Phase 1 Enabling Technology Readiness Assessment

Heart of Iowa Regional Transit Agency ITS4US Deployment Project

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Final Report — January 14, 2022
FHWA-JPO-21-887

COMPLETE TRIP
ITS4US

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Santosh Mishra, Brooke Ramsey	N/A

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16. Abstract

The Heart of Iowa Regional Transit Agency (HIRTA) is one of the 5 awardees for Phase 1 of the Complete Trip – ITS4US contract for its proposed concept ***"Health Connector for the Most Vulnerable: An Inclusive Mobility Experience from Beginning to End"*** (Health Connector) by the United States Department of Transportation (USDOT). The Health Connector solution intends to demonstrate an innovative concept that will address various bottlenecks associated with healthcare access for HIRTA communities. The Enabling Technology Readiness Assessment (ETRA) builds on the information provided in Concept of Operations (ConOps) and System Requirements (SyRS) documents and identifies maturity level of technologies that will be used for the Health Connector solution. The document follows USDOT Technology Readiness Level Guidebook to assess the readiness of each enabling technology for operational use. The ETRA also identifies if Health Connector will deploy an off-the-shelf technology or a feature will be developed for this project. Finally, the document provides a risk assessment of enabling technologies.

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Table of Contents

List of Tables

List of Figures

1. Introduction

The Enabling Technology Readiness Assessment (ETRA) document identifies maturity level of technologies that will be used for the Health Connector solution. The document follows The Technology Readiness Level Guidebook developed by FHWA/USDOT to assess the readiness of each enabling technology (ET) for operational use. The ETRA also identifies if the Health Connector solution will deploy an off-the-shelf technology or a feature will be developed for this project.

1.1. Intended Audience

The intended audience for the ETRA document includes the following:

- Members of the HIRTA ITS4US Complete Trip Project Team that are focused on the concept development (HIRTA, IBI Group, CTAA); design and deployment (Uber) and evaluation (ISU) along with other partners, and HIRTA project stakeholders.
- The USDOT Team managing and supporting the project.
- Performance management team evaluating the system.
- The IE team conducting an independent assessment of the success and outcomes of the project.
- Other entities implementing similar systems in the future.

1.2. Project Background

The Heart of Iowa Regional Transit Agency (HIRTA) is one of the 5 awardees for Phase 1 of the Complete Trip – ITS4US contract for its proposed concept ***"Health Connector for the Most Vulnerable: An Inclusive Mobility Experience from Beginning to End"*** (Health Connector) by the United States Department of Transportation (USDOT).

The Health Connector solution intends to demonstrate an innovative concept that will address various bottlenecks associated with healthcare access for HIRTA communities. Some of these challenges are the key reason behind missed appointments or unacceptable level of preventive or as-needed healthcare in HIRTA service area. For this deployment, the HIRTA team plan to implement a scalable and replicable solution that enables inclusive access to non-emergency medical transportation for all underserved populations and their caregivers by resolving access barriers with the use of advanced technologies. This solution will allow Dallas County residents without access to transportation who may be seeking a medical appointment to explore their transportation alternatives and book both medical and transportation appointments at the same time. Further, this solution will include information and wayfinding services to guide them at every step of their trip.

The referenced underserved populations' mobility needs vary based on the individual. This deployment will provide enhanced access to healthcare options for "all travelers" in Dallas County with a specific focus on underserved communities, including persons with disabilities, low income, rural, older adults, veterans, and persons with limited English proficiency (LEP).

In addition to addressing mobility needs, the proposed deployment will recognize the net impact that access to health services have on patient health care outcomes as well as both the financial and health outcomes from the perspective of the health care community/Dallas County Health Department (DCHD).

Figure 1 provides an overview of the Health Connector concept.

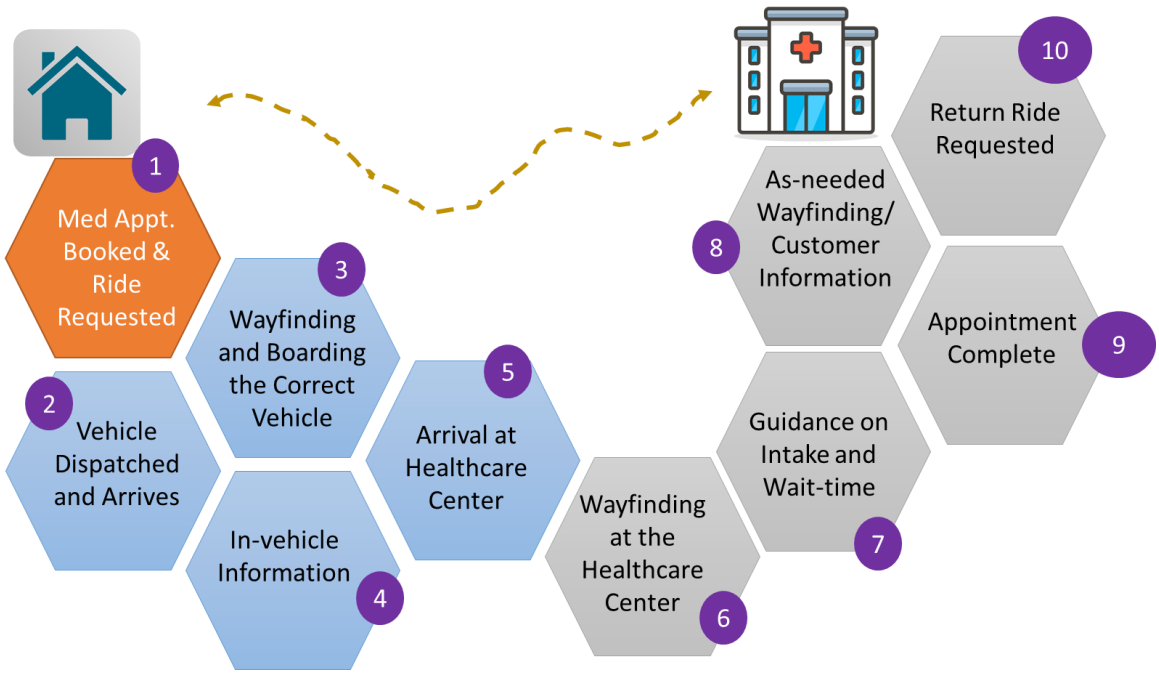

Figure 1. Overview of Health Connector System Concept (Source: HIRTA team)

The systems and interfaces involved in the context of Health Connector can be defined as follows:

- **Traveler-end Subsystem**: this subsystem includes the tools and technologies to be used by travelers or patients seeking transportation services for their medical appointments as part of pre-trip, en-route trip, on arrival and return trip activities.

- **Transportation Management Subsystem:** this subsystem includes the tools and technologies used to assist customer care and operations staff with reservations, scheduling, dispatching and administration activities.

- **Vehicle Subsystem**: this subsystem refers to the technologies deployed on vehicles to support Driver-end functions for manifest management, on-board customer information and customer payments.

- **Wayfinding Subsystem:** this subsystem refers to the technologies and infrastructure to be used for providing indoor positioning, orientation and step-by-step guidance on request to travelers.

- **Interfaces:**

    - **Access2Care:** this subsystem refers to the State of Iowa Medicaid Broker's system used for booking and managing Medicaid trips. HIRTA is one of the providers used by Access2Care.

    - **Health Navigator-end Subsystem:** this subsystem refers to the information and referral (I&R) system used by Dallas County Health Department (DCHD). This subsystem will be used to obtain medical and transportation appointment details or availability for a Dallas County resident health navigation/social care services.

    - **EHR/Medical Record Subsystem:** this subsystem refers to the systems used by partner hospitals and clinics for booking medical appointments and maintaining their appointments, including discharge and any subsequent referral activities.

Figure 2 provides a high-level context diagram of the system showing the above system components.

It should be noted that Medicaid trips will be booked by Access2Care when requested by Travelers and will be ingested in the HIRTA system when assigned to HIRTA as one of the Access2Care service providers. At that point, Travelers using Medicaid benefits will be able to use Traveler tools provided by Health Connector such as the wayfinding tool. So, on the day of the travel, Medicaid customers will benefit from the same tools as other Travelers.

