travelers. Once a feasible T-DISP and T-CONNECT strategy is found, it will be submitted to transit dispatchers for confirmation and execution.
- IDTO interfaces located at transit operation centers will enable transit operation staff to receive requests from the IDTO server and to communicate with bus drivers either

through voice or via text messages through transit management system to advise drivers to implement connection protection or dynamic operation.

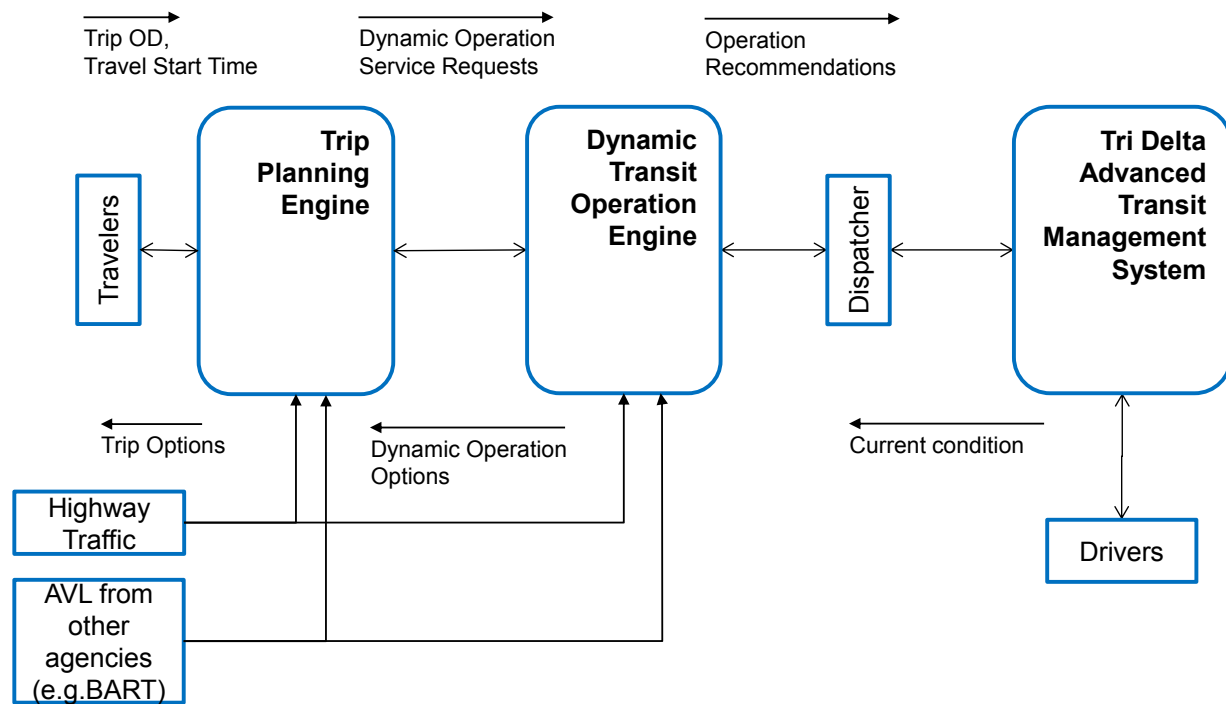


Figure 5 IDTO System Architecture

6 Operational Scenarios

A suite of IDTO scenarios to be implemented at Tri Delta Transit covers all three dynamic operations, as summarized in Table 2. Multimodal real-time traveler information system will be integrated with the dynamic transit operation in order to offer maximum benefit to travelers.

Table 2 Proposed IDTO Scenarios

Application	Scenarios
T-CONNECT	Train-to-bus connection protection at BART
	Bus-to-bus connection protection at key transfer points
T-DISP	Route deviation to avoid congestion (fixed-route)
	Route deviation to pick up passengers (fixed-route)
D-RIDE	To be defined

The following provides additional details of the dynamic operation scenarios.

6.1 Scenario 1: Dynamic Connection Protection (T-Connect)

IDTO T-Connect help travelers to make connections at major meet points by holding one bus up to predetermined time period to wait for the arrival of passengers from another arriving bus or BART.

6.1.1 Scenario 1(a) Passenger requesting T-Connect through trip planning

- 1) Passengers use the IDTO mobile app to plan and initiate a trip.
- 2) IDTO system tracks traveler's trip activities and determines that he/she is on a service bus or BART X.
- 3) IDTO system determines the connecting bus Y will arrive at the transfer stop before bus/train X arrives and, after evaluating the impacts of the connection prediction, advises bus Y to wait at the transfer station.
- 4) IDTO system confirms bus holding activity with the requesting passenger through their mobile IDTO app.

