Prototype Development and Demonstration for Integrated Dynamic Transit Operations

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16. Abstract

This document serves as the Final Report specific to the Integrated Dynamic Transit Operations (IDTO) Prototype Development and Deployment Project, hereafter referred to as IDTO Prototype Deployment or IDTO PD project. This project was performed under contract to the U.S. Department of Transportation (U.S. DOT) Intelligent Transportation Systems (ITS) Joint Program Office (JPO) in cooperation with the Federal Transit Administration (FTA). This final report provides a summary of the activities performed in conducting the IDTO PD project and documents the findings, lessons learned, and future considerations generated as an outcome of this work. As a prototype, IDTO was successful. It proved to be beneficial to the traveler, as throughout the demonstration period, users returned to use the application for trip planning/informational searches, and of those, over 25% took the action to monitor the trip and enable monitoring of transfers by the agencies to hold to allow for successful transfers. IDTO proved to be robust, with an uptime well over 95% based on 161 of 164 operational days. IDTO proved to be transferrable, deployed both in Columbus and Central Florida using the same core software tools. IDTO proved to be beneficial to transportation agencies, providing greater insight into system performance and allowing for adjustment to improve service. And finally, IDTO was insightful, identifying lessons learned that shape future research and deployment considerations.

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Executive Summary

This document serves as the Final Report specific to the Integrated Dynamic Transit Operations (IDTO) Prototype Development and Deployment Project, hereafter referred to as IDTO Prototype Development or IDTO PD project. This project was performed under contract to the U.S. Department of Transportation (U.S. DOT) Intelligent Transportation Systems (ITS) Joint Program Office (JPO) in cooperation with the Federal Transit Administration (FTA). The purpose of this report is twofold: to provide a summary of the activities performed in conducting the IDTO PD project; and, to document the findings, lessons learned, and future considerations generated as an outcome of this work.

Through the Dynamic Mobility Applications (DMA) Program, the U.S. DOT desires to improve current operational practices and transform management of future surface transportation systems. The DMA program was designed to enhance deployment of the technologies and applications and promote collaboration in research and development (R&D) related to transformative mobility applications. The IDTO PD project was aligned with the DMA Program's efforts involving application prototype development, testing, and coordinated research activities focused on a portfolio of high-priority mobility applications, commonly referred to as the IDTO Bundle. Development of the IDTO Bundle was informed by prior research in the Connected Vehicle (CV) Program and other ITS programs, as well as the development of other concurrent applications from other DMA projects.

The IDTO Bundle collectively included three applications: Connection Protection (T-CONNECT), Dynamic Transit Operations (T-DISP), and Dynamic Ridesharing (D-RIDE). The T-CONNECT application provided coordination between transportation providers and increased the likelihood of making successful intermodal, intra-modal (e.g., bus and commuter rail) and non-transit (e.g., shared ride) transfers. The T-DISP application linked multi-modal transportation options with travelers through dynamic transit vehicle scheduling, dispatching, and routing capabilities, allowing travelers to request and view multiple trip itineraries in real time. The D-RIDE application provided an automated ride matching system for carpool travelers, and allowed users to offer or request rides in real time, minutes prior to departure, or to make scheduled one-way appointments.

The scope of the IDTO PD project included: 1) the development and deployment of a prototype system that integrated these three applications into a single end-user product; 2) an operational field test in Columbus, Ohio, encompassing multiple partners/agencies and multiple modes; 3) a second demonstration of technical feasibility performed in conjunction with partners in Central Florida and, 4) controlled environment tests to demonstrate additional features. The two field demonstrations are referred to as Phase 1 and Phase 2 respectively.

During Phase 1, local riders in Columbus, Ohio, were recruited to participate in the program. Connect and Ride (or C-Ride, for short), the brand for the IDTO Application Bundle, was made available for both iPhone and Android users through their respective online stores, and was marketed throughout Columbus with a targeted emphasis on The Ohio State University (OSU) campus region. Central Ohio Transit Authority (COTA), the OSU Campus Area Bus Systems (CABS), and Capital Transportation, a local, private demand/response provider, all provided services and/or vehicles to support this effort. Numerous strategies were employed to recruit participants including local media, social media, and in-person presentations with select groups at OSU. Necessary institutional review board (IRB) processes were instituted and study participants were informed of their involvement in research. Data about their trips, along with survey data, was captured to support the related IDTO Impacts Assessment (IA) project, as performed by the Volpe National Transportation Center, as well as the broader DMA Independent Evaluation (IE) as performed by Booz Allen Hamilton. It is expected that reports will be available on the National Transportation Library, available at http://ntl.bts.gov.

Phase 1 ran from May of 2014 through December 2014. During this period, over 2,300 informational trip searches were performed by 186 distinct C-Ride users. Further, in the case of over 950 trips, (nearly half of the total informational searches performed), the traveler took an action that allowed IDTO to plan and monitor the trip. This second category, those that took action, is very revealing as this is a feature that had not previously existed in local trip-planning software.

Of these same actionable trips, 386 met the conditions for and were subsequently monitored for on-time performance of the associated vehicles. Variations in the schedule performance, specifically a delay in the incoming (approaching) vehicle, could potentially necessitate a T-CONNECT transfer protection request to the outbound (departing) vehicle, as initiated by the system, on behalf of these riders. Of these monitored trips, 11 trips resulted in this need for a T-CONNECT request to COTA. Table ES-1 highlights some of the key metrics associated with the project and the significance of these metrics.

Table ES-1. Key Metrics of IDTO Phase 1 Demonstration

Metric	Value	Significance
Number of System Users	186	Users who searched or logged at least 1 trip
Number of Return Users	106	57% of Users were Repeat Users
Number of Informational Searches	2316	Averaged 12.5 searches per User
Number of Actionable Trips	958	41% of Searches resulted in Actionable Trip
Duration of Operational Period (days)	164	Over 5 months of Data Collection
Operational Days with Trips	161	98% Uptime of IDTO System

Source: Battelle

The Phase 1 demonstration period also provided the mechanism to collect data about the operations of IDTO and the supporting agencies. Data logging was implemented in the IDTO prototype as a means to facilitate this capture. System logs also reveal that the IDTO prototype system recorded activity on 161 of a total of 164 operational days, and that an average of two informational searches were made each day. Further, there were no reported Crash Logs in either the Android or IOS developer portals. Together these are strong indicators of the system's up-time.

Feedback gathered through user-directed surveys, recurring interviews of key stakeholders, and feedback from social media were also used. Data related to the trips searches, monitored trips, system performance and user feedback captured as part of the Phase 1 demonstration was subsequently sanitized of any Personally Identifiable Information (PII) and provided to U.S. DOT and the IA Team via the Research Data Exchange (RDE).

Upon successful demonstration of Phase 1, a field trial in Central Florida, using an entirely new set of partners, was integrated and demonstrated. The IDTO PD Phase 2 demonstrated how the IDTO Bundle could be successfully deployed in a new location with new partners with minimal changes to the underlying product. A third demonstration phase, which showcased how D-RIDE could further complement and expand the T-DISP concepts, was then conducted in a controlled environment using the Columbus partners.

In addition to the positive findings generated from this work, valuable lessons learned were also uncovered. The lack of true standards for information exchange and the availability of reliable Automated Vehicle Location (AVL) data were the two biggest technical challenges that had to be overcome. Institutionally, data sharing, privacy, and operational impacts posed the biggest challenges. Finally, public perception and acceptance, particularly in these days of a highly competitive, fast moving, ”what have you done for me lately?” environment proved to be a challenge. The good news, from a traveler perspective, is that in the environments where IDTO was implemented, the number and frequency of routes offered by local transit partners, and their on-time performance, were such that the actual need for connection protection was minimal. In the end, based on the feedback and data collected from the PD efforts, the integration of multiple provider offerings to provide real-time multi-provider/multi-segment trip planning within a single tool emerged as the biggest potential benefit of the IDTO concepts. And with the recent but rapid emergence of private, for-hire transportation options such as Uber, the need and interest have blossomed well beyond those that were originally envisioned when IDTO was first conceptualized only five years ago.

In the end, the IDTO PD project met its intended expectations by fulfilling the following objectives:

- Demonstrating a prototype that can support both mobile and traditional web interfaces and is interoperable with existing transit and transportation service providers.
- Generating data that supports U.S. DOT DMA policy and program direction and provides a resource to other researchers and developers through the RDE.
- Generating technology solutions and institutional models that are compatible with legacy/enabling systems and relationships, and which consider institutional models that are replicable, and to a lesser extent, scalable.
- Observing and documenting the synergistic potential of the three applications that emphasize dynamic transit operations.

Chapter 1 Background

Background for IDTO Prototype Development and Deployment Project

In 2010, the U.S. DOT ITS Joint Program Office (JPO) launched its connected vehicle research program. The program includes development, deployment and demonstration of a suite of technologies and applications that use wireless communications to provide connectivity among vehicles, roadway infrastructure, and mobile devices. Within the connected vehicle environment, transit is a major component of the transportation system, and the use of connected vehicle technologies within this realm is expected to help improve safety, mobility, and convenience for transit riders.

U.S. DOT Dynamic Mobility Applications Program

Part of this broader connected vehicle research, the Dynamic Mobility Applications (DMA) Program was initiated to develop, test, demonstrate, and commercialize innovative mobility applications that leverage the multifaceted data collected from connected travelers, infrastructure, and vehicles.

The objectives of the DMA Program include:

- Creating applications using frequently collected and rapidly disseminated multi-source data from connected travelers, vehicles (automobiles, transit, freight), and infrastructure;
- Developing and assessing applications showing potential to improve the nature, accuracy, precision, and/or speed of dynamic decision making by both system managers and system users;
- Demonstrating applications predicted to improve the capability of the transportation system to provide safe and reliable movement of goods and people; and,
- Determining required infrastructure for transformative applications implementation, along with associated costs and benefits.

In 2011, the DMA Program identified six high-priority bundles of mobility applications that were thought to have the capability to improve the transportation system. Integrated Dynamic Transit Operations (IDTO) was one of these bundles, and as briefly described in U.S. DOT literature, IDTO seeks to facilitate passenger connection protection; provide dynamic scheduling, dispatching, and routing of transit vehicles; and facilitate dynamic ridesharing.[1]

[1] Benefits of Dynamic Mobility Applications – Preliminary Estimates from the Literature, FHWA-JPO-13-004, December 10, 2012, page 6.

IDTO Foundational Research

Significant prior research had been conducted and published in support of the development of the IDTO concepts and requirements. Of these, two particular documents were of key interest to the IDTO PD project.

The first, the *Assessment of Relevant Prior and Ongoing Research for the Concept Development and Needs Identification for Integrated Dynamic Transit Operations Report (FHWA-JPO-12-082),*[2] reviewed prior literature, research and technologies available at the time, and existing practices. The report found several studies that served as inputs to the development of the original IDTO concept and served as a resource for better understanding how the IDTO prototype might function.

The second document of significance to the IDTO PD project was the *IDTO Functional and Performance Requirements and High-Level Data and Communications Needs Report (*FHWA-JPO-12-085)[3]. This document built upon the concepts presented in the IDTO concept document, and detailed requirements based on the users' needs, performance, interfaces, and other system characteristics. This document also served as the starting point for the IDTO PD generated System Requirements document[4] under a process by which the IDTO PD team examined each requirement included in this original document, and based on the capabilities of the selected demonstration partners, accepted, revised, rejected, or created new requirements for this project.

Serving as preliminary inputs, these two documents shaped the direction of the IDTO development and aided in furthering the applications goal of transforming transit operations, mobility, and the user experience.

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[2] Mishra, Santosh and Butler, Carrie and Abuelhiga, Ayeshah and Giragosian, Anna and Lukasik, Dan and Hubbard, Elliot and Schweiger, Carol and Sanchez, Robert. *Assessment of Relevant Prior and Ongoing Research for the Concept Development and Needs Identification for Integrated Dynamic Transit Operations.* United States. Dept. of Transportation. ITS Joint Program Office, 2011, FHWA-JPO-12-082.

[3] Mishra, Santosh and Schweiger, Carol and Abuelhiga, Ayeshah and Butler, Carrie and Beasley, Kari and Sanchez, Robert. *Report on Functional and Performance Requirements, and High-Level Data and Communication Needs for Integrated Dynamic Transit Operations (IDTO).* United States. Dept. of Transportation. ITS Joint Program Office, 2012, FHWA-JPO-12-085.

[4] Timcho, Thomas and Burns, Matthew and Mishra, Santosh and Schweiger, Carol and Rizek, Jodi and Zink, Gregory. *Report on Functional Requirements and Software Architecture for the IDTO Prototype – Phase I Demonstration Site (Columbus).* United States. Dept. of Transportation. ITS Joint Program Office, 2013, FHWA-JPO-14-166.

Chapter 2 Project Information

Purpose/Objective

The IDTO Prototype Development and Deployment Project, hereafter referred to as IDTO Prototype Development or IDTO PD project, sought to answer the following primary study question:

> *Can the mobility of the local traveling public (especially travelers needing to utilize multiple transit providers on a given trip) be significantly improved by integrating the capabilities and offerings of the three public transit mobility applications (IDTO Bundle) within a single real-time system that can meet the public's expectations on trip performance and satisfaction?*

The three applications identified in this study question include Connection Protection (T-CONNECT), Dynamic Transit Operations (T-DISP), and Dynamic Ridesharing (D-RIDE). Collectively, these are known as the IDTO Application Bundle. The T-CONNECT application provided coordination between transportation providers and increased the likelihood of making successful intermodal, intra-modal (e.g., bus and commuter rail) and non-transit (e.g., shared ride) transfers. The T-DISP application linked multi-modal transportation options with travelers through dynamic transit vehicle scheduling, dispatching, and routing capabilities, allowing travelers to request and view multiple trip itineraries in real time. The D-RIDE application provided an automated ride matching system for carpool travelers and allowed users to offer or request rides in real time, minutes prior to departure, or make scheduled one-way appointments. Detailed descriptions of these applications follow.

In coordination with the concurrent IDTO Impacts Assessment (IA) project, led by the Volpe Center, the IDTO PD project built on the earlier concept work and furthered the associated research by accomplishing the following:

- Developed and deployed a prototype system that integrated the three identified transit-specific applications, the IDTO Application Bundle, into a single end-user product
- Conducted an operational field test in Columbus, Ohio, encompassing multiple partners/agencies, and multiple modes
- Conducted a second demonstration of technical feasibility performed in conjunction with partners in Central Florida.

These two field demonstrations, Columbus, Ohio, and Central Florida, are referred to as Phase 1 and Phase 2 respectively throughout this report.

Performed under contract for the U.S. Department of Transportation (U.S. DOT) Intelligent Transportation Systems (ITS) Joint Program Office (JPO) and in cooperation with the Federal Transit Administration (FTA), Battelle led the development and deployment efforts and was supported by TranSystems, Marketing Works, and the Transit Lab located at The Ohio State University (OSU). In conducting this research, the Battelle team designed, implemented, deployed and operated a functional IDTO demonstration system that allowed for the data collection and analysis necessary to address this study question. This project also included the support of seven (7) public-sector and private partners including the Central Ohio Transit Agency (COTA), LYNX, the on-campus transit services operated at both OSU and at the University of Central Florida (UCF), SunRail, Capital Transportation, and Zimride; all of whom provided access to staff, data, and other resources necessary to make this project successful.

IDTO Application Descriptions

This section describes the applications within the IDTO bundle based on the original description found in the *IDTO Report on Functional and Performance Requirements…* and as adapted to reflect the specific demonstration that was conducted as part of the IDTO PD project.

T-DISP

The T-DISP component of the IDTO bundle, as envisioned for the IDTO PD project, was expected to satisfy two distinct roles in the prototype. First, T-DISP was expected to demonstrate a dynamic demand/response-like service offering including dynamic transit vehicle scheduling, dispatching, and routing capabilities. Two different providers were originally planned to satisfy this capability, however implementation decisions on the part of both providers did not allow for integration of either during the period of performance of this project. Details of this are discussed further in Chapter 12. Second, T-DISP also provided the ability for travelers to perform real-time trip planning, via a mobile device, including options for coordinating offerings from multiple transportation service providers and modes (public transportation modes, private transportation services, shared ride, and walking), and creating a complete door-to-door trip. This latter offering blended new concepts and decision-support processes, existing transportation technologies, and inputs from the traveler regarding points of origin, destination, and desired arrival and departure times to provide a robust transportation tool.

Specifically, as implemented in the IDTO prototype, the T-DISP application utilized the global positioning system (GPS), communications, and mapping capabilities of personal mobile devices to enable a traveler to query and select travel options. A central system dynamically planned the trips, using schedule and availability information from the providers, and where feasible, scheduled in-service vehicles by matching compatible trips together. The application considered both public and private transportation providers, and included fixed-route bus, rideshare providers, and rail transit services.

The application was deployed on a common platform that allowed people to effectively communicate and access shared transportation resources more readily than currently occurs. The following features were included in the T-DISP application:

a) Data communication to exchange data and trip information between the Control Center and vehicles;
b) Computer aided dispatch/automatic vehicle location (CAD/AVL) systems to track vehicle locations and assist in messaging between drivers and dispatchers;
c) A common interface between CAD/AVL and messaging systems, especially in the case of a multiple agency/multiple transportation provider environment; and,
d) 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.

As previously identified, the multi-modal scheduling system intended to dynamically schedule service based on traveler preferences and requests and match them to available vehicles did not become operational in the same period as the IDTO demonstration, and thus was not demonstrated. In theory, this system would further enhance the basic functionality that exists within demand-response scheduling software to include a series of business rules and scheduling parameters that allow dynamic scheduling and dispatching.

Representative participants from the following entities were included in T-DISP:

- Public transit agencies;
- Private transportation providers; and,
- The IDTO Prototype software.

T-CONNECT

T-CONNECT provided travelers not only the ability to request a transfer between two different services providers, but unique to T-CONNECT was the added benefit of being able to hold, or protect these transfers in situations where doing so would enable a successful transfer. This feature was available both to travelers using their personal devices or when on-board select transit vehicles (with assistance from drivers or using agency-equipped on-board interactive devices). Based on the system status (system schedule, schedule adherence status and delay thresholds, and service variability), connection protection rules, and traveler requests, the system automatically determined the feasibility of a requested transfer. When a transfer request could be met, the system would notify the traveler and the driver of the vehicle to which the traveler intended to transfer. T-CONNECT was designed to work in both single agency and multi-agency environments across single or multiple modes of transportation.

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

T-CONNECT was 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.

When a T-CONNECT supported trip was underway, the system continued 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 were able to view status in real time directly on the T-CONNECT system, the T-CONNECT system also notified travelers as appropriate on their personal devices. As one example of this feature, when a traveler on a bus needed to transfer to a transit railway, he or she could request connection protection, and if system conditions were satisfied, the operator of the railway would be advised to hold or wait for the given bus to arrive.

D-RIDE

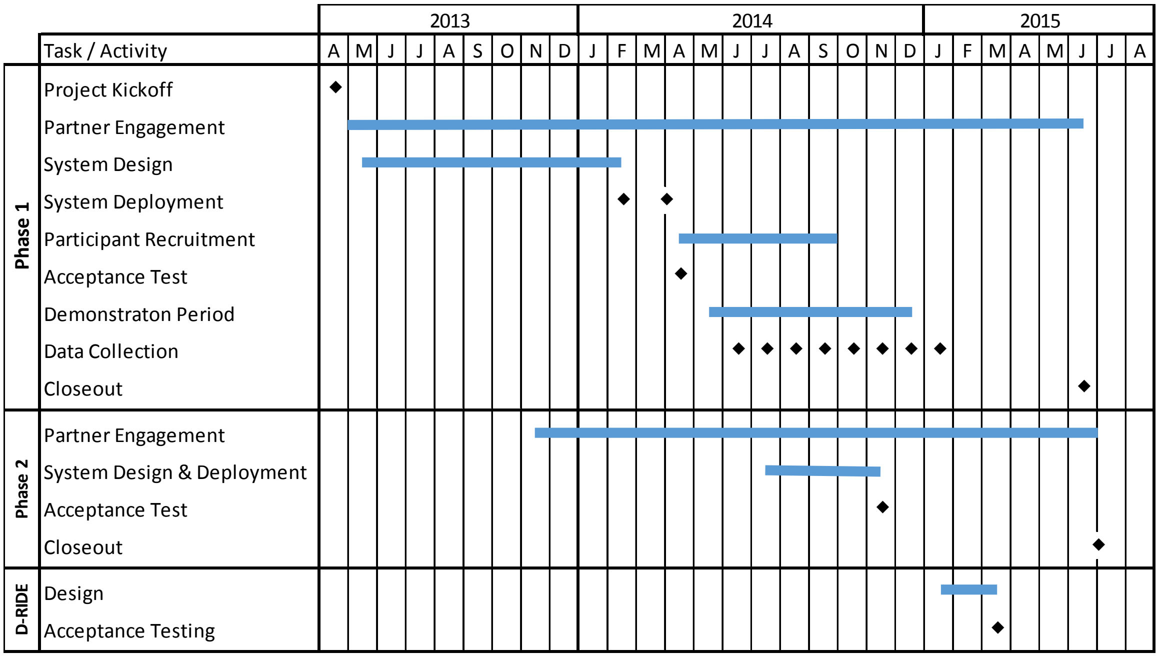
At the highest level, D-RIDE is an approach to carpooling in which drivers and riders can arrange trips in real time. Current systems do not have the functionality to dynamically match passengers to drivers, no matter their location, and usually require preplanning of carpool trips. In concept, the D-RIDE application would allow 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). This capability was implemented in IDTO, but the timing of the integration with the provider did not allow for this to be demonstrated during the Columbus demonstration period. Instead, this capability was shown in a controlled environment during latter stages of the project.

The D-RIDE application implemented the necessary decision logic to analyze inputs from both passengers and drivers pre-trip, during the trip, and post-trip. These inputs were translated into "optimal" pairings between passengers and drivers to provide both with a convenient route between their origin and destination locations.

As part of IDTO, the D-RIDE component was integrated beyond this basic function, and was included as part of the overall trip planning features, allowing for trips that included public transportation, private providers, and rideshare to all be integrated into a single system and ultimately allow trips that include several of these providers, in varying combinations, to meet the needs of the traveler.

Timeline

The IDTO PD Project was performed over a 28-month period beginning in April 2013 and included several key activities and accompanying milestones spanning two major phases and an added phase demonstrating the D-RIDE functionality. A timeline of these events is shown in Figure 2-1.



Source: Battelle

Figure 2-1. IDTO PD Timeline of Major Activities

Major Activities

Following are highlights of the major activities that occurred during the IDTO PD project, as shown in the above timeline. In several instances, references to other sections of this report are included to provide detailed information on the respective topic.

Project Kickoff

The IDTO PD project commenced in April 2013 with the Kickoff Meeting held in Columbus, Ohio. During that initial face-to-face meeting, U.S. DOT staff met with key individuals from Battelle, COTA, OSU Traffic and Transportation Management (TTM), and Capital Transportation. Details of each partner's operations, facilities, and equipment were shared. As part of the kickoff, a visit to the radio room at COTA, where dispatching operations occur, was conducted. Additionally, both CABS and Capital Transportation provided tours of the prospective routes and stops both in the OSU campus area as well as at Defense Supply Center Columbus (DSCC), using transit equipment representative of that expected to be available for the demonstration period.

Phase 1 Partner Engagement

Partner engagement for the Columbus demonstration initiated with the kickoff meeting and continued throughout the project. Specifics of each partner's participation are discussed in detail in subsequent sections of this report, but at a high level, it was comprised of three major activities: integration with partners' existing operations and systems to facilitate the IDTO Prototype; data collection, both baseline and for the operational period; and recurring status/observations and discussions with key personnel, as conducted by both the PD and IA

Teams. Table 2-1 summarizes the Phase 1 demonstration team partners, their roles, and the associated applications deployed during the field test.

Table 2-1. IDTO Phase 1 Demonstration Site Partners and Roles

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

Source: Battelle

Phase 1 System Design

System Design work began in earnest following the kickoff, and included the generation of an IDTO PD-specific set of System Requirements[5] and corresponding Systems Architecture and Design,[6] both tailored for the Phase 1 demonstration in Columbus. These documents captured the features and capabilities that were available for implementation based on the partners participating in the Columbus demonstration, and detailed the approach for implementing the IDTO prototype components, including the traveler application, partner equipment/applications, and interfaces to the partner systems. Chapter 5 offers an update to the originally published design, reflecting the design elements that were ultimately realized as part of this deployment.

Phase 1 System Deployment

Design and Implementation of the IDTO PD bundle and integration of the local partners' systems continued through the remainder of 2013 and into early 2014, culminating with proof-of-concept testing of the Mobile Data Terminal (MDT)/AVL deployed for Capital Transportation, and followed by integration testing with COTA and CABS. Upon successful testing, the hardware installation was completed on both the Capital Transportation shuttles as well as at COTA dispatch. The corresponding Android and iOS applications were also published in the respective online stores. Chapter 5 offers details of the deployment site and corresponding evaluation plans.

Phase 1 Participant Recruitment

[5] Timcho, Thomas and Burns, Matthew and Mishra, Santosh and Schweiger, Carol and Rizek, Jodi and Zink, Gregory. *Report on Functional Requirements and Software Architecture for the IDTO Prototype – Phase I Demonstration Site (Columbus).* United States. Dept. of Transportation. ITS Joint Program Office, 2013, FHWA-JPO-14-166.

[6] Herman, David and Brohard, Andrew and Burns, Matthew and Zink, Gregory and Timcho, Thomas. *System Design and Architecture for the IDTO prototype – Phase I Demonstration Site (Columbus).* United States. Dept. of Transportation. ITS Joint Program Office, 2013, FHWA-JPO-14-167.

Participant recruitment commenced in earnest in March 2014, with Marketing Works, charged with developing and implementing a strategy to attract and retain participants for this study. Recruitment took several paths, including strong social media presence as well as a big push on both local media outlets and from within the University. Enrollment exceeded 1000 users with this approach, but actual use of the system remained low, necessitating a change of strategy in July 2014, with a more targeted and incentivized approach to attract and retain riders. Details of the original plan and how the plan evolved in an effort to increase participation are included in Chapter 7.

Phase 1 Acceptance Testing

Prior to the start of the Demonstration Period in May 2014, the IDTO PD implementation was first demonstrated to U.S. DOT during a full-day acceptance test conducted in April 2014. Details of this Acceptance Test are included in Chapter 6.

Phase 1 Demonstration Period

Upon successful testing and U.S. DOT acceptance, the IDTO PD Phase 1 period officially commenced in May 2014. During this period, bi-weekly meetings were held between U.S. DOT, Battelle and the IA Team to provide status of system use, data collection, and other observations. Similarly, bi-weekly meetings were also held between Battelle and the local marketing efforts. Finally, Battelle met roughly every 6 weeks with the local partners to ensure that there were no major issues or concerns related to the IDTO PD operational period. December 2014 saw the end of the Phase 1 Demonstration Period, at which time the C-Ride application, as the IDTO bundle was branded, was shut off concurrent with the end of the fall semester at OSU.

Phase 2 Partner Engagement

Once the Phase 1 system was operational, attention turned to integrating the Phase 2 partners. Specifics of each partner's participation is discussed elsewhere in this report, but unlike Phase 1, which included a several month long baseline and operational data collection period, Phase 2 focused on integration with partners' existing operations and systems to facilitate the IDTO Prototype; and, to a lesser extent, recurring status/observations and discussions with key personnel, as conducted by both the PD and IA Teams. The Phase 2 partners included LYNX, the UCF, and Florida DOT's SunRail. Table 2-2 lists the Phase 2 site partners and their roles.

Table 2-2. IDTO Phase 2 (Orlando) Site Partners and Their Roles

Partner	Service	Role	Applications		
			T-CONNECT	T-DISP	D-RIDE
LYNX	Fixed Route/Schedule	T-CONNECT Provider	X		
UCF Shuttle	Fixed Route/Schedule	T-CONNECT Feeder	X		
SunRail	Fixed Route/Schedule	T-CONNECT Feeder	X		
Battelle	IDTO Prototype	System Integrator	X	X	X

Source: Battelle

Phase 2 Design and Deployment

Updates to the Phase 1 IDTO prototype for use in Phase 2 began in June 2014 and included a refresh of both the IDTO PD-specific set of System Requirements[7] and the related Systems Architecture and Design[8] documents. This revised set of documents reflected the features and capabilities that were available for implementation based on the partners participating in the Central Florida demonstration, and detailed the approach for implementing the IDTO prototype components, including the traveler application, partner equipment/applications, and interfaces to the partner systems. System testing began in mid-October 2014, and was performed both remotely and on-site in advance of the formal Acceptance Test. No formal hardware deployment was necessary as part of this phase.

Phase 2 Acceptance Testing

In November 2014, representatives of Battelle, TranSystems, and U.S. DOT participated in a 2-day formal acceptance test of the Phase 2 deployment of IDTO. Connections from UCF to LYNX and SunRail to LYNX were both demonstrated. Chapter 8 discusses the details of this phase.

D-RIDE Design

In December 2014, implementation of the Dynamic Rideshare (D-RIDE) component, as fulfilled by Zimride, began. Battelle and Zimride designed and agreed to an application programming interface (API) that allowed programmatic access to the available rides stored in the Zimride database. This API is documented as part of the Phase 2 System Design document previously referenced.

D-RIDE Acceptance Testing

The integration of D-RIDE was demonstrated in March 2015 to representatives of U.S. DOT and Noblis in Washington DC. This final demonstration showed the integration of a dynamic rideshare provider to enable address-to-address trips. Details of this acceptance are included in Chapter 9.

Data Collection

Data collection efforts were an ongoing process that extended nearly the duration of the IDTO PD project. Data in the form of route and schedule information, AVL, and estimated time of arrival (ETA) were all critical to the IDTO prototype algorithms used for planning and monitoring trips. This data was provided, as either static or dynamic data, as appropriate, for use by the IDTO systems. Additionally, baseline and operational data, which included those data already listed as

[7] Mishra, Santosh and Schweiger, Carol and Rizek, Jodi and Timcho, Thomas and Burns, Matthew and Zink, Gregory. *Report on Functional Requirements and Software Architecture for the IDTO Prototype: Phase 2 – Central Florida Demonstration.* United States. Dept. of Transportation. ITS Joint Program Office, 2015, FHWA-JPO-16-273.

[8] Herman, David and Brohard, Andrew and Burns, Matthew and Zink, Gregory and Timcho, Thomas. *System design and architecture for the IDTO prototype – Phase II Demonstration Site (Central Florida).* United States. Dept. of Transportation. ITS Joint Program Office, 2015, FHWA-JPO-16-274.

well as other transit-related data, such as passenger counts, wait-times, etc., as necessary for the IDTO IA, were also provided.

Project Closeout

In June 2015, closeout meetings, held in both Columbus and Central Florida, were conducted. During each meeting, U.S. DOT conducted site visits/meetings with each of the IDTO participants, collecting first-hand observations and input from the key stakeholders.

Chapter 3 Demonstration Plan and Partners' Roles

This chapter provides details related to the specific demonstration phases, the characteristics of the selected demonstration sites, and the roles of the corresponding partners.

Phase 1 Demonstration Plan and Partners

The goal of the IDTO PD demonstration included the following:

- Demonstrating a prototype that can support both mobile and traditional web interfaces and is interoperable with existing transit and transportation service providers.
- Generating data that supports U.S. DOT DMA policy and program direction and which will provide a resource to other researchers and developers through the Research Data Exchange.
- Generating technology solutions and institutional models that are compatible with legacy/enabling systems and relationships, and which consider institutional models that are replicable, and to a lesser extent, scalable.
- Observing and documenting the synergistic potential of the three applications that emphasize dynamic transit operations.

The IDTO Phase 1 demonstration included the deployment of the IDTO prototype system in Columbus, Ohio, and the recruitment of participants who utilized the IDTO prototype system in real-trip situations in order to generate the desired data. The Phase 1 demonstration included the development of a mobile application for both the iOS and Android platforms, the integration of a host of transportation providers, and the implementation of a common system to plan, schedule, and monitor all use of the IDTO prototype system, including collection of data to support the IA Team.

Our demonstration plan included the following steps:

1. Field deployment of the IDTO prototype system in a real-world operational environment using live data and integration into the operations of our partner transportation providers. This consisted of:
    a. Installation of IDTO-specific MDTs for use by Capital Transportation as both transfer request mechanism, as well as an AVL system
    b. Installation of a Dispatcher Portal application at COTA to augment their operations to support the T-CONNECT feature

   c. Publishing both the web-based IDTO Traveler Portal as well as iOS and Android applications to provide traveler access to the IDTO prototype system
   d. Deploying the cloud-based IDTO Middleware to serve as the central point or hub for all planning, scheduling and communications for the IDTO prototype system
2. Recruiting participants to utilize IDTO
3. Monitoring and reporting data collected.

The Phase 1 demonstration team consisted of COTA; the OSU TTM Department, which operates CABS; and Capital Transportation, a Columbus-based private-sector transportation provider that operates a demand/response shuttle service at the DSCC military base.

The Phase 1 demonstration team partners, their roles, and the associated applications deployed during the field test were previously identified in Table 2-1. Background information and details of the specific role for each of the Phase 1 partners is provided below.

COTA

COTA is the primary provider of public transit services in Central Ohio, offering both fixed-route bus service and paratransit services. Based on 2012 statistics, 69 bus lines traverse Central Ohio, with 21 routes passing through the OSU campus and four routes providing service to the DSCC base. Fifteen of these 25 routes directly intersect routes of the other transit providers for the Columbus demonstration (i.e., OSU CABS and Capital Transportation at the DSCC), enabling transfers to and from those buses. COTA also has a partnership with OSU, which permits OSU students to ride COTA buses for free anywhere in the system. In 2012, COTA averaged more than 40,000 weekly boardings by OSU students.