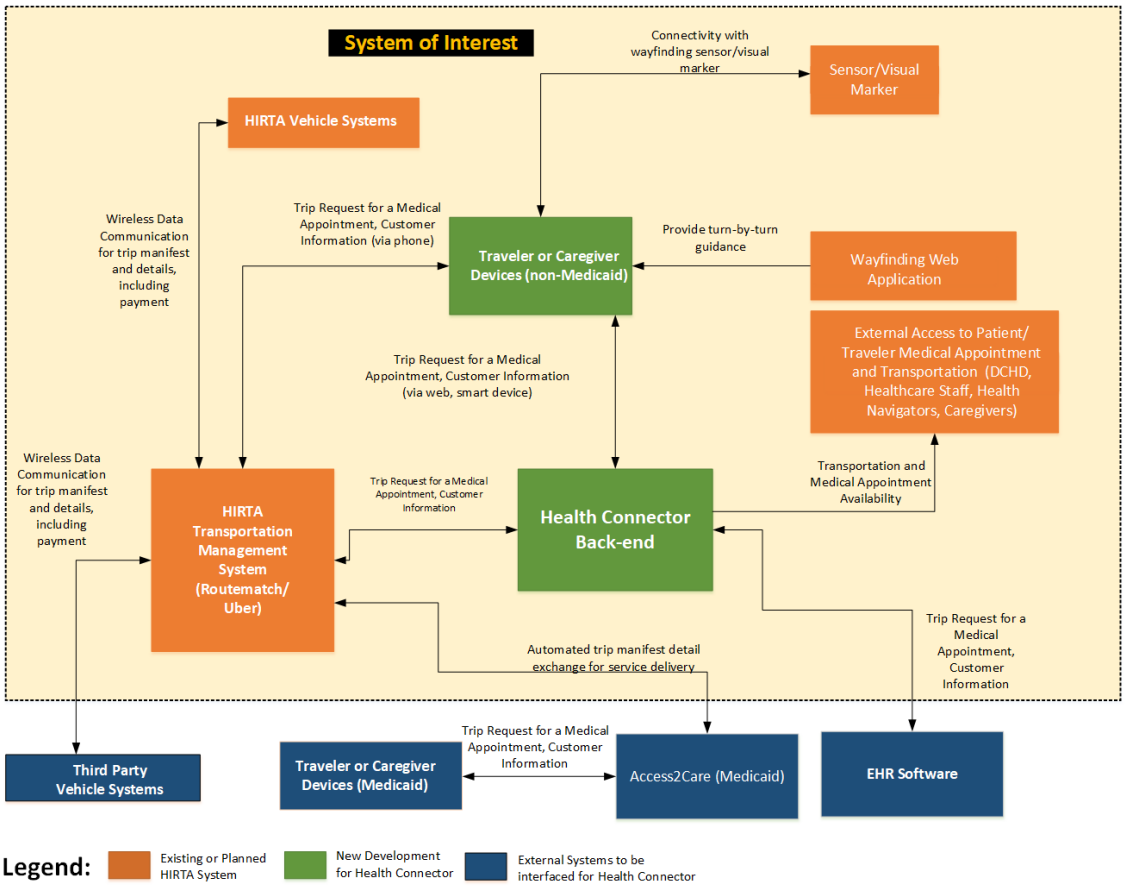

Figure 2. Generic System Context Diagram (Source: HIRTA team)

1.3. Scope

The ETRA document builds upon the needs and scenarios described in the concept of operations (ConOps) and system requirements specifications (SyRS) documents. The ETRA document further assesses readiness of each enabling technology to describe how a particular ET will help the HIRTA team in providing an integrated solution to meet the needs and requirements of the Health Connector solution.

1.4. Goals and Objectives

The purpose of the ETRA document is to guide the HIRTA project team and other entities aiming to deploy similar system in the future through a realistic assessment of underlying technologies as follows:

- Identify applicability of a technology in meeting the needs and requirements of the planned Health Connector solution.

- Assess maturity level of an identified technology.
- Determine risks and related impact associated with the identified technology with respect to its readiness for a deployment.
- Identify mitigation strategies, as needed, for high risk items.

1.5. References and Applicable Documents

The following documents were referenced when preparing this ETRA:

- Nate Towery et al., “Technology Readiness Level Guidebook,” Federal Highway Administration, US Department of Transportation, September 2017, Report No: FHWA-HRT-17-047
- US Government Accountability Office, “Technology Readiness Assessment Guide,” January 2020
- USDOT, “Complete Trip- ITS4US Deployment Broad Agency Announcement (693JJ3-20-BAA-0004)”
- HIRTA, “HIRTA - USDOT Complete Trip - final Proposal - v1.0 2020-07-31 (Volume 1),” July 2020.
- Santosh Mishra et al., “Phase 1 Concept of Operations (ConOps), Heart of Iowa Regional Transit Agency ITS4US Deployment Project,” August 2021, US Department of Transportation
- Santosh Mishra et al., “Phase 1 Systems Requirements (SysRS) Document,” Heart of Iowa Regional Transit Agency ITS4US Deployment Project,” October 2021 (expected), US Department of Transportation.
- Santosh Mishra et al., “Phase 1 Integrated Complete Trip Deployment Plan (ICTDP),” Heart of Iowa Regional Transit Agency ITS4US Deployment Project, January 2022 (expected), US department of Transportation.
- Santosh Mishra et al., “Phase 1 Human Use Approval (HUA) Summary (HUA), Heart of Iowa Regional Transit Agency ITS4US Deployment Project, December 2021 (expected), US Department of Transportation.

2. Identify Enabling Technologies

2.1. Technology Readiness Framework

The HIRTA team has selected the framework as described in the FHWA Technology Readiness Level (TRL) Guidebook for determining the readiness of enabling technologies for the Health Connector solution. The HIRTA team considered the following TRL frameworks as well:

- ISO Standard 16290 Space - Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment.
- US Government Accountability Office (GAO) Best Practices - Technology Readiness Assessment Guide.

Conceptually, these frameworks are similar and are designed to assess the maturity level of technology for specific project types (e.g., aerospace technologies, defense technologies). The HIRTA team has selected the framework presented in the FHWA TRL Guidebook since this framework has been specifically compiled by the USDOT for determining maturity of technologies for transportation research projects, particularly the Exploratory Advanced Research program. Questions defined in the FHWA Guidebook for assessing the maturity level were found to be the most relevant to the Health Connector operating environment.

An overview of the readiness level assessment framework as described in the FHWA TRL Guidebook is provided in the following subsections.

2.1.1. Basic Research:

This category refers to technologies that are in the initial stages of development and mostly limited to academia or proof of concept demonstrations for research and development purposes. The following 3 stages of TRLs are included in this category:

- **TRL 1- Basic Principles and Research:** This is the first level in the process of a technology development based on scientific principles through identification of relevant methodologies, and approaches.
- **TRL 2-Application Formulated:** TRL-2 refers to identification of applications for a particular technology along with relevant system components.
- **TRL 3-Proof of Concept:** TRL-3 refers to a stage when system feasibility along with performance measures are fully established and a technology can be used to demonstrate its utility for an application/ use case as a proof of concept.

2.1.2. Applied Research

This category refers to technologies that have gone past the stage of basic research and a demonstration can be performed in a controlled/laboratory environment.

- **TRL4-Components Validated in a Laboratory Environment**: TRL 4 refers to the stage of technology when requirements for an application can be verified at individual component level in a laboratory environment and integrations can be defined.

- **TRL5-Integrated Components Demonstrated in a Laboratory Environment**: TRL 5 refers to the stage of technology when it can be fully demonstrated in a controlled/laboratory environment for an application along with integrations among components.

2.1.3. Development

This category refers to the commercial development and testing stage of a technology and includes the following readiness levels:

- **TRL 6- Prototype Demonstrated in a Relevant Environment:** TRL 6 refers to a stage when technology prototype can be demonstrated outside laboratory environment using realistic test cases.

- **TRL 7- Prototype Demonstrated in an Operational Environment:** TRL 7 refers to a stage when a technology prototype can be demonstrated in a real-world operational environment involving user community.

- **TRL 8-Technology Proven in Operational Environment:** TRL 8 refers to a stage when a technology is fully tested in an operational environment for an application.

2.1.4. Implementation

This category refers to full readiness of a technology for commercial launch, adoption and operational use:

- **TRL 9-Technology Refined and Adopted:** TRL 9 refers to a stage when a technology is fully implemented commercially and adopted by the user community for an application.

2.2. Enabling Technologies Inventory

This section provides a description of technologies under the following subsystems, as described in Section 1.2:

- Traveler-end Subsystem
- Transportation Management Subsystem
- Vehicle Subsystem

- Wayfinding Subsystem

The summary in this section provides the current state of commercially available technologies that can help deploy the Health Connector system, which includes the above subsystems.

The enabling technologies are listed under above subsystem categories to contextualize technologies from end-user perspective (Traveler, Central or Driver) to be able to better answer TRL questions (see Appendix B) when assessing the maturity from end-user and operating environment perspective. Some enabling technologies (e.g., localization, mapping, vehicle mapping, booking/scheduling) are listed under multiple subsystems as the applicability of those technologies in the context of unique user groups for above subsystems is different which in turn impacts how those technologies are utilized by subsystems.

A key objective of the project is to ensure that technologies to be deployed for healthcare transportation as part of Health Connector can meet the needs of underserved travelers which include older adults, persons with disabilities, persons with LEP, persons with limited access to broadband access, persons living in rural areas, persons who are veterans, and persons with low income. In HIRTA team's assessment, Traveler-end and Wayfinding subsystems that primarily rely on smartphone and web-based applications have limited capabilities in addressing the needs of all Travelers. A summary of specific constraints with technologies are discussed in this section. Also, specific issues are discussed in Appendix B.

2.2.1. Traveler-end Subsystem

This section describes technologies that are utilized by Travelers using self-service applications, available via smart devices and web browsers. The level of capabilities available in the commercially available Traveler-end applications for planning and booking (e.g., ET#1 and ET#3) to meet underserved group needs vary by vendor. Most vendors provide support for non-English languages, allow information in accessible formats, and allow searching for trips that meet some of Travelers' mobility needs (e.g., wheelchair, personal companion, service animals). However, accommodations available in Traveler applications (ET #1, #3, #7) are limited in comparison to what agencies can provide using their central applications (e.g., ET# 10), particularly for mobility needs.

Commercially available Traveler-end applications described in this section have been in use for the limited functionalities they provide for underserved groups (e.g., limited support for languages, limited selection of mobility devices) and function well. However, given limitations, some Travelers prefer to contact customer service directly. HIRTA will also have call center as an alternate method available to Travelers in case their needs are not accommodated in the smartphone or web-based applications.

ET #1: Multimodal Trip Planner

Description: Refers to a web or mobile device application that allows a user to search for transportation alternatives involving multiple modes and per specific needs of underserved groups.

This technology is available in the form of proprietary applications available from multiple vendors (e.g., Uber, Lyft, Moovit, Hacon/Siemens). User searches may be logged for later analysis to improve trip planning capabilities and service performance.

There is also an Open Trip Planner (OTP) maintained by the open source community (https://www.opentripplanner.org/), however, capabilities in the OTP for planning of paratransit/demand response services are limited.

Currently, Routematch by Uber provides HIRTA's Amble App which does not provide trip planning feature.

Integration: The multimodal trip planner will allow HIRTA customers to search for HIRTA vehicles along with vehicles that may be available from other HIRTA partners.