6.1.2 Scenario 1(b) Passenger requesting T-Connect by selecting a bus

- 1) Passengers use the IDTO app to initiate a request for bus Y while traveling on bus/train X.
- 2) IDTO system tracks traveler's trip activities and determines that he/she is on a service bus/train X.
- 3) IDTO system determines the connecting bus Y will arrive at the transfer stop before bus/train X arrives and, after evaluating the impacts of the connection prediction, advises bus Y to wait at the transfer station.
- 4) IDTO system confirms bus holding activity with the requesting passenger through their mobile IDTO app.

There are a total of 11 routes operated by Tri Delta Transit that connects with BART and/or Park-N-Ride Lots. Tri Delta Transit has identified the following fixed-routes and key transfer points between Tri Delta Transit routes to be included in the T-CONNECT applications to be

tested in this phase of the project, as summarized in Table 3.

Table 3 Proposed IDTP Scenarios

Route	Major Connections	Peak Frequency	Off Peak Frequency	Span of Service
TDT 200 (Weekday)	Pittsburg/Bay Point BART Martinez Amtrak	60 -75 min	60 min	6:42 AM -7:10 PM
TDT 201 (Weekday)	Pittsburg/Bay Point BART Concord BART	30 min	60 min	6:09 AM – 7:33 PM
TDT 300 (Weekday)	Pittsburg/Bay Point BART Antioch Park-N-Ride Brentwood Park-N-Ride	20 min	30 min	4:12 AM – 10:00 PM
TDT 380 (Weekday)	Pittsburg/Bay Point BART Los Medanos College Antioch Park-N-Ride	30 min	50 min	3:14 AM – 11:31 PM
TDT 387 (Weekday)	Pittsburg/Bay Point BART Pittsburg Park-N-Ride Los Medanos College	60 min	60 min	4:48 AM – 9:18 PM
TDT 388 (Weekday)	Pittsburg/Bay Point BART Pittsburg Park-N-Ride Los Medanos College Antioch Park-N-Ride	30 min	60 min	5:06 AM – 11:28 PM
TDT 390 (Weekday)	Pittsburg/Bay Point BART Antioch Park-N-Ride	30 min	n. a.	3:50 AM – 7:28 PM 4:13 PM – 8:28 PM
TDT 391 (Weekday)	Pittsburg/Bay Point BART Pittsburg Park-N-Ride Los Medanos College Antioch Park-N-Ride Brentwood Park-N-Ride	30 min	60 min	4:03 AM – 1:14 AM
TDT 392 (Weekend)	Pittsburg/Bay Point BART Pittsburg Park-N-Ride Los Medanos College Brentwood Park-N-Ride	60 min	60 min	5:23 AM – 1:28 AM
TDT 393 (Weekend)	Pittsburg/Bay Point BART Los Medanos College Antioch Park-N-Ride Brentwood Park-N-Ride	60 min	60 min	5:23 AM – 1:19 AM
TDT 394 (Weekend)	Pittsburg/Bay Point BART Los Medanos College Antioch Park-N-Ride	60 min	60 min	5:22 AM – 1:49 AM

6.2 Scenario 2: Dynamic Dispatching (T-DISP)

In the areas or regions where dynamic transit services are designated, IDTO dispatches buses to meet with passengers or drop off passengers at predetermined pickup locations (marked with T-DISP station signs).

- 1) Passengers use the IDOT app to request transit service in the proximity of a designated IDTO stop by pushing a ‘waiting for route X’ button on the app.
- 2) The ‘passengers waiting’ information is communicated with the IDTO system.
- 3) IDTO evaluates the current operating condition and designates a near-by bus on the route the passenger requested to pick up the stop.
- 4) IDTO system communicates with the dispatcher center through an IDTO operation

interface.

- 5) The dispatcher center communicate with the designated bus driver to instruct route deviation.
- 6) The bus driver confirms the pickup.
- 7) The dispatcher center responds to the requesting passenger with a confirmation and estimated arrival through IDTO mobile app.
- 8) The bus operator makes route deviation and pick up passenger.

6.3 Scenario 3: Dynamic Ridesharing (D-RIDE)

Most existing dynamic ridesharing service is drive-to-work/home centralized, where a driver is matched with ridesharing passengers on the way to work or to home. Transit riders are a potential source for many dynamic ridesharing customers.