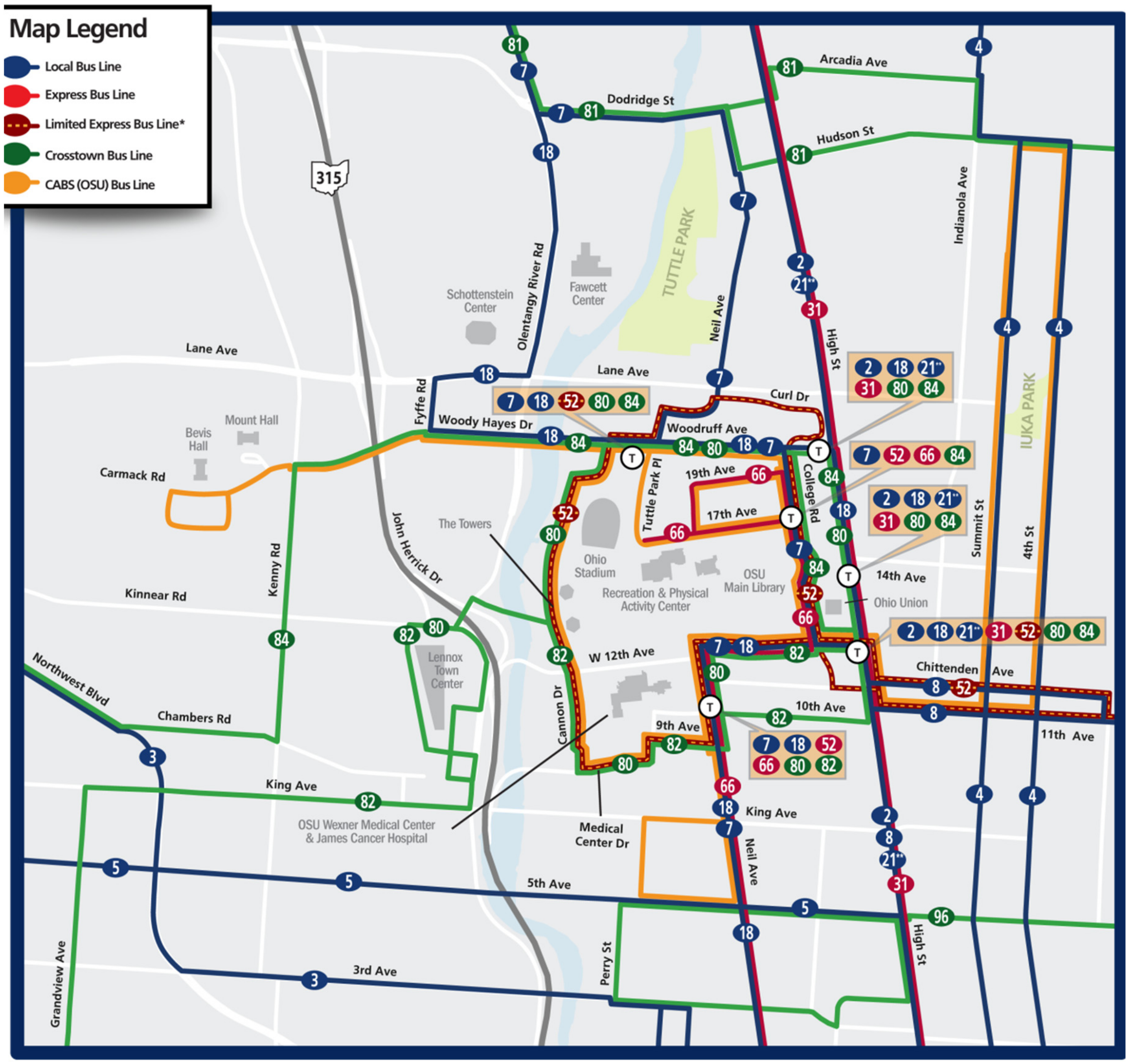
COTA served as the outbound T-CONNECT provider, offering select routes in the OSU Campus area as well as near DSCC as candidates for the T-CONNECT hold as determined by the IDTO system. In support of this effort, COTA allowed for IDTO PD Team members to install project-specific hardware at COTA's McKinley Avenue facility. COTA dispatchers were then trained on the use of the equipment and fully supported the efforts. COTA staff also made themselves and the requested data available to U.S. DOT and the IA Team.

CABS

The main campus of OSU is one of the largest single-site campuses in the U.S. and is located just north of downtown Columbus. The campus is situated on over 3,400 acres, has a population of more than 56,000 students, and employs more than 42,000. CABS is a free transit service provided by OSU TTM. CABS operates a daily fixed-route shuttle service. The CABS fleet consists of 30 buses on 7 routes, and comprises more than 30 route miles. Annually, CABS serves more than 4.5 million passengers. Up-to-date information for CABS buses is available to passengers via OSU's Transportation Route Information Program (TRIP), which utilizes GPS tracking to broadcast bus arrival times on its website, via electronic signs at stops across campus, and through a mobile phone application.

CABS served as an inbound provider for the T-CONNECT application. While no specific changes were made to operational procedures associated with CABS, nor was any additional equipment necessary for installation on their part, the OSU team fully supported the IDTO PD team by offering a live connection to the real-time AVL data provided through TRIP; and made their staff and the requested data available to U.S. DOT and the IA Team. Further, CABS dedicated a driver and bus for all testing activities, and allowed for artificial delays and disruption to be inserted to test and demonstrate the full capability of the IDTO applications.

Figure 3-1 illustrates the CABS and COTA routes located in the central campus area that were candidates for the T-CONNECT application.



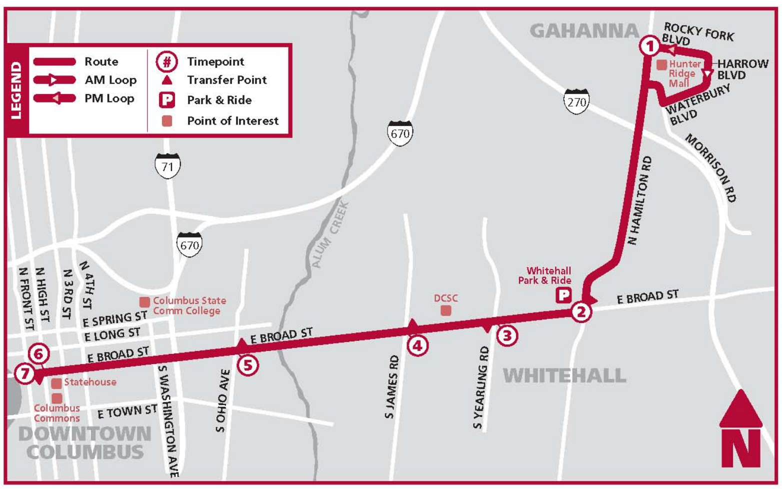
Source: COTA

Figure 3-1. COTA Serves the OSU Campus via Multiple Fixed-Route Bus Lines

Capital Transportation

Capital Transportation was formed in 1997 and is Central Ohio's largest minority-owned transportation service provider. Capital Transportation serves local school districts, government agencies, non-profits, and private organizations and groups. On the 530-acre DSCC military base, Capital Transportation operates demand responsive shuttle service to employees and tenants. This services attracts over 30,000 passengers per month, and also interfaces with COTA's neighboring fixed-route service.

During the demonstration, Capital Transportation served as the inbound segment for COTA's T-CONNECT transfers. Capital Transportation allowed for the installation of the MDT/AVL System in two of their shuttles serving the DSCC area. Capital Transportation riders where then afforded the ability of the system to protect the transfers from the Capital Transportation shuttle to adjoining COTA service. Figure 3-2 and Figure 3-3 show the COTA routes that service DSCC and for which Capital Transportation riders might be expected to transfer to. Capital Transportation staff were also trained on the operation of the MDT and its role in the IDTO project. Finally, Capital Transportation made available its staff and the appropriate data to support interviews and analysis by U.S. DOT and the IA Team.



Source: COTA

Figure 3-2. 1st of 2 Route Maps for COTA Service to DSCC – See Stops #3 & 4.

Source: COTA

Figure 3-3. 2nd of 2 Route Maps for COTA Service to DSCC – See Stop #7.

Battelle

Battelle's role in the IDTO demonstration included the development and operation of the IDTO prototype. The IDTO prototype encompassed the Travel Management Coordination Center (TMCC), as well as the mobile applications and data collection capabilities associated with the various efforts in this demonstration. Like the local partners, Battelle made available all necessary data (with PII removed) to the IA Team, as well as making IDTO PD project staff available to the U.S. DOT and IA Team for interviews.

Phase 2 Demonstration Plan and Partners

As noted previously, Phase 2 consisted of a demonstration of technical feasibility, showing that the IDTO bundle can be re-deployed elsewhere with minimal effort. Assigned researchers acted as passengers on the various transit options and tested the operability of the IDTO prototype. The IDTO Phase 2 demonstration was conducted in Orlando, Florida. Details of Phase 2 are included in Chapter 8.

The Phase 2 partners included:

- Central Florida Regional Transportation Authority (LYNX) – the bus system operated by the Authority
- UCF's on-campus transit system (as operated by Veolia) that was equipped with real-time AVL capability
- SunRail heavy commuter rail service for the greater Orlando area, which began operations in May 2014, and is also AVL capable.

Table 2-2, in a previous chapter, lists the Phase 2 site partners and their roles. Background information and details of the specific role for each of the Phase 2 partners is provided below.

LYNX

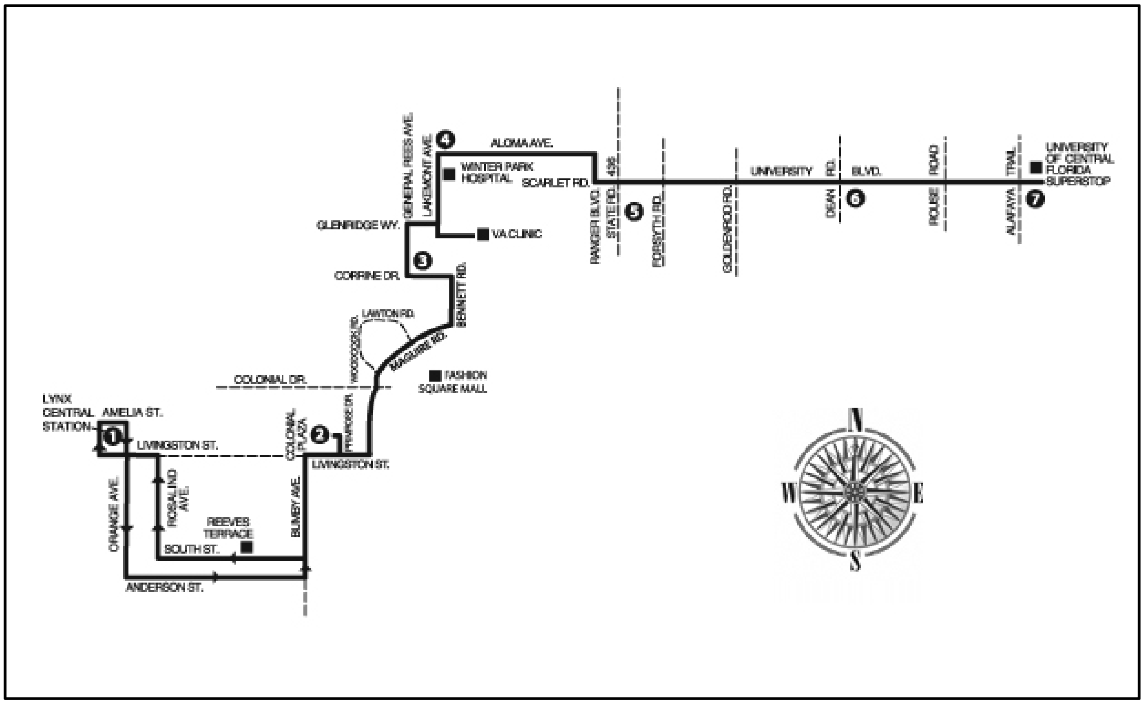
LYNX provides fixed-route and demand response services in Orange, Osceola, and Seminole counties with a total of 55 traditional fixed routes in an area of approximately 2,500 square miles. LYNX has one of the largest service areas of transit agencies of comparable size and serves small portions of surrounding counties as well. LYNX's core service area is home to 1,837,359 residents and the system boasts more than 30.1 million passenger trips in 2014.

For the Phase 2 demonstration, LYNX served as the outbound T-CONNECT provider, offering access to their general transit feed specification (GTFS) data stream, in order to support the demonstration. LYNX staff also made themselves and the requested operational data available to U.S. DOT and the IA Team.

UCF Campus Transit System

UCF provides an on-campus transit system that interconnects with LYNX. The system is led by the University's Parking and Transportation Services department working with the private company Veolia, and offers 11 campus shuttle routes. The system is used by more than 2 million students annually, and features a mobile website with AVL capabilities so students can estimate arrival times at designated bus stops.

UCF served as an inbound provider for the T-CONNECT application. While no specific changes were made to operational procedures associated with this service, nor was any additional equipment necessary for installation on their part, the UCF/Veolia team fully supported the IDTO PD team by offering a live connection to the real-time AVL system operated by the University, and made their staff and the requested data available to U.S. DOT and the IA Team for the demonstration and IA purposes. Figure 3-4 illustrates the service routes covered by UCF shuttles, including those used for the demonstration.



Source: University of Central Florida, Parking and Transportation Services

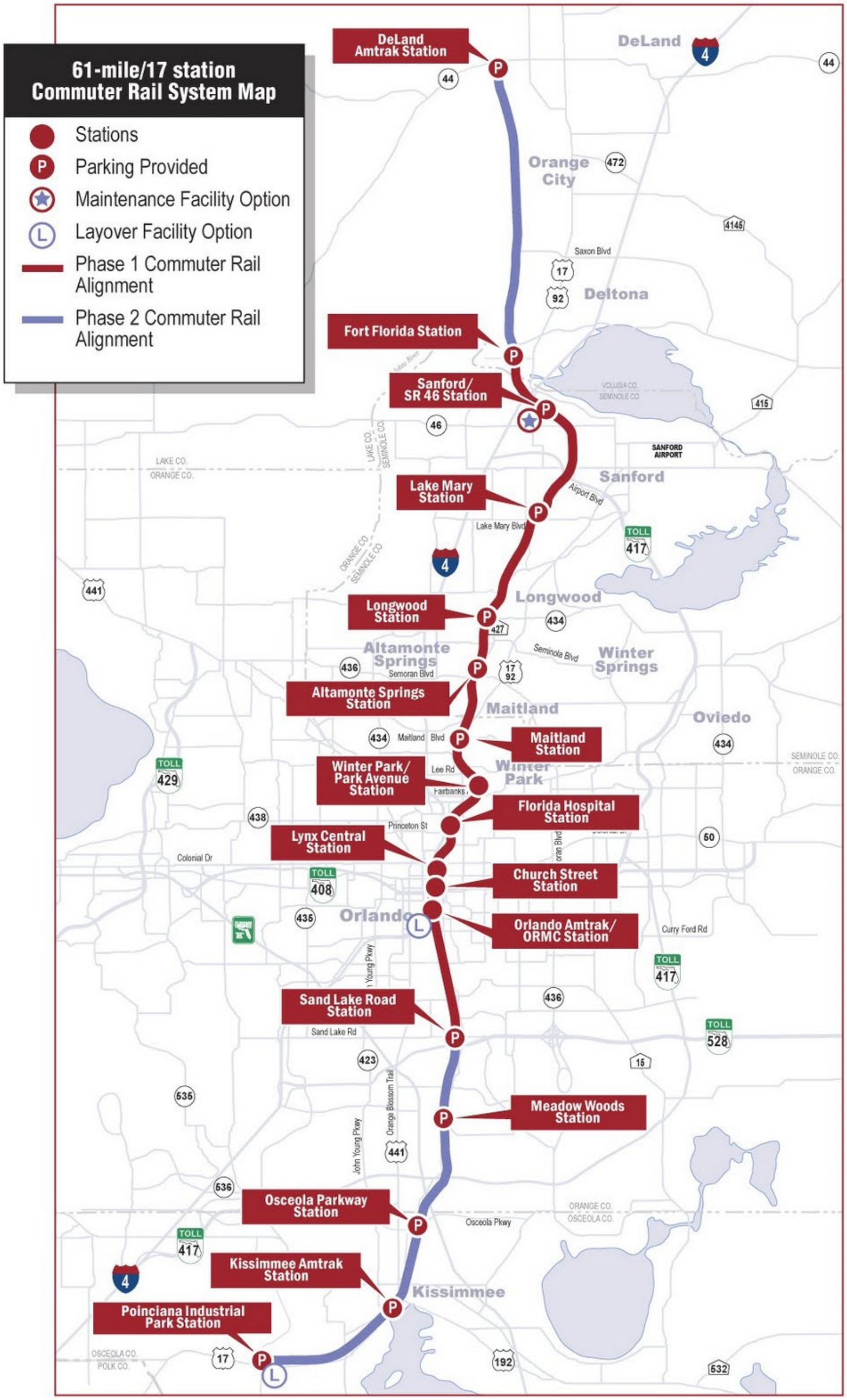
Figure 3-4. UCF Shuttle Campus Route

SunRail

SunRail is a new commuter rail service in Central Florida that began service in May 2014. The system links cities along the existing CSX railroad tracks through four major central Florida counties: Volusia, Seminole, Orange, and Osceola. SunRail service operates at 30-minute intervals during the A.M. and P.M. peak periods and averages approximately 3,200 riders per day. Since its inception, LYNX and SunRail have made efforts to coordinate scheduling.

SunRail served as an inbound provider for the T-CONNECT application. While no specific changes were made to operational procedures associated with SunRail, nor was any additional equipment necessary for installation on their part, the SunRail team fully supported the IDTO PD team by offering a live connection to the real-time AVL system operated by the agency, and made their staff and the requested data available to U.S. DOT and the IA Team.

Figure 3-5 illustrates the service routes covered by SunRail, including those used for the demonstration.



Source: SunRail

Figure 3-5. SunRail Station Map

D-RIDE Demonstration

A third demonstration was conducted to demonstrate the features of the D-RIDE application and the integration of it with the broader IDTO bundle. Not originally planned, this third demonstration became necessary as the privacy and third-party data use policies of the selected D-RIDE partner did not allow for inclusion in either of the actual field demonstrations. Instead, a controlled-environment demonstration, using only project team members as participants, was developed and performed, proving that both the concept of real-time ride offerings by mobile-phone equipped drivers was feasible, and that these D-RIDE offerings could be further integrated with the T-DISP trip-planning feature, to facilitate a complete door-to-door solution for system users.

In order to demonstrate this capability, the architecture of the original Phase 1 demonstration system was expanded to add the D-RIDE component. Further, schedule data from Phase 1 partner COTA remained as a partner to support this demonstration. Serving the role of the D-RIDE provider was Zimride.

Zimride

Zimride, a service of Enterprise Rent-A-Car, is one of the largest web-based carpool and ridesharing programs in the United States. Zimride uses social networking to perform ride matching services for drivers and passengers, and has partnerships with both Facebook and ZipCar. Zimride has over 130 university and corporate campus clients and serves approximately 350,000 users.

During this demonstration phase, the T-DISP component of the IDTO deployment was expanded to include Zimride as the D-RIDE partner. Zimride implemented an API that allowed for IDTO to query the system for available rides and allow these rides to be included in trip planning options of C-Ride. Zimride subsequently allowed for sample rides to be added to a private Zimride account via website access established specifically for this project.

Finalization of IDTO Transit Agency Policies

Establishing and documenting agreements between transit partners on topics such as honoring T-CONNECT requests and their willingness to provide cross-agency transportation options was critical to this demonstration. One advantage to Phase 1 is that the proposed transit partners (COTA, OSU CABS, and Capital Transportation) already interface with each other and have had a successful history of collaboration and coordination of services. For example, approximately 16 percent of the COTA ridership consists of OSU students, thereby providing a natural platform and incentive for cooperation and inter-agency agreements.

For this demonstration, COTA allowed a given bus on a given route to be delayed up to one (1) minute in order to honor a T-CONNECT request, so long as the current route schedule was not delayed beyond five (5) minutes, and that no individual bus was held more than once per route. COTA dispatchers were able to review and deny any T-CONNECT request as necessary. The default behavior of the system was however to reject the T-CONNECT request automatically if no dispatcher interactions occurred within a configurable window of time associated with the transfer request. Riders, in turn, received updates on the status of their transfer as they progressed through their saved trip.

Chapter 4 System Development

This chapter provides details related to the development activities conducted in support of the IDTO prototype.

System Requirements

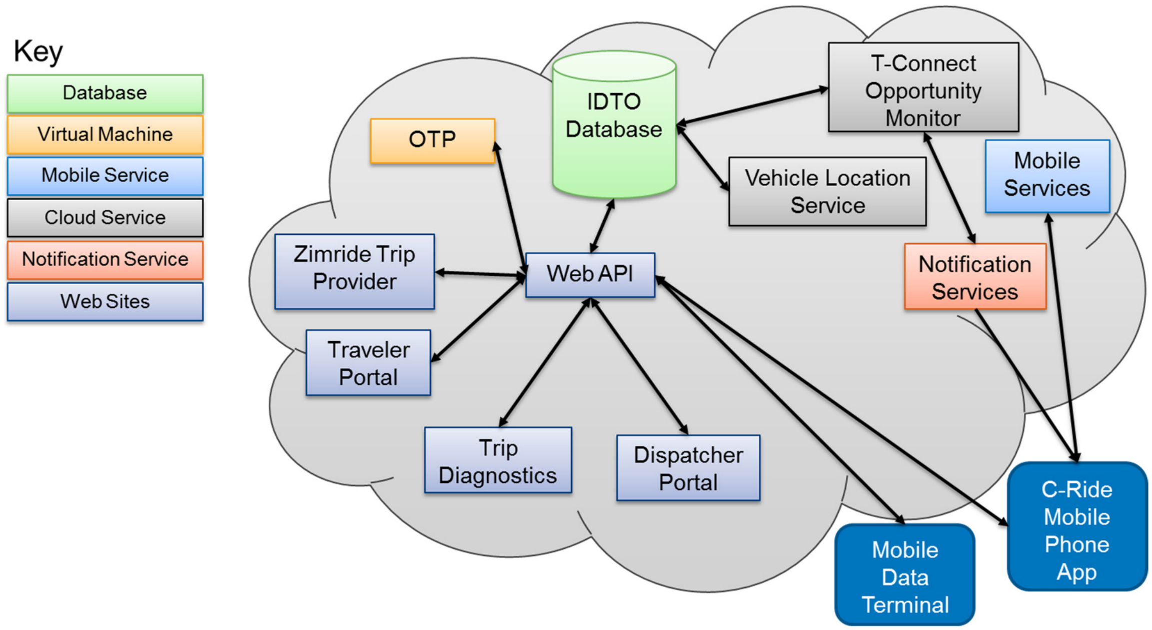
As previously noted, the IDTO PD project built on previous U.S. DOT-sponsored research. This prior research was responsible for several foundational reports, including:

- Report on Stakeholder Input on Transformational Goals, Performance Measures and User Needs for Integrated Dynamic Transit Operations (FHWA-JPO-12-084)
- Assessment of Relevant Prior and Ongoing Research for the Concept Development and Needs Identification for Integrated Dynamic Transit Operations Report (FHWA-JPO-12-082)
- Integrated Dynamic Transit Operations Concept of Operations (FHWA-JPO-12-083)
- Report on Functional and Performance Requirements, and High-Level Data and Communications Needs for Integrated Dynamic Transit Operations(FHWA-JPO-12-085)
- Test Readiness Assessment Summary for Integrated Dynamic Transit Operations (FHWA-JPO-12-086).

Starting with the "Functional and Performance Requirements…" report, the IDTO PD team assessed each requirement and determined if the current mix of partners could allow the requirement to be implemented and demonstrated as-is, not at all, or with modification. This assessment and any corroborating information was captured in the IDTO-specific version of System Requirements FHWA-JPO-14-166 for the Columbus partners, and similarly in FHWA-JPO-16-273 for Central Florida.

Architecture and Design

The full system design and architecture for the Columbus Phase 1 deployment can be found in document *FHWA-JPO-14-167 IDTO System Design and Architecture*. In the course of implementation, the planned versus actual design varied slightly. Figure 4-1 illustrates the architecture of the actual implementation. Some of the items shown in this figure that were generic in the original design have been specifically identified in this figure. For example, the Rideshare Service, D-RIDE, has been implemented as the Zimride trip provider, because it necessitated a unique interface to integrate this provider with IDTO. The dynamic scheduler service was removed between the planned design and the field. The services originally envisioned in this role experienced deployment delays unrelated to IDTO, but nonetheless, were unavailable for inclusion in the IDTO PD project. The following details the major components as shown in Figure 4-1 and as implemented in this revised architecture.



Source: Battelle

Figure 4-1. IDTO Prototype Architecture (Implementation)

IDTO System Components

As embodied in Figure 4-1, the IDTO PD deployment can be organized into the following categories:

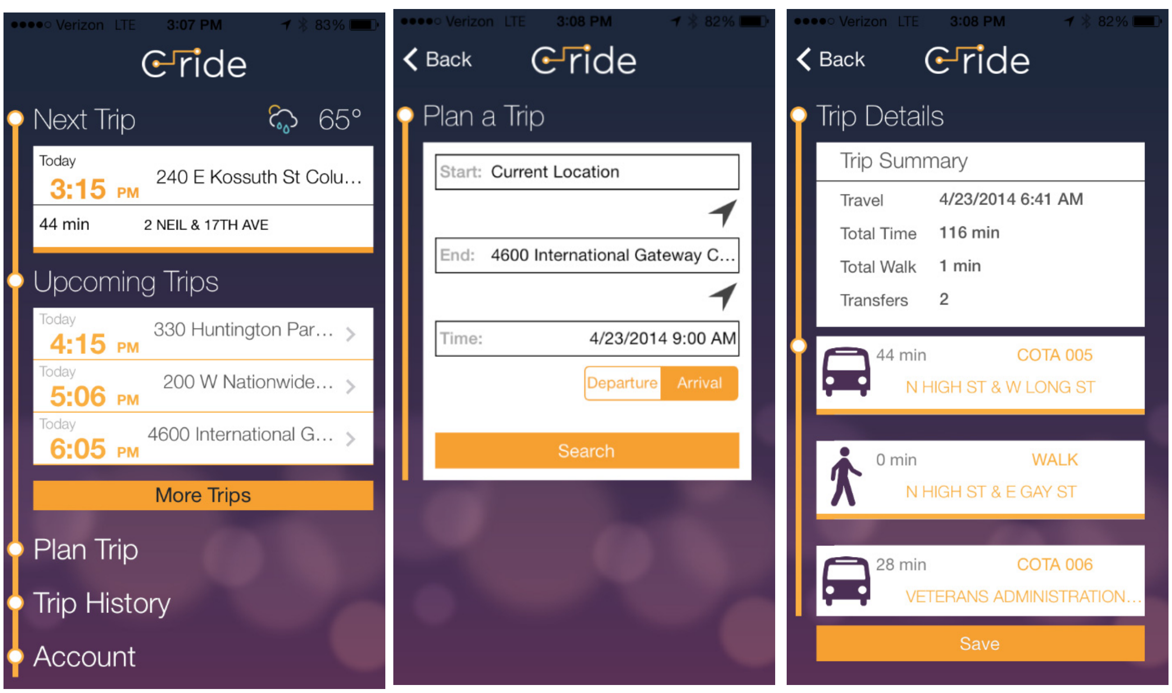
- Traveler Interfaces;
- Agency Interfaces;
- Cloud Services; and
- Route Aggregators and Trip Planning.

Traveler Interfaces

The traveler interfaces are the visual user interfaces made available to the traveler via either a smartphone application or a traditional web browser.

Mobile Application

The IDTO mobile phone application was published under the name Connect and Ride (C-Ride) in both the Google Play Store and the Apple App Store. The C-Ride application allowed travelers to interact with the IDTO prototype system. These interactions included account creation, accessing the system using secure credentials, searching for transit trip options, saving a trip, deleting a trip that has not started, viewing upcoming trips, viewing trip history, and making account modifications, including updating traveler options. The C-Ride application allowed the user to request trips that might contain T-CONNECT opportunities or a D-RIDE segment. The mobile application would aid in facilitating trips by giving travelers reminders, using the phone's operating system (OS) notifications feature before their trip would start. The mobile application would also relay T-CONNECT request status information to travelers whose trips had a T-CONNECT opportunity that turned into a T-CONNECT request. Figure 4-2 shows sample screen captures from the mobile device for the Next Trip, Plan a Trip, and Trip Details screens in the C-Ride application.

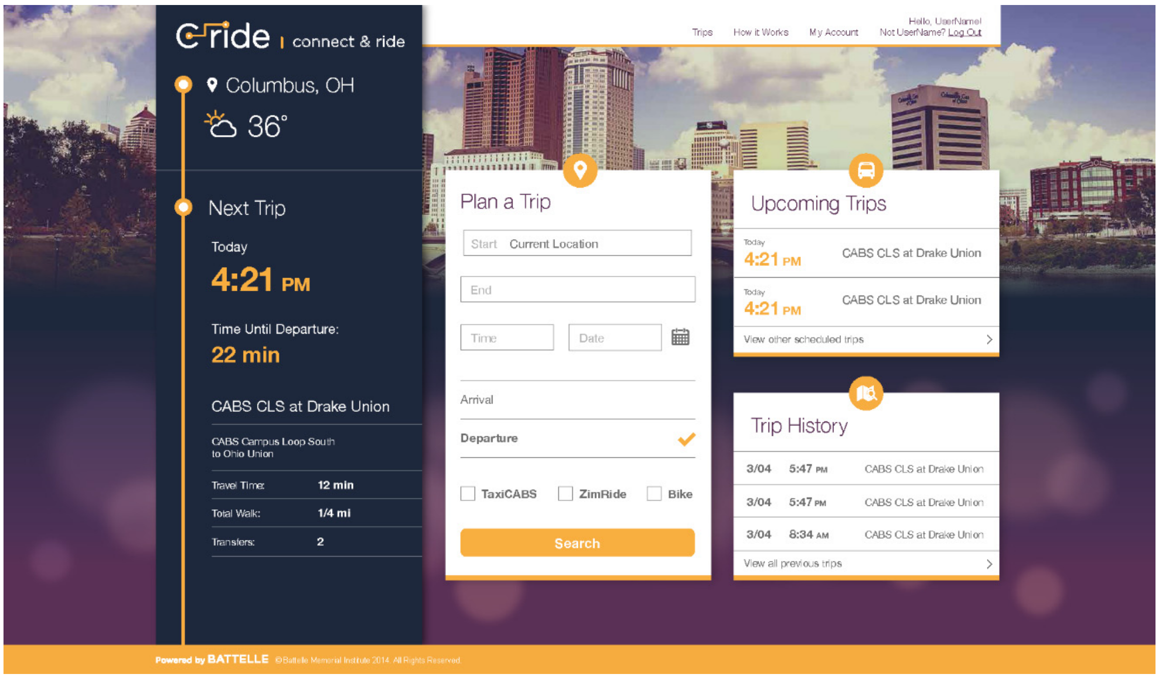


Source: Battelle

Figure 4-2. Next Trip, Plan a Trip, and Trip Details Screens from C-Ride App

Traveler Portal Website

The traveler portal is similar to the IDTO mobile application, C-Ride, in that it allows a traveler to interact with the IDTO system. The traveler can create an account, access the system using secure credentials, search for transit options, save trips, view trip details, manage trips, view saved trips and trip history, and perform basic account management. The website differs from the mobile application in that it does not implement an ability to provide the traveler real-time notifications about upcoming trips or T-CONNECT request status changes, because it assumes this interface would be used pre- and post-trip, but not during. Figure 4-3 offers an example screen capture of the trip planning page as seen via the traveler portal.



Source: Battelle

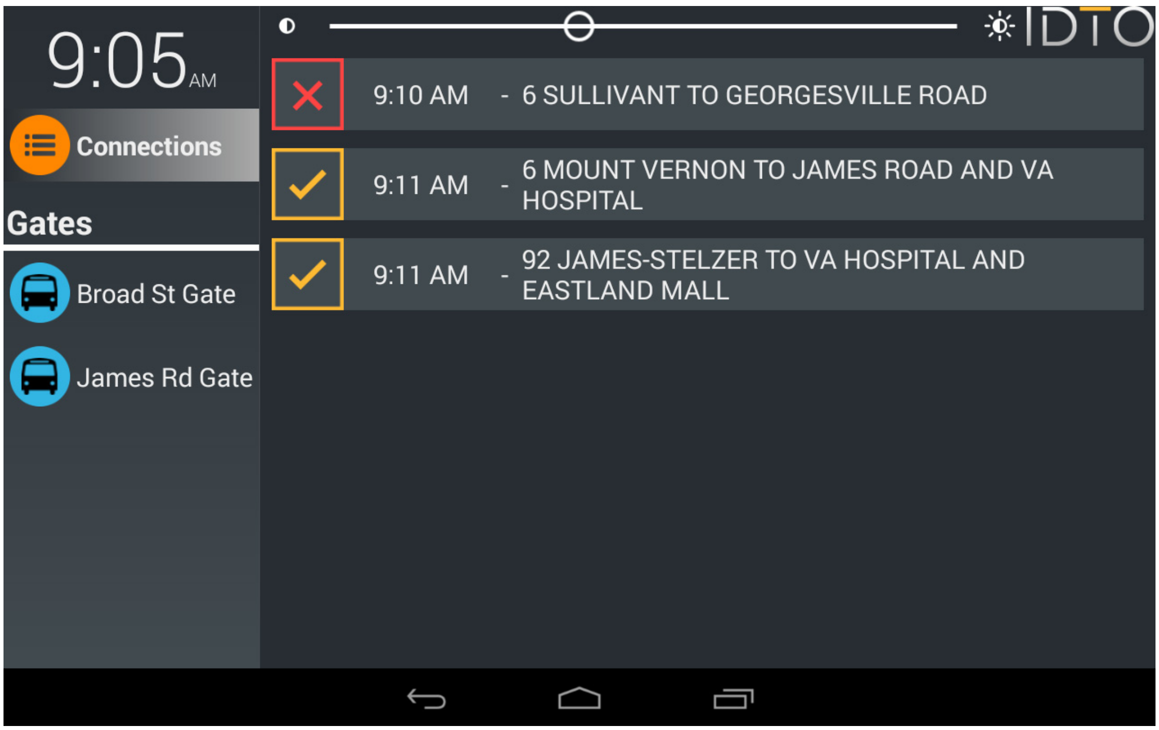
Figure 4-3. IDTO Traveler Portal Interface

Agency Interfaces

The agency interfaces were implemented as a part of this project in order to support the necessary functionality of IDTO in instances where existing functionality did not previously exist, or in instances where it was not practical to integrate with the existing interfaces (i.e. proprietary).

Mobile Data Terminal

The Mobile Data Terminal (MDT) enabled a bus driver to interact with the IDTO system on behalf of a traveler in order to schedule trips. The MDT for IDTO was designed to be used on a shuttle bus where there were dedicated stops to allow transfer to outbound T-CONNECT providers. The MDT allowed the shuttle bus driver to select which gate and which transferring outbound bus a traveler would be riding. The MDT also sent GPS positions, which were monitored by the vehicle location monitor, to generate estimated time of arrival to the fixed destinations. Those times were used by the trip opportunity monitor for T-CONNECT monitoring. A screen shot of the MDT showing accepted and rejected T-CONNECT requests is shown in Figure 4-4. As part of the IDTO PD demonstration, the MDT was deployed on the Capital Transportation fleet that operated at DSCC.

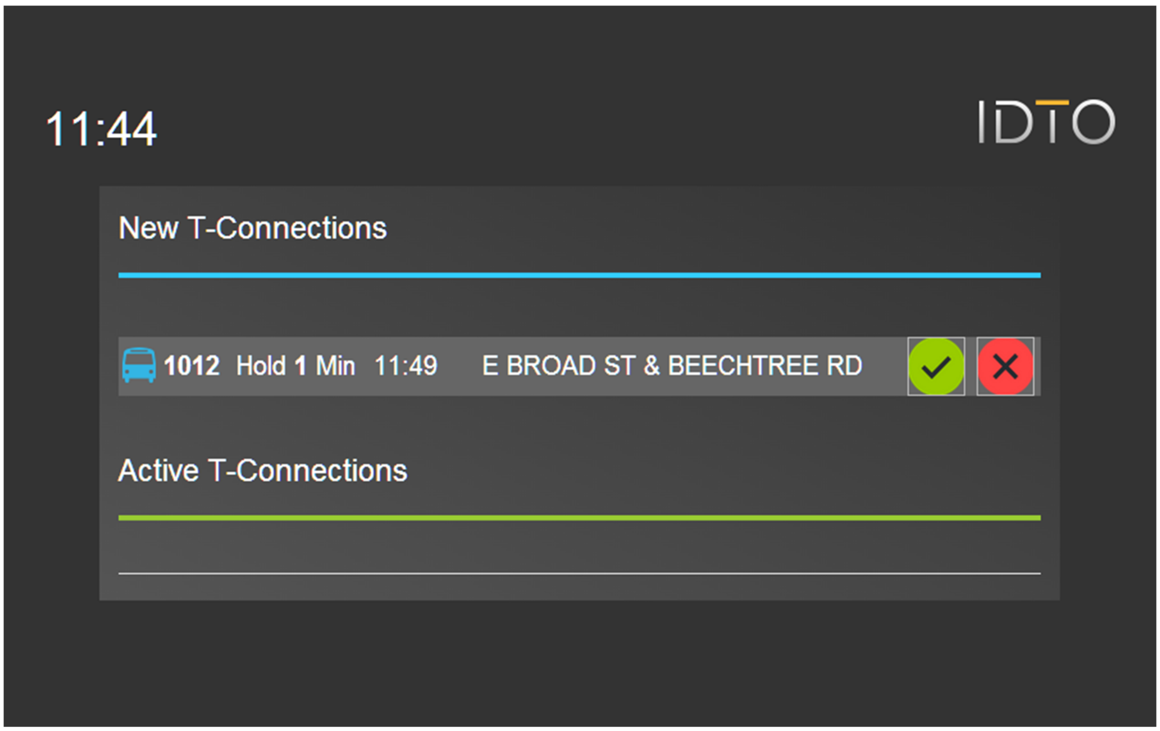


Source: Battelle

Figure 4-4. Mobile Data Terminal Screen

Dispatcher Portal

The Dispatcher Portal displayed all T-CONNECT Requests to the T-CONNECT provider's dispatcher for their review and approval. A dispatcher would receive an audible tone from the Dispatcher Portal when a new T-CONNECT Request was available for review. The dispatcher then reviewed the new T-CONNECT request information and either approved or rejected the request based on whether the request could be fulfilled. The dispatcher portal updated the request in the IDTO Database through the web API based on the dispatcher's action. A screen shot of the Dispatcher Portal showing a new T-CONNECT request is shown in Figure 4-5. Three instances of the Dispatcher Portal were deployed at COTA's dispatch/radio room to support the Phase 1 deployment.