Procurement: The trip planning application will be deployed as part of the Traveler Application (Web and Mobile-based) that will be procured off-the-shelf with the Uber Transit platform from Uber Technologies. Amble App will be replaced by Uber Transit App.

Traceability:

- **User Need(s):** All trip planning-related needs for Travelers are met by this technology.
- **System Requirement(s):** All trip planning related requirements are met by this technology.

ET#2: Localization:

Description: Refers to technologies that allow Travelers or the applications used by Travelers to determine their current location. This function is accomplished by using sensors built into devices (e.g., GPS) or geolocation web services (for browsers that don't have access to GPS location).

Integration: Localization technology will be used by the Traveler-end applications (trip planning, booking) to determine current location.

Procurement: There is no procurement needed for this technology. It is assumed that this technology will be available in Traveler devices via built-in GPS receiver on mobile devices (if location services enabled) or geolocation web services, if a browser does not have access to GPS location.

If GPS-based localization services are not enabled or are unavailable, Travelers will enter their pickup location address manually which will be geocoded by the built-in mapping service (ET #6). Certain pickup locations, however, may have many entrances or exit points. In those situations, Travelers can identify specific entrance and exit points when booking a trip to help Driver with pickups.

For indoor locations, where GPS may not be available to provide a desired level of accuracy, wayfinding localization function identified in ET#22 for the wayfinding subsystem will be used to determine the location of Travelers for indoor wayfinding related functions.

Traceability:

- **User Need(s):** All trip planning, booking and traveler information-related needs require this technology. Wayfinding is another function that requires localization and is discussed later in this section for ET#21.
- **System Requirement(s):** All trip planning, booking and traveler information-related requirements are enabled by this technology.

ET#3: Trip Booking:

Description: Refers to technologies that allow Travelers to book a trip for a trip itinerary searched by a trip planner. Trips can be booked in advance or in real-time using HIRTA vehicles or vehicles provided/operated by third parties. Off-the-shelf products for such function are available from vendors such as Trapeze, Ecolane, HBSS, CTS, Via, Spare, Rideco and many others. However, capabilities of products vary in how they can address trip requests for unique use cases (e.g., ADA paratransit, demand response, on-demand service).

Currently, no open source alternatives are available to accomplish trip booking functions. Also, no open data transactional standard is widely adopted for open or proprietary/third-party trip planners (discussed for ET #1) to accomplish booking using off-the-shelf booking platforms. Two applicable

standards, Transactional Data Standard and GTFS-on demand are still in the process of being developed and adopted by the vendor community.

Currently, Routematch by Uber provides HIRTA's Amble App. Through Amble App, trip requests from Travelers are sent to agency for booking and approval in the central Routematch software application. Booking is then completed by a HIRTA scheduler and confirmation is sent to the Traveler via Ample App.

Integration: Booking function will be integrated with the multimodal trip planner (ET#1).

Procurement: Trip Booking for Health Connector will improve the current experience with Amble App. Booking function will be part of the Traveler Application (Web and Mobile-based) that will be procured off-the-shelf with the Uber Transit product from Uber Technologies. Amble App will be replaced by the Uber Transit App.

Traceability:

- **User Need(s):** All trip booking -related needs for Travelers are met by this technology.
- **System Requirement(s):** All trip booking -related requirements are met by this technology.

ET#4: Mobile Payment

Description: Refers to technologies that allow Travelers to pay for a trip using their smart devices (e.g., smartphones or smart watches). Payments can be accomplished using payment media stored in customer profiles, using a third-party tokenization service that provides payment tokens for bankcards (e.g., Braintree/PayPal, WorldPay, Visa), or using wallet-based payment method available from third party providers (e.g., Apple, Google Samsung). Mobile payment can also be accomplished via a Traveler's smart device using debiting prepaid accounts linked to their profiles once the trips are completed.

At HIRTA, Travelers use RMPay mobile app (separate than Amble App) that is provided by Routematch by Uber which provides mobile payment functionality through debiting of prepaid balance stored in customer account once a trip is complete. No additional hardware is needed for validation of payment on vehicles as Drivers can see the payment status on their terminals.

Travelers can add funds using a bankcard in the RMPay app or using the Rider web application, or by presenting cash/check on-board to Drivers. Travelers can also contact HIRTA customer service via phone or in-person to add funds to their accounts.

Integration: Mobile payment technology will be integrated with the planning and booking applications.

Procurement: The technology will part of the Traveler Application (Web and Mobile-based) that will be procured off-the-shelf with the Uber Transit for seamless integration with Routematch software application. This application will provide an integrated payment solution along with planning and booking and will replace RMPay solution.

Traceability:

- **User Need(s):** All trip payment needs for Travelers are met by this technology.
- **System Requirement(s):** All trip payment -related requirements are met by this technology.

ET#5: Advance and Real-time Traveler Information

Description: Refers to technologies that allow Travelers to obtain information on the status of their trips in advance or in real time. Information can be provided on-demand or Travelers can opt in to receive notifications based on their preferences. This technology uses sensors inside user devices

(e.g., GPS) to provide context sensitive information in real-time. Advance or real-time Notifications can be provided in the form of email, text or alerts using mobile operating system (Android or iOS)-provided push notification features.

In addition, off-the-shelf technologies exist to provide text and email-based based alerts that are independent of operating systems-based push notification features. Further, for Travelers, who may prefer voice messages, interactive voice response (IVR) systems/web services are available off-the-shelf that can be integrated with central system applications to send automated outbound calls, or to receive/respond to automated incoming calls. Providers of such off-the-shelf products include 1) omnichannel platform providers such as Twilio, Amazon Connect, Genesis; and 2) transit specific product providers such as Unified Dispatch, Inc. (UDI), Enghouse Systems and Trapeze.

Unlike fixed-route, there is no standard data feed like GTFS-real time for communicating real-time status on demand response services so all off-the-shelf products require a custom interface using proprietary XML/Voice XML or JSON-based data formats with central systems generating such data (e.g., Routematch in the case of HIRTA).

HIRTA's Amble App currently provides on-demand real-time trip status information. Also, HIRTA provides day-before reminders using an IVR system but no real-time information is available through the IVR system.

Integration: Real-time traveler information technology will be integrated with trip planning and booking functions.

Procurement: The technology will part of the Traveler Application (Web and Mobile-based) that will be procured off-the-shelf with Uber Transit. This application will provide an integrated real-time information solution along with planning and booking to provide on-demand/push notification real-time information via multiple dissemination channels. Amble App will be replaced by Uber Transit App.

Traceability:

- **User Need(s):** All user needs related to advance or real-time traveler information (on demand or notifications) are met by this technology.
- **System Requirement(s):** All requirements related to advance or real-time traveler (on demand or notifications) are met by this technology.

ET#6: Web-based Mapping

Description: Refers to technologies that allow applications to provide map-based functions (e.g., location display, geocoding, routing, visualization). Typically, these maps are provided by mobile OS providers (e.g., Google Maps, Apple Maps) and details available in those maps and user experience varies by the mapping service provider. There are also third-party mapping service providers (e.g., Mapbox, Open Street Maps, Here, Tom Tom, Waze and others). However, some application developers utilize their own web-based mapping services or use an integrated mapping/visualization experience by sourcing/licensing mapping data from various providers (e.g., Uber, Lyft, Curb Mobility, Doordash, Amazon).

Integration: Mapping technology will be integrated with all Traveler-end applications.

Procurement: The cloud-based mapping service will be built into the off-the-shelf Uber Transit product procured from Uber Technologies. Uber Transit utilizes map data from multiple providers and will be responsible for keeping map data current.

Traceability:

- **User Need(s):** All user needs related to planning, booking and traveler information are met by this technology.

- **System Requirement(s):** All requirements related to planning, booking and traveler information are met by this technology.

ET#7: Multilingual Support

Description: Refers to technologies that allow users to choose to pick the language of their choice when launching an application. Such capabilities are typically driven by the setting of the device running the application. Also, some applications allow changing languages on-the-fly at the time of application use.

Currently, HIRTA Travelers with limited English proficiency (LEP) do not have access to applications in the language of their choice. They contact HIRTA customer service and are assisted using a telephone-based multi-party translation service line.

Integration: No integration needed.

Procurement: No procurement needed as the applications to be deployed will support 30+ languages based on Travelers' device settings. Languages to be supported include those that are the top languages of residents with LEP in the HIRTA's service area (e.g., Spanish, French, German, Russian, Korean, Chinese, Vietnamese).

Traceability:

- **User Need(s):** All user needs related to supporting the needs of LEP are supported by this technology.
- **System Requirement(s):** All requirements related to supporting the needs of LEP are supported by this technology.

2.2.2. Transportation Management Subsystem

ET#8 Customer Identity/Account Management

Description: Refers to technologies that allow an application to electronically obtain and store customer identity data (e.g., name, address, favorite pick-up and drop-off locations, contact information) and other relevant personal information (e.g., mobility needs, eligibility for a funding source for transportation) for providing desired transportation services.

In the context of demand response services such as Health Connector, it refers to applications that provide the ability to complete the Traveler registration function and customer profile management. Also, it allows to link eligibility of customers profiles to specific funding programs. These functions are available through self-service web or mobile-based tools, or Travelers can complete such functions contacting a customer service representative (CSR).

Integration: Customer profile will be integrated with Traveler-end applications.

Procurement: No additional procurement is needed since the features exist in the current Routematch by Uber application. A limited registration capability will also be made available through the Uber Transit product that will be procured off-the-shelf, as stated earlier, to allow Travelers to self-register or to have Health Navigators or healthcare providers to register those Travelers, if needed.

Traceability:

- **User Need(s):** All user needs related to customer eligibility and registration are met by this technology.
- **System Requirement(s):** All requirements related to customer eligibility and registration are met by this technology.