There are a number of flexible transit service scenarios that can fit into this category, including peak period feeder bus service to connect travelers to major Park-N-Ride lots, or to pick up passengers along a selected route when the scheduled bus is fully loaded, allowing the loaded bus to travel directly to its destination (e.g., BART), or to provide supplement service during peak periods to reduce travelers' waiting time due to infrequent off-peak normal transit service. If there is enough time and budget, PATH proposes to include taxi-sharing as a backup for the demand responsive transit service, when transit service is not timely available. Under this situation, travelers going the same direction from the same origination (e.g., BART) will be grouped together, and the travelers will be informed to contact the taxi service provider to arrange a taxicab for their first or last miles of travel. The proposal team is aware of California Public Utilities Commission (CPUC) regulations and that taxis are licensed and regulated by cities and counties. Once this proposal is awarded, the project team will work with the CPUC, Contra Costa County and concerned cities to obtain exemptions for taxi-sharing during the demonstration period.

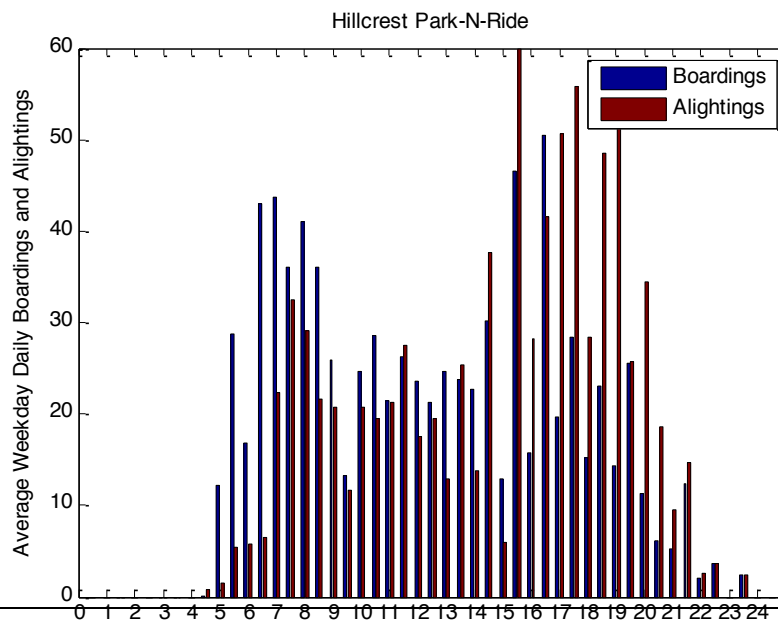


Figure 6 Boarding and alighting numbers at Antioch Park and Ride lot

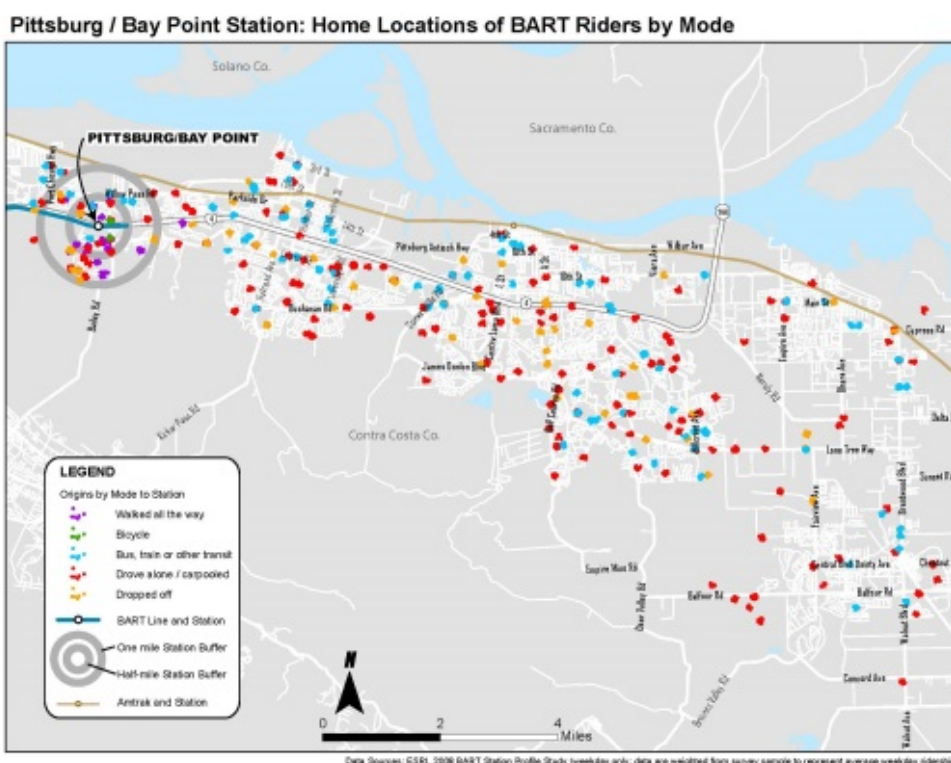


Figure 7 Home location of BART riders by mode (Pittsburg/Bay Point station)