Source: Battelle

Figure 4-5. Dispatcher Portal Showing New T-CONNECT Request

Cloud Services

T-CONNECT Opportunity Monitor

The T-CONNECT Opportunity Monitor, or TOM, was the main component of the T-CONNECT system for IDTO. The goal of T-CONNECT was to improve rider satisfaction and reduce expected trip time for travelers by increasing the probability of automatic intermodal or intra-modal connections. T-CONNECT protected transfers between both transit (e.g., bus, subway, and commuter rail) and non-transit (e.g., shared ride) modes, and facilitated coordination between multiple agencies in order to accomplish these tasks. TOM monitored trips scheduled by IDTO riders for T-CONNECT opportunities, including where a transfer would occur and when the possibility of missing a transfer occurred. These trips were retrieved from the IDTO Database, including the trip's scheduled departure time, the trip's steps, including transit authority name, Transit Vehicle Route Number, departure time, departure stop location, arrival time, and arrival stop location. All T-CONNECT requests and responses were logged to the IDTO Database for purposes of verifying system functionality and post-demonstration evaluation by the IA Team.

TOM also notified the traveler of the status of any T-CONNECT request on his or her trip. The T-CONNECTION status was sent using the notification service available on the traveler's mobile device. These T-CONNECT notifications included the creation of a T-CONNECT and any status updates for that T-CONNECTION.

IDTO Database

The IDTO Database was the main persistent storage component of the IDTO system. The database contained storage tables for participant information, trip information, and system configuration. The underlying IDTO Database was housed as an instance of SQL Azure in Microsoft's Azure cloud environment, allowing access to it from all authorized participants, via the web API, and enabling it to serve the two distinct locations with only a single instance. The final database schema, complete with the data definition language (DDL) scripts necessary to recreate the database are part of the software component, was published on the Open Source Application Development Portal (OSADP).

Web API (Application Programing Interface)

The web API was a RESTful[9] web service, which served as the main interface into the IDTO system. The smartphone application or the traveler portal and the IDTO cloud platform would interface to the IDTO system using the web API to send and receive data to fulfill the traveler's needs. The web API had methods for account registration, account management, travel option searches, trip selection, save trip management, and notifications. Data exchanged between a client and the web API utilized the JavaScript Object Notation (JSON), a lightweight, human readable format for transferring data in a platform-agnostic manner.

Vehicle Location Service

The Vehicle Location Service gathered location information for the inbound vehicles for active T-CONNECT trips. The location information came from a variety of external sources, and included ETA for the stop or station at which the 'protected' transfer took place or the location of a vehicle. Depending on the source of the data, if ETA was not present, the vehicle location service generated an ETA. This ETA was an approximation based on current location, and drive time to the location where the T-CONNECT transfer would take place. The ETA was then supplied to the TOM for processing T-CONNECT requests.

Notification Service

The Microsoft Azure Notification Service allowed the IDTO system to send notifications to the mobile devices. The mobile application would register for notifications, if the user granted access, and would send trip start notifications and T-CONNECT request status notifications to the user.

[9] https://msdn.microsoft.com/en-us/library/azure/dd179355.aspx

Mobile Service

The Microsoft Azure Mobile Service bundle was used to manage accounts in the IDTO System. This service stored usernames and passwords securely, and enabled the mobile application and the traveler portal to verify user account information.

Route Aggregators and Trip Planning

Open Trip Planner (OTP)

The IDTO System used Open Trip Planner to search for transit trip options. Open Trip Planner (OTP) is an open-source platform for multi-modal and multi-agency trip planning. It provided a RESTful API for use by third-party applications for trip planning searching. OTP relied on open data standards including the general transit feed specification (GTFS) for transit scheduling and OpenStreetMap for street networks. Multiple GTFS feeds from multiple agencies were loaded into OTP to allow transfers between different agencies in the same geographic location. Similar to the SQL Azure instance, a virtual machine, housed in the Microsoft Azure cloud, was used to deploy the OTP software. OTP is available at http://www.opentripplanner.org/.

Zimride Trip Provider

The Zimride trip provider was an example of a rideshare trip provider. This provider allowed searching of the Zimride instance for trips that either were fulfilled by the rideshare provider, or trips that could use the rideshare provider and transfer to another mode of travel. The Zimride trip provider returned trips that were viewable in the mobile application just like the trips that were returned by the OTP instance.

Standards and Messages

Separate from the industry standard for message exchange, such as GTFS, GTFS-Real Time (RT), and others, the implementation of IDTO, as a computer software system, leveraged industry standards for developing and deploying interfaces used by the various components for data exchange. These are highlighted below.

JavaScript Object Notation (JSON)

Data interchange with the IDTO web API web service utilized the JavaScript Object Notation (JSON), a lightweight, human readable format for transferring data in a platform-agnostic manner. JSON is an open standard format that uses text to transmit data objects consisting of attribute-value pairs, and can be consumed by many computer systems written in a variety of programming languages.

IDTO Web API Messages

The IDTO web API allowed clients to access a variety of data stored in the IDTO system. The messages for the web API calls can be found in the referenced document, *FHWA-JPO-14-167 – IDTO System Design and Architecture, Section 5; IDTO Data Model and Schema.*

Test Visualization Tools

In support of system health and status monitoring, troubleshooting, and the monitoring of internal system functions during demonstration testing, a web-based visualization tool was developed. Details of these follow.

Trip Diagnostics Web Page

The trip diagnostics web page allowed administrators to have an inside view of the IDTO system as it was functioning in real time. This was the main diagnostic tool that allowed administrators to monitor the performance of the IDTO system. An administrator could monitor the ETA for all inbound vehicles for an agency using the trip diagnostics tool. Another feature was the ability to monitor an in-progress trip for T-CONNECT request generation. A test observer or administrator could watch the trip from the start and see how the IDTO TOM's algorithms compared the ETA of the inbound vehicle with the planned arrival time, and the T-CONNECT generation time. Once the ETA of the inbound bus was later than the scheduled departure of the outbound trip, the trip diagnostics site would display the internal status changes determined by the TOM for the T-CONNECT Request generation, and then display any further changes to that T-CONNECT activity based on either the expiration or action taken by the dispatcher. Also provided on the trip diagnostics web page was a list of notifications that had been sent per trip. All information that was displayed in this site allowed debugging of the system if any issues occurred.

Development

Development of the IDTO PD was performed over a period of approximately 16 months, spanning all phases of the project. Commencing initially in August 2013, the development of the IDTO prototype system implemented the processes and tools necessary to safely, efficiently, and securely develop, manage, and test the software produced as part of this effort, and at the same time, meet the goals of the open-source initiatives prescribed by U.S. DOT. Additionally, because of the multi-platform support included as part of the IDTO PD effort, ensuring a consistent look and feel across the applications was critical.

As indicated in Figure 4-1 above, web services, mobile services, databases, and other components were all necessary to fulfill the requirements of the IDTO PD. Given the tight coupling of all of these varying systems, a decision was made to utilize Microsoft .NET as the common development platform across all systems, including both the smartphone devices, as well as any web/cloud presence. Further, in order to ensure a common look and feel, in the form of a consistent brand across all platforms, a style guide was developed and implemented. Appendix B includes the style guide that was utilized for the IDTO PD applications, branded as Connect and Ride or C-Ride for short. The same style elements used for the website were implemented on the mobile device.

Mobile device development itself explored an emerging concept to allow support of multiple device platforms using a single code-base. Xamarin[10], a software library for use in Microsoft .NET, in theory, allowed for development of iOS, Android, and Windows applications using only C#. It was determined that Xamarin was only appropriate for the traveler C-Ride application. The software for the Android Nexus 7 tablet (used as the MDT) and for the iOS implementations both used their native C languages respectively.

[10] https://xamarin.com/

Finally, all backend services, whether the database, the instance of OTP, or the other IDTO logic, were all housed in a Microsoft Azure environment https://azure.microsoft.com/en-us/.

Testing

Testing was performed in conjunction with the IDTO Prototype Test Plan.[11] A subset of this plan was subsequently used to support the U.S. DOT acceptance testing as documented in Chapters, 5, 8 & 9 herein.

[11] IDTO Prototype Test Plan, Battelle document 100026848-210, 2015-May-01.

Chapter 5 Installation, Checkout, and Acceptance Testing – Phase 1

In preparation for the formal start of the IDTO demonstration phase held in Columbus, a series of controlled tests and demonstrations were prepared and conducted as a final checkout of the system, in advance of and during a formal U.S. DOT acceptance. These tests were conducted with members of the IDTO PD Team serving as the travelers, and actual, but 'not-in-service' shuttles and buses where used to traverse the given routes. The formal U.S. DOT acceptance was conducted on April 29, 2014, and served as a process gate whereby satisfactory completion allowed the operational period to proceed. The preparation tests and related activities were conducted over the days and weeks leading up to this event. The remainder of this chapter serves to document the activities and results, along with any necessary user training required to achieve the desired readiness level and initiate the formal, naturalistic study.

Installation and Checkout

The equipment and associated software necessary to perform the acceptance testing and subsequent demonstration period for this phase included the following:

Mobile Data Terminal (Capital Transportation)

Two (2) Google Nexus 7 Android tablets with AT&T 4G LTE service were preloaded with the MDT software developed by Battelle, and configured in kiosk mode. These devices were mounted in two (2) Capital Transportation Ford F350 cutaway shuttle buses. Figure 5-1 illustrates an MDT installed in a shuttle using a custom mount. Devices were connected to 12V power obtained from the accessory port of the vehicle. Once powered, the LTE connectivity was verified on the MDT. Following this, the MDT-equipped shuttle was driven through a series of courses located as DSCC and the following confirmed:

- Position data acquired from the tablet device was received and stored in the cloud-based IDTO database.
- Transfer requests, as performed on the MDT, were also recorded in the IDTO database.
- Responses to T-CONNECT requests (both accepted and rejected) were displayed on the MDT.

STATUS: Checkout passed.

Source: Battelle

Figure 5-1. MDT Installation in Capital Transportation Shuttle

Dispatcher Portal (COTA)

Three (3) Apple iPad Gen3 with Wi-Fi only feature, and preloaded with the Dispatcher Portal application, were installed using multi-position viewing arms in the COTA Radio/Dispatch Room. They were powered locally and were also connected to a private Virtual Local Area Network (VLAN) that allowed them to access the Dispatcher Portal website, and only that website. Similar to the MDTs, the tablets used by the dispatchers were also in kiosk mode, allowing the application to be accessed only by the dispatcher.

- Connectivity was confirmed by injecting T-CONNECT requests into the IDTO T-CONNECT Opportunity Monitor using a test device, and
- The displays of these requests were confirmed on the Dispatcher Portal terminal.

STATUS: Checkout passed.

Real-Time Vehicle Location Data (OSU CABS)

No specific equipment was installed on the OSU CABS vehicles as they already included an AVL system that transmitted vehicle position location, on a recurring basis, to the OSU TRIPS system, for access by travelers and to update message signs, etc. with this data. Further, this data was made available to C-Ride via an external interface of the TRIPS system. Normal indication also showed minimal inbound vehicle delays. Tests were, however, made with the demonstration bus as follows:

- Confirm the receipt of and the latency associated with the position messages.

STATUS: Checkout passed.

C-Ride Mobile Application (Rider)

During this checkout & test phase, a member of the test team, serving the role of the CABS/COTA rider, was supplied with both a Google Nexus 5 Smartphone with AT&T LTE service and an Apple iPhone 5s with LTE service. The C-Ride application was installed on both of these devices, and positioning was enabled on both devices. As required, access to the GPS position feature of the phone was explicitly granted to the C-Ride application. Using the devices, the traveler inputted a series of trip requests, starting and ending at various locations in the service area. Upon saving these trips, the traveler then completed the following:

- Confirmed that trips were saved in the Trips log as indicated on the device
- Verified that the IDTO database received and stored the request.

STATUS: Checkout passed.

Test Laptop (IDTO Admin/Test Operator)

The IDTO Admin/Test Operator, in addition to receiving a representative example of both the MDT and Dispatcher Portal terminal, was equipped with an LTE-enabled Windows 7 laptop that allowed access to the public-facing C-Ride website and the IDTO Admin Portal/Microsoft Azure cloud services website. Tests were completed as follows:

- Access to these sites was confirmed at the various test locations, including onboard both the CABS bus and the Capital Transportation shuttle.
- The Test Operator used the trip diagnostics webpage on the Admin portal to verify that requests were properly being recorded, monitored, and, as appropriate, issued.

STATUS: Checkout passed.

Training

Training for the IDTO Demonstration was conducted in two ways: For the drivers and dispatchers who were expected to use the system and react to its indications, in-person training was prepared and conducted by the Battelle team. Training material in the form of both PowerPoint slides and an online video was available to all C-Ride users (aka travelers) both during the direct recruiting activities (if applicable), or via the C-Ride website.

And while not explicitly part of the training exercise, the privacy and policy statement that all participants had to agree to before being able to use the C-Ride application also contained elements of information that assisted in training participants. For example, ____________________.

The IDTO Training Plan[12] and the accompanying training slides are available under separate cover.

STATUS: Completed – Training completed both with COTA dispatchers and Capital Transportation drivers and driver supervisor.

Acceptance Testing/Results

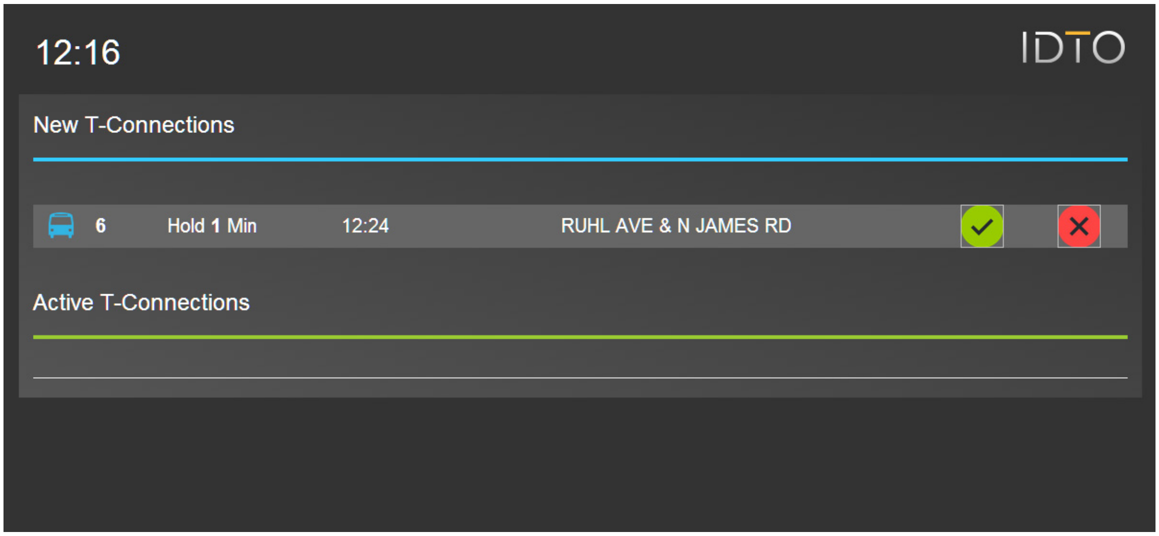
The objective of Phase 1 was to demonstrate the functionality of the IDTO Prototype for both the T-DISP and T-CONNECT applications. T-DISP provided real-time, dynamic access to both the OSU CABS and COTA schedules in order to facilitate trip planning. Additionally, the application facilitated T-CONNECT transfers from both CABS and Capital Transportation to COTA. The Phase 1 checkout involved testing the IDTO Prototype from the following user perspectives:

- COTA Dispatcher;
- Capital Transportation Driver; and,
- Traveler.

[12] Prototype Development and Prototype Demonstration for Integrated Dynamic Transit Operations (IDTO) – Training Plan, Battelle document 100026848-323, May 2015.

Dispatcher Portal Interface (COTA Dispatcher)

The COTA dispatcher interface was available as a web-based portal. IDTO-specific tablet devices were installed at COTA. The touchscreen interface allowed dispatchers to view incoming requests (New T-CONNECTs) and accept or reject them. If approved, transfers would appear as Active T-Connections. Requests were automatically rejected if no response was given within 2 minutes (see Figure 5-2).



Source: Battelle

Figure 5-2. Dispatcher Portal with Pending T-CONNECT Request

Demonstration Objectives and Results

The demonstration objectives for COTA included the following:

- Demonstrate receipt of incoming T-CONNECT request;
- Demonstrate dispatcher actions to accept, reject, and auto-reject (default if no action is taken);
- Demonstrate ability of T-CONNECT to hold bus for 1 minute or less if current delay is less than 5 minutes and the bus was not previously held on same route; and,
- Demonstrate status of active T-CONNECTs.

Following are the results of each of these objectives and the corroborating observation or data.

Test Objective	Pass/Fail	Observation/Result
Confirm Transfer Request Received	Passed	Requests were indicated on Dispatcher Portal terminal
Test Dispatcher Response Function – Accept Request	Passed	Requests status were indicated on MDT as indicated by yellow '✓' on MDT display.
Test Dispatcher Response Function – Reject Request	Passed	Request status was indicated on MDT as 'not accepted' as indicated by red 'X' on MDT display.
Test Dispatcher Response Function – Request Timeout	Passed	Requests were indicated on MDT in same manner as previous step

Mobile Data Terminal (Capital Transportation Driver)

The Capital Transportation driver interface utilized the Android-based LTE-enabled tablet installed in shuttle buses servicing DSCC. This interface allowed the driver to view current COTA bus schedules and ETAs, request T-CONNECT transfer protection, and view the status of requests. Additionally, this device provided previously non-existent AVL capability that was used for the IDTO project.

Demonstration Objectives and Results

The demonstration objectives for the Capital Transportation interface included the following:

- Ability to view upcoming COTA schedule at each stop;
- Ability to request transfer on behalf of the rider; and,
- Ability to monitor status of T-CONNECT, including requested, accepted, and rejected.

Following are the results of each of these objectives and the corroborating observation or data.

Test Objective	Pass/Fail	Observation/Result
View Upcoming COTA Schedule	Passed	Schedules were displayed on MDT with sufficient time (>9 minutes) from current time.
Request Transfer – Monitor for T-CONNECT	Passed	Request status is indicated on Dispatcher Portal as seen by entry shown in display.
Receive Transfer Request Approval	Passed	Request status indicated as approved on MDT as indicated by yellow '✓' on MDT display.
Receive Transfer Request Rejected	Passed	Request status indicated as rejected on MDT as indicated by red 'X' on MDT display.

C-Ride Mobile Application (CABS/COTA Riders)

The transit user application was available for traveler-owned devices via web, iOS, or Android interfaces. The interface allowed for trip planning, viewing current trip details, trip history, and notifications (not available via web).

Demonstration Objectives

The demonstration objectives for the transit user application included the following:

- Demonstrate trip planning, including CABS to COTA planning with trip details
    - For iOS, current location and address searches, as well as the depart vs. arrive option will be demonstrated
- Show trip backlog
- Show current trip
- Show Notifications, including
    - Trip about to start (5 minutes in advance),
    - T-CONNECT issued (bus late and 1 minute hold request accepted), and
    - T-CONNECT denied (bus late, but hold request denied).
- Demonstrate Application download
- Demonstrate account registration
- Show trip cancel
- Show trip history
- Show cloud features.

All objectives were demonstrated during the acceptance test using an Apple iOS device. Select features, where distinct from the iOS environment, were also demonstrated using an Android device.

Additionally, the web portal, which is available for transit users, was also demonstrated during the acceptance testing. The demonstration objectives for this portal included the following:

- Demonstrate web-based account signup
- Demonstrate trip planning
- Show trip backlog (schedule at least two CABS to COTA trips)
- Show current trip
- Show trip history
- Edit account settings
- Show change password.

Table 5-1 identifies which features were tested for which platform. A checkmark indicates a successful demonstration of the feature. 'Not demonstrated' indicates that the feature is available on the stated platform, but was not demonstrated during this testing activity. 'N/A' means the feature is not available for the given platform, which is true for the web interface as it relates to both GPS position activities, as well as Notifications.

Table 5-1. Summary of Acceptance Test Activities

Feature	iOS	Android	Web Interface
Application Download	✓	✓	N/A
Account Registration	Not Demonstrated	Not Demonstrated	✓
Plan and Save Trip – Current Location	✓	✓	N/A
Plan and Save Trip – Populate Start Address	✓	Not Demonstrated	✓
Plan and Save Trip – Use Arrival Time	✓	Not Demonstrated	Not Demonstrated
Show Notifications – Trip Start	✓	✓	N/A
Show Notifications – T-CONNECT Accepted	✓	✓	N/A
Show Notifications – T-CONNECT Rejected	✓	✓	N/A
Show Trip Backlog	✓	✓	✓
Show Trip Details	✓	✓	✓
Cancel Trip	✓	✓	✓

Source: Battelle

Chapter 6 Phase 1 Participant Recruitment

In support of the participant recruitment process, and in advance of the Phase 1 performance period, the IDTO PD team retained the services of a local firm, Marketing Works, to develop a comprehensive recruiting approach for the Columbus area. Together, Battelle and Marketing Works met several times with the respective communications specialists and other various interest groups at OSU. An initial plan for participant recruitment was formulated and put into effect in conjunction with the official go-live of IDTO in May of 2014. Weekly meetings were held to assess the numbers attained, and a 60-day assessment was conducted to evaluate how the plan was performing overall. As a result of the assessment, a need for a shift in participant recruitment was identified. An updated strategy was then crafted, approved, and subsequently implemented. Recruitment efforts ended in early October 2014.

This chapter details the original and revised plans for recruiting participants in for the study and the outcomes of their implementation. Further, this chapter also documents the relevant news/media coverage generated in response to these plans, as well as metrics on the effectiveness of the social media campaigns.

Original Plan

As developed in conjunction with Marketing Works in support of the IDTO's overall objectives, the initial recruitment, which focused on the following high-level objectives, was implemented in a staged rollout beginning in April 2014. The objectives included:

- Promote C-Ride, while also drawing attention to the need to create synergies between transportation options.
- Encourage and spur people to download the app.
- Encourage engagement with the app, specifically driving toward a target of having 6,000 riders in the period.
- Publicize the fact that OSU is a pilot for the Battelle project, a testament to the campus of having solid public transportation solutions in place and being forward thinking.

The largest area of focus for recruitment efforts was on the OSU campus, where there was a high concentration of potential riders for CABS to COTA transfers. Based on the ridership data provided by COTA, for periods when school was in session, there were an average of 750 potential connections per month at the two campus-area stops initially targeted. These numbers were based on the number of OSU students who used their student ID in lieu of paying the fare in cash for a COTA bus.

Table 6-1 identifies the tactics and measurement employed for the broader Columbus and Central Ohio recruitment efforts, and Table 6-2 highlights the focus of the on-campus efforts. Results and observations specific to each of these areas are also captured.

60-Day Assessment

In continuing to work to improve participation in the study, a 60-day assessment was conducted in conjunction with the marketing/communications team. At that time, it was determined that the user return rate, or the likelihood of someone using the tool on a recurring basis, was assessed, and it was determined that the return rate was lower than planned. In response, a set of questions was emailed to 387 registered users. Following is a summary of the results:

- 14 respondents
- One person indicated more than 5 uses of the app; majority had used it once or twice
- 57 percent said that the application was not easy to use.
- Improvements needed: user experience, bus schedule options, and time and location entry were the top issues.
- 50 percent were dissatisfied followed by 35 percent very dissatisfied with the application.
- 50 percent said the app was not useful, followed by 43 percent who said they used another application.
- 8 of the 14 respondents were either very unlikely or unlikely to use the application in the future.

Usability issues identified as part of this user feedback were considered and several of them were implemented in response to this feedback. Specifically, the following were added:

- A ‘view on map’ function, which allowed the traveler to view both the entire trip, as well as individual segment related to the requested trip
- The creation of Favorites, allowing a person to store and reuse addresses or locations
- Intelligent location searches that assisted in completing the address by appending ‘Columbus, OH’ to the search string (if needed) and passing it through Google’s address lookup to verify and address.

All of these suggested improvements were implemented in both the iOS and Android versions of the C-Ride software and were available for the next round of participant recruitment.

Table 6-1. Initial C-Ride Recruitment Strategy (Broad Reach)

Element	Description	Tactics	Measurement	Results/Observations
Media Outreach	News release/conference to announce initiative; periodic updates at key touch points or milestones	1. Event to demo app to draw TV, print media from throughout central Ohio, including campus coverage via Lantern and UWeekly outlets at OSU 2. Feature story on users pitched to various outlets; ongoing angles pitched to reflect milestones (first 1,000 rides, etc.) 3. Share coverage, links on social sites	Monitor and track coverage, impressions	Media Outreach and results are detailed in separate section of this report.
Social Media Outreach	Facebook, Twitter, YouTube and Instagram pages for Columbus Rides, foster ongoing engagement and sharing	1. Develop and launch the social sites, including video of how to use the app 2. Launch campaigns to increase fans and followers, boost posts to increase reach 3. Hold monthly contests with giveaways to encourage engagement and sharing of ride experiences and images 4. Video testimonials from early adopters, users (network of ambassadors)	Monitor followers, track engagements with posts, track social sharing	Social Media Outreach and results are detailed in separate section of this report.
Blogger Outreach	Influential Columbus and campus bloggers	1. Invite to test the app in advance screening, share on their networks 2. Pitch and share the story 3. Tap into UWeekly social interaction sites (more than 7,000 followers)	Track coverage, comments and sharing of blog posts	This strategy was not pursued distinctly, but was partially fulfilled via Twitter

Table 6-1. Initial C-Ride Recruitment Strategy (Broad Reach) (Continued)

Element	Description	Tactics	Measurement	Results/Observations
Collateral	Fliers, posters, stickers	1. Develop fliers, posters, and stickers for hanging in key locations on campus 2. Fliers for distribution at events and on campus	Fliers and materials distributed – potential impressions	Developed postcards and flyers both for broader audience as well as those specific to target audience. Examples are included in the appendices of this report. Further, ran video advertisement on Student Union billboards.
Events	Leverage key events; create events	1. Scavenger Hunt – participants use combination of rideshare and transfers to find items on campus, winners receive prize (potential media opportunity) 2. Partner with radio stations/radio remotes during key events in campus area	Track attendance and participation for impression numbers	This strategy was initiated, but as the type of trips COTA-only versus CABS-to-COTA was heavy to the former, efforts were redirected in attempt to increase the latter.

Source: Battelle

Table 6-2. Campus-Specific Outreach Plan

Element	Description	Tactics	Measurement	Results/Observations
Student Orientations	Orientation packets, informational tables for new students – held in June and July	1. Distribute flier in campus packets 2. Establish informational tables with student demonstrating app and providing fliers	Track impressions, distributions	Distributed postcards in new student orientation packages. Participated in Commuter Days event, focused on off-campus students who used public transportation.
Test Group	Exclusive test group to commit to ridership and provide feedback	1. Identify and secure students to commit to be test riders 2. Offer incentives to participants and/or secure buy-in through tie to higher cause; seek engagement of their professors 3. Organizations are initial focus, such as Triangle Fraternity (engineering) and Alpha Kappa Psi (business)	Number of rides, survey feedback	This strategy was not pursued.
Student Move-in Week	Fliers, signage, tables, walkabouts, sidewalk chalk campaign for awareness	1. Post fliers in residence halls 2. Engage with new students, distribute fliers 3. Post signage at high-traffic areas 4. Engage sororities and fraternities	Track impressions, distributions	The strategy was not pursued after the 60-day assessment concluded that the grass roots recruitment was not meeting expectation.

Table 6-2. Campus-Specific Outreach Plan (Continued)

Element	Description	Tactics	Measurement	Results/Observations
Student Organizations	Leverage their events, communications	1. Meet with groups to secure buy-in, ambassadors 2. Communications disseminated through their channels	Track impressions, distributions	This strategy became the focus of the re-tooled efforts and is discussed in greater details in separate section of this report.
The PRactice	OSU student PR team	1. Engage the student agency to conduct additional grassroots activities on campus 2. Initial meeting February 23 on campus	Establish metrics in concert with PRactice team members	The timing of the demonstration period did not align with the school-year schedule and as a result, continued engagement with this group was not feasible.
Student/Life – University Housing	Posters in residence halls, housing (approval required by ResLife)	1. Distribute/post fliers on community boards in university housing 2. Submit two weeks prior to posting for approval	Track impressions, distributions	The strategy was not pursued after the 60-day assessment concluded that the grass roots recruitment was not meeting expectation.
Local Student Celebrities	Identify and engage for testimonials in various channels (social, print, etc.)	1. Create college ambassadors (i.e., football players, other personalities) to download and use app 2. Video ambassadors, share in channels	Track impressions, engagement	The strategy was not pursued after the 60-day assessment concluded that the grass roots recruitment was not meeting expectation.

Source: Battelle

Revised Strategy

The revised strategy, given the constraints on revising the application functionality, focused on shifting to a targeted group of individuals to meet objectives. The emphasis of this new strategy included the following:

- Direct, face-to-face recruitment and explanation of the app.
- Leveraging existing collateral and messaging nuggets to explain the benefits of the app; however, additional incentives were outlined based on the size and commitment of the group.
- Survey distribution to shift from current structure to distribution after each trip.
- In conjunction with this strategy shift, all public facing initiatives used to generate brand awareness of the C-Ride app were discontinued.

Further, as noted in the prior subsection, usability concerns were also addressed in the C-Ride software. A new release of the application was created to address those concerns.

The plan included engagement of student organizations that have 300+ members and efforts to recruit and incentivize their member students and faculty to participate in the pilot study. The team leveraged existing relations with nonprofit 501(c)(3) student organizations at OSU. Two groups were identified, and for each, the team conducted a 30-day engagement that included the following activities:

- Trained the organization with step-by-step details on how to use the application, answering any questions
- Implemented an incentive plan that equated to one dollar per ride and encouraged the organization to engage their peers to assist in meeting their goals. The model was that one ride, no matter the source, would result in a one dollar donation directed to the organization's charitable funds
- Provided weekly updates to the organization on their metrics of success.

The result of this revised effort was an additional 140 trips, which are reflected in the bump in usage that can be seen in the mid-September through mid-October timeframe as include in the demonstration period data presented in Chapter 8.

Media Efforts

As was prescribed in the original recruitment strategy, the objective of this tactic was to introduce the Connect and Ride mobile application to the Columbus market and position it as the go-to application to help the central Ohio community plan and manage public transportation trips via CABS and COTA. Table 6-3 provides a list of the relevant outlets, links to the articles[13], along with statistics related to the 'shares'[14] accumulated on the various, related social media sites.

[13] Note: The links included here are not within the control of the PD team, and as such, may no longer be valid at the time of access.

[14] A 'share' is the situation where a user of social media feels forwards (aka 'shares') a link to an online item to others, presumably because the user finds the item of interest.

While this proved to have limited success in sustaining long-term use of the application, it did provide for short-term increases in enrollment and usage.

Table 6-3. Local Media Outlets and Related Social Media 'Shares'

Outlet	Description	Shares via…			
		Facebook	Twitter	LinkedIn	Google+
WCMH 4	Local television station	42	9	N/A	N/A
The Lantern	OSU student newspaper	18	22	N/A	
Columbus Business First	Weekly newspaper, daily online newspaper	14	6	1	N/A
Columbus Dispatch	Local daily newspaper	19	1	N/A	1
Fleet News Daily	Transit news for drivers, fleets and transit authorities	5	N/A	N/A	N/A
Metro-Magazine	Trade magazine for bus and rail transit	2	1		N/A
Orlando Business Journal	Daily online newspaper	2	5	1	N/A
The Transit Wire	Trade magazine for bus and rail transit	1	2	N/A	N/A
WBNS 10	Local television station	41	16	N/A	N/A

Source: Marketing Works

The information was also syndicated on key local and industry news sites including:

- Transit Columbus
- Experience Columbus
- Mass Transit Magazine
- World News
- Columbus.org
- HighBeam Research
- Ohio State Transportation and Traffic Management webpage
- U.S. Department of Transportation.

Social Media Activities

In addition to the media coverage discussed above, a typical social media presence was created on the following channels in order to generate awareness of Connect and Ride (C-Ride):

- Facebook
- Instagram
- Twitter
- YouTube.

All C-Ride social channels experienced steady growth after launching the mobile application and received both local and trade media coverage. Most notably, the C-Ride Twitter page received a large increase in followers due to cross promotions with partners (e.g., Battelle, COTA, and OSU) and media mentions. Table 6-4 captures the growth experienced over the period, beginning in April 2014 and running through September 4, 2014, for each social media channel.