ET#9 Mapping and Geocoding

Description: Refers to built-in mapping function within central application for the following geographic information system (GIS) functions:

- Allow an application to geocode customer addresses and point of interest (POI) locations that may be used for requesting pick-up and drop-off events.
- Serve as the basemap for scheduling and routing engine within the central application.
- Serve as the basemap by the vehicle tracking application for location visualization.

Map data may be static (e.g., sourced from Tele Atlas/ TomTom or Here maps) and used with an off-the-shelf mapping/visualization product (e.g., ArcGIS from Esri), or a web-based mapping services (e.g., Google Maps) may be used. For static maps, periodic updates are required to ensure accurate map data is being used for performing GIS functions. Also, it is critical that mapping data for Traveler-end system and Transportation Management Subsystem is consistent.

This technology is built into most commercially available demand response scheduling products and is available within the existing Routematch by Uber application as well. Routematch by Uber uses static maps.

Integration: No integration with other applications.

Procurement: This technology is used by the current Routematch by Uber application and no additional procurement is identified. Uber Transit, however, has its own backend, and utilizes web-based mapping service.

Traceability:

- **User Need(s):** No separate user need is identified.
- **System Requirement(s):** No separate requirement is identified but part of registration, scheduling and vehicle tracking requirements.

ET#10 Scheduling, Rescheduling and Optimization

Description: Refers to technologies that allow scheduling and rescheduling trips in advance, or in real-time based on Traveler request. Also, this technology includes a built-in optimization engine to generate optimized runs and trip manifests for drivers. These parameters are based on several parameters (e.g., on-board time, dwell time, street segment travel time). Several products also support real-time optimization that allows a system to perform continuous optimization using relevant system parameters to ensure the most productive utilization of system resources.

This technology is built into most commercially available demand response scheduling products and is available within the existing Routematch by Uber application as well.

Integration: No integration with other applications.

Procurement: Additional advancements to efficiently support real-time booking and real-time schedule optimization for Health Connector, off-the-shelf product, Uber Transit from Uber Technologies, will be procured.

Traceability:

- **User Need(s):** Relates to the needs for scheduling and optimization.
- **System Requirement(s):** Relates to the requirements for scheduling and optimization.

ET#11 Third-Party Brokerage

Description: Refers to technologies that allow an application to identify a service provider best suited to provide a trip based on system configurations and Traveler needs by brokering trips to third-party providers.

Integration: Integration with third party transportation management systems using open Application Programming Interface (APIs) offered by systems used by the third-party service providers for a bi-directional interface (e.g., Lyft, taxi company). HIRTA currently does not have a third-party provider and this detail will be determined when a provider is identified and any requirements for API-level integration as necessary will be documented in the SyRS document.

Another alternative will be to configure third-party service providers as vehicle/service provider pools within HIRTA system and trips will be dispatched to those service providers if additional capacity is needed. HIRTA is currently planning to implement this approach since the expected pool of third-party providers are small operators (e.g., volunteer drivers, small taxi operators) in rural areas that may not be using their own transportation management systems.

Procurement: This technology is utilized in Routematch by Uber application. Additional advancements for utilizing multiple providers in real-time will be added through off-the-shelf procurement of Uber Transit product from Uber Technologies.

Traceability:

- **User Need(s):** Relates to the needs for third-party service providers.
- **System Requirement(s):** Relates to the requirements for third-party service providers.

ET#12 Vehicle Tracking

Description: Also known as automatic vehicle location (AVL), refers to technologies that allow an application to track location of a vehicle and visualize that on a basemap.

Integration: Use of APIs provided by third-party service providers, when available, for obtaining vehicle locations when third-party service providers are utilized and operate their own systems for transportation management.

Procurement: This technology is utilized in Routematch by Uber application. Since management of trips in real-time will be handled in Uber Transit for Health Connector, as stated earlier (ET#6), Uber Transit central application will be used for vehicle tracking.

Traceability:

- **User Need(s):** Relates to the needs for vehicle tracking.
- **System Requirement(s):** Relates to the requirements for vehicle tracking.

ET#13 Computer-aided Dispatching (CAD)

Description: Refers to technologies that allow an application to electronically communicate with a vehicle to send and receive operational messages; and communicate on the status of trip performance. It includes details such as actual pick up time, actual drop off time, no show events, missed trips. Also, CAD allows Dispatchers to communicate with Drivers in real-time.

This technology is built into most commercially available demand response scheduling products and is available within the existing Routematch by Uber application as well.

Integration: Integration with third party systems using open APIs for obtaining status of trips, when third-party service providers are utilized and operate their own systems for transportation management.

Procurement: This technology is utilized in Routematch by Uber application. Additional advancements for obtaining trip performance data in real-time will be added through off-the-shelf procurement of Uber Transit product from Uber Technologies. Also, Uber Transit will provide the capability to efficiently manage trip assignments/reassignments in real-time.

Traceability:

- **User Need(s):** Relates to the needs for dispatching.
- **System Requirement(s):** Relates to the requirements for dispatching.

ET#14 Estimated Time of Arrival (ETA) Prediction

Description: Refers to technologies that allow an application to use computer algorithms to generate predictions for upcoming vehicle arrivals. Vendors use a variety of techniques to improve predictions such as calibration of prediction models using historical performance data, and by applying machine learning techniques. When updated, ETA , is communicated to Drivers and Travelers.

This technology is built into most commercially available demand response scheduling products and is available within the existing Routematch by Uber application as well.

Integration: No integration.

Procurement: While no separate procurement is needed, Uber Transit product that will be procured, as mentioned earlier, will be utilized for Health Connector trips for improved ETA accuracy for real-time operations. ETA logic in the planned application accounts for real-time traffic conditions and any other data relevant for estimating accurate ETAs.

Traceability:

- **User Need(s):** Relates to the needs for arrival predictions.
- **System Requirement(s):** Relates to the requirements related to arrival predictions.

ET# 15 Electronic Health Record (EHR) Interface

Description: Refers to technologies that allow interface between transportation management systems and an EHR system for the purpose of automatically obtaining medical appointment time and location data so transportation can be booked accordingly. Such interfaces can be accomplished using APIs compliant with Fast Healthcare Interoperability Resources (FHIR) standard developed by Health Level Several International (HL7). FHIR defines data formats and open representation state transfer (REST) APIs for exchanging medical appointment data or health record data (not required for Health Connector). Alternatively, EHR providers offer proprietary APIs for data exchange.

Integration: Traveler-end and central systems will be integrated with EHR system.

Procurement: This will be a new development for HIRTA. Development approach is still under discussion with EHR provider and will not be finalized until Phase 2 design.

Traceability:

- **User Need(s):** Relates to the needs related to EHR interface for obtaining medical appointment related data (e.g., time and location of appointment along with customer identifier).
- **System Requirement(s):** Relates to the requirements for EHR interface.

ET#16 Medicaid Brokerage Interface

Description: Refers to technologies that allow an interface with a Medicaid brokerage software. In the case of Health Connector, this interface will be needed with Access2Care that offers bi-directional APIs.

Integration: Traveler-end and central systems will be integrated with the brokerage system. Development approach is still under discussion with Access2Care and will not be finalized until Phase 2 design.

Procurement: This will be a new development for HIRTA.

Traceability:

- **User Need(s):** Relates to the needs for Medicaid brokerage Interface.
- **System Requirement(s):** Relates to the requirements for Medicaid brokerage Interface.

2.2.3. Vehicle-end Subsystem

This section summarizes information related to technologies to be deployed on-board vehicles. HIRTA is currently utilizing these technologies (except ET#20). However, as discussed in the subsections below, planned application for Health Connector will allow HIRTA to efficiently provide real-time responsive service and manage vehicles provided by third parties.

ET#17 Vehicle Tracking

Description: Refers to in-vehicle technologies that allow tracking of location of a vehicle. Typically, it is facilitated by built-in GPS receivers in the in-vehicle hardware. When GPS is not available, this capability is provided using dead reckoning technology which uses vehicle odometer and gyroscope. For Health Connector, GPS-based approach will be used since a use case for dead reckoning has not been identified by the HIRTA project team.

This technology is currently provided using tablet hardware and in-vehicle software from Routematch by Uber.

Integration: No integration is needed.

Procurement: The Driver component of Uber Transit product from Uber Technologies will be procured and utilized to support just-in-time dispatching of trips booked in real-time.

Traceability:

- **User Need(s):** Relates to the needs for vehicle tracking.
- **System Requirement(s):** Relates to the requirements for vehicle tracking.

ET#18 Turn-by-Turn Navigation

Description: Refers to in-vehicle technologies that allow Drivers to navigate to a location using map-based or text-based step-by-step guidance. Such technology is available off-the-shelf from Apple Maps, Google Maps, Waze, Here Maps and many other providers.

At HIRTA, this technology is currently provided using tablet hardware and in-vehicle Driver application that utilizes offline maps from Sygic Maps.

Integration: No integration is needed.

Procurement: As stated in ET#16, Driver app for Uber Transit product will be utilized for Health Connector which provides its own web-based turn-by-turn navigation function.

Traceability:

- **User Need(s):** Relates to the needs for turn-by-turn navigation.
- **System Requirement(s):** Relates to the requirements for turn-by-turn navigation.

ET#19 Electronic Manifest Management

Description: Refers to in-vehicle technologies that allow Drivers to view upcoming trips, view details of a trip, and communicate on the status of a trip (e.g., pick-up, drop off, no-show) to the central application. Such technology is common available from all demand response service solution providers.

This technology is currently provided within the Driver application using tablet hardware by Routematch by Uber.

Integration: No integration is needed.

Procurement: HIRTA will add off-the-shelf procurement of Uber Transit product from Uber Technologies that will provide capabilities to manage trip booking and management in real-time and support just-in-time dispatching.

Traceability:

- **User Need(s):** Relates to the needs for electronic manifests.
- **System Requirement(s):** Relates to the requirements for electronic manifests.