Figure 6 plots average weekday boarding and alighting numbers by time-of-day at Antioch Park-N-Ride lot, with each bar representing a 30-minute averaging over a three-month period. This Park-N-Ride lot is also a transfer hub of Tri Delta Transit where eight out of 13 weekday bus routes and all weekend routes connect here⁸. Express route 300 connects Pittsburg/Bay Point BART with Antioch Park-N-Ride lot via state highway 4 without any stop in between these end points. This route carries one half of all boarding numbers at this Park-N-Ride lot. As shown in Figure 7, there are significant more boarding travelers than alighting travelers in the morning

⁸ http://www.trideltatransit.com/park_ride.aspx

peak and the reverse trend during the afternoon peak (approximately 35 more transit riders per 30 minutes), indicating those riders drove to the Park-N-Ride lot and transferred to a bus.

Figure 7 illustrates the home origin for BART riders at the Pittsburg/Bay point station. Each dot represents the home location of the rider and the color of the dot represents the mode to get to BART (red – drive alone/carpooled, yellow – dropped off, blue – transit). Of those 4,728 average weekday daily riders, 48% drive alone, 9% carpool, 16% are dropped off and another 21% use transit to get to BART. The distributions of home locations and mode to BART clearly show that there is a great potential to match those riders for ridesharing, either to a Park-N-Ride lot to connect with BART via a transit bus or directly to BART.

Integrating dynamic ridesharing with T-CONNECT and T-DISP will benefit these potential ridesharing customers in the way that they can make requests to be serviced better through the IDTO bundle. Furthermore, this integration allows travelers who usually drive to have access the real-time transit information and to directly interact with the transit system in a seamless manner, potentially leading to a permanent shift to transit.

D-RIDE will incorporate an existing ridesharing application. The operation scenario will be designed in conjunction with the ridesharing application developer.

7 Summary of Impacts

7.1 Operational Policies

Evolving from existing schedule based transit operation to dynamic transit operation may present a challenge. Dynamic connection protection or dynamic route change may create delays to the passengers waiting at downstream bus stops. As vast majority of the transit riders are familiar with and used to schedule based transit operation, dynamic transit operation may need to be introduced gradually using selected routes.

It is agreed with Tri Delta Transit that T-Connect will be operated at major bus stations where transit lines crosses. The waiting time for T-Connect will not exceed 5 minutes. Additional operation policies to consider the number of passengers on-board vs. the number of passengers waiting-at-stations may be considered if passenger count information can be provided via transit management system in real-time.

T-DISP will be designed and tested along two TDT fixed-routes (i.e., route 387 and 388). T-DISP will allow route deviations following pre-determined routes and stop locations. Bus stop signs will be established for dynamic dispatched buses. A round trip of T-DISP bus shall not exceed a predetermined maximum trip time.

Public outreach will need to be carried out to educate travelers about dynamic transit operation so that they would know what to do and to expect.

The above and additional issues on operation policies will be analyzed throughout the project and the results will be included in the final project report.

7.2 Impacts

Operational and organizational impacts will be analyzed during the project and the results will be included in the updated ConOps and final project report.

7.3 Benefits and Costs

Dynamic Transit operation will benefit travelers as well as transit agencies. IDTO can become an integral part of new TDT's transit operation plan – to enable Tri Delta Transit to deliver improved transit service. Integrating IDTO with TDT's existing real-time system to deliver consistent information between the two systems to passengers. Dynamic transit operations information delivery has great potential to attract more people to use real-time transit information

The benefits and costs analysis will be conducted through customer surveys and discussion with transit stakeholders. The findings from this in-depth analysis will be included in the final project report.

7.3.1 Benefits

Dynamic transit operation will offer significant benefit to travelers with improved convenience, reduced travel time. The quality trip experience for transit travel offered by dynamic transit operation can attract more transit riders, with an ultimate goal of making transit as a portion of the solutions for congestion relief.

A more detailed benefit analysis and cost-effectiveness for transit operation will be analyzed during the project.

7.3.2 Costs

Costs will be analyzed during the project and the results will be included in the updated ConOps and final project report.

8 Analysis of the Proposed IDTO

An in-depth analysis to include customer surveys and discussion with transit stakeholders will be conducted to evaluate the improvements, and disadvantages and limitations. The findings from this in-depth analysis will be included in the final project report.

8.1 Summary of Improvement

We will conduct further study through field testing, customer surveys, interaction with stakeholders and additional analysis to address improvements of IDTO to the transit operation, customer experience and possibly the condition of the overall transportation system.

8.2 Disadvantages and limitations

This study will analyze the disadvantages and limitations of the proposed system during the project and explore the possible means to overcome these disadvantages and limitations.