Table 6-4. C-Ride Social Following Progress

Social Channel	Pre-Launch	Post-Launch	June 4	July 8	Sept 4
Facebook	16	29	45	62	63
Instagram	20	25	25	36	31
Twitter	6	7	12	36	50
YouTube	0	1	3	7	7

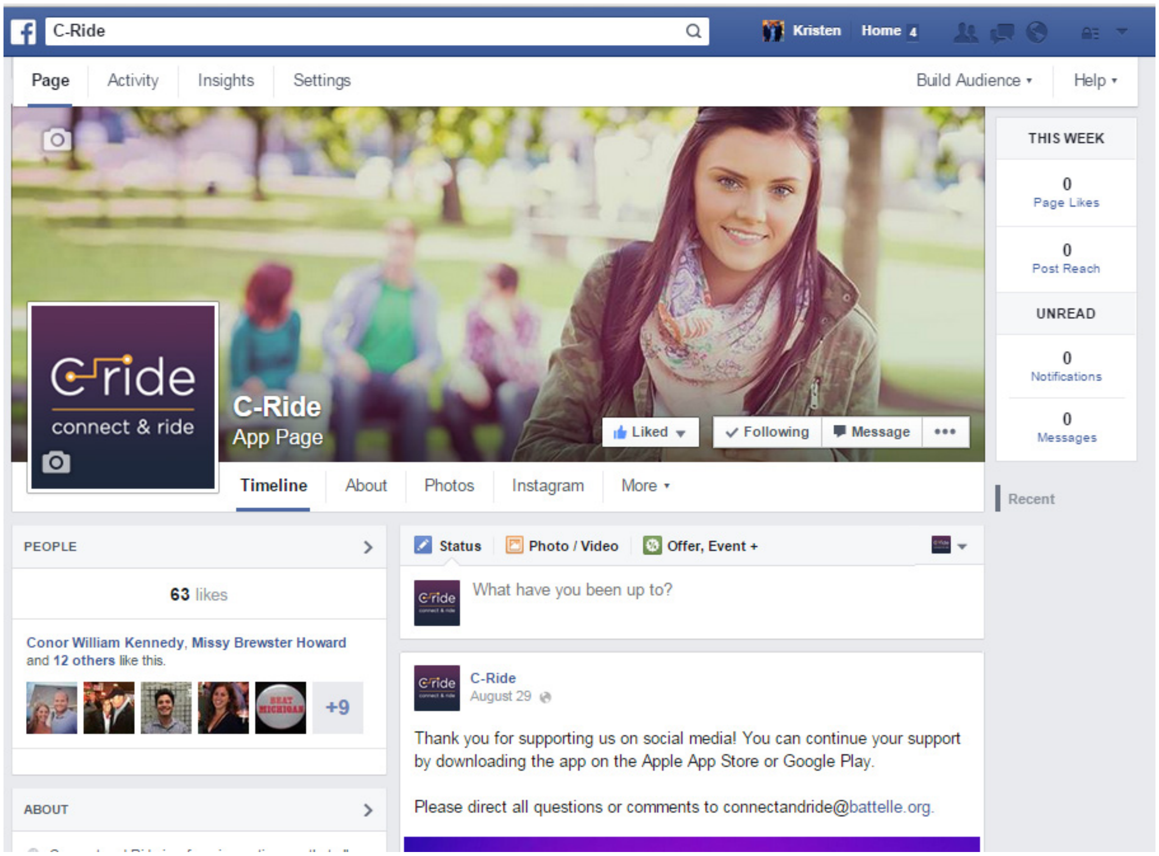
Source: Marketing Works

After decreasing the amount of engagement from each social channel and launching the phase out messaging, social channels received a slight decrease.

NOTE: All social media channels were removed December 1, 2014.

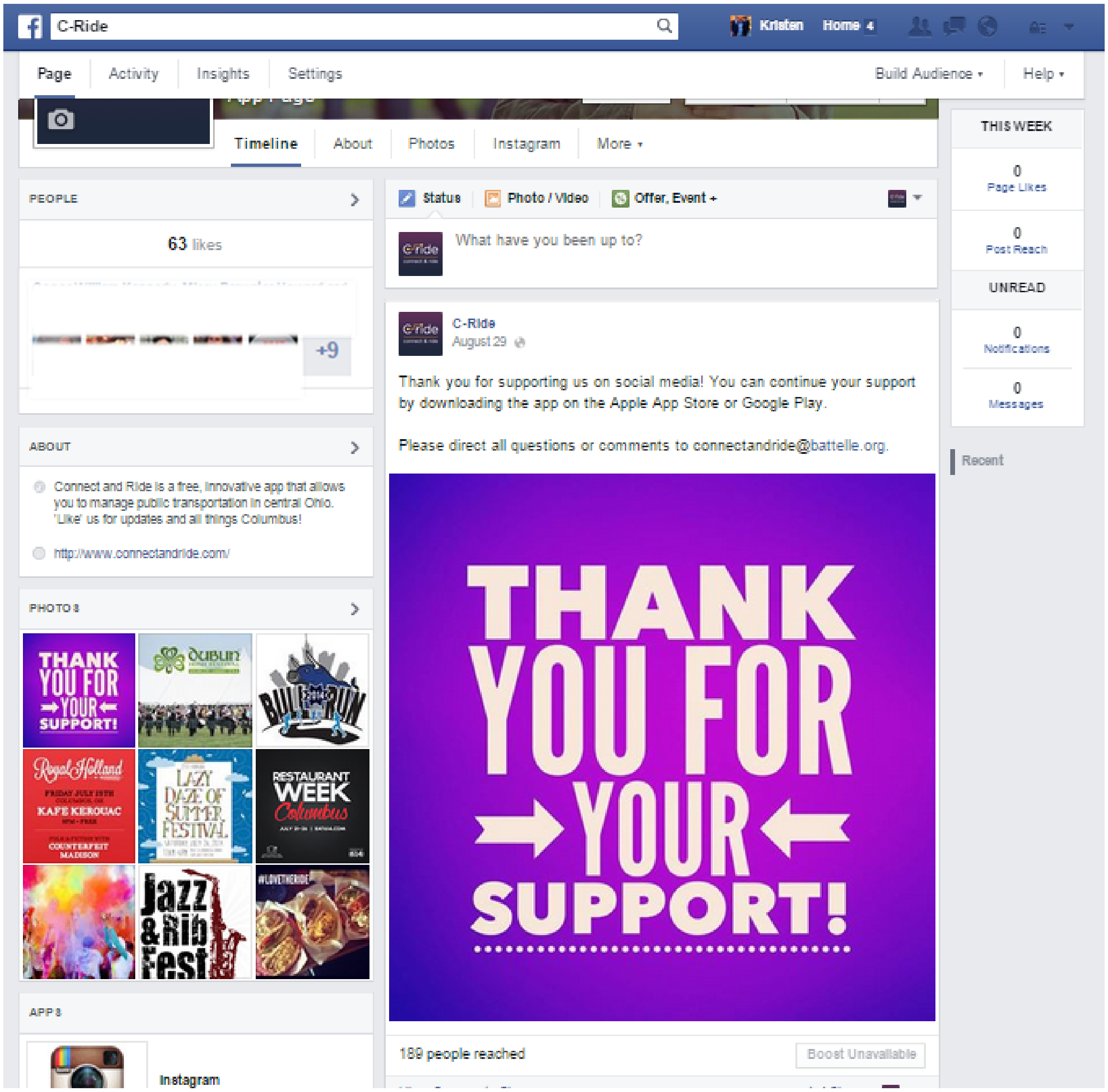
Facebook

The Facebook campaign focused on promoting the use of C-Ride as a convenient, alternative choice for traveling to attend several local community events that occurred starting in May 2014 and extending through the summer. It also served as a means to collect customer feedback, as well as to answer questions posed by riders. Figure 6-1 shows the main portion of the Facebook landing page, and includes the C-Ride logo and other common branding elements, including a recurring photo of a young, female user. Figure 6-2 shows a detailed post and also includes a collage (lower left) of several of the local events for which C-Ride was promoted.



Source: Battelle and iStock

Figure 6-1. C-Ride Facebook Landing Page

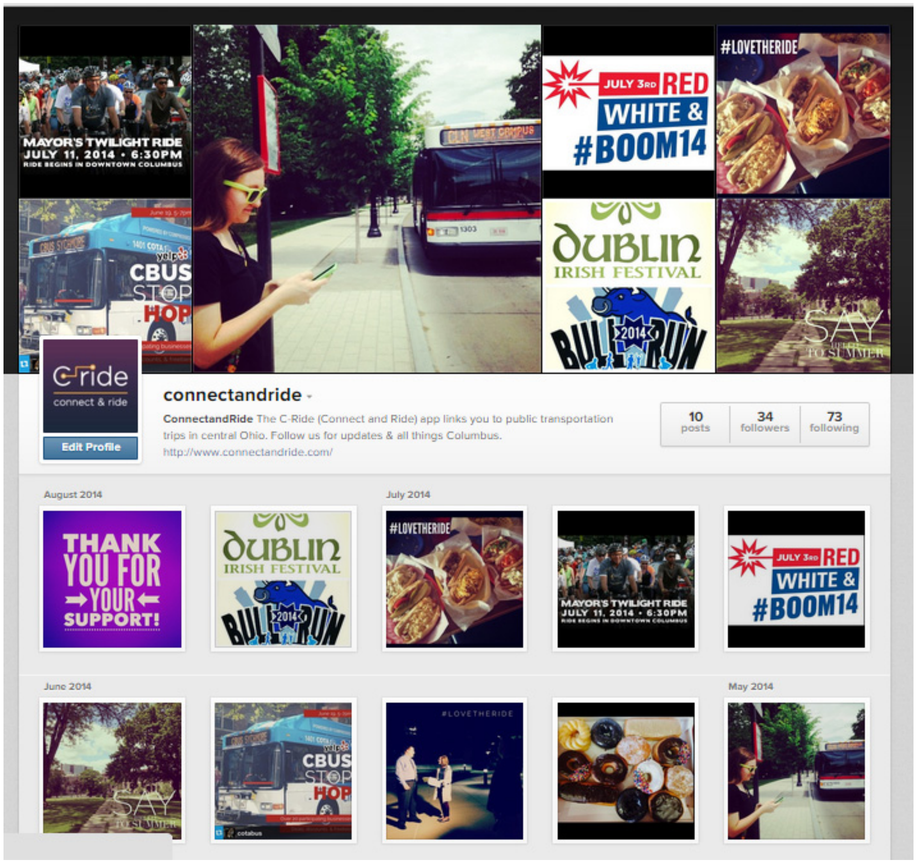


Source: Facebook

Figure 6-2. Example Posts on C-Ride Facebook Page

Instagram

Instagram was used to promote local events and other activities for which C-Ride was a transportation option. Figure 6-3 shows an example of the Instagram landing page for C-Ride and examples of the many events that were promoted during the operational period.

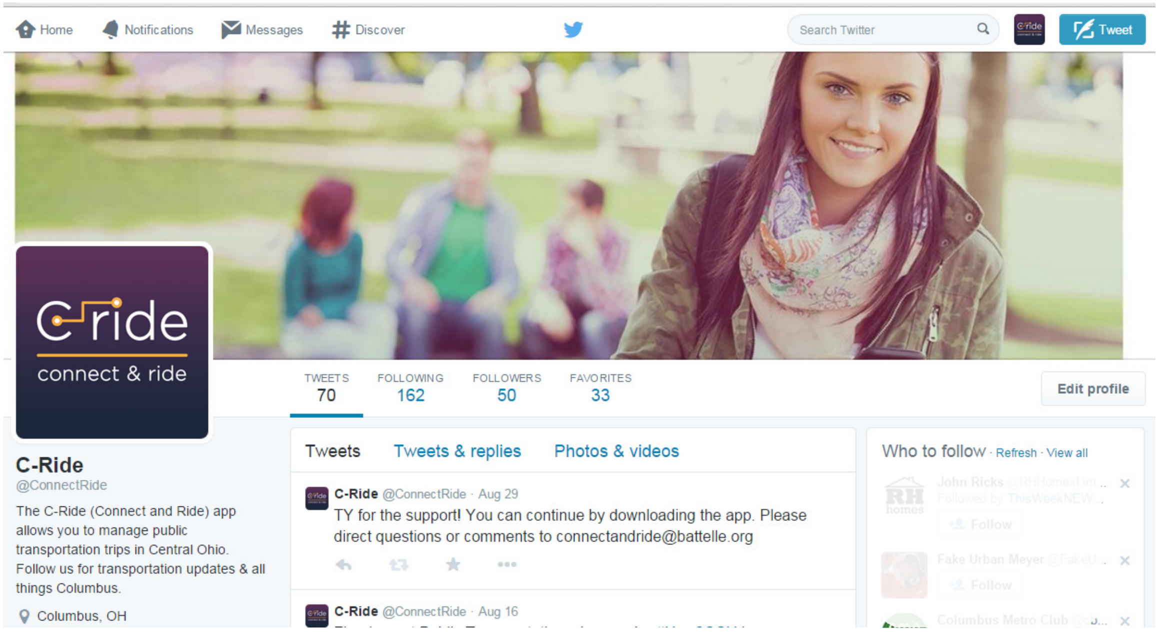


Source: Instagram

Figure 6-3. C-Ride Instagram Landing Page

Twitter

Twitter, like Facebook, served as both a mechanism to promote the use of C-Ride as well as to provide a forum for feedback as it relates to the application. Figure 6-4 provides a screen capture of the Twitter landing page, again showing the familiar logo and images. Appendix A includes the complete log of the tweets that occurred over the 3+ months of active social media efforts.



Source: Twitter

Figure 6-4. C-Ride Twitter Landing Page

YouTube

The final social media outlet used was YouTube. Informational videos, showing how to use the C-Ride application, were made available to users. Unlike other social media sites, a specific landing page for C-Ride presence was not implemented, but instead, links to YouTube videos were included as part of entries on Facebook, Twitter, and the Connect and Ride website.

Chapter 7 Phase 1 Demonstration Plan and Results

The IDTO Demonstration Phase in Columbus, Ohio, officially commenced on May 25, 2014, and ran through December 17, 2014. During that period, a total of 1085 recorded trips were taken.

This chapter presents details on data collection and analysis, including the research questions to be tested, data collection and requirements plan, agency policies, and results of the demonstration testing. Further, details of the ridership metrics and the data captured and provided to the IA Team are described.

Data Collection and Analysis

A data collection and analysis plan provided input to the IA Team to assist them in their conduct of the Impacts Assessment. This demonstration had been designed, and was implemented, to assess the performance of the IDTO prototype and its applications in a controlled, data-rich research environment. The hypothesis testing and other information provided in this chapter focused on the objectives of the IA Team. Battelle was responsible for providing the IA Team with access to the raw data generated by this demonstration, which would allow the IA Team to perform their assessment of impacts. Furthermore, information gathered from this demonstration will allow the U.S. DOT to fully evaluate the potential benefits of these applications for future development and investments and assess the ability of the IDTO bundle and its corresponding applications to meet these objectives

Research Questions to be Tested

The principal study question to be addressed by this demonstration is as follows:

> *Can the mobility of the local traveling public (especially travelers needing to utilize multiple transit providers on a given trip) be significantly improved by integrating the capabilities and offerings of the three public transit mobility applications (T-CONNECT, T-DISP, D-RIDE) within a single real-time system that can meet the public's expectations on trip performance and satisfaction?*

Other objectives of this demonstration are as follows:

- Successfully demonstrate the extent to which the prototype can support both mobile and traditional web interfaces and is interoperable with existing transit and transportation service providers.
- Generate data that will inform U.S. DOT DMA policy and program direction and provide a resource to other researchers and developers through the RDE.

- Generate technology solutions and institutional models that are compatible with legacy/enabling systems and relationships and that are also scalable and replicable.
- Observe the synergistic potential of the three applications that emphasize dynamic transit operations.

Data Collection Requirements and Plan

The IDTO Demonstration collected data for analysis from the Phase 1 demonstration in Columbus. On a weekly basis, metrics were published for the following:

- Number of travelers registering with the IDTO prototype.
- Number of trip searches made through the prototype.
- Number of trips saved within the prototype following a trip search.
- Number of trips eligible to be monitored through T-CONNECT by the transit partners (i.e., COTA).
- Number of trips where a T-CONNECT request was issued (e.g., notice issued to hold a COTA bus for a registered traveler).
- Number of trips where the T-CONNECT request was honored (accepted by dispatcher).

Note that the count in each item is a subset of the count in the preceding item. The distinction between trips initiated by the Capital Transportation Shuttle at DSCC and those initiated from separate CABS-to-COTA or COTA-only sources can also be produced.

Post-Trip Survey Questions

At the end of every 5 trips or once monthly, participants who had completed a trip for the period were sent an e-mail message containing a link requesting that they complete a brief online survey on the performance of the IDTO prototype in identifying and securing trip connections, as well as their general use of the prototype and their satisfaction with their experiences.

1. Did you successfully complete the DATE trip as it was originally planned? (YES/NO)
2. Did you receive any ‘trip notification’ messages during the trip? (YES/NO)
3. Was this information useful in completing your trip? (YES/NO)

Post-Study Survey Questions

A post-study survey was administered to the demonstration participants to elicit their feedback on the following related to the use of the IDTO prototype:

- Number of times a trip was planned
- Ease of use
- Areas of improvements
- Overall satisfaction level
- Reasons for not using the prototype
- Likelihood of future use
- Any unaddressed needs.

The survey consisted of the following statements for which the participant was asked to respond on a 5-point scale (strongly disagree, disagree, neutral, agree, and strongly agree):

- The Trip Planning feature of the C-Ride application allows me to FIND travel alternatives during heavy traffic or other disruptions.
- The Trip Planning feature of the C-Ride application allows me to USE travel alternatives during heavy traffic or other disruptions.
- The Connection Protection feature of the C-Ride application helps me make transfers between different types of transportation.
- The Connection Protection feature of the C-Ride application improves my ability to make transfers between different transit services providers.
- The C-Ride application reduces the impact that heavy traffic or other disruptions have on my trips.
- The Connection Protection feature of the C-Ride application allows me to FIND travel alternatives during heavy traffic or other disruptions.
- The Connection Protection feature of the C-Ride application allows me to USE travel alternatives during heavy traffic or other disruptions.
- The Rideshare feature of the C-Ride application allows me to FIND and USE travel alternatives during heavy traffic or other disruptions.

For purposes of conducting the post-trip and post-study surveys, Battelle utilized Survey Monkey, the leader in online survey tools. At appropriate times during a participant's use of the IDTO application, surveys were directed to the registered email address of each participant, and the results tabulated and made available for analysis by the IA Team.

Results and Associated Findings

The raw data collected by the IDTO PD System during the operation of the prototype system, a period spanning May through December 2014 is comprised of the following information:

- Registered Users (de-identified)
- Informational Trip Searches
- Trips Actions
- Trips that were T-CONNECT qualified
- Trips that were monitored for T-CONNECT
- Trips for which COTA Dispatch was notified, and
- Trips for which a T-CONNECT was accepted.

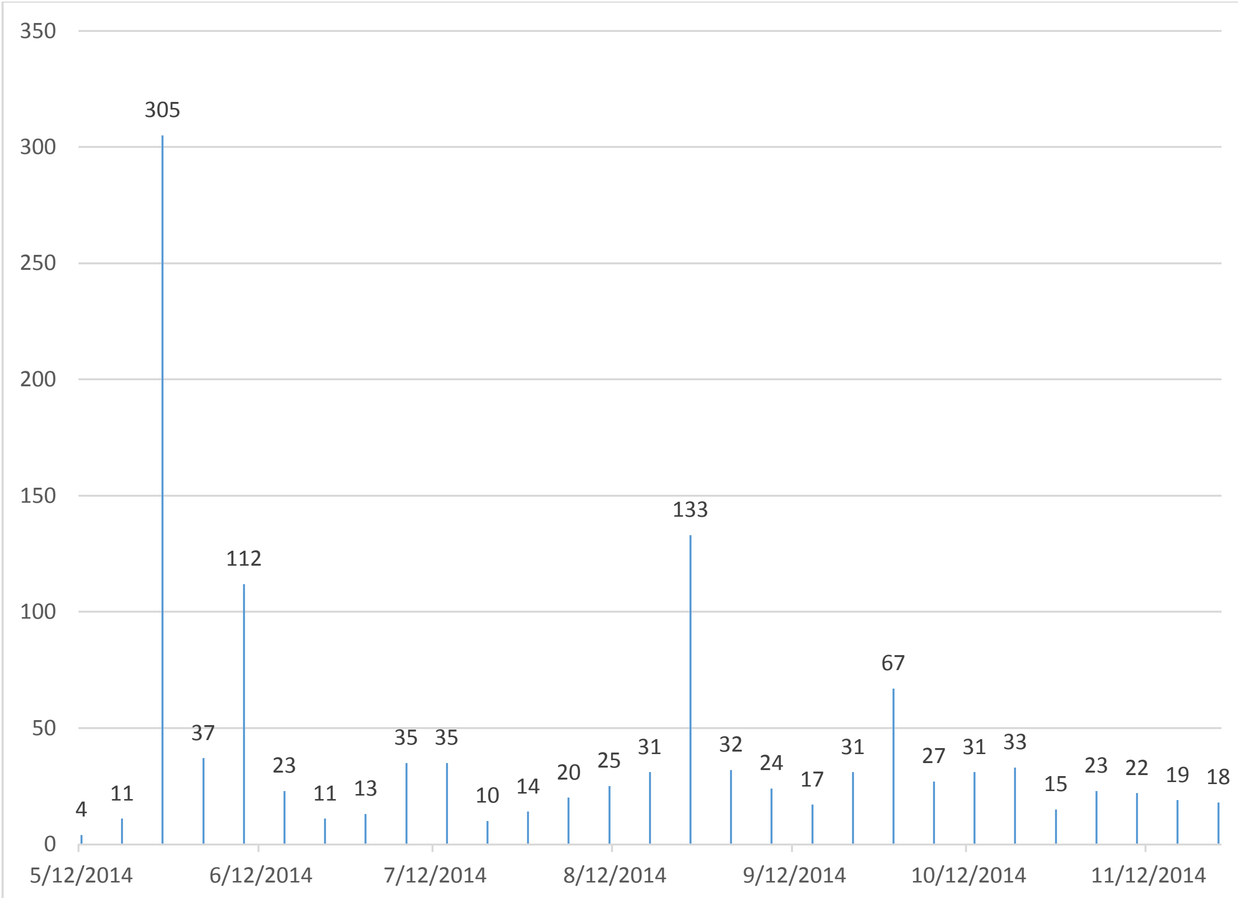
Following are a series of discussions and associated figures that convey the trends associated with C-Ride metrics captured over the course of the data collection period, and the resulting findings.

New Travelers per Week

This data in Figure 7-1 reflects the weekly number of new users that created an account in the C-Ride system and the correlation with specific recruitment activities. The early spike in late May reflected the initial marketing efforts including local TV and print press visibility. The 2nd bump in late August reflects the influx of returning OSU students, and finally, the bump in late September/ early October reflects the final targeted outreach efforts. In total, 1178 people created an account for C-Ride, establishing the total pool of potential users.

Finding

In today's proliferation of available transit and travel applications, distinguishing one application from another can be a challenge. As noted in the metrics captured in Phase 1, spikes in the selection of C-Ride occurred when highly visible marketing activities were presented to the traveler; otherwise the adoption rate was fairly consistent, but low as compared to the observed spikes. Interest by over 1000 people in such a short period does, however, speak to at least a casual interest in the utility of an application of this sort, but when considered in conjunction with the user feedback, it is critical to be able to capture and retain the user's interest. IDTO only had limited budget and revision cycles to achieve some of these usability needs, but as the data evidences, these incremental improvements, combined with marketing activities, kept new users adopting the application throughout the course of the demonstration period.



Source: Battelle

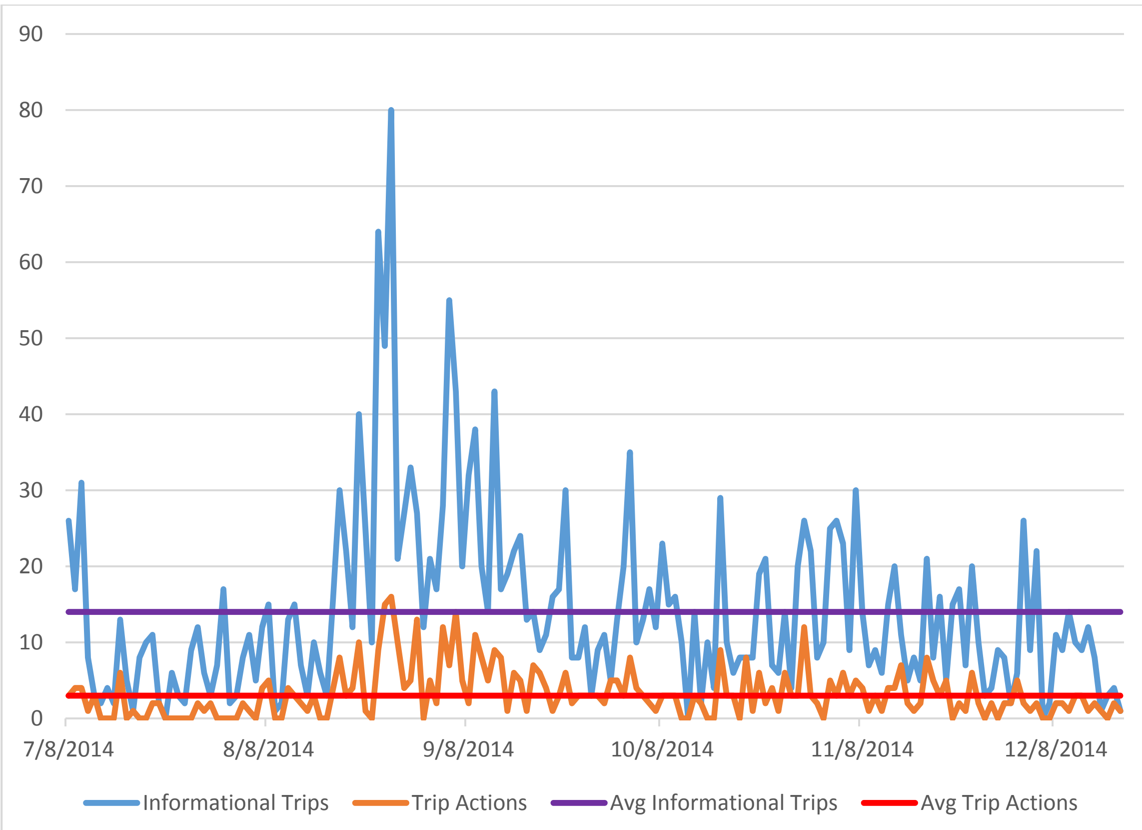
Figure 7-1. New Travelers per Week

System Utilization

Figure 7-2 represents two key metrics, the number of Informational searches performed, and the number of times the user took action to allow the system to monitor the selected trip. This data is plotted daily, and the mean value for each type is also included. In IDTO terms, informational searches return the trip or trips that met the traveler's search criteria (i.e., start and end locations, and either departure or arrival time) when a trip search was performed in C-Ride. Trip actions go a step further with the traveler selecting to save the trip and allowing for it to be monitored for T-CONNECT opportunities. Note that the number of informational searches metric was not originally captured, but was added in early July. Starting in July, a comparison can be made on the number of searches performed compared to the number of actions taken. It should also be noted that the data captured in this figure is based on trips searched or saved by distinct C-Ride users utilizing the mobile application or website.

Finding

This data reveals a positive interest and acceptance on the part of travelers to support the actions and data gathering necessary for the IDTO prototype to perform its functions. Consistent with early metrics, the late August and early September spike in informational searches and trip actions are consistent with the targeted marketing activities and OSU students resuming the fall semester. Beyond this surge, however, usage continues, both for searches and trip monitoring, at a consistent level. More interesting may be the percentage of users who do take action. As indicated by the average values for both informational and actionable trips, over 20% of users chose to take an action after planning a trip. This is significant behavioral change considering that prior to IDTO, there was limited to no ability to affect this form of interaction with transit agency operations.

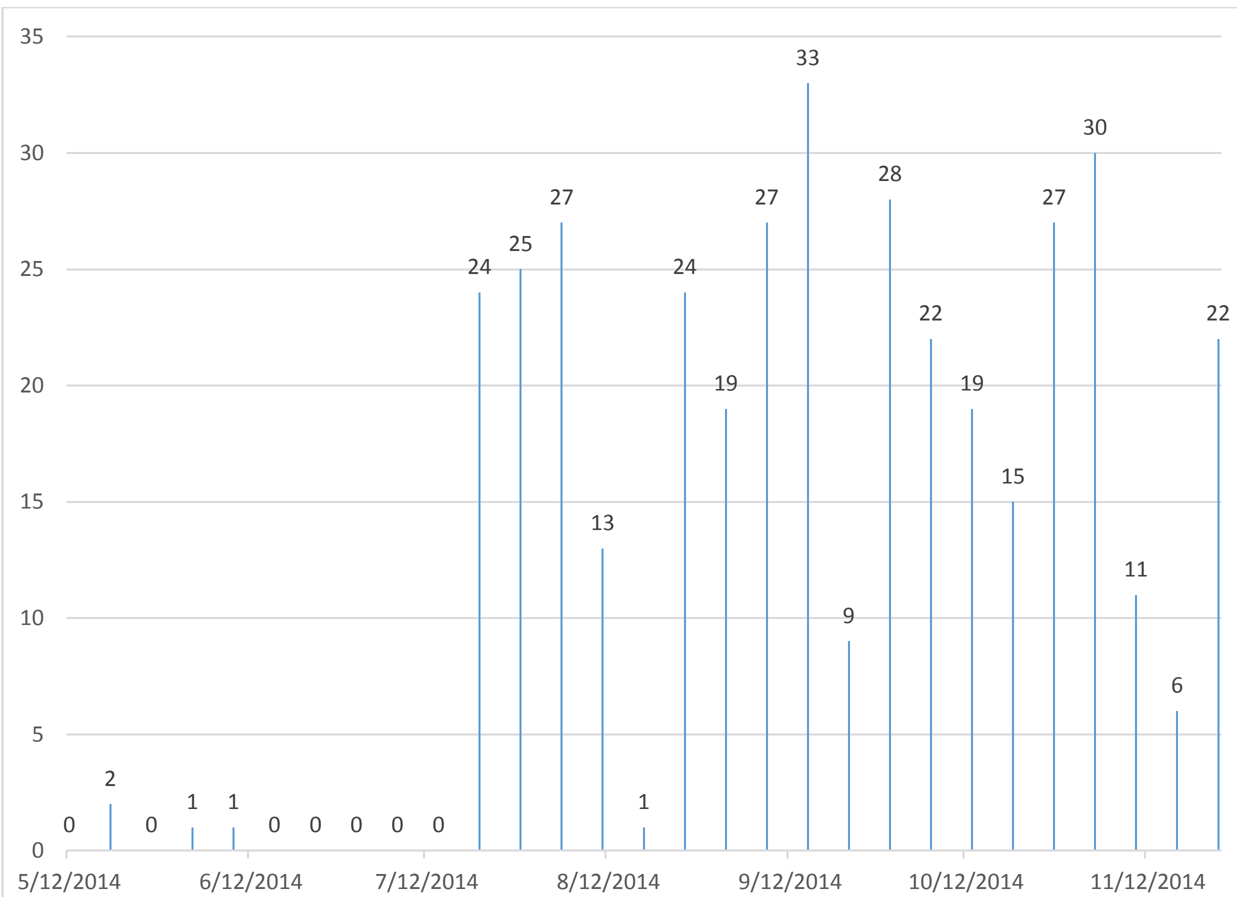


Source: Battelle

Figure 7-2. IDTO System Utilization

T-CONNECT Opportunities Per Week

Figure 7-3 represents the number of trips saved in the IDTO system that include a transfer, whether CABS to COTA, or Capital Transportation to COTA. The majority of the counts represent the latter, the Capital Transportation use of the system. Trips in this category are the only ones that are monitored by the system for T-CONNECTs, and as will be seen in subsequent analysis, only a smaller quantity of these shown herein necessitate the 'hold' request to the dispatcher. Results during the first 2 months of data collection indicate minimal or zero 'monitored' trips. This is due in part to two occurrences. First, OSU students ended their spring semester in early May, resulting in a significant reduction in the number of potential CABS users for this period. This reduction was expected, and the decision to hold to the demonstration period schedule was made. The second contributing factor was limited Capital Transportation utilization. As is discussed later, Capital Transportation performed both an unplanned equipment change and incurred staffing changes during the early period of the demonstration that resulted in the MDT not being properly used. This was eventually corrected in mid-July. The large increases in utilization reflected in this graph in mid-July are reflective of the resolution of these MDT issues, and the continued higher utilization of the system from that period through the end of the demonstration are a blend of both Capital Transportation originated trips as well as C-Ride application users.



Source: Battelle

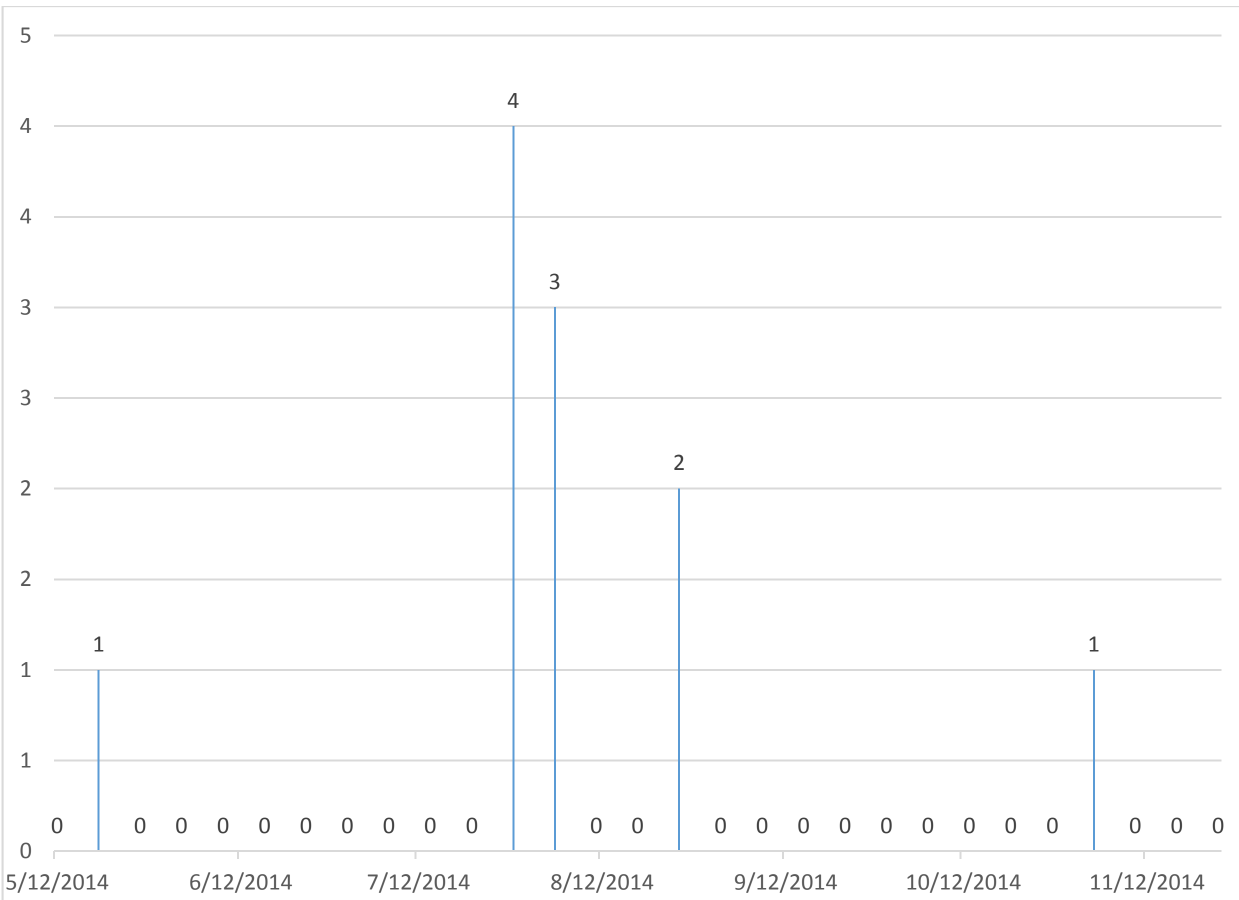
Figure 7-3. T-CONNECT Opportunities per Week

Finding

This data indicates that the fully operational system, particularly as implemented as part of daily operations, can be accepted and benefit those operations. As discussed above, once the installation and use issues were resolved, Capital Transportation, in particular, regularly used the system as part of their operations.

T-CONNECT Requests Per Week

The data in Figure 7-4 reflects the number of actual trips for which a T-CONNECT was determined to be necessary and appropriate, and which was subsequently issued to COTA Dispatch. In total, there were 11 such instances, and it is likely that the first instance, occurring in the second week of the demonstration period, is an artifact of continued testing by the test team and not an actual C-Ride user.