ET#20 Multilingual On-board Infotainment

Description: Refers to in-vehicle technologies that allow providing multilingual information on-board when Travelers are en-route. HIRTA currently does not use any technology to provide such information to Travelers on-board its vehicles.

HIRTA is planning to provide static public service information of relevance to Traveler trips (e.g., details related to COVID-19 protocol or other safety measures at the facility on arrival, information on ongoing construction at a facility impacting entrance or exit, general information on impact on HIRTA service due to expected weather event, and service promotions). The information will be available in accessible format and in 30+ languages.

Travelers will have access to real-time information on their trips through Traveler Application and no on-board infotainment equipment is planned to provide that information. Also, given vehicles may be shared by multiple Travelers, there may also be privacy concerns with providing trip-specific information on-board using a shared electronic device (e.g., electronic display).

Other use cases of on-board traveler information include announcement of upcoming destinations using audio-visual methods (e.g., using PA speaker and an electronic display), however, that is not planned as part of this project given additional subsystems and interfaces will be necessary to accomplish that functionality. Also, while such type of information is required on fixed-route vehicles, it is not common to provide that for demand response services.

Integration: No integration is needed.

Procurement: This technology will be procured off-the-shelf from NaviLens.

Traceability:

- **User Need(s):** Relates to the needs for on-board Traveler information.
- **System Requirement(s):** Relates to the requirements for on-board Traveler information.

ET#21 Vehicle to Central Communications

Description: Refers to in-vehicle technologies that allow communication between vehicle and central locations. The communication will be cellular for data and two-way radio using land mobile radio (LMR) technology for voice communications. Cellular communication will be enabled using built-in modem in the in-vehicle Driver terminal.

Integration: No integration.

Procurement: No procurement needed since the existing tablet hardware on vehicles can be used. This hardware will also be capable of running planned Uber Transit Driver application.

Traceability:

- **User Need(s):** Relates to the needs for vehicle to central communications.
- **System Requirement(s):** Relates to the requirements for vehicle to central communications.

2.2.4. Wayfinding Subsystem

The wayfinding subsystem planned for Health Connector relies on access to smartphone and this is documented as a limitation since some Travelers may not have access to smartphones or may not be comfortable with the functions available via smartphone devices. While infrastructure can be deployed to provide non-smartphone-based wayfinding tools using Bluetooth beacon or similar methods, it is cost prohibitive for the needs of this project. HIRTA Team plans to make smartphone-based tools available to Travelers and will plan to provide training in case they are not familiar with using smartphone-based wayfinding functions as planned for the Health Connector system, Further, as documented in the SyRS, HIRTA team is planning to install kiosks at strategic locations within the hospital building to provide wayfinding guidance on-demand to travelers who are not comfortable with smartphone-based functions. However, the extent of wayfinding information that can be provided via such kiosks will be limited (e.g., floor layout with office locations, pickup location in reference to an exit point).

ET#22 Wayfinding Localization

Description: Refers to technologies that assist Travelers to determine their current location and orientation with the help of Traveler application, and sensors or visual markers. This will be needed when Travelers are indoors since GPS cannot be utilized to provide the current location of Travelers. Travelers will utilize their smart devices and the wayfinding localization infrastructure using visual markers or sensors installed at strategic locations indoors to get assistance with the following:

- Identification of current location of Traveler when indoors for requesting context sensitive help, either using smart devices, or through a customer service representative via a voice call or text message.
- Identification of pickup location when booking a return trip when indoors. The wayfinding localization infrastructure will help Travelers determine the pickup location along with the exit point.
- Obtaining step-by-step guidance (ET#24) when indoors.

Integration: No integration is currently planned in the ConOps or requirements between Uber Transit Traveler Application and Wayfinding Application. However, an integrated experience is being explored between Uber and Navi Lens to automatically launch Navi Lens based on drop off or pickup location per user preference, but such development will not be specific to only Health Connector use cases. .

Procurement: This technology will be procured off-the-shelf from NaviLens.

Traceability:

- **User Need(s):** Relates to the needs for outdoor and indoor wayfinding.
- **System Requirement(s):** Relates to the requirements for outdoor and indoor wayfinding.

ET#23 Information

Description: Refers to technologies that assist Travelers to obtain relevant information with the help of Traveler application, and sensors or visual markers when located indoors.

Integration: No integration.

Procurement: This technology will be procured off-the-shelf from NaviLens.

Traceability:

- **User Need(s):** Relates to the needs for outdoor and indoor wayfinding.
- **System Requirement(s):** Relates to the requirements for outdoor and indoor wayfinding.

ET#24 Step-by-step Guidance

Description: Refers to technologies that assist Travelers to obtain step-by-step guidance with the help of Traveler application, and sensors or visual markers. Guidance can be available in form of text-based information, audio guidance, map-based information or using augmented reality-based tools.

Integration: No integration.

Procurement: This technology will be procured off-the-shelf from NaviLens.

Traceability:

- **User Need(s):** Relates to the needs for outdoor and indoor wayfinding.
- **System Requirement(s):** Relates to the requirements for outdoor and indoor wayfinding.

3. Technology Readiness Level (TRL)

This section provides an assessment of maturity level for each of the ETs described in Section 2. A readiness level is determined using the framework described in the FHWA TRL Guidebook.

3.1. TRL Assessment Process

The TRL Assessment process was conducted through the following considerations:

- Utilizing a panel consisting of the subject matter experts (SMEs) that are part of the project team. Assessment was conducted based on the experience of the SME panel in deploying enabling technologies for 50+ agencies of all size over the past 20+ years. The SMEs have experience with all Traveler-end, vehicle-end and central technologies listed in Section 2.2. While SMEs have general experience with wayfinding solutions at conceptual level, they lack in-field/deployment experience with the proposed technology. HIRTA team partner NaviLens has advised the team on use cases for the proposed wayfinding solution.

- Indoor localization and wayfinding functionality (e.g., for information purpose or step-by-step guidance) was not found to be mature enough for widespread commercial deployments. In particular, limited deployment of such applications is available in the United States, particularly in the transit environment. Proposed technology has been deployed so for only in the New York City Transit subway station environment in the United States.

- Overall, it was determined that the enabling technologies to be used for planned system have been deployed for operational use before. However, those technologies have not been deployed in the operating environment as that relates to this project where coordination among a service provider (HIRTA), social work organization (DCHD) and healthcare providers is needed for delivery of transportation services for underserved groups.

- Assessment was based on performance of enabling technologies across a large pool of vendors and not just the HIRTA partners. Questions per FHWA TRL Guidebook assessment guidelines were answered for each of the enabling technology (see Appendix B).

3.2. TRL Ratings for Inventoried Enabling Technologies

Table 1 provides the TRL assessment and justification for the identified TRL rating for an ET. These rating were developed based on the framework defined in the FHWA TRL Guidebook. The final rating for an ET indicates the highest TRL for which all questions per TRL Guidebook were answered as “Yes.” Please see for a detailed analysis on ratings. The Tables in Appendix B also

provide further reasoning where response to assessment questions for an ET was determined to be a “No.”

Table 1. TRL Assessment for Enabling Technologies

Enabling Technology	TRL	Justification
ET#1 Multimodal Trip Planner	7	This technology has been widely deployed by a variety of vendors using both proprietary and open data/source solutions. While open ecosystem is still under development, the technology selected has been in operation for 10+ years. Lower TRL is being used as an off-the-shelf application will be deployed for the Health Connector operating environment.
ET#2 Localization (Traveler-end)	9	This technology has been implemented by a variety of transportation and non-transportation applications for 10+ years and no issues were determined with respect to its use in Health Connector operating environment or with user groups.
ET#3 Trip Booking	7	This technology has been widely deployed by a variety of vendors for 10+ years. Lower TRL is being used as an application will be deployed for the Health Connector operating environment.
ET#4 Mobile Payment	7	This technology has been widely deployed by a variety of vendors for 5+ years using a off-the-shelf payment services (tokenized or non-tokenized). Lower TRL is being used as an off-the-shelf application will be deployed.
ET#5 Real-time Traveler Information	7	This technology has been deployed in web-based and mobile phone-based format for 10+ years but capabilities for the services as proposed for real-time responsiveness have not been validated for the Health Connector operating environment.
ET#6 Mapping (Traveler-end)	9	This technology has been deployed in web-based and mobile phone-based format for 10+ years and no issues were determined with respect to the Health Connector use cases.
ET#7-Multilingual Support	5	While multilingual support has been made available by operating system providers (Apple, Google, Microsoft) or third-party services, the project team has not validated such capabilities yet for the needs of the HIRTA communities.

Enabling Technology	TRL	Justification
ET#8 Customer Identity/Account Management	7	This technology has been deployed for 20+ years but has required registration through customer service staff. Capabilities as planned to enable self-service capabilities in limited capacity has not been validated.
ET#9 Mapping and Geocoding	7	This technology has been deployed for 20+ years but reliance has been on static maps.
ET#10 Scheduling, Rescheduling and Optimization	6	This technology has been deployed for 20+ years. Real-time optimization has been implemented by app hailing services for 10+ years, however, deployment of those capabilities in conjunction with a demand response service such as HIRTA's and for user communities planned for Health Connector has been limited.
ET#11 Third-party Brokerage	5	This technology has been implemented by paratransit/demand response vendors for engaging taxi industry and for small providers to provide mobility management functions. The TRL is rated lower, however, since the implementation for real-time responsiveness has been limited which is a key requirement for the Health Connector solution.
ET#12 Vehicle Tracking	7	This technology has been deployed in the transit industry for 20+ years but focus on real-time responsiveness as planned for Health Connector has been very limited.
ET#13 Computer-aided Dispatch	6	This technology has been deployed in the transit industry for 20+ years but focus on real-time responsiveness as planned for Health Connector has been very limited.
ET#14 Estimated Arrival Prediction	7	This technology has been deployed in the transit industry for 20+ years. The TRL is rated lower though since accuracy of prediction has not been reliable.
ET#15 EHR Interface	4	There have been limited implementations of transportation management systems and EHR systems and largely the interface is done using proprietary APIs. This interface will require a new development for HIRTA so a lower TRL rating is used.
ET#16 Medicaid Brokerage Interface	4	Interfaces between transportation management systems and Medicaid brokerage systems have been deployed for 10+ years using interface control document (ICD)-based approach but interface through a modern API-based (e.g., REST) approach is limited. This will be a new development for HIRTA so a lower TRL rating is used.