Source: Battelle

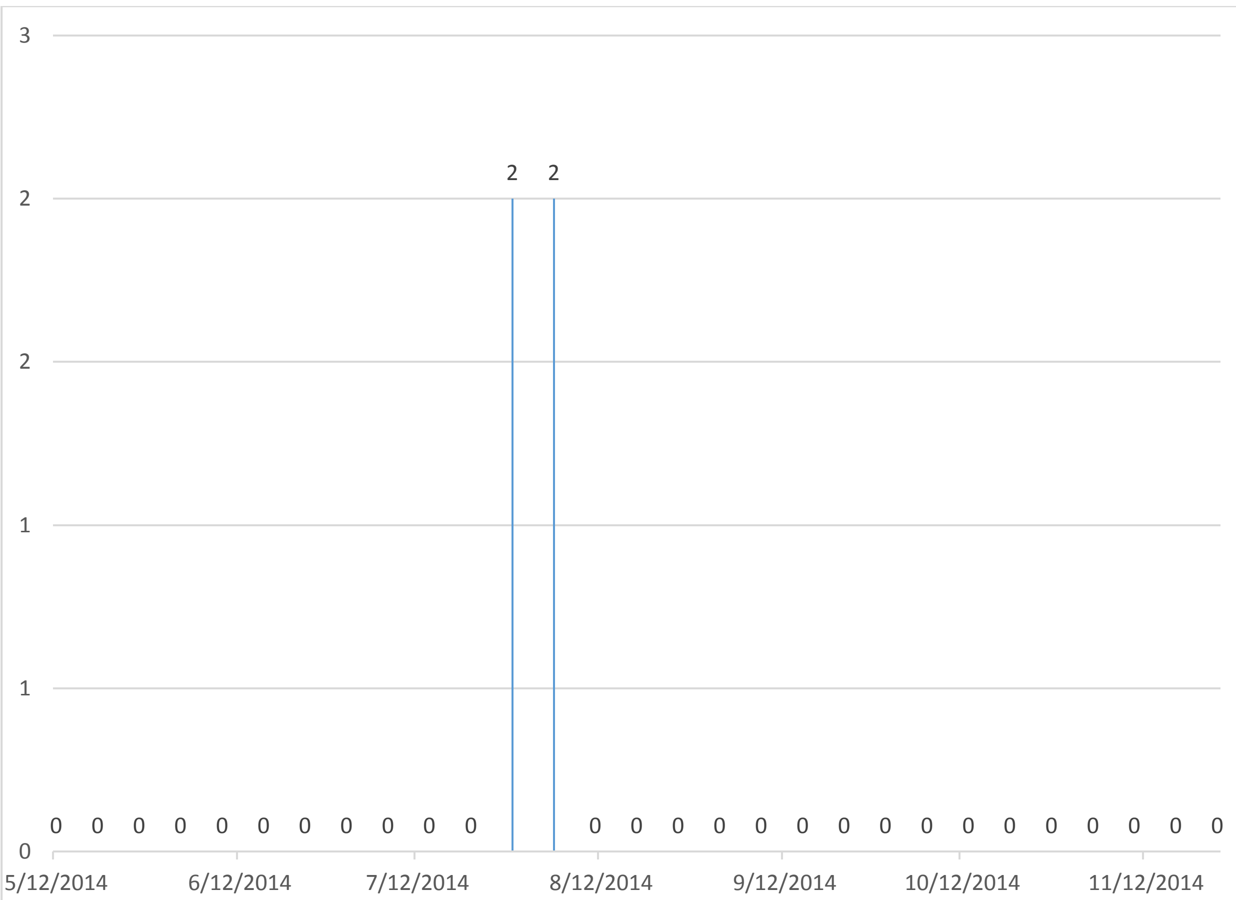
Figure 7-4. T-CONNECT Requests per Week

Finding

This data indicates that as the Capital Transportation driver became more familiar with the system, the likelihood of a requiring a T-CONNECT lessened. As IDTO provided the shuttle driver real-time awareness of both his/her respective arrival time at a transfer point, it also provided the schedule information of the connecting service, allowing the driver to better plan the routes dynamically, as well as improve performance by reaching the exit gate (aka ‘security checkpoint’) with sufficient time for rider transfer to COTA.

Accepted T-CONNECT Requests Per Week

In this final figure, Figure 7-5, the number of T-CONNECT requests approved, per week, by COTA Dispatch is shown. A total of four (4) requests, out of the total 11 requests made (see prior figure), were accepted by COTA. No reason is known why the other seven were denied, but the database flag indicates they were rejected using the default time-out period and not as an active input from a dispatcher.



Source: Battelle

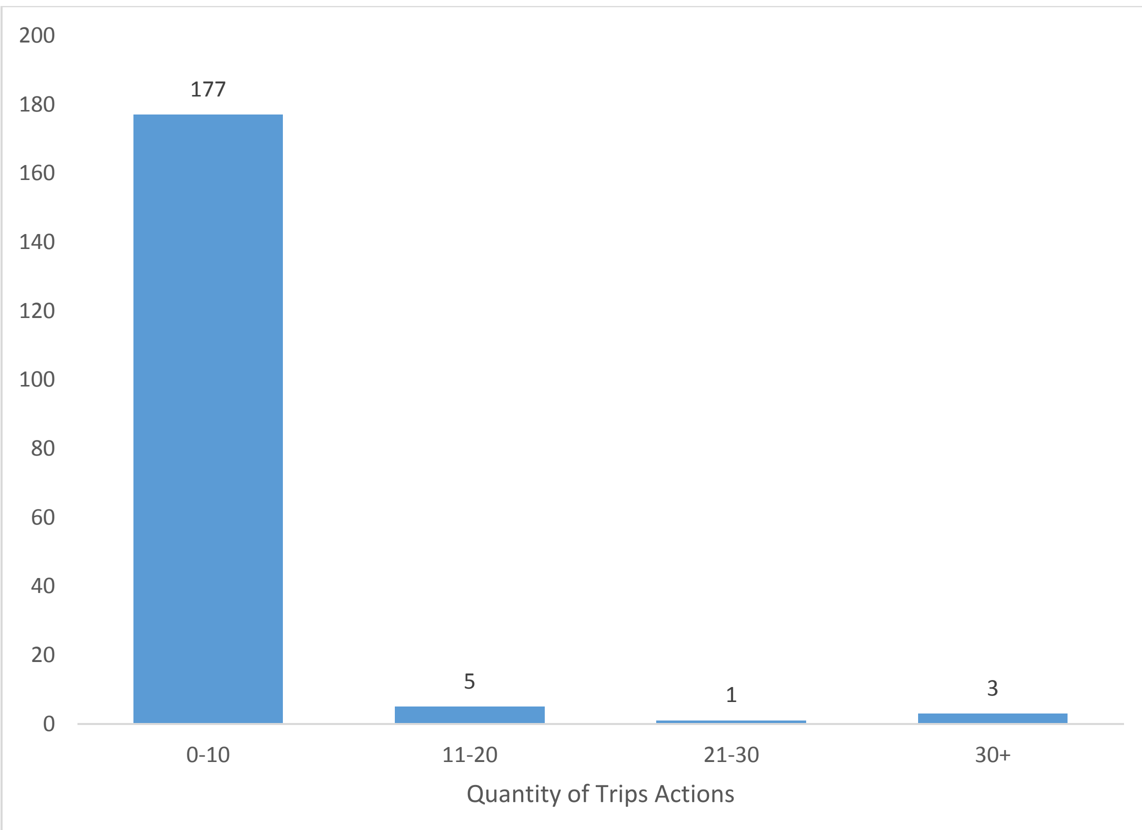
Figure 7-5. Accepted T-CONNECT Requests per Week

Number of Trip Actions per User

Figure 7-6 reflects an aggregation of the number of trip actions each user took. Starting from the left side, a total of 177 travelers saved between 0 and 10 trips. Five (5) travelers had between 11 and 20 actionable trips captured, one (1) traveler used the system for a trip action between 21 and 30 times, and three (3) travelers exceeded 30 uses of the system. Not included in this data are the trips originating at Capital Transportation.

Findings

This data reflects a trend showing 186 distinct users who used IDTO not only for information, but also to consider a trip action. Similar to an early finding, this reveals that there is interest on the part of travelers for these types of tools, and that for some, it can be integrated into their daily commute.



Source: Battelle

Figure 7-6. Trip Action Aggregation

Data Totals

Table 7-1 shows the raw summary data that comprises the previous data analysis and corresponding graphs.

Table 7-1. Summary Table of IDTO Collected Metrics

Week Starting	# of Travelers	# of Searches	# of Trips Saved	# of Trips Monitored for T-CONNECT	# of Trips requesting T-CONNECT	# of T-CONNECTs accepted
5/12/2014	4	0	2	0	0	0
5/19/2014	11	0	9	2	1	0
5/26/2014	305	0	48	0	0	0
6/2/2014	37	0	35	1	0	0
6/9/2014	112	0	33	1	0	0
6/16/2014	23	0	15	0	0	0
6/23/2014	11	0	14	0	0	0
6/30/2014	13	0	6	0	0	0
7/7/2014	35	88	17	0	0	0
7/14/2014	35	40	8	0	0	0
7/21/2014	10	55	34	24	0	0
7/28/2014	14	35	29	25	4	2
8/4/2014	20	54	40	27	3	2
8/11/2014	25	63	28	13	0	0
8/18/2014	31	178	33	1	0	0
8/25/2014	133	274	93	24	2	0
9/1/2014	32	224	65	19	0	0
9/8/2014	24	158	71	27	0	0
9/15/2014	17	106	64	33	0	0
9/22/2014	31	80	32	9	0	0
9/29/2014	67	116	58	28	0	0
10/6/2014	27	87	34	22	0	0
10/13/2014	31	68	37	19	0	0
10/20/2014	33	83	62	15	0	0
10/27/2014	15	102	55	27	0	0
11/3/2014	23	136	61	30	1	0
11/10/2014	22	75	32	11	0	0
11/17/2014	19	82	31	6	0	0
11/24/2014	18	66	39	22	0	0
Totals	1178	2170	1085	386	11	4

Source: Battelle

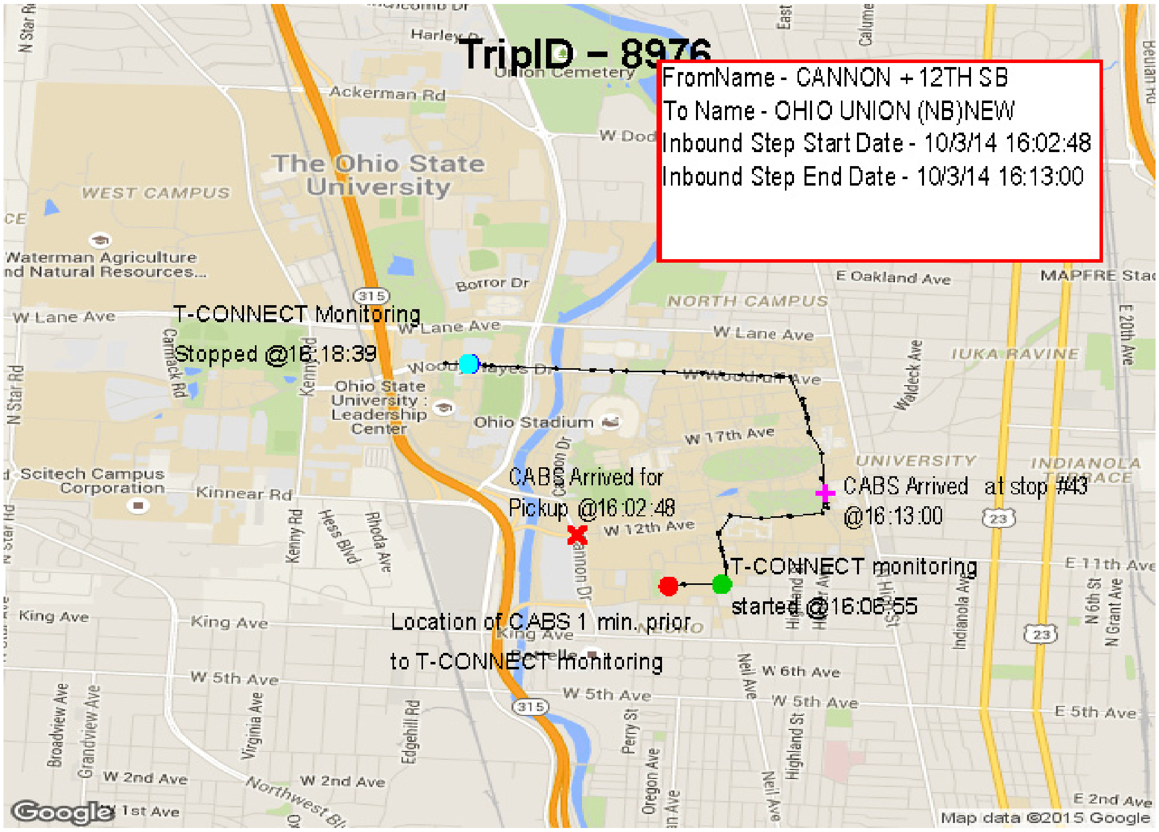
Data Validation

As discussed previously, system logs and corresponding traveler activities indicate that the IDTO prototype system was operational throughout the duration of the demonstration period. Simply being operational, however, did not ensure that the system performed its intended functions correctly. As such, following are examples of data associated with the various types of IDTO trips captured as part of the phase 1 demonstration. These serve as evidence of successful performance of the intended IDTO functionality.

CABS to COTA Transfer

The system design indicates that the IDTO prototype, specifically the T-DISP function, will allow for the identification and selection of transportation services that utilize a CABS to COTA connection. Further, the design specifies that in the case of these multi-agency transfers, the system will monitor and, if conditions exist, perform a T-CONNECT hold request to COTA.

Using system performance data captured by the tool, the occurrence of this form of transfer can be validated. As an example, Trip # 8976, which took place on 10/3/14, yields data that validates the system functions are performing as expected. The AVL data of the CABS bus and corresponding key timepoints are plotted in Figure 7-7. In this example, the passenger initiated the trip at Cannon & 12th Ave (Red ‘X’) using the CABS Campus Loop South (CLS) circular route, and traveled to the Ohio Union at Stop #43 (purple ‘+’). From there, the passenger boarded the COTA #7 at College Rd & 12th Ave, destined for S. High St and W. State St. Based on system criteria, including stop location and outbound route, this trip qualified as a T-CONNECT candidate, and as such, was monitored by the system for a T-CONNECT opportunity. The green marker reflects the time at which trip monitoring began, in advance of the upcoming transfer location. The red marker is the location of the CABS bus 1 minute prior to the start of this monitoring. It is included to show the distance the bus traveled in 1 minute, as well as the direction of the travel, moving from red to green. The light blue marker indicates the location of the CABS bus at the time the system monitoring was completed, which corresponds with the scheduled departure time of the outbound COTA bus. So, in this instance, the COTA bus was expected to arrive at stop #43 at 16:18 (UTC). As shown in this graphic, the CABS bus actually arrived at Stop #43 at 16:30 UTC, and this same bus is clearly past the desired transfer point (blue marker) when monitoring stopped. As evidenced by this plot of the CABS AVL data with respect to the COTA schedule, this trip did not necessitate a T-CONNECT request to be made.



Source: Battelle/Google

Figure 7-7. CABS AVL for TripID 8976

Capital Transportation to COTA Transfers

We further observed that the reliable, on-time performance of the incoming vehicles limited the number of T-CONNECT opportunities that might be otherwise be monitored. However, for those instances where a delay did occur, we can confirm the following

- The source of all eleven (11) T-CONNECT requests issued to COTA was Capital Transportation
- For the 11 T-CONNECT requests, evidence exists that they were indeed warranted
- For the 4 approved T-CONNECTs, evidence exists they were indeed necessary.

Figure 7-8 through Figure 7-10 show the path of the Capital Transportation shuttle, along with timepoints indicating where the vehicle was located relative to the corresponding bus stop, shown as two red ‘x’s. Figure 7-8 shows the AVL data of a trip where an accepted T-CONNECT request occurred. Figure 7-9 represents a trip where the request was warranted, but automatically declined by the system. Figure 7-10 shows an example of a trip that was monitored, but a T-CONNECT request was not indicated. In all three examples, we consider the start of the trip as the point where driver uses the installed MDT to select an outbound COTA bus. This point in time is represented by the black marker in the first two figures. The Red marker shows the location of the vehicle 30 seconds prior to this Driver request. Further, in the case of the first two examples, the green maker shows the timepoint (and location) when the system issued the

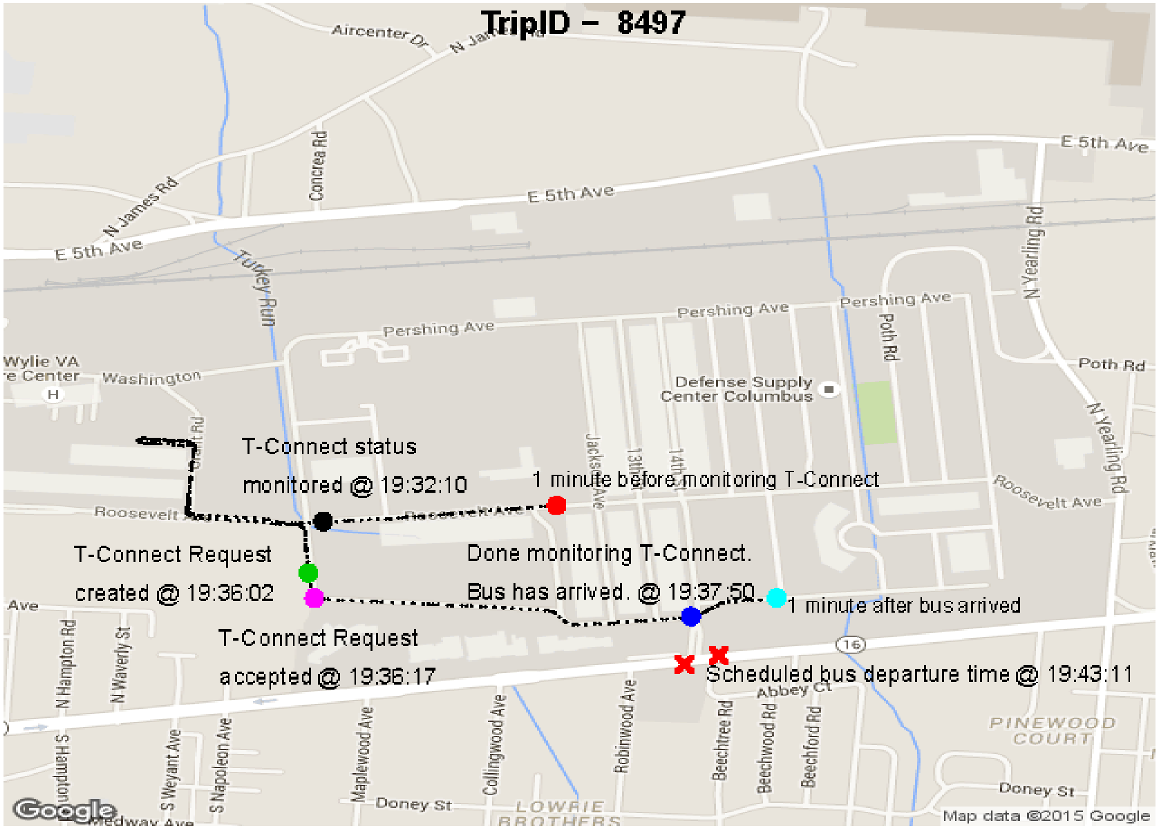
T-CONNECT request. The third example does not include this as the T-CONNECT was not issued, only monitored. The first example also includes a purple marker showing the timepoint when the T-CONNECT was accepted by COTA. The dark blue marker in all three examples indicates the location of the Capital Transportation shuttle at the time the corresponding COTA bus was to have departed the bus stop, and finally, the light blue marker indicates the location of the shuttle 30 seconds after the scheduled departure of the COTA bus.

As seen in the first two figures, the shuttle had traversed the route starting with the red marker and ending in light blue, and passed by the transfer point depicted as the two red dots located adjacent to each other in the lower right portion of the graphic in sufficient time to allow for the transfer. In each of these example, the ETA of the shuttle was such that it was expected to arrive at the drop-off location just north of the COTA stop (red ‘x’s), and the timing was such that a T-CONNECT request was warranted.

In Figure 7-8, looking at the plot of AVL data, the speed of the shuttle was such that the current ETA warranted a T-CONNECT. Also as shown, the request was approved within 15 seconds of its issuance to COTA Dispatch, at 19:36:17 UTC. Ultimately, the shuttle arrived in time to support the transfer, including the walk time of 2 minutes allowed for by OTP.

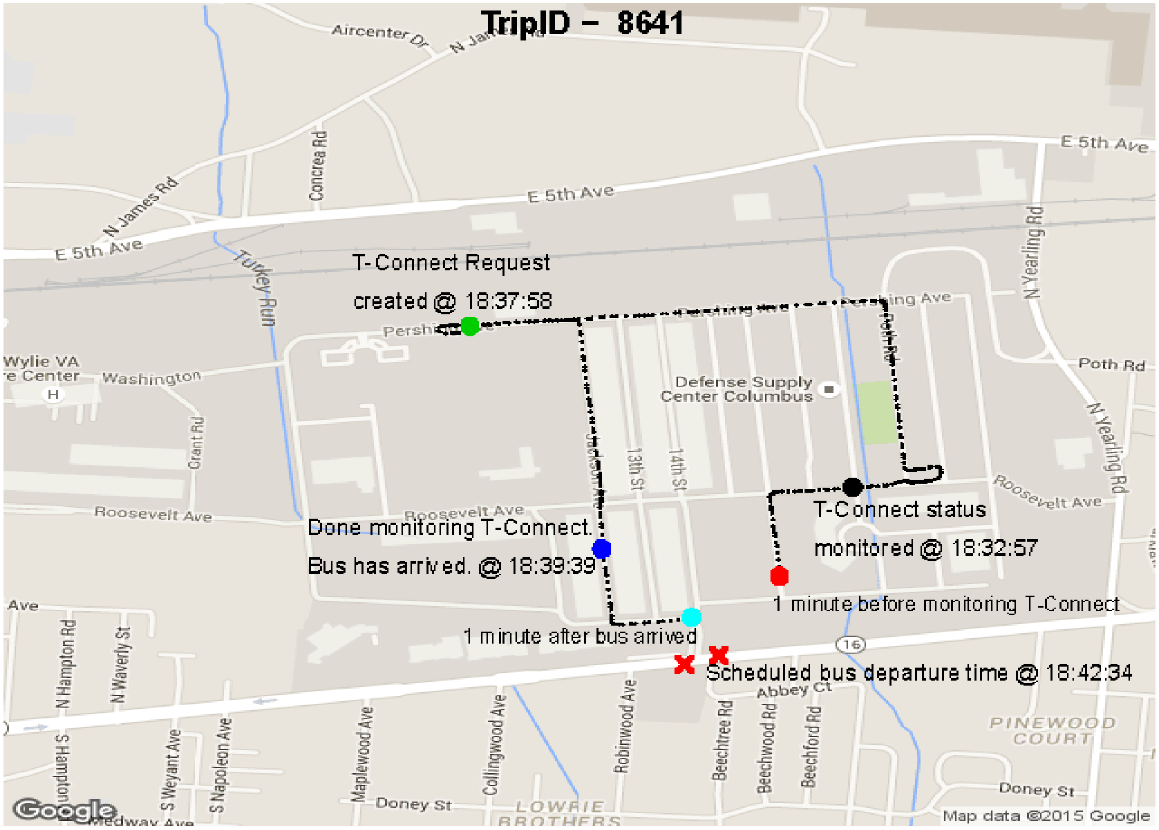
In Figure 7-9, the ETA of the bus again warranted the T-CONNECT request; however, in this instance, it was not accepted by COTA. As shown by the light blue indicator, the location of the bus, plus the added walking time, ultimately exceeded the departure time of the COTA bus.

Finally, in Figure 7-10, the T-CONNECT monitoring ceased on the point when the system realized the shuttle would arrive in sufficient time ahead of the planned COTA bus departure, a margin of nearly 7 minutes in this example.



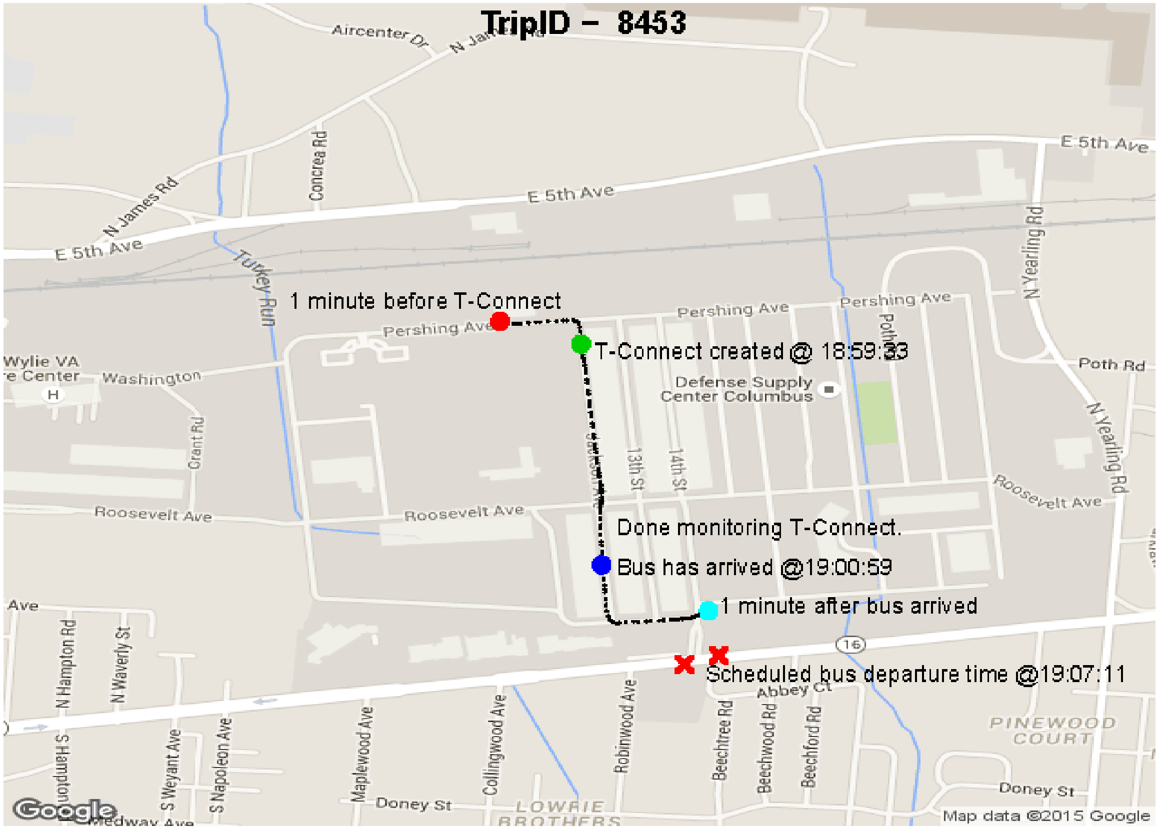
Source: Battelle/Google

Figure 7-8. Accepted T-CONNECT Example



Source: Battelle/Google

Figure 7-9. Rejected T-CONNECT Example



Source: Battelle/Google

Figure 7-10. Monitored T-CONNECT Example (No T-CONNECT Issued)

Chapter 8 Prototype Installation, Checkout, and Acceptance Testing – Phase 2

A key outcome of the DMA program was the establishment of a robust library of proven, open-source prototype software to be made available for future deployment opportunities by other state, local, and regional agencies and organizations. The Phase 1 demonstration served to prove the robustness and functionality of the software. The Phase 2 demonstration went so far as to demonstrate the system's flexibility and adaptability by deploying the IDTO prototype in a different geographic environment with a new roster of transit services partners, and with minimal changes to the core IDTO system. As identified in Table 2-2, the Battelle team also added a new mode (commuter rail), a requirement of the prototype system as prescribed in the original task order proposal request (TOPR). This demonstration provided further evidence of the functionality of the system, and the possibility for future adoption by other partners, agencies, and jurisdictions.

As this phase consisted purely of the technical proof-of-concept, there was no need or intent to recruit participants, nor operate the system in Central Florida outside of the test and acceptance demonstration. Instead, the IDTO PD team, after integrating the new partners into the IDTO system, served as the travelers and conducted a series of tests in collaboration with this second set of partners. The specific locations of the test were determined based on the schedule of the demonstration as well as that of the transit service providers' offerings at the time. Both the T-DISP and T-CONNECT features were again demonstrated in this location. T-DISP provided real-time, dynamic access to LYNX, UCF, and SunRail schedules in order to facilitate trip planning. Additionally, the application supported T-CONNECT transfers from both UCF and SunRail to LYNX.

The formal U.S. DOT Acceptance of this Task, Task 5 of the Project Plan, was conducted on November 5, 2014, and the preparation tests and related activities were conducted over the days and weeks leading up to this event. The remainder of this chapter serves to document the activities and results of this acceptance demonstration.

Equipment Installation and Checkout Plan for Phase 2

Equipment that was utilized by the Battelle team to facilitate this demonstration was limited to two smartphones (one Android and one iOS), pre-loaded with the IDTO application software, and a single Apple iPad device used as the dispatcher terminal. Both the smartphones and the iPad had internet connectivity provided via cellular connectivity, as provided by Battelle. A second, cellular-enabled tablet device was also made available to access the respective agency/provider AVL applications in order to compare arrival times from these applications with those of IDTO.

All AVL data used in Phase 2 was obtained from devices already installed and deployed by the respective agencies, and no IDTO-specific devices were installed in any vehicle or in the dispatch radio room. As such, no operator or driver training was necessary. Drivers who participated in the demonstration were briefed as to their specific role at the time of the demonstration, and with approval of the supervisor or manager supporting the demonstration.

Table 8-1 provides equipment requirements for both the participants and the transit operators supporting this testing.

Table 8-1. Equipment Requirements for the IDTO Prototype

Type of Equipment	Requirement Description	Role	Comments
Mobile Device	iOS 7 and above Android 4 and above	Test Participant	Participant's personal phone/ device
Wi-Fi Tablet with web browser	iPad Gen 3	LYNX Dispatcher	• Provided by Battelle • Cellular-enabled

Source: Battelle

Checkout of the equipment was conducted using the actual deployed equipment, as well as functioning iOS and Android user devices owned by Battelle. The equipment checkout was performed, in-place, in advance of the demonstration test. The checkout consisted of the following:

- Mobile Device
  - Confirmed LTE Access at test locations
  - Confirmed receipt of GPS signal at test locations
  - Verified operation of application by scheduling, saving, and reviewing saved trips
- Dispatcher Portal
  - Confirmed Wi-Fi access via portable MiFi hub
  - Verified that incoming T-CONNECT requests were displayed.

STATUS: Checkout passed.

Training

As the test participants for this phase were comprised of members of the IDTO PD team only, no formal training was necessary. Because the operations of the UCF shuttle routes were the only controlled testing performed in this acceptance test, instructions to the UCF shuttle driver were provided in advance of the actual test by IDTO PD team members during the dry-run testing.

Acceptance Testing/Results

The objective of Phase 2 was to demonstrate the functionality of the IDTO Prototype for both the T-DISP and T-CONNECT applications in Central Florida. T-DISP provided real-time, dynamic access to LYNX, UCF, and SunRail schedules in order to facilitate trip planning. Additionally, the application supported T-CONNECT transfers from both UCF and SunRail to LYNX. The Phase 2 checkout involved testing the IDTO Prototype from the following user perspectives:

- LYNX Dispatcher
- Traveler on UCF Shuttle
- Traveler on SunRail.

Dispatcher Portal (LNYX)

LYNX's role only required supplying GTFS and AVL data to support the outbound T-CONNECT concepts. However, as an operator of a transit services, LYNX provided useful feedback for future U.S. DOT consideration. A series of discussion questions were presented to LYNX personnel.

Discussion Objectives

The discussion topics for LYNX included the following:

- Receipt of incoming T-CONNECT requests
- Dispatcher actions to accept, reject, and auto-reject
- Rules for T-CONNECT to hold bus for 3 minutes or less
- Status of active T-CONNECTs.

RESULTS: LYNX staff were generally in favor of the T-CONNECT feature, particularly as it related to incoming SunRail trains, but expressed concern with the need to pay attention to this extra source of information. Dispatcher route assignment, such as odd vs. even, would require similar filtering on the Dispatcher Portal, but this is a feasible addition. Direct integration of T-CONNECT into their current CAD/AVL was also indicated as a desirable feature. With respect to their operational needs, in particular considering their relationship and scheduling activities tied to SunRail, the idea of a built-in, system generated, SunRail to LYNX T-CONNECT request, monitored and processed as necessary using current rules, was also cited as a potential feature. Current practice of LYNX staff is to monitor and continually refresh the SunRail website, checking on arrival status, and to then communicate this ETA to LYNX drivers via radio or MDT, and either indicate hold or proceed when the vehicle is at the corresponding stops. Subsequent discussions with SunRail and their decision not to make a public API available for route-schedule adherence data however precluded implementation of these LYNX-suggested features.

Traveler (UCF to LYNX Transfer)

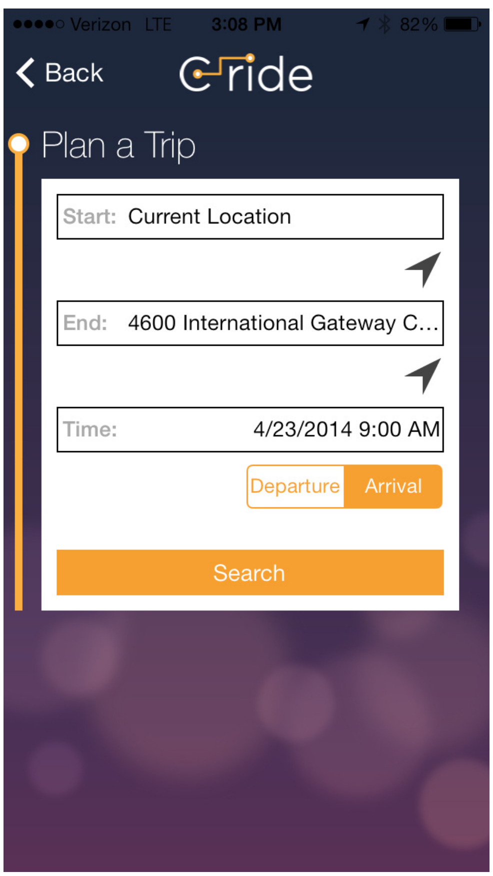
This scenario, which served to show both T-DISP and T-CONNECT functionality, was conducted by an IDTO PD team member serving as the traveler. The scenario replicated how a traveler originating from UCF could user his or her personal mobile device to schedule and monitor UCF to LYNX transfers.

Demonstration Objectives

The demonstration objectives for the transit user application included the following:

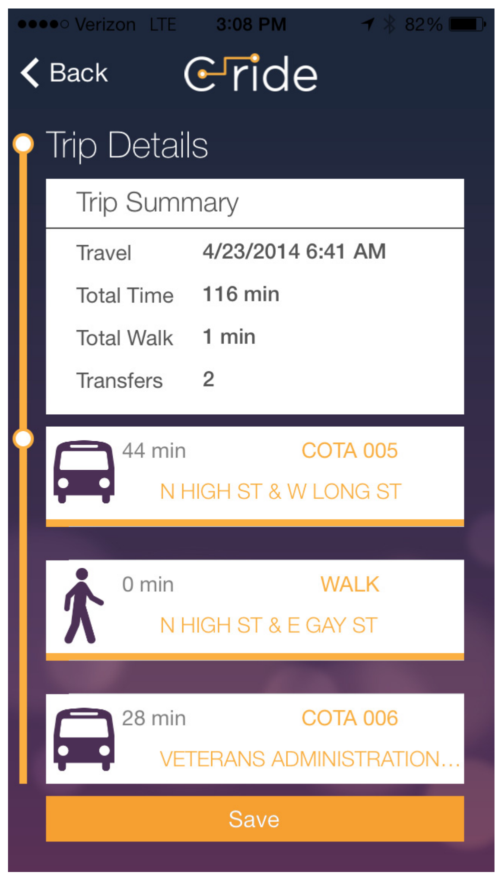
- Demonstrate trip planning, including UCF to LYNX planning with trip details.
    - For iOS, current location and address searches, as well as the depart vs. arrive option, will be demonstrated.
- Show trip backlog
- Show current trip
- Show Notifications (if possible), including
    - Trip about to start (5 minutes in advance),
    - T-CONNECT issued (bus late and 1 minute hold request accepted), and
    - T-CONNECT denied (bus late, but hold request denied).

All objectives were demonstrated using an Apple iOS device. Live screen shots were not captured so as to not interrupt or distract from the actual demonstration. As such, the data shown in the figures below is representative, but does not reflect actual data entered or received during this phase.



Source: Battelle

Figure 8-1. C-Ride Plan a Trip Screen (iOS)



Source: Battelle

Figure 8-2. C-Ride Save Trip (iOS)

Plan and Save Trip

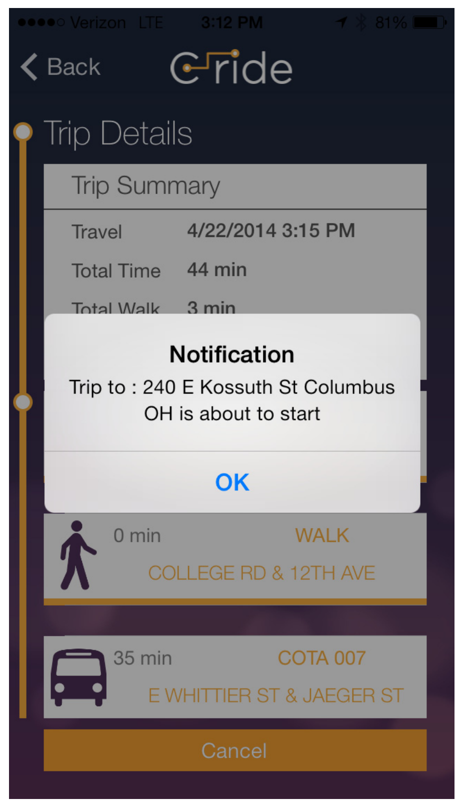
1. Begin at the CFE Federal Credit Union Arena on UCF campus
2. Using the iOS C-Ride application, select Plan a Trip (see example in Figure 8-1)
3. Use the Current Location Feature for Start location
4. Enter Orlando Fashion Mall as the End location
5. Ensure that 'Departure' is selected
6. Press the Search button – depending on time of day, at least one option should be shown that includes UCF Black Shuttle to the Transit Center, and then take either the Lynx 104 or 13
7. Select the first option, which should be next upcoming trip
8. Save the Trip using the 'Save' button, as shown in Figure 8-2
9. Using the IDTO Admin portal, confirm that the request has been saved in the system.
10. Close and reload C-Ride and confirm that the Trip is shown in Application

RESULT: Passed – Timestamped record in the T-CONNECT request report was consistent with the time of the user action.

Show Notifications – Trip Start (iOS)

1. Continuing from the trip scheduled in the prior step, hold the UCF bus's departure until noted.
2. Observe the Trip Start Notification (See Figure 8-3).

RESULT: Passed – Trip Start Notification Received.

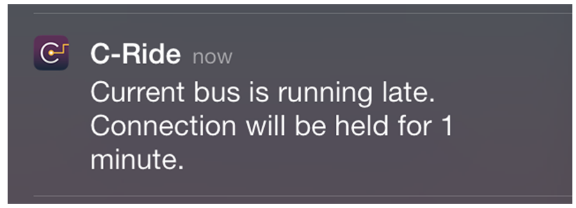


Source: Battelle

Figure 8-3. Trip Start Notification (iOS)

Show Notifications – T-CONNECT Accepted

1. Continue to Hold the UCF Shuttle until a T-CONNECT request is generated. This request can be monitored using the Dispatcher Portal.
2. Accept the request on the Dispatch Terminal.
3. At the same time, have the UCF Shuttle proceed on the planned route.
4. Observe the notification received. See Figure 8-4.
5. Stop at next Bus Stop.



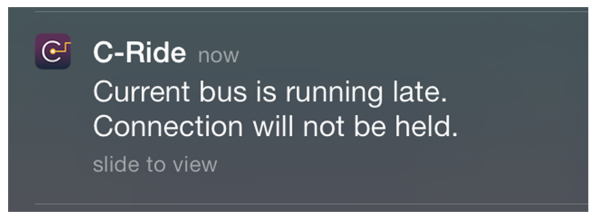
Source: Battelle

Figure 8-4. T-CONNECT Accepted Notification (iOS)

RESULT: Passed – T-CONNECT Accepted Notification Received.

Show Notifications – T-CONNECT Rejected

1. Schedule and Save the next trip starting from current location using C-Ride.
2. Hold the UCF Shuttle bus until a T-CONNECT request is generated.
3. Reject the request on the Dispatch Terminal.
4. Observe the notification received. See Figure 8-5.



Source: Battelle

Figure 8-5. T-CONNECT Rejected Notification (iOS)

RESULT: Not Verified – Corresponding LYNX schedule did not accommodate replicating this feature in Phase 2.

Explore Trip Planning Feature (iOS)

1. Using the same Plan a Trip process as above, explore the options available to the user:
   i. Enter a known starting address instead of using the current location
   ii. Press Search
   iii. Explore the difference in options retrieved
   iv. Similarly, toggle between Depart and Arrive times
   v. Press Search
   vi. Explore the responses provided

RESULT: Passed – Changes to the search criteria, both in terms of addresses and depart/arrive time, resulted in different route options being provided. This demonstrated how IDTO is using data from the transit partners in the Central Florida region.

Show Trip Backlog

1. Using the same Plan a Trip processes as above, generate and save at least two trips in the future, one on the same day and the second on a future day
2. Close and reload C-Ride
3. Observe Next Trip and Upcoming Trip portion of C-Ride application

RESULT: Passed – Saved Trips were displayed on C-Ride application

Trip Details

1. Select an Upcoming Trip to view the Trip Details

RESULT: Passed – Trip Details were displayed.

Traveler (SunRail to LYNX Transfer)

This scenario, conducted by an IDTO PD team member, replicated how a SunRail commuter traveler could use his or her personal mobile device to schedule and monitor SunRail to LYNX transfers. Similar to above, it demonstrated both T-DISP and T-CONNECT functionality.

Demonstration Objectives

The demonstration objectives for the transit user application included the following:

- Demonstrate trip planning, including SunRail to LYNX planning with trip details.
  - For iOS, current location and address searches, as well as the depart vs. arrive option will be demonstrated.
- Show current trip

All objectives were demonstrated using an Apple iOS device. Live screen shots were not captured so as to not interrupt or distract from the actual demonstration. As such, the data shown in the figures presented above in Chapter 8 is representative, but does not reflect actual data entered or received during this phase.

Plan and Save Trip

1. Begin at the Florida Hospital Health Village station
2. Using the C-Ride application, select Plan a Trip (see example in Figure 8-1 above)
3. Use the Current Location Feature for Start location
4. Enter 400 W Church St, Orlando, FL, as the End location
5. Ensure that 'Departure' is selected
6. Press the Search button – depending on time of day, the trip will have a train ride to Lynx Central Station with a transfer to a Lynx Bus (20, 40, or 36 to 20)
7. Select the first option, which should be next upcoming trip.
8. Save the Trip using the 'Save' button, as shown in Figure 8-2 above.
9. Using the IDTO Admin portal, confirm that the request has been saved in the system.
10. Close and reload C-Ride and confirm that the Trip is shown in Application

RESULT: Passed – Timestamped record in the T-CONNECT request report was consistent with the time of the user action.

Show Notifications – Trip Start (iOS)

1. Continuing from the trip scheduled in the prior step, hold the UCF bus's departure until noted
2. Observe the Trip Start Notification (See Figure 8-3 above)

RESULT: Passed – Trip Start Notification Received.

Explore Trip Planning Feature (iOS)

1. Using the same Plan a Trip process as above, explore the options available to the user:
    i. Enter a known starting address instead of using the current location
    ii. Press Search
    iii. Explore the difference in options retrieved
    iv. Similarly, toggle between Depart and Arrive times
    v. Press Search
    vi. Explore the responses provided

RESULT: Passed – Changes to the search criteria, both in terms of addresses and depart/arrive time, resulted in different route options being provided. This demonstrated how IDTO is using data from partners in the Central Florida region.

Trip Details

1. Select an Upcoming Trip to view the Trip Details

RESULT: Passed – Trip Details were displayed.

Chapter 9 Prototype Checkout and Acceptance Testing – D-RIDE

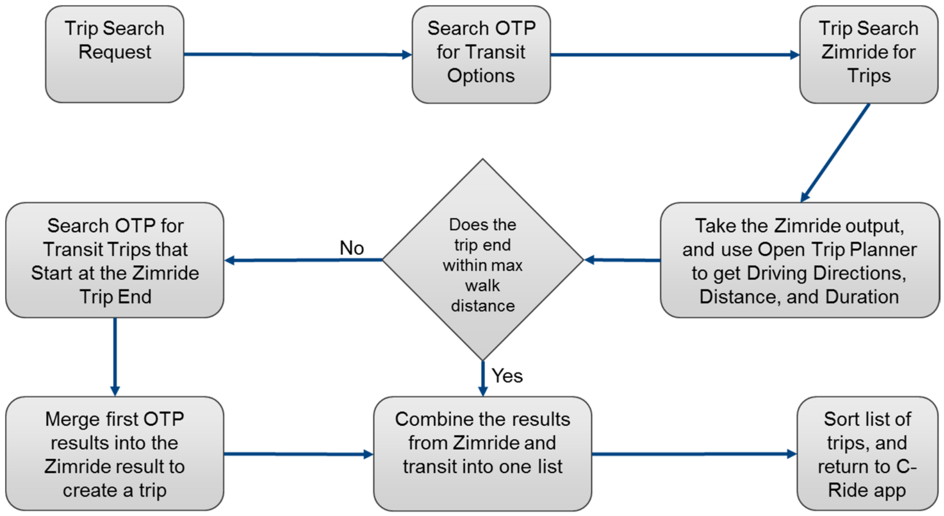
After a series of delays, the PD Team was able to negotiate a satisfactory agreement with Zimride and subsequently implement a limited but functional interface between the IDTO software and that of the dynamic rideshare partner. Ultimately, the functionality that was implemented demonstrated how a rideshare partner can be integrated into a trip planning tool to allow for both a rideshare-only offering, as well as how this same rideshare provider might be coupled with other transit services to provide a complete door-to-door trip. This satisfied key elements of both the D-RIDE and T-DISP concepts.

As part of this final demonstration of IDTO functionality, conducted March 12, 2015 at U.S. DOT Headquarters in Washington, D.C., the team demonstrated how rideshare offerings can be created in the Zimride service (via a private website operated by Zimride) and how IDTO, via the Connect and Ride application, can find these offerings, use the offerings either individually or in conjunction with other transit providers, and display these offerings to the user.

The example functionality that was demonstrated utilized service providers offered only in the Columbus region, and as such, Zimride-only and Zimride to/from COTA connections were the only two modes that were feasible to be demonstrated.

Integration of the D-RIDE Component

IDTO implemented a web API that allowed the mobile application to search for trips in the IDTO system regardless of provider. As noted previously, OTP was the original provider for trip planning, and supported all of the providers that supplied GTFS data. Zimride, however did not offer GTFS, nor did it offer an API for access to their system. The solution was to add a new software component (Zimride provider) that would query the Zimride system using their newly developed API in order to locate acceptable trips. Figure 9-1 shows the process by which the C-Ride application queried both the OTP provider and the Zimride provider, as well as how it used OTP to calculate walking distance and other trip characteristics. This added capability allowed for the demonstration of both the T-DISP component of IDTO, by allowing for multiple partner and multiple-mode scheduling in a dynamic manner, as well as demonstrating the D-RIDE concepts of on-demand scheduling/allocation based on both traveler and driver schedules.



Source: Battelle

Figure 9-1. D-RIDE Integration with T-DISP

Equipment Installation and Checkout

The equipment necessary to perform this acceptance testing included the following:

- C-Ride enabled Android Smartphone with valid user account
- Valid Zimride account for the traveler
- Valid Zimride account for the rideshare provider (i.e., the driver)
- Operational IDTO System, including functioning interfaces with COTA and Zimride

Prior to the demonstration, access to both C-Ride and Zimride was confirmed using both the traveler Smartphone as well as an internet-connected laptop running Windows 7 and Internet Explorer 10.

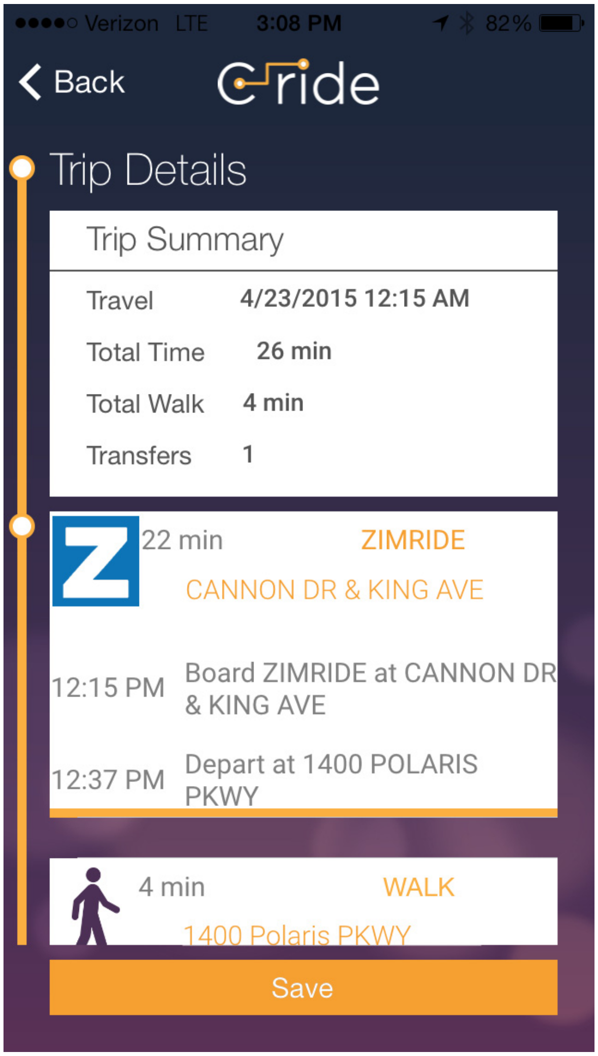
STATUS: Checkout passed.

Training

As no operational period nor participants were involved in this demonstration, no formal training was necessary for this phase.

Demonstration Scenario

- A driver has posted a D-RIDE commute using Zimride that will occur M-F starting at 12:15 pm and returning at 4:00 pm. The trip starts at the same location as our Phase 1 on-campus demo, 1849 Cannon Dr., Columbus, OH 43210 (aka Drake Union). The D-RIDE trip ends at Huntington Park near downtown Columbus.
- The C-Ride user account will be logged into on the mobile application.
- C-Ride on an Android device will be used to search for trips from the Drake Union to the Ohio Theater (39 E State St., Columbus, OH 43215) in downtown Columbus.
- The application will return any transit-only options found in IDTO (via OTP) along with D-RIDE options that will transfer to transit.
- When the details of the trip are viewed, notice that trips that include a D-RIDE step have a distinct icon, in this case, Z for Zimride. See Figure 9-2.
- Upon saving the trip, the user will be notified that he or she is saving a trip with a rideshare provider, and the user needs to finish booking the trip on the provider's website.
- Trip options are then displayed together in the same list. D-RIDE trips will start with a D-RIDE step and be shown in the list, and Zimride being the transit provider
- The trip details page is the same as before. D-RIDE steps have a distinct icon.
- When a user saves a multi-modal trip, the user will be notified to complete the required scheduling of the Zimride portion using the Zimride website, and the user will be redirected the appropriate site
- Travelers will receive notifications when a trip with a D-RIDE step is about to start



Source: Battelle

Figure 9-2. C-Ride Plan a Trip Screen with D-RIDE (iOS)

Acceptance Testing/Results

- STEP 1: Log into http://www.Zimride.com/columbus and show Driver Trip
  - ACTION: Using laptop, logged in as ‘driver’ and displayed the driver’s recurring trip beginning at the Drake Union and ending at Ohio Theatre.
- STEP 2: Log into C-Ride on Mobile device and select trip for 12:15 pm using the addresses indicated earlier (these are saved as favorites)
  - ACTION: Using Android devices, logged in as ‘traveler’ and generated trip for 12:15 PM using the noted addresses.

- STEP 3: Select Zimride option and show map
  - ACTION: Traveler selected the trip that includes the Zimride Option.
- STEP 4: Save Trip
  - ACTION: Traveler saved Trip in C-Ride application
- STEP 5: Show how trip is confirmed on Zimride website (mobile version)
  - ACTION: Traveler is re-directed to Zimride website to confirm the trip.
  - Driver is notified of request and approved the request.
  - Traveler is notified of acceptance.
  - Traveler is provided notification when Trip starts.

RESULTS: As indicated, the demonstration proved successful and a rideshare partner's system was successfully integrated and demonstrated to interact with a separate transit agency's system, allowing for a complete door-to-door service.

Chapter 10 Coordination with other U.S. DOT Programs

As specified in the TOPR and as facilitated throughout the duration of this project, the Prototype Development Team was expected to coordinate with several other related U.S. DOT research projects associated with the DMA program and the broader U.S. DOT Connected Vehicle program. As is documented in this section, Battelle satisfied this requirement as prescribed, and as new engagements were identified, made all reasonable efforts to support these concurrent and related efforts. Following is a list of the efforts/engagements, both required and added, along with a discussion on the level of engagement which occurred, data exchanged, and, if known, outcomes of each exchange.

IDTO Impacts Assessment

The Battelle Team supported the concurrent efforts of the IDTO Impacts Assessment program, as led by the Volpe National Transportation Center. This program has responsibility for integrating resulting outputs and data from the PD program into a broader and independent assessment of the impact of the prototype deployment. The Battelle team engaged the IA Team throughout the development, deployment, and implementation phases, including scheduled bi-weekly meetings, and as necessary, separate, focused meetings. Under this effort, we identified and collected the specific data elements needed to support its evaluation. This data took three forms: specific partner-provided data, such as GTFS files, AVL data and communications logs; prototype system data, such as trip searches made, trips saved, and trips monitored; and finally, feedback from users and stakeholders.

Partner Data took various forms depending on the role of the partner, and their level of technology insertion. For instance, COTA was able to provide data related not only to static schedule data, in the form of the GTFS files, but also fare box data, AVL data, communication logs, and stop information were made available to support the IA Team. At a different level of technology insertion, Capital Transportation used a manual dispatch system, via phone, with trip logs that were recorded manually by the driver. These logs, which provided pickup time, trip origin, and destination, were collected, summarized, and also provided to the IA Team. As previously noted, the additional equipment added to the Capital Transportation fleet captured AVL data that was also made available to the IA Team. Table 10-1 provides a list of the data needs/formats requested by the IA Team, and the corresponding ability of the respective partner to provide this data. The outcomes of the analysis supported by this data as conducted by the IA Team is outside of the scope of this report, but will be available in a separate report to be published via the National Transportation Library (NTL).

Table 10-1. Partner Data Provided for Impacts Assessment

Data Type	COTA	OSU	Capital Trans
Baseline (historical) ridership and transfer data – Passengers per vehicle or per day by route and service (split by season/periods of different demand or performance and by vehicle transfers, if relevant)	✓	✓	
Baseline (historical) schedule data – Scheduled arrival times by stop and route (split by season/periods of different demand or performance, if relevant)	✓	✓	
Baseline (historical) vehicle position data – Mean and standard deviation (known or estimated) of arrival times by stop and route (split by season/periods of different demand or performance, if relevant)	✓	✓	
Cost data – Unit costs by bundle element (e.g., T-CONNECT implementation costs per vehicle), shared costs by bundle element (e.g., costs of implementing T-DISP outside of vehicle-specific costs), unit operating costs by service type (e.g., hourly operating cost of COTA bus services)	✓	✓	✓
Current (demonstration) ridership data – Passengers per vehicle or per day by route and service (split by periods of different demand or performance, if relevant)	✓	✓	✓
Incident logs – Times of service disruptions by service	✓		
Logs of communications between drivers and dispatchers either over radio or mobile data terminal	✓		
Service logs – Indicators of status changes, nature of schedule changes (e.g., held by x minutes), time and duration of route changes	✓		
Vehicle position data – GPS coordinates (latitude, longitude)	✓	✓	✓

Source: Battelle

Prototype System Data is comprised of the data collected by the IDTO PD System during the actual operation of the System, a period spanning May through December 2014. This data was captured within the SQL Azure cloud-based RDBMS (relational database management system) that was provisioned for this program, and included data related to the following:

- Registered Users (de-identified)
- Trip Searches
- Trips Saved
- Trips that were T-CONNECT qualified
- Trips that were monitored for T-CONNECT
- Trips for which Dispatch was notified, and
- Trips for which a T-CONNECT was accepted.

This data was originally provided in the form of a SQL Server backup file, but after consultation with the IA Team, the submittal approach was revised to use comma-delimited files that better supported their analysis activities. This same data was provided to the U.S. DOT RDE, as detailed below.

Stakeholder and User Feedback was a shared effort on the part of the Battelle Team and the IA Team. As part of the prototype deployment, we prepared (in cooperation with the IA Team), published and then solicited survey feedback from users of the system via the online tool, Survey Monkey (www.surveymonkey.com). These surveys were planned to be automatically generated both on a monthly basis, for any active user during that period, or automatically after 5 trips by a user. Additionally, Battelle both supported the scheduling of partner interviews, conducted during three (3) different time periods over the course of the project, and provided responses to the IA Team as a stakeholder in the process. Stakeholder interviews were held with the following agencies/providers:

- COTA
- CABS
- Capital Transportation
- LYNX
- SunRail
- University of Central Florida.

A summary of the user survey results are included in a prior section, and the results of the stakeholder surveys are expected to be part of the IA Final Report.

DMA Program Evaluator

Similar to the support of the IDTO IA contractor as discussed above, the Battelle Team supported the overall DMA Program Evaluation Contractor, Booz Allen Hamilton, in their role of analyzing the effectiveness of the DMA program in application development and in the assessment of the potential impacts of widespread operational deployment of all of the high-priority mobility applications. This support was provided by the sharing of project documentation, supporting teleconferences to specifically answer questions, and responding to written questionnaires and inquires.

Open Source Application Development Portal

In an effort to make the outcomes of all of the DMA projects available to the public, including the software components developed as a part of IDTO and other prototype efforts, U.S. DOT established what is referred to as the open source application development portal or OSADP. A source code repository and development environment modeled after the popular SourceForge site (www.sourceforge.net), the OSADP allows registered users to collaborate and share software that supports the U.S. DOT connected vehicle vision. As a requirement to upload the code, the following had to be produced:

- Readme.txt
- Release-Notes.txt
- License.Txt (in accordance with Apache 2.0)
- Attribution.txt

These files, along with the source code for the IDTO mobile application (both iOS and Android versions), the Mobile Data Terminal (Android), the Dispatcher Portal (iOS), the T-CONNECT opportunity monitor (.NET), the IDTO Website (.NET), and the other supporting features were submitted to, approved, and ultimately published to the OSADP in March 2015.

Research Data Exchange

Complementing the OSADP, the U.S. DOT's Data Capture and Management (DCM) program was established supporting sharing of research data generated by the DMA and other projects. Under DCM, the RDE was created to house and publish this data. As specified in the IDTO PD TOPR, this project anticipated generation of data to be published on the RDE.

In order to be eligible for submission to the RDE, data must both be free of any PII, and must also be accompanied by a metadata dictionary, generated in accordance with ASTM E2468-05[15]. The metadata dictionary was completed, and the de-identified data, structured in the same format as provided to the IA Team, was submitted to the RDE for publication.

DMA Policy Analysis

In support of the IDTO Policy Analysis work conducted by the Volpe National Transportation Center (a separate team from the IA), Battelle staff provided input to and review of the Policy and Institutional Issues for Integrated Dynamic Transit Operations (IDTO) report[16], as prepared by Volpe. Many of the same lessons learned as identified herein are included as topics in this report, but are presented as policy considerations for future deployment of the IDTO bundle.

ITS Standards Assessment

The Battelle Team provided inputs to this U.S. DOT-sponsored effort as it relates to the use, or lack thereof, of standards pertaining to ITS, Transit, and CV-related topics. The following discussion items were shared with the Noblis/Consystec team that performed this work:

General Transit Feed Specification (GTFS) was used with reasonable success for all partners that had some form of schedule, whether fixed time, or fixed headways. As GTFS is primarily used to satisfy the demand for Google Transit, not all elements as included in the documentation were interpreted the same, requiring a least one iteration with two of the partners. GTFS is not technically a standard, managed by a Standards Development Organization (SDO), but at its best, may be considered an industry specification. It is recommended that the concept embodied by GTFS, if not the GTFS format itself, be considered for standardization by an SDO.

[15] ASTM E2468-05(2012), Standard Practice for Metadata to Support Archived Data Management Systems, ASTM International, West Conshohocken, PA, 2012, www.astm.org

[16] Bettisworth, Caitlin and Hassol, Josh and Maloney, Cynthia and Sheridan, Amy and Sloan, Suzanne. *Dynamic Mobility Application Policy Analysis: Policy and Institutional Issues for Integrated Dynamic Transit Operations (IDTO),* United States Dept. of Transportation, ITS Joint Program Office, 2015, FHWA-JPO-14-134.

GTFS Real-time was considered as a possible source of real-time location data, but it was not readily available from the partners, nor has it been published by an SDO. It is less mature, and likely more uncertain than its GTFS counterpart. No recommendation to continue development or recommend adoption of GTFS Real-time was made.

Agency AVL data was identified as a key element to the success of the T-CONNECT concept; however, no standard had been adopted by any of the partners included. Instead, IDTO built custom interfaces for each of the partners that did provide AVL data. The Battelle team did recommend that considerations be made to develop a real-time location message standard that can be implemented by agencies based on their existing AVL technologies.

Transit Communications Interface Protocol (TCIP), is an existing suite of Transit ITS-related standards, which were originally considered, but found not to support, the needs of this prototype implementation. No recommendations were made with respect this finding.

Traditional **ITS Standards**, such as those embodied within the National Transportation Communications Interface Profile (NTCIP) were also considered, but found not to support the needs of this prototype implementation. No recommendations were made with respect to this finding.

The term **"Connected Vehicle Standards"** refers primarily to those standards associated with the securing, encoding, and transmitting of data using Dedicated Short Range Communication (DSRC) technologies. These standards, which include SAE J2735:2009, IEEE 1609.X and IEEE 802.11p among others, did not include the necessary messages to support the needs of IDTO. Nor did this project attempt to adapt or modify these standards to support IDTO. In the future, the concept of a personal mobility message, which IDTO could leverage, would be a consideration, but the specific format, content, or appropriate SDO is outside of the scope of this effort.

Chapter 11 Outreach Activities

To engage transit industry stakeholders and share targeted messages to grow awareness and interest in the project's activities, the Battelle Team, at the direction of and in coordination with the U.S. DOT, either prepared and presented, or supported the preparation of, the following industry-related outreach activities.

2nd Connected and Self-driven Vehicles Symposium (June 17, 2014 – New Brunswick, NJ) – On the campus of Rutgers University, Battelle prepared and presented an approximately 20-minute overview of the IDTO Application Bundle and the coordinated PD and IA efforts.

Transit ITS Best Practices Workshop (November 13, 2014 – Detroit, MI) – This transit-specific workshop attracted agency, academia, vendor, and consultant participation. Battelle prepared and presented the IDTO PD project, including the system design and architecture at the time.

T3 Webinar on Transit Safety & Mobility Applications in a Connected Vehicle World (May 14, 2014) – This Talking Technology and Transportation (T3) Webinar, which is part of the U.S. DOT ITS Professional Capacity Building Program, featured two Battelle-led transit related connected vehicle discussions, both IDTO and the previously completed Transit Safety Retrofit Package (TRP). Battelle prepared and presented this roughly 45-minute webinar, which coincided with the go live date of the Phase I demonstration in Central Ohio. The T3 webinar series is designed to be interactive, and featured an introduction by the U.S. DOT GTOM, Mr. Ronald Boenau, and an online question and answer period. A recording of this webinar is available in the T3 Webinars archive found at http://www.pcb.its.dot.gov/t3_webinars.aspx.

ITS World Congress 2014 (September 9, 2014 – Detroit, MI) – Battelle co-authored and presented the paper entitled ***Implementing the IDTO Bundle: Leveraging Today's Emerging Technology to Benefit the Traveling Public*** as part of this globally attended ITS conference. This paper focused on the use of open-source tools, and the capabilities of smart devices, including phones and tablets, to implement the concept of IDTO, both from the traveler perspective, but also in support of agency goals. This paper is available as part of the conference proceedings, accessible online at http://itswc.conferencespot.org/?qr=1.

Transit ITS Best Practices Workshop (Orlando, FL – November 7, 2014) – Battelle prepared and provided for a presentation by Mr. Boenau on the preliminary findings of the Phase I demonstration to the audience of agency, academia, vendors, and consultants.

DMA Webinar Series (February 17, 2015) – Battelle prepared and provided preparation guidance to the U.S. DOT Task Monitor, Mr. Ronald Boenau, for his presentation of the IDTO program, both PD and IA, as part of the DMA Webinar series. One of seven such webinars, these were conducted as an information dissemination activity in advance of the release of the Connected Vehicle Pilot Demonstration solicitation, part of the broader U.S. DOT research roadmap. A recording of this presentation may be found on the DMA section of U.S. DOT ITS JPO website, located at http://www.its.dot.gov/dma/index.htm.

Chapter 12 Summary and Conclusions

Programmatic Accomplishment

The Prototype Development and Prototype Demonstration for Integrated Dynamic Transit Operations program served to further the objectives of the DMA Program as follows:

First, it confirmed the feasibility to integrate the functionality of the three distinct applications contained within the IDTO bundle (T-CONNECT, T-DISP, and D-RIDE) into a single environment that supports both mobile and traditional web interfaces, and which is interoperable with existing transit and transportation service providers. In doing so, it demonstrated an ability to provide a complete commuter trip whereby a traveler is able to identify, book (as necessary), and embark upon trips that will commence and conclude at locations not always serviced directly by traditional transit offerings, essentially moving toward door-to-door service, with the added bonus of having protected transfer points, where possible.

Second, it provided a real-world environment, whereby the conduct of the demonstration test of this prototype system, in accordance with a detailed experimental plan, allowed for the collection of data and lessons learned. And while not resulting in the quantity of trips originally envisioned, the activities that were conducted and the data that was collected do provide a foundation that will allow U.S. DOT to determine if it is feasible to implement these applications; what the benefits, real and perceived, to the traveler really are; and whether additional research in this area should be conducted.

Technical Accomplishments

Mobile Devices Facilitating IDTO Apps

A key question answered was that a GPS-equipped mobile device had the ability to support not only the basic features of the IDTO applications, such as trip planning/guidance, but more importantly, the advanced features of IDTO such as real-time location awareness and real-time notifications.

The former was proven by implementing a current location feature as part of the trip planning functionality. A user could select to start (or end) a trip at the current location as determined by the mobile device's location services. As was discovered during the Phase 2 testing, subtle but critical updates to iOS resulted in a change to how the application used the location services. In the new release, previous 'free' access to location services as used by C-Ride was severely restricted, resulting in a change to how the application obtained user location information.

These same location services were also used as a means to determine if a user was on an inbound vehicle. This is a critical element of the T-CONNECT Opportunity Monitoring system, as it is highly desirable to issue T-CONNECTs for only those transfers that are likely to occur. By confirming that a user is indeed on the inbound vehicle, T-CONNECTS can be issued, when warranted, with a high degree of confidence.

Real-time notifications also proved to be available and useful to the traveler, providing up to the moment status on trip starts and T-CONNECT/transfer status.

Use of Real-time Data from Providers to Support T-CONNECT

The logic used to identify and generate a hold request on an outbound vehicle is dependent on both planned and real-time schedule and vehicle location data, along with the appropriate rules (e.g., up to 1 minute hold if less than 5 minutes off schedule). Planned schedule information was provided in the form of GTFS files from each of the providers. This data was necessary to initially schedule the trip (a T-DISP function). However, once a trip had been initiated, the real-time data was critical to the success (reliability) of the determination for a connection protection.

As demonstrated in IDTO, it was imperative to be able to obtain the real-time data from the inbound vehicle in order to facilitate any form of connection protection calculation. Had this data not been available, it could only be assumed that the scheduled and actual performance were in synch. With the data, T-CONNECTs could be generated based on the estimated arrival of inbound vehicles as opposed to using the schedule departure time of the outbound vehicle, allowing for further refined algorithms. Unfortunately, as was the case in both Columbus and Central Florida, the outbound partners, COTA and LYNX, did not have real-time AVL data available to integrate into IDTO. However, as demonstrated both in Columbus with both CABS and Capital Transportation, and again in Florida with the UCF shuttle, the availability of the real-time location data allowed for the connection protection request to be issued when the actual arrival (we held the vehicles to cause the need for the T-CONNECT) did not match the plan.

The greatest challenge of the use of the real-time data, however, was reconciling the varied formats of the data. While generally simple in what it includes, no two providers used the same format, requiring unique interfaces to be developed for each. As a future item, it is suggested that a standard be adopted for conveyance of AVL and arrival data, whether it be GTFS-RT or another format.

Integration of OTP with T-DISP, D-RIDE, and T-CONNECT Functions

IDTO brings together a need for a trip planning system, asset scheduling, and real-time position monitoring systems. As was detailed in the design discussion above and in other supporting documents, OTP was selected to serve as the trip planning tool due to both its ability to serve in that capacity, but also due to its ‘open’ nature. OTP, however does not have any form of position monitoring or asset scheduling, and as such, that set of functions was implemented outside of OTP but with close ties to OTP. Further, OTP did not possess an ability to integrate the D-RIDE provider into the trip planning process. As such, functionality to support both the broader T-DISP with D-RIDE and the T-CONNECT functions was developed separately. Though a series of repetitive software interactions between the systems, IDTO can string together fairly simple multi-provider trips. The scalability of this approach is a concern as the number and types of providers could increase. However, as both providers and tools move toward a more standardized and open environment, the opportunities for success increase.

Lessons Learned

Human Subjects Research Age Issue and App Store Rating

Per our Institutional Review Board (IRB) process, it was determined that limiting participants to only those 18 years or older significantly decreased the requirements necessary to recruit and use their data in the IDTO study. Participants under 18 would require parental permission and similar other approvals. As such, it was agreed that only participants 18 years and older be allowed to participate. Adherence checks for this rule could be implemented in a few ways, but one of the easiest ways to try to ensure compliance is to impose restrictions, via parental control ratings in the app store. Both Apple and Google have a means to impose a ratings value on software; however, the issue with restricting the application to users 18 and over is not an easy one to solve using just the restrictions provided by the app stores. For example, a rating of 17+ on the Apple App Store means “May contain frequent and intense realistic violence, unrestricted internet access, frequent and intense mature, horror, and suggestive themes; also strong sexual content, nudity, strong language, alcohol, tobacco, and drugs which may not be suitable for children under the age of 17. Whenever an app of this rating is requested for download, a message will appear, verifying if the user is 17 or older, and asking to confirm the purchase for this reason.” Our application does not contain any of the items called out in the description. Therefore, our rating is 4+, which means that the application contains no objectionable material. In order to restrict our participants, we modified the application’s description in an attempt to receive the 17+ rating. Apple does look at the content of the application when reviewing, and will change the content rating based on their findings. In our case, the app was moved back down to 4+.