Enabling Technology	TRL	Justification
ET# 17 Vehicle Tracking	7	This technology has been deployed for 20+ years, however, an off-the-shelf application will be deployed which has not been tested in the Health Connector operating environment.
ET#18 Turn-by-turn Navigation	9	This technology has been deployed for 20+ years. Initial deployments were using maps stored natively on devices. Modern applications use web-based mapping and provide advanced information (e.g., real-time traffic, incidents).
ET#19 Electronic Manifests	6	This technology has been deployed for 20+ years. However, a lower rating is being used since new functionalities to enable just-in-time dispatching will be deployed which will be new for the HIRTA operations and the communities.
ET#20 Multilingual on-board Infotainment	4	This technology has been deployed using electronic message signs, but limited text-based information has been provided. Planned approach has been tested in only limited environments so a lower TRL rating is used.
ET#21 Vehicle to Central Communication	9	This technology has been deployed for 30+ years.
ET#22 Wayfinding Localization	4	Deployment footprint for indoor environments is limited so a lower TRL rating is used. Also, door-to-door wayfinding solution for transit are very limited.
ET#23 Information (Wayfinding)	4	Deployment footprint for indoor environments is limited so a lower TRL rating is used. Also, door-to-door wayfinding solution for transit are very limited.
ET#24 Step-by-Step Guidance (Wayfinding)	4	Deployment footprint for indoor environments is limited so a lower TRL rating is used. Also, door-to-door wayfinding solution for transit are very limited.

4. Risk Assessment

This section lists all known and anticipated risks that may affect the deployment. The risks are listed in Table 2. Further, Section 4.2 provides a mitigation plan for identified risks. These risks will also be included in the Risk Register.

As discussed in Appendix B, planned technologies have not been deployed as an integrated system in the past, even though some of the planned components (e.g., Uber Transit) will be available from the same vendor that provides the current Routematch by Uber system.

Also, HIRTA team anticipates that this assessment will have to be updated as additional details on these enabling technologies emerge through the design stage in Phase 2. Risk Register will be updated as the risk status of an item is modified from the current assessment.

4.1. Assessing Risk

Table 2. provides a list of risks associated with each ET and provides its impact level as follows:

- **High**: The technology is critical, and the identified risk has the potential to have an adverse impact on the system operation and user experience. A recurring issue may also impact project deployment leading to unintended outcomes if the risk is not timely mitigated.
- **Medium**: The risk has the potential to adversely impact the system operation and user experience but it not considered critical as alternatives to a technology could be considered.
- **Low**: The risk is expected to cause only minor impact on system operation and could easily be resolved after noticing temporary issues.

Table 2. Risk Assessment for Each Enabling Technology

Risk ID	Enabling Technology	Risk Description	Impact Level
R-TRV-1	ET#1	Information for third party providers may not be up-to-date resulting in incorrect results during trip planning search.	Low
R-TRV-2	ET#1, ET #3	New Traveler application will have to be tested to accommodate the needs of all underserved groups.	High
R-TRV-3	ET#2	Malfunctioning in localization technology could result in system's inability to provide context-sensitive information. However, Traveler may either use alternate location service, use a different device or enter location manually.	Medium

Risk ID	Enabling Technology	Risk Description	Impact Level
R-TRV-4	ET#3	A malfunctioning API/interface may limit the ability to book transportation with third party providers. In particular, the booking application may not meet the needs of all Travelers for real-time response.	Low
R-TRV-5	ET#3	Real-time booking using Traveler app is a new function for HIRTA and its reliability using HIRTA driver/vehicle resources will have to be tested.	Medium
R-TRV-6	ET#3	Transition from existing Amble App to proposed Traveler application may present learning curve for some users.	Medium
R-TRV-7	ET#4	Payment service used by the application could be unavailable. This may result in Drivers resorting to cash or other non-electronic payment methods.	Low
R-TRV-8	ET#4	Replenishment functionality may not be functional for prepaid debit accounts at times. This will require Travelers to use alternate methods but does not impact operations in any way.	Low
R-TRV-9	ET#4	Discount Coupon/Credit functionality exists in the planned application but has not been tested in the Health Connector operating environment.	Medium
R-TRV-10	ET#4	Transition from existing RMPay App to proposed Traveler application may present learning curve for some users.	Medium
R-TRV-11	ET#5	Inaccurate traveler information based on unreliable ETA can impact traveler experience. However, Traveler could still see vehicle location and get a general sense of wait time for pick-up.	Medium
R-TRV-12	ET#5	Inaccurate and unintended real-time notifications can adversely impact Traveler experience.	Low
R-TRV-13	ET#5	It will be critical to ensure all push/pull information channels dissemination channels (e.g., email, text, IVR, web access) are always operational so needs of all Travelers are met.	High
R-TRV-14	ET#6	Visualizing location may be impacted if mapping service is not accessible or is slow to load on a device.	Low
R-TRV-15	ET#7	Language translation may not be accurate. Application will have to be extensively tested with persons with LEP. In some cases, additional steps may need to be taken beyond just relying on translation capability within the device (e.g., engaging with community representatives to ensure accuracy of translation, particularly, public service announcements).	High
R-TRV-16	ET#8	Customer data is not regularly updated leading to incorrect information in their profile. This is, however, not a technology limitation.	low

Risk ID	Enabling Technology	Risk Description	Impact Level
R-TMS-1	ET#9	Maps may not be up to date leading to incorrect address geocoding which may cause delays and safety issues. This is, however, not a technology limitation.	Medium
R-TMS-2	ET#9	Since Routematch by Uber and Uber Transit central applications will be used in parallel for specific use cases, discrepancy in mapping between those two products may cause unexpected issues with data when exchanged between both systems. Testing will have to be conducted to proactively resolve such issues.	Low
R-TMS-3	ET#10	Constraints applied to schedule optimization algorithm due to underlying parameters could adversely impact system performance.	Medium
R-TMS-4	ET#11	A malfunctioning API/interface to push trips to third-party providers may limit the system capacity. Details of API must be determined, and proof of concept should be demonstrated before proceeding with API-based solution. An alternative to register smaller operators within the HIRTA platform should be considered for seamless operation.	Medium
R-TMS-5	ET#11	Data for provider resources (e.g., drivers, vehicles) may not be current.	Low
R-TMS-6	ET#11	Provider's policy may limit what data might get collected for their vehicles/drivers. Currently, there is no standard data format for transactional data exchange.	Medium
R-TMS-7	ET#12, ET#17	Accuracy of the GPS-based location could be limited due to hardware issues at times, particularly since no external GPS antenna will be used.	Medium
R-TMS-8	ET#12	Location of third-party vehicles may be unavailable or not available at desired time interval, depending on their preferred configurations (e.g., location refresh threshold).	Medium
R-TMS-9	ET#13	Due to lack of a transactional data standard, limited information on third party services may be available, as allowed per their policy and API.	Low
R-TMS-10	ET#14	When using APIs for obtaining real-time data from third party service providers, there may be inaccuracies in calculated ETA based on the extent of data available.	Medium
R-TMS-11	ET#14	ETA will have to be calibrated based on HIRTA service area and system parameters (e.g., typical travel times on street segments, typical boarding time). Extensive testing of ETAs per target measures will be needed.	Medium
R-TMS-12	ET#15	A proprietary interface will be developed to accomplish the desired functionalities. This interface has not been developed so extensive testing will be needed.	High

Risk ID	Enabling Technology	Risk Description	Impact Level
R-TMS-13	ET#16	A proprietary interface will be developed to accomplish the desired functionalities. This interface has not been developed so extensive testing will be needed.	High
R-VEH-1	ET#18	Incorrect geocoding of address in the system may result in unintended routing guidance if the destination is automatically selected from pick-up or drop-off addresses.	Medium
R-VEH-2	ET#21	Cellular data outage (at system level or carrier level) may impact real-time responsiveness of the system, particularly in the situation of high trip volume.	High
R-WFS-1	ET#22, 23, 24	Technology infrastructure (e.g., sensors or visual markers) installed inside facilities is not sufficient to support indoor navigation functions.	High
R-WFS-2	ET#22, 23, 24	Wayfinding system does not have up to date information on the technology infrastructure.	High
R-WFS-3	ET#22, 23, 2422	Technology used for indoor navigation is not designed to operate in a healthcare facility environment.	High
R-WFS-4	ET#22, 23, 24	Indoor maps used for the indoor navigation are not accurate/reliable.	High

4.2. Mitigating Risk

Table 3 provides a mitigation plan for high risk items identified in Table 2 along with anticipated probability of the likelihood of occurrence of those items. The risk probability can be categorized as follows:

- High: occurs once a month.
- Medium: occurs once every 3 months.
- Low: occurs once a year.

Table 3. High-Impact Risk Mitigation Plans

Risk ID	Risk Probability	Mitigation Plan
R-TRV-2	Medium	SyRS document identifies specific requirements by underserved groups, where applicable. Also, specific attention is being given to underserved groups as part of Task 8-Human Use Approval summary and Task 9-Participant Training deliverables. In Phase 2, HIRTA Project team will build upon Phase1 requirements to design and configure features prior to launch. Further training will be delivered as per training plan as developed in Phase 1 and refined further based on design and testing discussions in Phase 2.

Risk ID	Risk Probability	Mitigation Plan
R-TRV-13	Medium	While the HIRTA team has included various dissemination channels in the SyRS document to meet the needs of all underserved groups, reliability and availability of those channels may depend on external factors at times (e.g., device malfunction, communication outage). Also, in some cases, information may not be accurate due to data limitations. Phase 1 requirements clearly define expectations for real-time information delivery. Also, performance targets have been set for information accuracy. Further in Phase 2, design and testing will focus on ensuring meeting the requirements and user needs. Also, based on experience with deployment and rollout of Amble App and RM Pay mobile and web applications, HIRTA team understands training needs associated with launch of Traveler-end applications that are also utilized by underserved groups. The Training Plan captures the training approach which will be further elaborated in Phase 2 with training materials that will be developed.
R-TRV-15	Medium	HIRTA plans to work with the community members in ensuring language translation features are acceptable. This is being addressed in Task 9-Participant Training and Task 11- Outreach Plan documents. Further, in Phase 2, language translation features provided through the Traveler application will be extensively tested.
R-TMS-12	High	This item is being tracked in the risk register. Also, alternative approaches for implementing functionality are being planned so a direct interface with an EHR is not necessary for booking transportation for a pre-scheduled medical appointment.
R-TMS-13	Medium	This item is being tracked in the risk register. The scope interface is under discussion with Access2Care and may not be finalized until Phase 2 design. However, the HIRTA team will be able to follow the current process where a direct interface with Access2Care may not be necessary.
R-VEH-2	Low	Given low probability, overall impact on the program is low. Also, two-way radio along with the standard operating procedures for reduced mode of option will be activated in such situation.
R-WFS-1	Medium	HIRTA team is still evaluating wayfinding system provider for indoor navigation. The HIRTA team is considering evaluating technologies from more than one provider in Phase 2 prior to proceeding with a field deployment. At this point, probability of this risk is still considered medium.
R-WFS-2	Low	For a selected technology, a standard operating procedure in partnership with the healthcare facility deploying indoor navigation function will be developed in Phase 2 to maintain the data.
R-WFS-3	Low	Any considerations regarding operational use will be addressed through vendor selection and design process in Phase 2.

Risk ID	Risk Probability	Mitigation Plan
R-WFS-4	Low	As stated earlier, a standard operating procedure in partnership with the healthcare facility deploying indoor navigation function will be developed in Phase 2 to maintain the map data.

Appendix A. Acronyms and Glossary

Access2Care

A transportation broker for State of Iowa Medicaid program that performs booking and scheduling and works with service providers such as HIRTA for successful delivery of Medicaid-eligible trips.

ADA – Americans with Disabilities Act

Refers to the civil rights legislation passed and signed into law in 1990 to prevent discrimination against people with disabilities.

API- Application Programming Interface

Software middleware that allows two devices or applications to exchange data with each other.

APN: Access Point Name

A communication gateway for enabling cellular data communications over a carrier network. Public or private APN configurations are used depending on data security needs.

AWS: Amazon Web Service

A commercial cloud-based hosting service provided by Amazon.

BAA- Broad Agency Announcement

A procurement instrument used by USDOT.

Billing

Refers to the process of invoicing third-party funding sources (e.g., Medicaid) after a successful delivery of a trip. Billing is typically done on a monthly basis.

CHNA - Community Health Needs Assessment

Refers to the Community Health Needs Assessment Report developed by Dallas County in 2019.

CCB- Change Control Board

A body of subject matter experts tasked to manage change control process for work products, schedule or other relevant matters related to a project or program.

CDL- Concept Development Lead

Key project team member tasked with leading Phase 1 concept development activities.

CO: Contract Officer

The CO will serve as the USDOT point of contact for any concerns related to the contracts.

COR - Contract Office Representative

The Contract Office Representative will serve as the USDOT representative for this project and is responsible for coordination and review of the proposer's work.

Cost Allocation

Refers to the process of associating a funding source that should be billed for a trip in a shared ride scenario when riders covered by separate funding sources share the vehicle for their trips and trip purposes at the same time.

CSV- Comma Separated Value

A common text-based file format that is supported by many platforms and programs.

CT- Census Tract

A geographic region defined for the purpose of collecting census data.

CTAA – Community Transportation Association of America

One of the project Partners who will lead stakeholder engagement on this project.

DCHD – Dallas County Health Department

One of the project Partners who will lead integration with health care services.

DR-Demand Response

Refers to a service that is not run on a fixed route or a schedule (e.g., dial-a-ride, vanpool etc). This requires making trip booking by contacting the service provider (e.g., HIRTA). However, DR is different than an ADA Paratransit service which is provided as a complement to a fixed route and is governed by specific requirements provided in 49 CFR- Part F. HIRTA operates only DR Service in Dallas County and all discussion in this document is related to DR Service.

Dispatching

Refers to an operations management function which involves assigning vehicle, tracking fleet location, managing schedule adherence, managing trip manifests and other operational functions.

DMP – Data Management Plan

The Data Management Plan is Task 3 of Phase 1 and will describe the approach for data collection, processing, storage and utilization.

DOT – Department of Transportation

The government department responsible for transportation. In this report, this generally refers to either the State of Iowa's DOT or the United States DOT referred to as Iowa DOT and USDOT, respectively.

EDI – Electronic Data Interchange

In this context, refers to the electronic data interchange (EDI) format messages developed by HIPAA following American National Standards Institute (ANSI) X12 standard for electronic data exchange and are used to communicate with third-party health care provider systems (e.g., Medicaid).

EHR – Electronic Healthcare Record

Refers to the healthcare information management system used by hospitals for patients' healthcare-related appointments, transactions, and records management.

FHIR- Fast Healthcare Interoperability Record

A standard developed to describe and exchange health records in electronic format.

FHWA- Federal Highway Administration

A USDOT agency in-charge of highway transportation.

FTA- Federal Transit Administration

A USDOT agency in-charge of public transportation.

GTFS – General Transit Feeds Specification

GTFS is a standard to provide static public transportation schedule information. The standard has been expanded to include real-time passenger information (GTFS-real-time), flexible services (GTFS-flex) and accessible routing within stations (GTFS-pathways).

HIPAA – Health Insurance Portability and Accountability Act of 1996

Provides guidelines for data protection of sensitive patient health information.

HIRTA - Heart of Iowa Regional Transit Agency

Rural, regional public transit agency in central Iowa. HIRTA will serve as Proposer/Applicant for the Complete Trip - ITS4US project.

HL7 – Health Level Seven International

A not-for-profit, standards developing organization focused on electronic health information.

HN-Health Navigator

Refers to services provided by Dallas County Health Department to Dallas County residents in identifying resources as necessary for improving social determinants of health.

HUA- Human Use Approval Summary

A deliverable in Phase 1 for Task 8 that outlines the process to be used for human subject participation in the program for research and evaluation purposes.

HTTPS: Hyper Text Markup Language Secure

A protocol for accessing data/information over internet using Transport Layer Security (TLS)/ Secure Socket Layer (SSL).

ICTDP – Integrated Complete Trip Deployment Plan

The Integrated Complete Trip Deployment Plan is a deliverable of Task 13 under Phase 1.

I&R: Information and Referral

Refers to public and private entities that help their customers in identifying resources for health and human services and other needs.

IPFP - Institution, Partnership, and Financial Plan

The Institution, Partnership and Financial Plan is a deliverable of Task 10 under Phase 1.

IRB- Institutional Review Board

An institutional body that reviews and approves research methods to ensure ethical standards are followed, particularly when involving human subjects.

ISU– Iowa State University

Iowa State University is a public research university with multiple campuses in the State of Iowa and will be engaged as the research and evaluation partner in Phases 2 and 3.

IVR: Interactive Voice Response

A technology that allows humans relying on phone systems to interact with computer programs using natural voice or alphanumeric input using phone keys. This is an alternative used to provide services to populations that may not have access to web-based devices.

IP- Internet Protocol

A network layer protocol for enabling data exchange over Internet.

JSON: Java Script Object Notation

Open standard and human readable data format for storing and transmitting electronic data.

KPI – Key Performance Indicators

Represents primary metrics used to assess the success of a project or operations.

LEP – Limited English Proficiency

Refers to individuals who have a limited ability to read, speak, write, or understand English.

LTE: Long Term Evaluation

A telecommunication standard for wireless communications using mobile devices, also referred as 4th generation wireless.

MOD: Mobility-on-demand

A USDOT program that intends to support the develop of an ecosystem that provides safe, reliable and sustainable solution for all. MOD includes both trips made by Travelers or Trip replacements (e.g., courier network services (CNS) such as food delivery).

MPM: Mobility Performance Metrics

MPM is a program being led by the FTA to develop performance measures that focus on new mobility modes (e.g., micromobility, TNC).

NDSP- Non-Dedicated Service Provider

NDSP refers to operators providing service under contract (e.g., taxis) to an agency (e.g., HIRTA).

NEMT – Non-emergency Medical Transportation

The provision of transportation to patients for medical appointments, lab visits, and other routine care. Generally, used in the context of Medicaid service only.

NOFO- Notice of Funding Opportunity

Formal announcement of availability of funding by US federal agencies for one of the financial assistance programs.

PII – Personally Identifiable Information

Refers to any data that can distinguish an individual, either alone or when linked with other available data.

PML-Program Management Lead

HIRTA project team member in-charge of managing all project and program management activities.

Provider

Provider in this context mainly refers to an entity performing service delivery for requested trips, sometimes also referred as service provider. the HIRTA team have also used healthcare partners as providers in some cases but referred as ‘healthcare providers.’

REL- Research and Evaluation Lead

HIRTA team member responsible for managing the research and evaluation as part of Phase 3 and guiding the concept development and deployment activities as part of Phase 1 and 2.

Reservation

Refers to the act of booking a trip based on a request from a customer. Reservation is available to only to registered customers.