Google does a similar rating system with their applications as well. The best practice to limit users is to either ask for their age, birthdate, or some other sort of age verification when the user creates an account. This keeps the app rating in the stores true, but limits who can use the application.

Privacy with Zimride vs. IDTO PD Privacy Policy

The IDTO PD project is considered research, and the data that is acquired as part of the project is similarly classified as research data. As part of the IRB review of the project, the nature of all data that would be collected about a participant, including names, emails, and position data, was identified and documented in the agreement that all participants must accept before their data is allowed to be used for research. This data may include PII data, as that is the nature of this type of data collection activity; however, prior to submitting any data to U.S. DOT, all PII is removed. This policy and the actions taken are fairly standard for our type of research. Zimride, however, has a much more limiting privacy policy, and as such, required that our privacy policy at least met the same level of protection as did theirs. Further, Zimride’s policy prevented to use of the Zimride data by third parties, which would include IDTO. Several negotiation sessions were held and language was crafted, but the recently completed acquisition of Zimride by Enterprise Holdings, and the contractual language gap between the two entities, prevented the actual deployment of Zimride as the D-RIDE partner as part of any real-world operational capacity. Given these constraints, a controlled environment test, limited to IDTO PD team members, was the extent of the demonstration where Zimride was integrated with IDTO.

Difference in Privacy Rules between Ohio and Florida

Ultimately overcome by the challenges in ratifying Battelle's privacy policy with Enterprise Holdings Inc.'s privacy policies, a difference in the privacy laws of the two deployment states, Ohio and Florida, also necessitated additional IRB and legal discussions. The details of these differences are beyond the scope of this report, however; this discovery is important to understand for future deployment opportunities, particularly when third-party private providers are involved.

Licensing with CAD/AVL Tool for TaxiCABS

While the launch of the TaxiCABS service was never realized during the conduct of the IDTO PD project, discussions on how the in-place system used by OSU for current demand/response and paratransit operations might be used to satisfy the needs of the T-DSIP were held. Had TaxiCABS been implemented, the intent was to query the current CAD/AVL system in-place at OSU in order to determine availability of rides, and to possibly book a ride. Upon examination of the CAD/AVL vendor's license, however, any reverse engineering or external access to the data in the tool would be considered a violation of the license. Since TaxiCABS was no longer going to be deployed, neither OSU nor the IDTO PD team explored his any further, but it does raise a concern related to future integration of various vendor system components.

Budget for TaxiCABS

During the initial demonstration design, OSU had planned to launch a new real-time demand responsive service for faculty and staff of the University. The service, entitled TaxiCABS, was identified as the service provider to test the dynamic dispatching (T-DISP) functionality of the IDTO prototype. However, due to funding cuts, this service was never implemented by OSU.

CABS – GTFS Files were not of Proper Format for OTP

GTFS defines a common format for public transportation schedules and associated geographic information. GTFS feeds allow public transit agencies to publish their transit data and allow developers to write applications that consume that data in an interoperable way. A GTFS feed is composed of a series of text files collected in a ZIP file. Each file models a particular aspect of transit information: stops, routes, trips, and other schedule data.

Our data from CABS was generated by their scheduling system, but the GTFS file that was given would not load into OTP. Small modifications needed to be made to get the CABS GTFS file to be recognized by OTP. This shows that while Google believes that GTFS is a standard for transit information, the standard is not followed by everyone in that industry.

T-CONNECT Rules

As implemented in Columbus, COTA allowed for up to 1 minute of hold time, assuming that this hold would not result in the bus falling more than 5 minutes behind schedule. Further, a rule was also implemented to ensure that no bus was held more than once on any given route. These rules where intended for all routes and all times of day. Further, these restrictions were in part due to considerations of the current driver performance evaluations, which consider exceeding the maximum behind schedule value a performance issue. LYNX in Florida, on the other hand, indicated that they would at least initially support a hold of up to three (3) minutes. The variance between these two providers is not insignificant, and is likely to be one of the more critical discussion topics related to future deployment.

Capital Transportation – Failure to Use/Failure to Monitor

During the course of the evaluation, a lapse in data from the MDT/AVL installed on the Capital Transportation buses was detected. Upon further inquiry, it was identified that the original shuttle on which the equipment was installed had been placed out of service and a different shuttle deployed. The operator did not move the tablet mounting bracket to the new vehicle, but rather simply laid the tablet on the floor on the vehicle. Apparently in this location the device didn't receive sufficient GPS coverage to record any events, resulting in sporadic or missing data all together.

SunRail – Data Sharing

SunRail had concerns about sharing ETA data and AVL data for their trains because it would drive customers away from their website. SunRail is funded by the Florida Department of Transportation (FDOT), and their website allows travelers to plan and search for SunRail trip options from station to station. The website itself has advertisements that generate revenue for SunRail, and the mobile device could move travelers away from their site, resulting in lost revenue.

SunRail – Data Errors

The data that we were retrieving from SunRail's web API contained errors and sometimes the data itself was not available. We compared the data retrieved from their interface with the data that SunRail presented on their website for tracking the trains and found that both showed the same inconsistencies. Sometime trains would disappear from the website and web interface. We came to the conclusion this was due to the train not reporting its location and ETA information to their system. This could be due to a faulty internet link, or an outage in the AVL system on the train. Sometimes we would see the train, but the ETA information would be old. The data reported would be in the past, and the ETA for the next stop would not be updating. And to complicate issues even more, sometimes their web API would report ETAs for the next stop, and then two stops away, completely skipping a stop. Due to the inconsistencies of the data, using SunRail as an inbound T-CONNECT provider posed some challenges.

UCF – Use of GTFS Schedule Data on Fixed Headway Service

The shuttle system employed at UCF utilized a GTFS file supplied to their CAD/AVL systems as a mechanism to help keep the shuttle on its intended schedule. As this service operates using a fixed headway approach, meaning at regular, consistently timed intervals (i.e. 'every 10 minutes'), a GTFS schedule file was not expected. However, the system operators and the corresponding CAD/AVL vendor used this approach in a creative way to help maintain the fixed intervals between shuttles. In different operational scenarios, these GTFS files could serve as schedules and could be used as part of the trip planning environment, which is how they were used in IDTO. However, since the shuttle can vary from them, and since their use in this environment is for maintaining the headway, it needs to be noted that this approach may not be the best way to satisfy a requirement for real-time trip monitoring, or even trip planning.

Flexbus Deployment Delay

Flexbus, the multi-city sponsored dynamic demand/response service that was originally planned for deployment in Central Florida on a schedule that favored IDTO, was never realized. After the decision in Central Ohio to not deploy the OSU TaxiCABS application, Flexbus was and remained a great opportunity for inclusion in IDTO. The system, consisting of location-aware tablet devices installed in vehicles, and available smartphone and kiosk applications used to request service, provided a glimpse of what the role of lightweight LTE devices and similar technology may be in the future of transit applications.

Availability of AVL Data

Both COTA and LYNX, which served as the outbound T-CONNECT provider, did not have AVL readily available for consumption by the IDTO system. This limitation resulted in having to use the static planned times from the GTFS as part of the T-CONNECT algorithm. And while this did not significantly affect our ability to demonstrate T-CONNECT functionality, in real-world use, the further refinement of the algorithm would benefit tremendously from this data.

Users Did Not Save Trips

During the demonstration in Columbus, the C-Ride application had 1,120 downloads for iOS and 433 for Android. The target was to have users take a total of 6,000 trips during the 6-month demonstration period. In order to meet that goal, we needed 600 participants to take a total of 10 trips each. Unfortunately, we fell short of that goal. After the first month of low numbers, we added some more logging of the way travelers were using the application. What we noticed after adding the additional logging is that less than half of the trip searches turned into actual saved trips in the system.

One solution to this is to change the way that trips are searched for and saved in the system. Making it easier for users to save trips from the search results screen will reduce the number of button presses and screens shown to save a trip. One such approach would be to automatically save a trip when the details of the trip are viewed, and then develop a more sophisticated method by which the system monitors and subsequently cancels a trip if a traveler doesn't embark on the first leg of the trip.

Recommendations for Future Research

Tap on/Passenger on Bus

One challenge faced during the IDTO demonstration was knowing when a traveler actually took a scheduled trip. Knowing if the traveler did not take a trip would remove the concern of scheduling an unneeded T-CONNECT. If travelers had to 'tap on' using a smart card or equipped smartphone, or pay a fare, or some other means that would notify the IDTO system that a traveler who saved a trip has boarded the inbound bus, the IDTO system would know that a traveler took the trip, that a trip can be monitored for T-CONNECTs, how many T-CONNECT travelers are on an inbound vehicle, etc. The IDTO system would have more statistics showing how many trips were fulfilled, and how many trips were not taken. This information could be useful to transit agencies as they plan their schedules and routes.

Trip Saving Modifications

Travelers saved only about half of the trips they searched for in the IDTO system. If the system would automatically save trips that were viewed and had a method of knowing which trips travelers took, then the IDTO system could possibly have more trips to monitor for T-CONNECTS. Making the application a little more streamlined in the process of searching for trips, displaying results, and saving trips would help in generating more saved trips in the IDTO system.

More T-CONNECT Locations

During the demonstration, we limited the number of T-Connection locations, and specifically for Columbus, we limited T-Connections to two inbound providers (CABS and Capital Transportation) and to one outbound provider (COTA). Ideally there would be no limitations to who can be the inbound or outbound provider, and all transfers would be available for connection protection. This depends on the availability of the ETA data linked in real time to specific stops.

Monitoring of Outbound Buses

Adding the monitoring of outbound buses will aid in the generation of T-CONNECT requests. If the outbound bus is already going to be late, and that lateness fulfills the need of a T-CONNECT, then a T-CONNECT request will not need to be generated. This also allows for the monitoring of very late outbound buses that are so late they pass the maximum late window for holding, thus resulting in a system rejected T-CONNECT Request.

Automatic Trip Options on Rejected T-CONNECT Request

When a T-CONNECT Request is rejected, the application should show alternative trips to the user starting at their transfer location. Adding this feature will allow a reroute GPS type feature and would be a benefit to the traveler. The benefit might not be as great as holding the bus for a T-CONNECT, but having the data automatically given to you as a traveler has benefits and does not require any action on the part of the traveler.

Value and Benefits of this Work

The basic concept of IDTO, which is the opportunity to improve transit operations and the traveler experience by integrating three distinct but related transit operational functions into a single mobile application, was feasible. Further, the IDTO PD project proved that these concepts could be deployed across multiple service providers located in multiple geographic regions and spanning a variety of transportation modes.

The IDTO PD bundle provided a unique opportunity to experience, and in many cases overcome, challenges to its implementation: technically, contractually, and institutionally. The IDTO PD efforts revealed how much of a gap really existed between the current state of the practice and the concepts embodied in IDTO. And in examining these successes and gaps, we are able to ascertain the value and benefits of this work. Following is a discussion that demonstrates the value of the results, put in context with the overarching goals of the project.

To recap, the principal study question that was to be addressed by this demonstration was:

> *Can the mobility of the local traveling public (especially travelers needing to utilize multiple transit providers on a given trip) be significantly improved by integrating the capabilities and offerings of the three public transit mobility applications (T-CONNECT, T-DISP, D-RIDE) within a single real-time system that can meet the public's expectations on trip performance and satisfaction?*

The straightforward answer is perhaps. The results of the demonstration gave evidence that the concepts embodied in IDTO are feasible to implement from a technical perspective, even across varying service-provider types/modes and environments, as long as access to robust, current vehicle location data is available and users themselves are willing to enable location services on their mobile devices to support these applications. What was more meaningful, however, was the identification of the challenges and gaps, both technical and institutional, associated with the implementation of these transformative concepts.

From the PD perspective, the lack of true standards for information exchange, and the availability of AVL data were the two biggest technical challenges that had to be overcome. Institutionally, data sharing, privacy, and operational impacts posed the biggest challenges. Finally, public perception and acceptance, particularly in these days of a highly competitive, fast moving, "What have you done for me lately?" environment posed the biggest challenge. The good news, from a traveler perspective, was that, at least in the environments where IDTO was implemented, the number and frequency of routes offered by local transit partners were such that the actual need for connection protection was minimal, except possibly in situations with long headways (time between buses) or in situations like the last bus of the day. In the end, based on the feedback and data collected from the PD efforts, the integration of multiple provider offerings to provide real-time multi-provider/multi-segment trip planning within a single tool emerged as the greatest potential benefit of the IDTO concepts. With the recent but rapid emergence of private, for-hire transportation options such as Uber, the need and interest have blossomed well beyond those that were originally envisioned when IDTO was first conceptualized only five years ago.

In the end, the IDTO PD project met its intended expectations by fulfilling the following objectives:

- Demonstrating a prototype that can support both mobile and traditional web interfaces and is interoperable with existing transit and transportation service providers.
- Generating data that supports U.S. DOT DMA policy and program direction and provides a resource to other researchers and developers through the RDE.
- Generating technology solutions and institutional models that are compatible with legacy/enabling systems and relationships, and which consider institutional models that are replicable, and to a lesser extent, scalable.
- Observing and documenting the synergistic potential of the three applications that emphasize dynamic transit operations.

APPENDIX A. Abbreviations

API	Application programming interface
AVL	Automated vehicle location
CABS	Campus Area Bus System (Columbus, Ohio()
CAD	Computer aided dispatch
COTA	Central Ohio Transit Authority
C-Ride	Connect and Ride
CV	Connected vehicle
DCM	Data capture and management
DDL	Data definition language
DMA	Dynamic Mobility Applications
D-RIDE	Dynamic Ridesharing
DSCC	Defense Supply Center Columbus (Ohio)
DSRC	Dedicated short-range communication
ETA	Estimated time of arrival
FDOT	Florida Department of Transportation
FTA	Federal Transit Administration
GPS	Global positioning system
GTFS	General Transit Feed Specification
GTFS-RT	GTFS-Real Time
GTOM	Government's Task Order Monitor
IA	Impacts Assessment
IDTO	Integrated Dynamic Transit Operations
IE	Independent evaluation
IRB	Institutional Review Board
ITS	Intelligent Transportation System
JPO	Joint Program Office
JSON	JavaScript Object Notation
MDT	Mobile Data Terminal
NTCIP	National TCIP
NTL	National Transportation Library

OS	Operating system
OSADP	Open source application development portal
OSU	The Ohio State University (Columbus, Ohio)
OTP	Open Trip Planner
PD	Prototype Deployment [Development]
PII	Personally identifiable information
R&D	Research and development
RDBMS	Relational database management system
RDE	Research Data Exchange
SDO	Standards development organization
T3	Talking Technology and Transportation (U.S. DOT)
TCIP	Transit Communications Interface Protocol
T-CONNECT	Transfer Connection Protection
T-DISP	Dynamic Transit Operations
TMCC	Travel Management Coordination Center
TOM	T-CONNECT Opportunity Manager
TOPR	Task Order Proposal Request
TRIP	Transportation Route Information Program (Ohio State Univ.)
TRP	Transit Safety Retrofit Package
TTM	Traffic and Transportation Management (Ohio State Univ.)
U.S. DOT	United States Department of Transportation
UCF	University of Central Florida
VLAN	Virtual local area network

APPENDIX B. C-Ride Style Guide

IDTO
CONNECT & RIDE
STYLE GUIDE

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C-Ride Style Guide

MAIN COLOR PALETTE

18283C	5A3056	F9AE40	AA66CC	6E6E6E	B2B2B2
Left-hand Itinerary Column	Top Nav Menu, Headings	Top Nav Menu, Buttons, Lines, Icons, Text, Footer	Secondary Buttons, Bus Transfers, Icons	Main Text	Field Names

BUTTONS

Primary Button		Secondary/Details Button		Delete/Cancel Button	
F9AE40	FFCB04 Hover/Click	AA66CC	D493F9 Hover/Click	FF5F5F	EE334B Hover/Click

BACKGROUND GRADIENT

18283C → 5A3056

C-Ride Style Guide

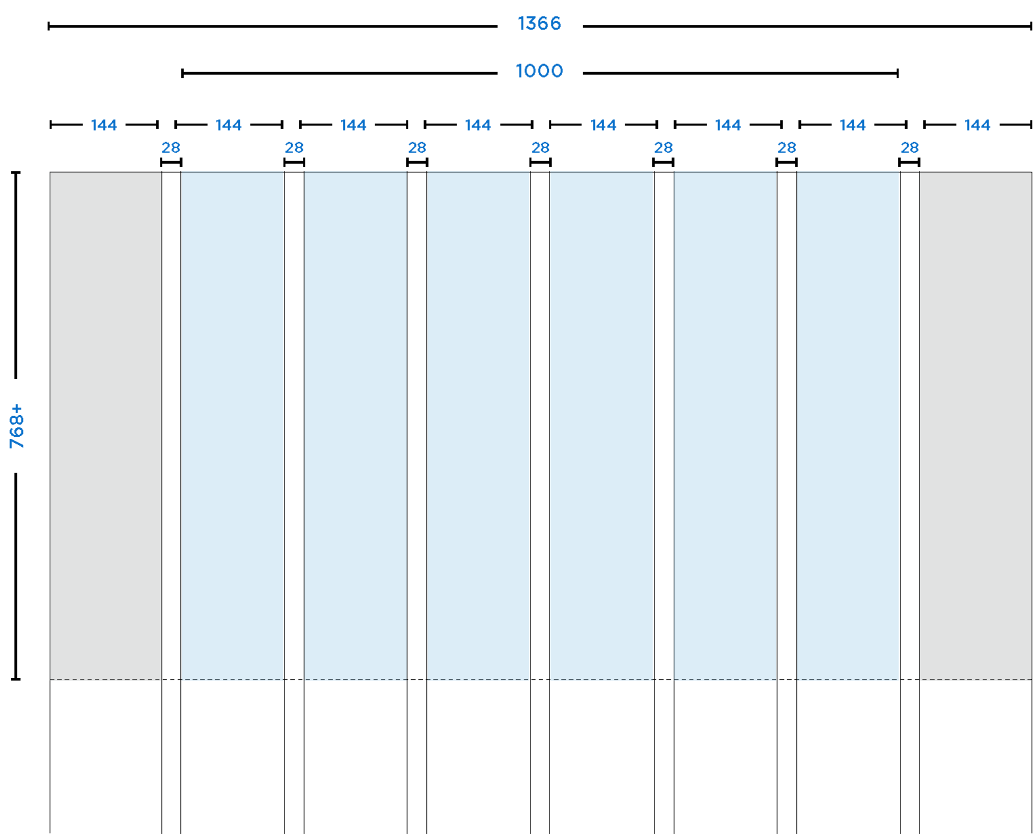
WEBSITE STRUCTURE

Overall Size
1366 x 768 px

Grid Structure
Column Width: 144 px
Gutter/Margin Between Columns: 28 px

GRID STRUCTURE USE

The grid lines are intended to separate boxes, images, charts, text, etc. in a consistent way. The columns below shaded in gray represents the space left for the background of the website. The area colored in blue is the area to be used to layout all content for the website.



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C-Ride Style Guide

BACKGROUND

SKYLINE BACKGROUND

Background skyline image is a Photoshop file with the blue gradient built into the file. Image and content centered in browser.

- Size:1366 x 370
- If the browser width extends beyond 1366 px, fill with 18283C

GRADIENT BACKGROUND

Directly below the skyline background, a gradient fills the remainder of the background, top to bottom:

- 18283C ——> 5A3056

BOKEH OVERLAY (OPTIONAL)

Transparent PNG file, anchored to the bottom of the skyline background.

- Size:1350 x 400

BLUE COLUMN

Transparent PNG file, anchored to the bottom of the skyline background.

- 316 px wide, height extents the full length of the browser
- 4 px drop shadow

FOOTER (OPTIONAL)

Footer is anchored to the bottom of the browser and does not disappear if the user scrolls.

- 34 px high, extends full width of the browser window
- Located above the blue column
- Color: F7AC40
- Powered by BATTELLE: 130 x 11 px
- Copyright: Helvetica Regular, 9pt, FFFFFF

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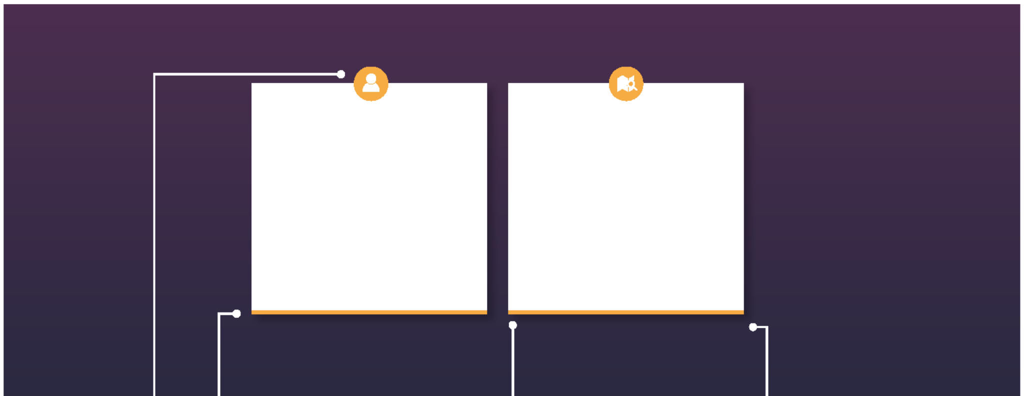
GRAPHIC BOX CONSTRUCTION



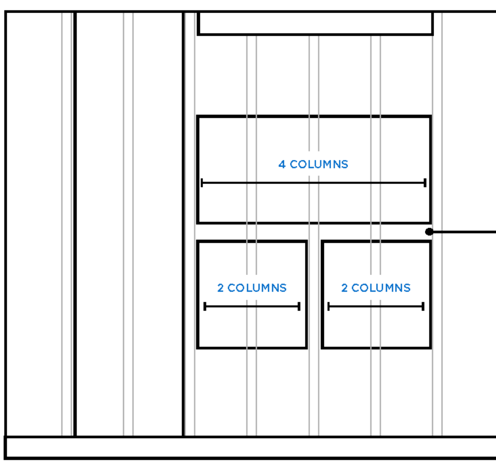
Line Color: F9AE40
Size: 4 px

Box Color: FFFFFF

Drop Shadow:
X: 3 px
Y: 3 px
Size: 4 px
Color: 000000

ICONS

Centered at the top of the box. Only used for different types of website functions shown on the same page.



BOX LAYOUTS

Boxes can be laid out in a variety of ways as long as the width of the box spans 2 or 4 columns. The height does not have a set size.

LEAVE A 28 PX MARGIN BETWEEN ALL BOXES

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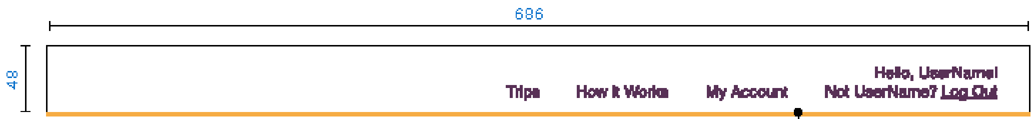
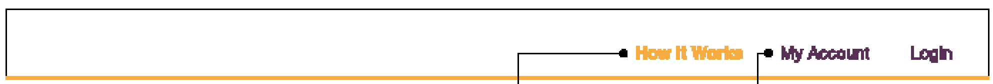
WEBSITE ELEMENTS

MAIN NAVIGATION



Navigation Upon Login: Landing Page

Line
- 2 px, Hex: F7AC40

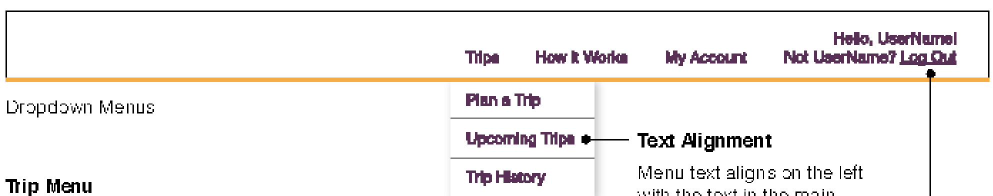


Navigation Not Logged In: Landing Page

Hover/Click Current Page
- Helvetica Bold, 11 px
- Hex: F7AC40

Font
- Helvetica Regular, 11 px
- Hex: 5A305S

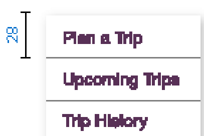
DROPDOWN MENUS



Dropdown Menus

Text Alignment
Menu text aligns on the left with the text in the main navigation.
- 12 px padding on left and right sides

Trip Menu



Menu Dividing Line
- Hex: SESESE
- 1 px Line
- Drop Shadow: 2 px, 2 px, Size 3 px 000000 @ 25% Opacity

Interactivity
For any website links that are embedded in text, it must always be underlined. Links can also be set in Helvetica Neue Bold if more emphasis is needed.

How It Works Menu

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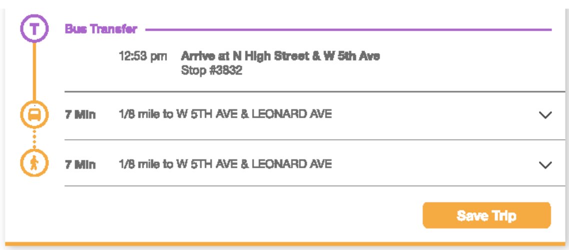
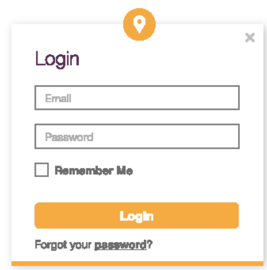
PRIMARY BUTTON STYLE

- Fill: F9AE40
- Hover/Click: FFCB04
- Text: Helvetica Neue, Bold, 16 px, FFFFFF
- 5 px edge radius



Button Width: 4 Column Box

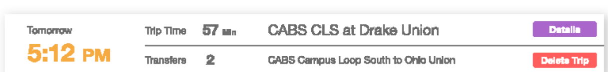
For buttons part of boxes that extend four column widths (660 px), buttons should still be 30 px high with 40 px of padding to the left and right.

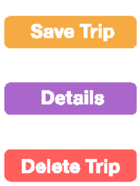


Button Width: 2 Column Box

If the button is part of a box that spans only two column widths (316 px), the width should span the full width of the box with padding.

TRIP BUTTONS





- 70 x 17 px, 3 px edge radius
- Helvetica Bold, 10 px, FFFFFF
- 8 px padding around buttons

BUTTON COLORS

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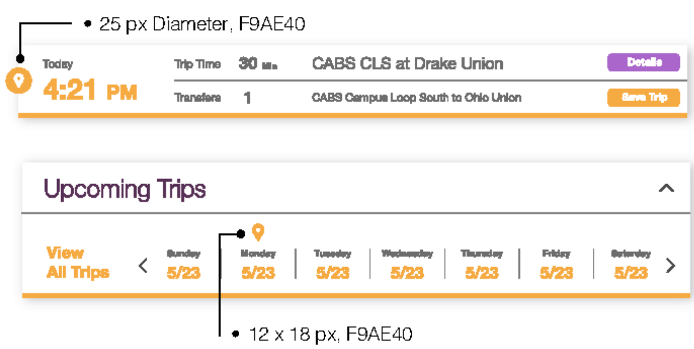
SECTION ICONS

Section icons are used for differentiation when more than one section box is on a given page (e.g., landing page: signed in). The icons inside are simple, filled illustrations of the section's main purpose.

- 40 px diameter, F9AE40
- Located in the center of the top of a box, with the icon emerging halfway (20 px) above the box

NAVIGATIONAL BUTTONS/ICONS

These navigational icons are used as buttons to select the city location and potentially favorite places the user frequents. The navigational icons can also be used as hover/select icons to let the user know which trip or day they are reviewing.



CALENDAR ICON

The calendar icon allows the user to call up a calendar to help them visually select a date for a trip.

- 20 x 20 px, 6E6E6E

PRINTER ICON

The printer icon allows the user to print or save a pdf of their trip details.

- 18 x 19 px, 6E6E6E

TRIP ICONS

The trip icons are used to the left of the trip details screen to allow the user to visually see the requirements of their trip. The dotted line between the man and the bus signifies walking, whereas the solid line signifies riding. The purple transfer icon signifies when a user has to transfer bus lines.

- Transport: 30 x 30 px, F9AE40
- Transfers: 30 x 30 px, AA66CC

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FONTS: ITINERARY BAR

FONT EXAMPLE	TEXT	SPECIFICATIONS
Columbus, OH Next Trip	• City Location • Next Trip	• Helvetica Neue, Light, 24 px • FFFFFF
Today	• Date/Time Label	• Helvetica Neue, Regular, 26 px • FFFFFF
4:21 PM	• Trip Time	• Helvetica Neue, Bold, 40 px • F9AE40, AM/PM: 22pt
22 min	• Departure Time	• Helvetica Neue, Bold, 26 px • F9AE40
CABS CLS at Drake Union	• Destination	• Helvetica Neue, Regular,18 px • FFFFFF
Travel Time: 12 min Total Walk: 1/4 mi	• Trip Information	• Label: Helvetica Neue, Regular,12 px • Measure: Helvetica Neue, Bold,12 px • FFFFFF

FONTS: MAIN PAGES/FEATURES

FONT EXAMPLE	TEXT	SPECIFICATIONS
Plan a Trip	• Section Heading	• Helvetica Neue Light, 24 px • 5A3056
CABS CLS at Drake Union	• Body Text	• Helvetica Neue Light, 12 px • 6E6E6E

FONTS: FIELDS

FONT EXAMPLE	TEXT	SPECIFICATIONS
Start Current Location	• Fields • Size: 30 px Tall	• Helvetica Neue Regular, 14 px, 6E6E6E • 1 px line around the field, 6E6E6E • Field Descriptors: Helvetica Neue Regular, 14 px, B2B2B2
Arrival Departure ✓ ☐ TaxiCABS ☐ ZimRide ☐ Bike	• Check Boxes • Size: 45 px Tall	• Arrival: Helvetica Neue Regular, 14 px, 6E6E6E • Departure: Helvetica Neue Bold, 14 px, 6E6E6E • Check Boxes: Helvetica Neue Bold, 14 px, 6E6E6E
Email Password ✓	• Create an account • Size: 30 px Tall	• Helvetica Neue Regular, 14 px, FFFFFF • 1 px line around the field, FFFFFF • Field Descriptors: Helvetica Neue Regular, 14 px, B2B2B2

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FONTS: LANDING PAGE UPCOMING TRIPS

FONT EXAMPLE	TEXT	SPECIFICATIONS
	• Date	• Helvetica Neue, Regular, 9 px, 6E6E6E
Today 4:21 PM CABS CLS at Drake Union	• Time	• Helvetica Neue, Bold, 22 px, F9AE40 • PM/AM: 14 px
View other scheduled trips >	• Destination	• Helvetica Neue, Regular, 14 px, 6E6E6E
	• Other Scheduled Trips	• Helvetica Neue, Regular, 12 px, 6E6E6E

FONTS: LANDING PAGE TRIP HISTORY

FONT EXAMPLE	TEXT	SPECIFICATIONS
3/04 8:34 AM CABS CLS at Drake Union	• Date/Time	• Helvetica Neue, Bold, 14 px, 6E6E6E
	• Destination	• Helvetica Neue, Regular, 12 px, 6E6E6E
View all previous trips >	• Other Scheduled Trips	• Helvetica Neue, Regular, 12 px, 6E6E6E

FONTS: SEARCH RESULTS/UPCOMING TRIPS

FONT EXAMPLE	TEXT	SPECIFICATIONS
Today	• Date/Trip Time/Transfers/Details	• Helvetica Neue, Regular, 11 px, 6E6E6E
4:21 PM	• Time	• Helvetica Neue, Bold, 20 px, F9AE40 • PM/AM: 20 px
30 Min	• Time/Transfer	• Helvetica Neue, Bold, 16 px, 6E6E6E
CABS CLS at Drake Union	• Destination	• Helvetica Neue, Regular, 16 px, 6E6E6E

FONTS: TRIP DETAILS

FONT EXAMPLE	TEXT	SPECIFICATIONS
Travel 12:39 PM, 2/25/14 Total Time 36 min	• Label • Text	• Helvetica Neue, Regular, 14 px, 6E6E6E • Helvetica Neue, Bold, 14 px, 6E6E6E
6 Min COTA 84 HILLIARD/ARLINGTON OSU to 84	• Time • Destination	• Helvetica Neue, Bold, 14 px, 6E6E6E • Helvetica Neue, Regular, 14 px, 6E6E6E
Bus Transfer	• Bus Transfer	• Helvetica Neue, Bold, 16 px, AA66CC • 1 px line, AA66CC

FONTS: UPCOMING TRIPS CALENDAR

FONT EXAMPLE	TEXT	SPECIFICATIONS
Monday 5/23	• Day • Date	• Helvetica Neue, Regular, 9 px, 6E6E6E • Helvetica Neue, Bold, 16 px, F9AE40
View All Trips	• View All Trips	• Helvetica Neue, Bold, 16 px, F9AE40

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Stock Photography Should Match the Following:

- Vibrant
- Saturated
- Lighter Background.
  Avoid images that have a black/dark background, lots of shadows or images that appear ominous.
- Choose candid images.
  Try not to choose images that look like they were shot in a studio, use unnatural lighting or were shot from an unnatural vantage point.

CITY SKYLINE PHOTOGRAPHY

For each city that is a part of C-Ride, a unique skyline image will appear as the background for the website. A panoramic image is preferred for the background.

CONTEXTUAL PHOTOGRAPHY

Although C-Ride is designed for anyone with web access or a mobile device who desires to schedule mass transit, it is mainly focused on college students, faculty and staff. The millennial demographic is the focus of the contextual photography.

Imagery should be vibrant and active. Environmental photography should show mass transit (i.e., a mix of buses, cars, etc) as part of a cityscape.

Mimicking photography filters commonly used in apps such as Instagram, stock imagery is altered in Photoshop using the C-Ride color palette to create warm, purple and gold hues within the imagery.

IDTO USER INTERFACE PAGE LAYOUTS

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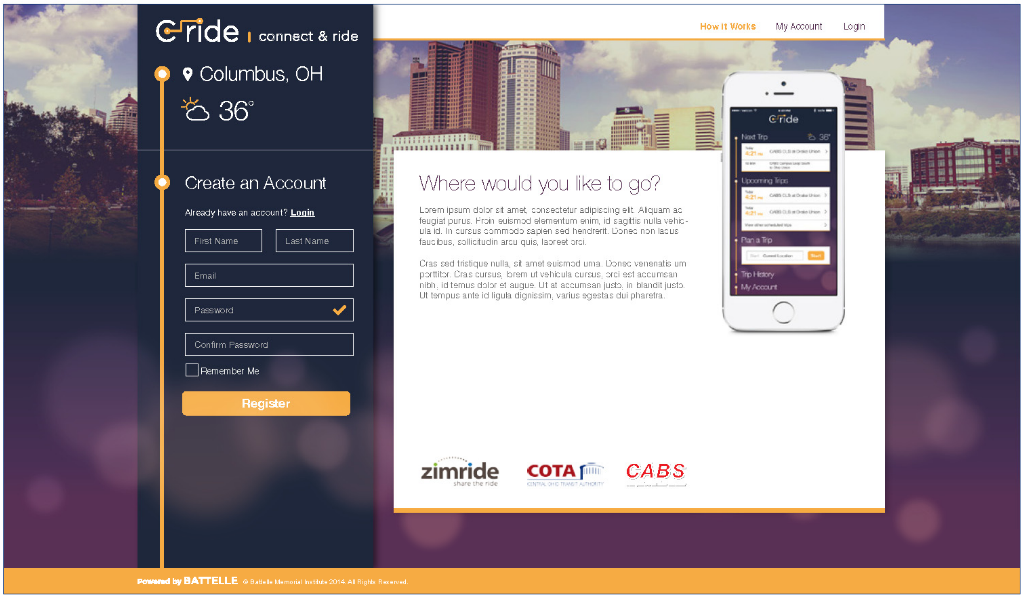
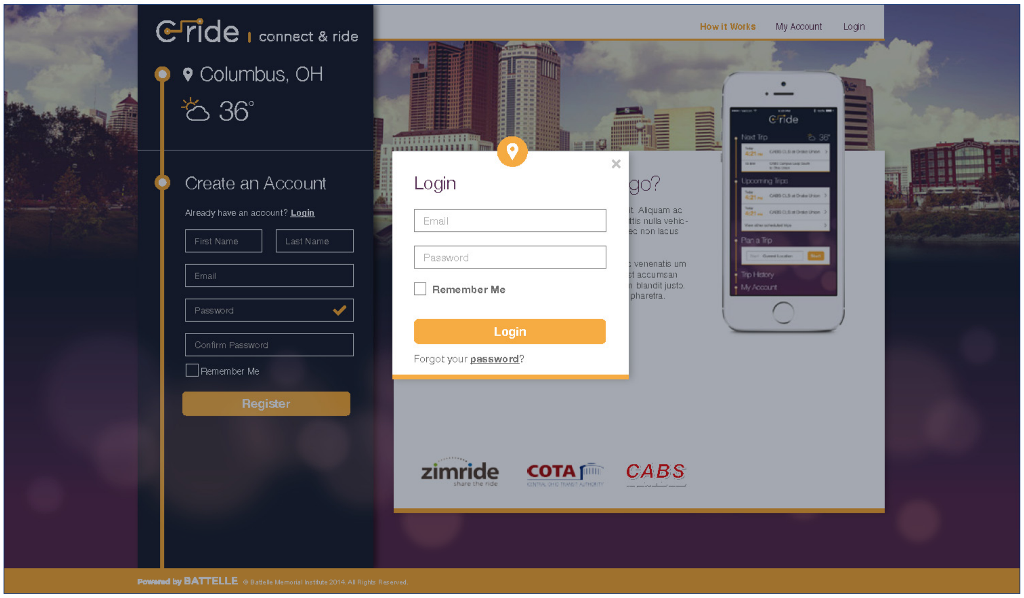
C-Ride Style Guide

LANDING PAGE (NO ACCOUNT)



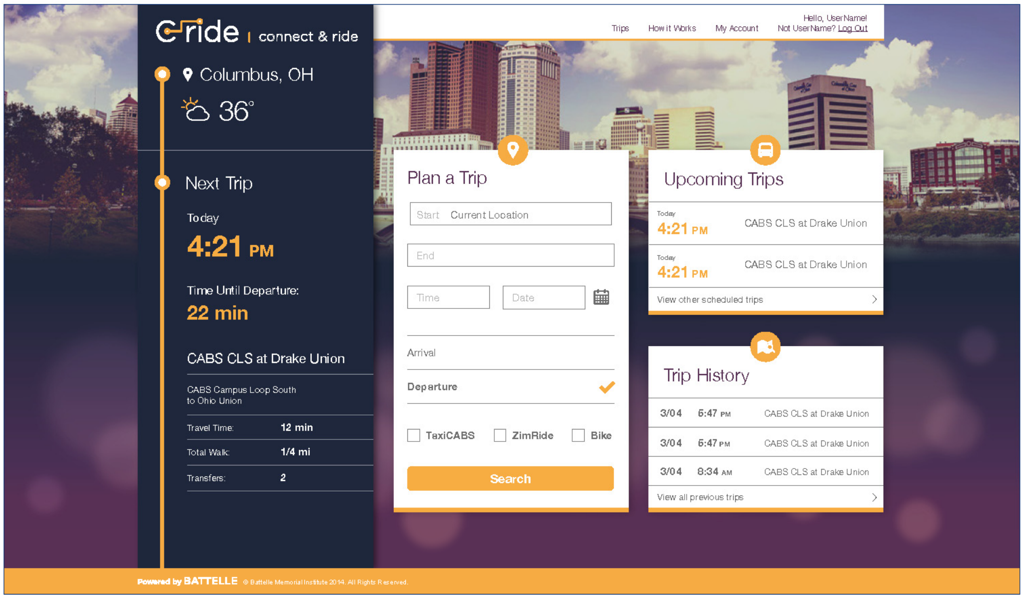
C-Ride Style Guide

LOGIN DIALOG BOX



C-Ride Style Guide

LANDING PAGE (LOGGED IN)



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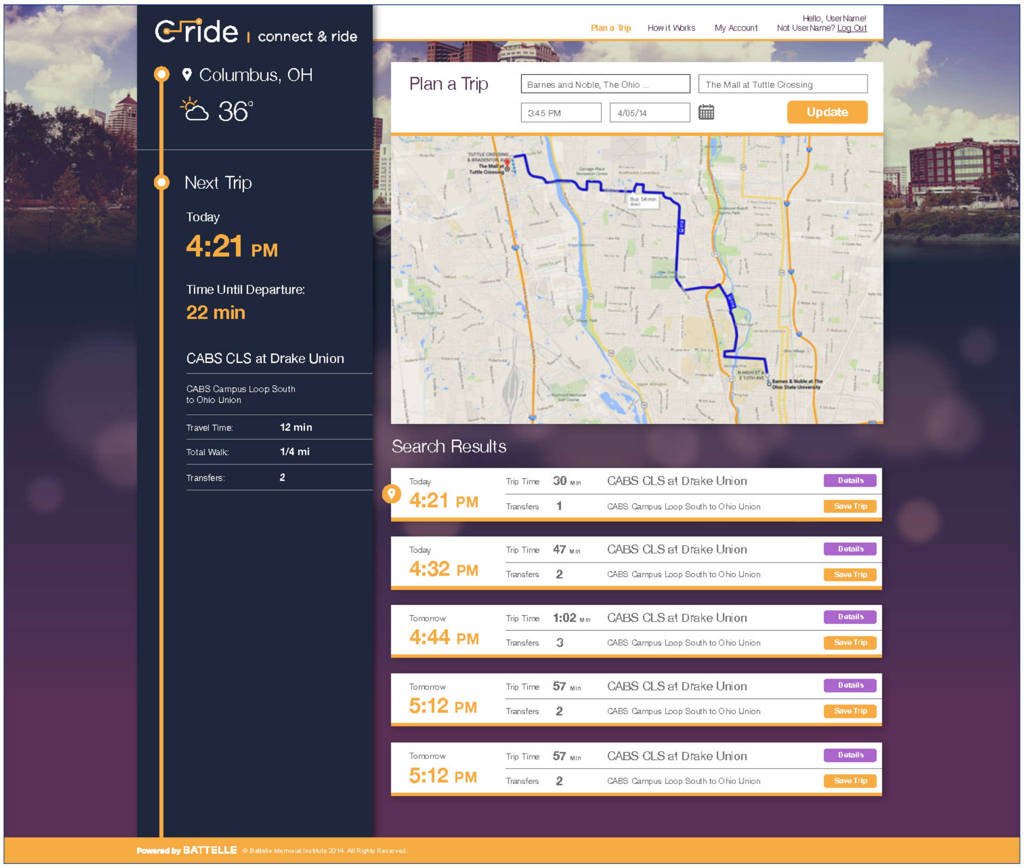
PLAN A TRIP



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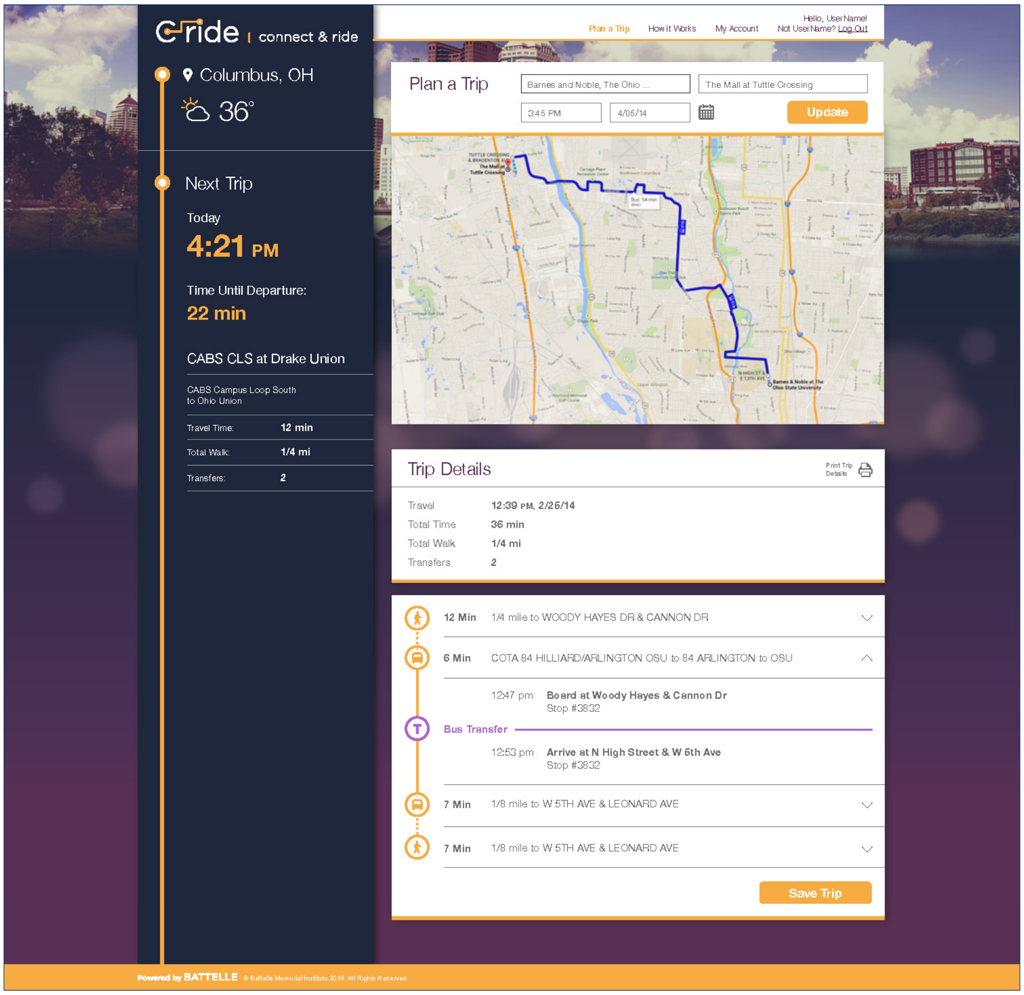
TRIP DETAILS



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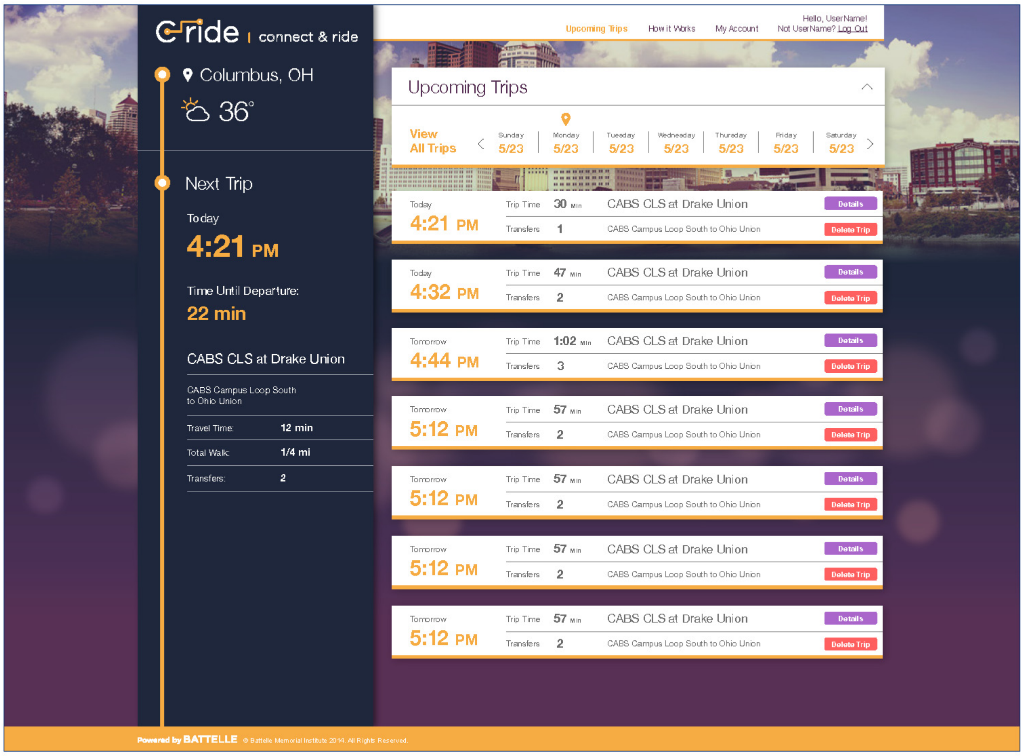
UPCOMING TRIP

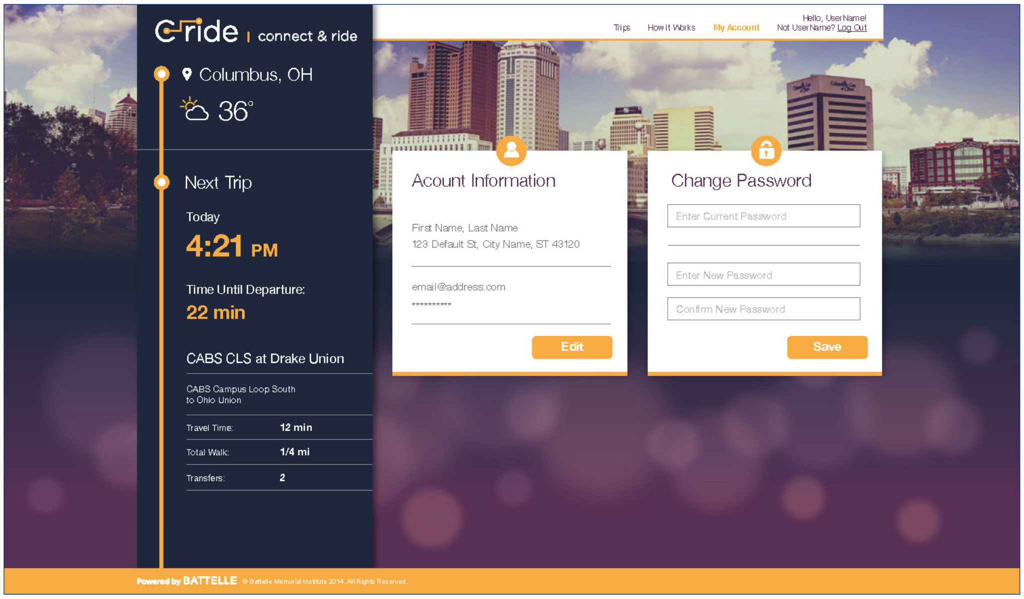


C-Ride Style Guide

ABOUT C-RIDE

C-Ride Style Guide

MY ACCOUNT



APPENDIX C. Twitter Dialog

Date	Tweet Text	Expanded URLs
5/26/2014	Happy #MemorialDay! How do you plan to spend the day in honor of the men and women who have served our country?	
5/29/2014	Want to learn more about C-Ride? Check out @Battelle's latest interview w/ @TracyT10TV http://t.co/ZrFlt2jahL #LovetheRide via @10tv	http://bit.ly/1kk2L5N
5/29/2014	C-Ride is available! Use the app to plan #Cbus trips via @OhioState's CABS & @COTABus. Where will you go today? http://t.co/i9NK91TrCT	http://ow.ly/i/5ILT4
5/29/2014	Thanks for sharing! RT @FleetNewsDaily: â€œConnect and Rideâ€ App to Simplify Public Transport Options in Ohio http://t.co/ulUd7KP6LI â€¦	http://fleetnewsdaily.com/connect-ride-app-simplify-public-transport-options-ohio/
5/29/2014	TY for sharing! MT @COTABus: We're partnering w/ @Battelle & @OhioState's CABS to provide the new @ConnectRide app! http://t.co/fIng7JzcJE	http://ow.ly/xoR4H
5/29/2014	Thanks for sharing, @OhioState_TP!	
5/30/2014	TY for the story @LaurenMGibbons! RT @DispatchAlerts: App that streamlines busing tested on COTA, Ohio State riders http://t.co/dRybvz62sr	http://bit.ly/1o4XDGE
5/30/2014	We're glad to be a part of it! @Battelle @Reuters @soldiersystems @GlobalBioD @WinnerH2O #FF	
6/3/2014	TY for sharing! RT @columbusbiz1st: @Battelle has unveiled an app that links @COTABus with @OhioState bus service: http://t.co/4uIfQNGjzL	http://bizj.us/ww97l
6/4/2014	#new2osu and stuck in the rain? Download C-Ride to help you get around #cbus while staying dry (for the most part!)	
6/5/2014	TY for sharing! MT @professorjosh: Later this year, @Battelle's C-Ride app to test in Orlando - @OBJUpdate http://t.co/eeCb7KCKws	http://buff.ly/1nOcERq
6/5/2014	TY for the article! MT @MassTransitmag: C-Ride App Simplifies Public Transportation Use in @COTAbus, OSU Locations http://t.co/bvmKxBLS4w	http://MassTransitmag.com/11489840
6/5/2014	Member News: C-Ride App Simplifies Public Transportation Use at Columbus-Area, OSU Locations http://t.co/NgBaBZDjDu via @columbuschamber	http://bit.ly/1oZMWJt
6/5/2014	TY! MT @columbuschamber: New @Battelle app to make public #transportation simpler: http://t.co/EbIJBDlC3i cc: @COTAbus, @OhioState_TP	http://ow.ly/xG3Xa

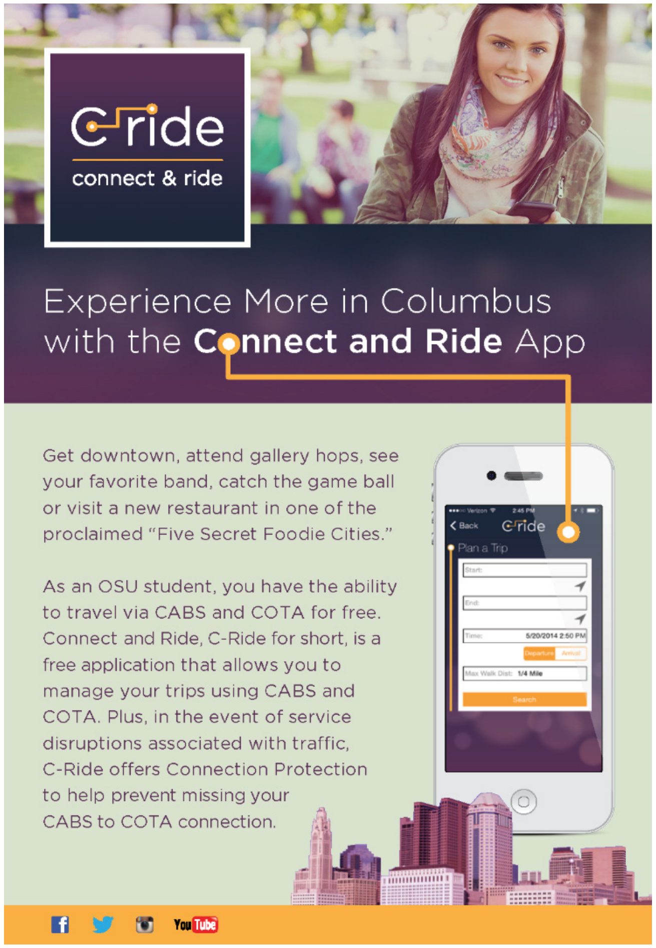
Date	Tweet Text	Expanded URLs
6/6/2014	Happy #NationalDonutDay! What's your favorite donut shop in #cbus? http://t.co/qTFAzKteyl	http://twitter.com/ConnectRide/status/474913471021068288/photo/1
6/11/2014	We are LIVE this morning at @Battelle w/ @nbc4i! Stay tuned for additional info throughout day. #LoveTheRide http://t.co/jrSj8ljiU0	http://twitter.com/ConnectRide/status/476654823232638977/photo/1
6/11/2014	TY! RT @Battelle: Thx to @nbc4i @bethNBC for the early story about #lovetheride @ConnectRide w/@OhioState & @COTABus http://t.co/CUmKkT0TnI	http://ow.ly/xSXhQ
6/11/2014	TY for sharing! RT @bethNBC: A cool new app....columbus is the test market for it...http://t.co/097vTNxu9l	http://www.connectandride.com/Home/Index?ReturnUrl=%2F
6/12/2014	See how @OhioState students plan to use Connect and Ride for CABS, @COTABus trips http://t.co/ZYeK3wE6U2 via @TheLantern #LoveTheRide	http://bit.ly/1v45AzU
6/12/2014	@NotOhioStCABS Thanks for the RT!	
6/12/2014	Thanks for the article! RT @TheLantern: Need to catch a COTA or a CABS? There's a new app that wants to help http://t.co/PrLF2fI8Zk	http://buff.ly/1mNoYuN
6/13/2014	TY! RT @Battelle: This week we are thankful for @CBUSRegion @dr_herman @andybachman @CBRNEcc @ConnectRide @kristen_mckee #FF	
6/13/2014	It's official - we are well into #WorldCup2014! Where do you plan to watch the games in #Cbus this weekend?	
6/14/2014	Happy #614Day! Celebrate and #RideMoreCMore in #Cbus via @OhioState's CABS and @COTAbus	
6/17/2014	Wow - great news! MT @TheLantern: The freshmen class at the Cbus campus is expected to be about 7,100 students this fall #new2osu	
6/19/2014	We can't wait! RT @COTABus: Need plans tonight? #catchtheCBUS during the CBUS Stop Hop, 5-7p! http://t.co/E5aBFCMbif	http://ow.ly/ycrdU
6/19/2014	#DumpthePump Day Fact: In 2013, Americans took 10.7 billion trips on public transportation, the highest in 57 years! http://t.co/H7PmYchS8R	http://ow.ly/i/5XS4n
6/20/2014	There are 2 great festival this weekend! Enjoy music, food & fun at @cmhpride festival & parade or @JUNETEENTHOHIO festival #RideMoreCMore	
6/24/2014	#OSUTraffic Alert: Expect heavier traffic this weekend due to the @SOOhio Summer Games on campus http://t.co/3MD8GSG5TB via @OhioState_TP	http://bit.ly/1l82Z0m

Date	Tweet Text	Expanded URLs
6/24/2014	TY for the update! RT @OhioState_TP: 11th Ave is back open. The ER will now resume regular service.	
6/28/2014	#OSUTraffic Alert: Coffey Road will only be open to 1-way northbound traffic today & tomorrow http://t.co/3MD8GSG5TB via @OhioState_TPÂ	http://bit.ly/1l82Z0m
6/28/2014	Instead of spending time trying to find parking for @ComFest, spend more time at the festival! #RideMoreCMore	
7/1/2014	Join us in welcoming the 15th #OSUnewprez - Dr. Michael Drake! http://t.co/MKGUUy7nHZ via @TheLantern	http://bit.ly/1o3CHiU
7/3/2014	While the rest of Columbus is parking for #BOOM14, you'll be finding a better seat! #RideMoreCMore	
7/3/2014	#Traffic Update: Restrictions will go into effect before, during & after #BOOM14 to ease traffic flow. http://t.co/yU2AA7WYeG via @NBC4i	http://bit.ly/1mkwySx
7/3/2014	Get a better seat for #BOOM14 by using C-Ride to get you there! #LoveTheRide	
7/4/2014	Happy 4th of July! Due to the holiday, there will be no @OhioState CABS service today. @COTAbus will run on holiday schedule.	
7/7/2014	#OSUTraffic Alert: CABS reroutes thru 7/28 due to close of eastbound 12th ave, south of 12th ave garage http://t.co/59GVzKIwOt via @OSU_S2F	http://bit.ly/1k5lbIC
7/7/2014	We'll show you the best route! MT @ohiounion: #New2OSU tip: Explore #Cbus w/ @COTABus, students ride free w/ BuckID http://t.co/lnYDkjHaw4	http://go.osu.edu/jk3
7/8/2014	#OSUTraffic Alert: Look out for cyclists Friday 6:30 - 7p during the Mayor's Twilight Run! http://t.co/JhroNDGfjS via @OhioState_TP	http://bit.ly/1r6J7Ra
7/9/2014	Hey, @Brutus_Buckeye! You are in the know of all fun things #Cbus. Let's show #new2osu students how to explore the city.	
7/9/2014	@prpnews thanks for sharing!	
7/11/2014	What if you didn't drive your car today? See how you can use #PublicTransit in #Cbus: http://t.co/OrMc064NPA via @COTABus	http://bit.ly/1tvijOE
7/11/2014	Join @MichaelBColeman & local celebs tonight as they bike through #Cbus during the Mayor's Twilight Ride! Onsite registration open 5-6:15p	
7/12/2014	.@ColsNightMarket is back! Check out more than 100 sidewalk retailers tonight from 6-11p. Share ur photos using #RideMoreCMore	

Date	Tweet Text	Expanded URLs
7/16/2014	Can't wait to attend! MT @OUAB: Want to be 1st to know ab campus events? Sign up for alerts! #new2osu #DiscoverOUAB http://t.co/5NsBEn0PXZ	http://ow.ly/xZnPj
7/18/2014	#RideMoreCMore this weekend at the Jazz and Rib Fest! Join in on the fun Friday & Saturday 11am - 11p or Sunday 11a - 8:30p!	
7/22/2014	What restaurants do you plan to visit during @614Magazine Restaurant Week?	
7/22/2014	.@DispatchAlerts enlisted 9 interns to find the best transportation option in #Cbus. Here's what they found: http://t.co/0RdO8jpS9E	http://bit.ly/1nRGQ7I
7/23/2014	Are you #New2OSU and here for orientation? Let C-Ride help you explore the city! #RideMoreCMore	
7/23/2014	Today's #NationalHotDogDay! Connect a ride and grab a bite to eat w/ friends @DirtyFranksDogs! #LoveTheRide http://t.co/KBIggsmrsZ	http://ow.ly/i/6bSiF
7/24/2014	@taz288 we're very sorry about this. A glitch is causing a complication we're working to correct. Please stay tuned for updates.	
7/24/2014	Why did the chicken cross the road? To connect and ride! #LoveTheRide #OldJokeDay	
7/24/2014	TY for sharing the #OSUTraffic Alert! RT @OSU_S2F: 5th Ave Bridge closed for work 7/28 - 8/4 http://t.co/pg0h5RUoHK http://t.co/PZQVit1cxh	http://bit.ly/1kayE7V,http://twitter.com/OSU_S2F/status/492368661651279872/photo/1
7/25/2014	What a great idea! MT @614Magazine: @BalletMet celebrates National Dance Day w/ free classes tom. starting at 10a http://t.co/R3JvSFqhuW	http://ow.ly/zzGxi
7/25/2014	#Traffic Update via @COTABus: Lines 16 & 87 rerouted from Cassady btwn Drake & Cumberland due to water main break. http://t.co/jnhObp50g0	http://bit.ly/1rRkbxk
7/25/2014	#Arts are alive in #Columbus! Listen to Folk & Fiction tonight @booksatkerouac starting at 9pm	
7/26/2014	Looking for something fun to do today? #RideMoreCMore to the Lazy Daze of Summer festival from 11am - 6pm next to @GViewLibrary!	
7/30/2014	TY for the mention! MT @OSU_OffCampus: Looking for a convenient way to get around? Download @connectride to use CABS & COTA in one place!	
8/1/2014	Looking to try something new? Check out the @DublinIrishFest to see some amazing performances and try some authentic #Irish food!	
8/1/2014	Catch the #Cbus to run a 5k or 10k at the @BullRunColumbus this Saturday! #LoveTheRide	

Date	Tweet Text	Expanded URLs
8/4/2014	Are you #New2OSU? C-Ride is here to make getting to places much easier! #LoveTheRide	
8/4/2014	ICYMI: C-Ride pushed out an update over the weekend correcting the authentication token error.	
8/4/2014	@taz288 C-Ride pushed out an update over the weekend correcting this issue. TY for your continued support.	
8/6/2014	Navigating through Columbus when you're #New2OSU can seem confusing, with C-Ride, finding your ride just became much simpler!	
8/9/2014	There's so much of Columbus to explore when you're #New2OSU, let C-Ride help you get where you want to go #RideMoreCMore	
8/11/2014	When you're #New2OSU everyday is a new adventure, let C-ride help you get there #LoveTheRide	
8/13/2014	Show us what interesting places you find when you're #New2OSU, we'd love to see where you like to go! #LoveTheRide	
8/16/2014	Figuring out Public Transportation when you're #New2OSU has never been easier, C-Ride has got your back! #LoveTheRide	
8/29/2014	TY for the support! You can continue by downloading the app. Please direct questions or comments to connectandride@battelle.org	

APPENDIX D. Outreach Materials



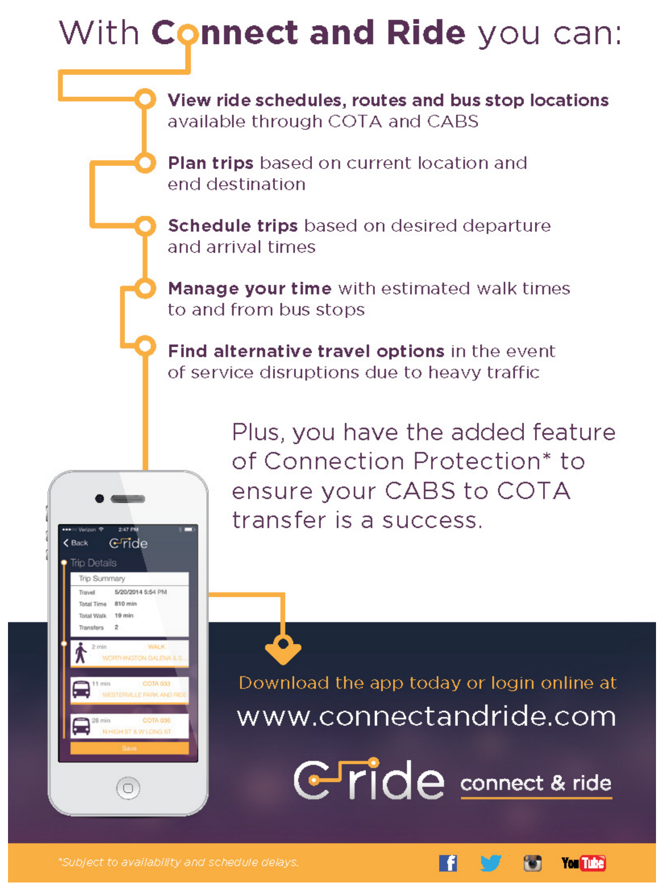
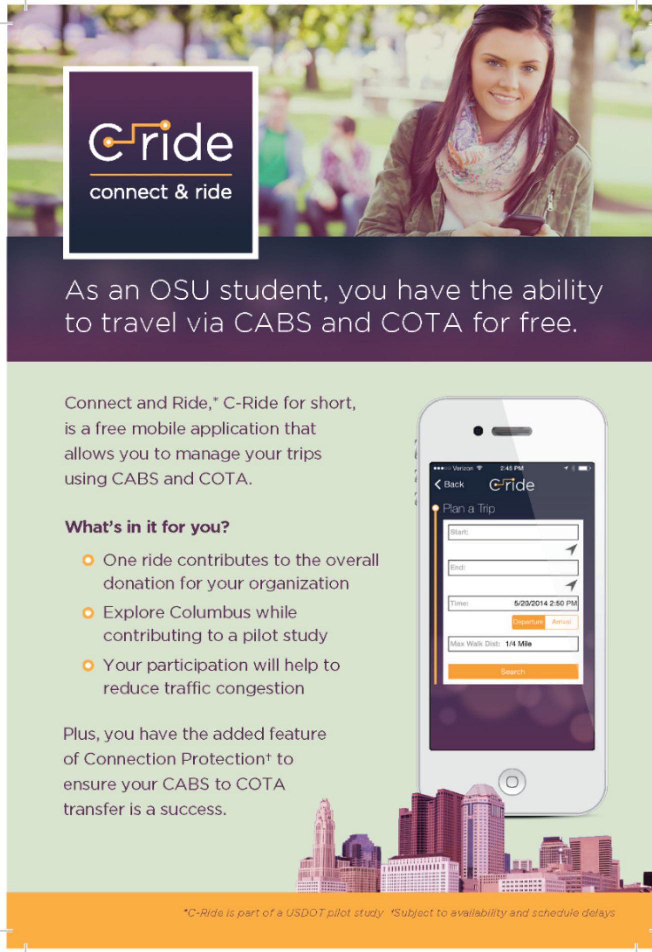


Figure D-1. OSU Incoming Student Postcard (Front/Back)



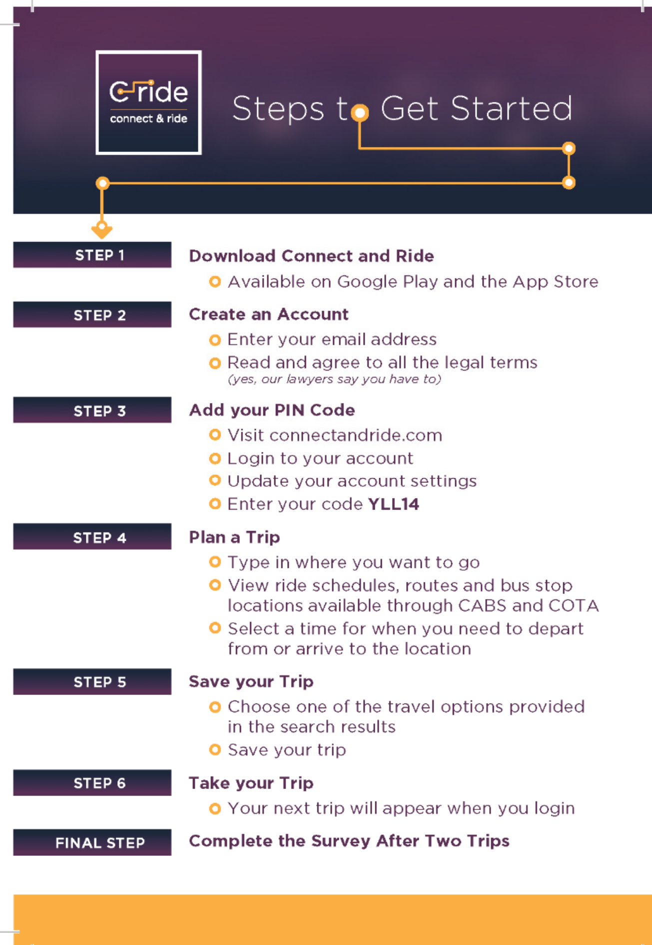


Figure D-2. Targeted Group Recruitment Postcard (Front/Back)

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-16-276

U.S. Department of Transportation