REST- Representational State Transfer

A popular protocol to enable data exchange over the Internet using web APIs. HTTP/HTTPS is used for communication protocol and data in HTML, JSON, XML or other formats may be used for exchange.

SAE- Society of Automobile Engineers

Professional standards development organization, primarily focused on aerospace, automotive, and commercial vehicles (e.g., trucking).

Scheduling

Refers to the process of identifying driver and vehicle resources and their runs/shifts for a given work-day. Scheduling is typically performed for all requests received until 24 hours in advance. Booking within 24-hour notice and on-demand is offered but not encouraged due to limited system capacity and resources.

SDL- Systems Development Lead

HIRTA team member responsible for all systems engineering aspects of the project.

SEL- Stakeholder Engagement Lead

HIRTA team member responsible for stakeholder engagement focused activities.

SFTP- Secure File Transfer Protocol

Protocol used to securely transfer file between networked devices.

SEMP – System Engineering Management Plan

A System Engineering Management Plan describes how systems engineering process of planning, design, and deployment is applied to a project.

SHP- Shape File Format

Common spatial data format developed and regulated by Esri.

SMP – Safety Management Plan

A Safety Management Plan describes the steps to be taken to ensure the safety of the project stakeholders and beneficiaries.

Smart Device

Refers to smartphone, smartwatch and similar personal devices that may be internet enabled and are equipped with sensors.

TAG – Transportation Advisory Group

The TAG is a diverse group of community stakeholders and business representatives interested in the advancement and improvement of public transportation in the HIRTA service area.

TAZ- Traffic Analysis Zone

A geographical unit used to conduct traffic /transportation analysis, constructed using census block information.

TCP- Transmission Controls Protocol

A transport layer protocol that is focused on assured delivery of data packets over an IP network.

TDS: Transactional Data Standard

Open data standard for exchanging transactional data (booking, payment, service coordination) between different systems or system components. Available in TCRP Report 210 - Development of Transactional Data Specifications for Demand-Responsive Transportation (http://www.trb.org/Main/Blurbs/180593.aspx)

TMS- Transportation Management System

All systems and tools to be used by HIRTA for managing day-to-day delivery of transportation services. This will be provided by various products offered by Uber Technologies.

TNC – Transportation Network Company

Encompasses a group of companies that provide on-demand Ridehailing services.

UUID-Universal Unique Identifier

Encrypted label used for assigning a unique ID to a field in a computer system, network or program.

UDP- User Datagram Protocol

A transport layer protocol that uses connectionless datagrams for applications that need time-sensitive data transmission but do not require assured delivery

Wayfinding

Refers to the tools and technologies that assist in orientation, locating objects, and step-by-step navigation to destinations in outdoor and indoor environments using visual markers, sensors or physical signage.

Appendix B. Ratings for Enabling Technologies and TRL Assessment

This Appendix provides TRL assessment for each technology. This assessment is the basis of ratings determined in Section 3.

Table 4 provides assessment of ET# 1- ET#7 that will be used by Traveler-end applications.

Table 4. Technologies used by Traveler-end Subsystems

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
1	**Basic principles and research**	Do basic scientific principles support the concept?	Y	Y	Y	Y	Y	Y	Y
1	**Basic principles and research**	Has the technology development methodology or approach been developed?	Y	Y	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
2	**Application formulated**	Are potential system applications identified?	Y	Y	Y	Y	Y	Y	Y
2	**Application formulated**	Are system components and the user interface at least partly described?	Y	Y	Y	Y	Y	Y	Y
2	**Application formulated**	Do preliminary analyses or experiments confirm that the application might meet the user need?	Y	Y	Y	Y	Y	Y	Y
3	**Proof of concept**	Are system performance metrics established?	Y	Y	Y	Y	Y	Y	Y
3	**Proof of concept**	Is system feasibility fully established?	Y	Y	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
3	**Proof of concept**	Do experiments or modeling and simulation validate performance predictions of system capability?	Y	Y	Y	Y	Y	Y	Y
3	**Proof of concept**	Does the technology address a need or introduce an innovation in the field of transportation?	Y	Y	Y	Y	Y	Y	Y
4	**Components validated in laboratory environment**	Are end-user requirements documented?	Y	Y	Y	Y	Y	Y	Y
4	**Components validated in laboratory environment**	Does a plausible draft integration plan exist, and is component compatibility demonstrated?	Y	Y	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
4	**Components validated in laboratory environment**	Were individual components successfully tested in a laboratory environment (a fully controlled test environment where a limited number of critical functions are tested)?	Y	Y	Y	Y	Y	Y	Y
5	**Integrated components demonstrated in a laboratory environment**	Are external and internal system interfaces documented?	Y	Y	Y	Y	Y	Y	Y
5	**Integrated components demonstrated in a laboratory environment**	Are target and minimum operational requirements developed?	Y	Y	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
5	**Integrated components demonstrated in a laboratory environment**	Is component integration demonstrated in a laboratory environment (i.e., fully controlled setting)?	Y	Y	Y	Y	Y	Y	Y
6	**Prototype system demonstrated in a relevant environment**	Is the operational environment (i.e., user community, physical environment, and input data characteristics, as appropriate) fully known?	Y	Y	Y	Y	Y	Y	Proposed application will utilize multilingual capabilities within devices and operating systems but experience of user communities with those capabilities is not known.

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
6	**Prototype system demonstrated in a relevant environment**	Was the prototype tested in a realistic and relevant environment outside the laboratory?	Y	Y	Y	Y	Y	Y	Y
6	**Prototype system demonstrated in a relevant environment**	Does the prototype satisfy all operational requirements when confronted with realistic problems?	Y	Y	Y	Y	Y	Y	Y
7	**Prototype demonstrated in operational environment**	Are available components representative of production components?	Y	Y	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
7	**Prototype demonstrated in operational environment**	Is the fully integrated prototype demonstrated in an operational environment (i.e., real-world conditions, including the user community)?	Y	Y	Y	Y	Y	Y	Technology has been made available in languages as needed for the project for proposed application but no record exists for testing with for all user communities identified for this project.

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
7	**Prototype demonstrated in operational environment**	Are all interfaces tested individually under stressed and anomalous conditions?	Y	Y	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
8	**Technology proven in operational environment**	Are all system components form-, fit-, and function-compatible with each other and with the operational environment?	User interface and capabilities for trip planning and booking in Routematch by Uber and Uber Transit apps/websites are different. Health Connector will utilize Uber Transit interface but Routematch by Uber interface provides features to accommodate additional mobility preferences. any differences in features will be addressed as part of design in Phase 2 to address the needs of all underserved groups through a unified interface.	Y	User interface & capabilities for trip planning/booking in Routematch by Uber & Uber Transit apps & websites are different.Health Connector will utilize Uber Transit interface but Routematch by Uber interface provides features to aid additional mobility preferences. any differences in features will be addressed as part of design in Phase 2 to address needs of underserved groups through a unified interface	Currently, mobile payment capability in RMPay is limited to debiting of prepaid account. Uber Transit app also allows use of credit card associated with customer profile along with prepaid account debit. A consistent experience will be offered for Health Connector customers through prepaid account use. Also, there will be a capability to apply discount coupon/credit provided by partners.	Similar to trip planning and booking, real-time information capability available in Amble App and Uber Transit are different. Health Connector is planning to utilize Uber Transit for real-time information capabilities which has not been used in a similar operating environment before.	Y	Y

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
8	**Technology proven in operational environment**	Is the technology proven in an operational environment (i.e., meet target performance measures)?	Target performance measures as defined in the PMESP are yet to be evaluated.	Y	Target performance measures as defined in the PMESP are yet to be evaluated.	Target performance measures as defined in the PMESP are yet to be evaluated.	Target performance measures as defined in the PMESP are yet to be evaluated.	Y	Technology has not been tested with all user communities
8	**Technology proven in operational environment**	Was a rigorous test and evaluation process completed successfully?	System as proposed has not yet been tested.	Y	System as proposed has not yet been tested.	System as proposed has not yet been tested.	System as proposed has not yet been tested.	Y	Technology has not been tested with all user communities
8	**Technology proven in operational environment**	Does the technology meet its stated purpose and functionality as designed?	System as proposed has not yet been tested.	Y	System as proposed has not yet been tested.	System as proposed has not yet been tested.	System as proposed has not yet been tested.	Y	Technology has not been tested with all user communities

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
9	**Technology refined and adopted**	Is the technology deployed in its intended operational environment?	Technology has been used in similar transportation environments before but has not been used in the environment similar to Health Connector (e.g., focus on healthcare trips, strong focus on underserved groups, rural area, third-party providers).	Y	Technology has been used in similar transportation environments before but has not been used in the environment similar to Health Connector (e.g., focus on healthcare trips, strong focus on underserved groups, rural area, third-party providers).	While capabilities are provided in similar environments for delivery of trips, capability to apply discount coupon/credit has not been deployed/tested in a similar environment.	Various advanced features as planned to provide real-time information in the context of healthcare transportation have not been deployed (e.g., pick up spot notification, feedback on real-time notification).	Y	While capabilities exist in the proposed application, no record of utilization by similar user communities is documented.

TRL Rating	TRL Description	Questions	ET#1	ET#2	ET#3	ET#4	ET#5	ET#6	ET#7
9	**Technology refined and adopted**	Is information about the technology disseminated to the user community?	Representatives for different underserved groups have been engaged but participants in this program have not been engaged.	Y	Representatives for different underserved groups have been engaged but participants in this program have not been engaged.	Users have been introduced to RMPay but not Uber Transit.	Representatives for different underserved groups have been engaged but participants in this program have not been engaged.	Y	Representatives for different underserved groups have been engaged but participants in this program have not been engaged.
9	**Technology refined and adopted**	Is the technology adopted by the user community?	An integrated healthcare transportation as planned (combination of Routematch and Uber) has not been deployed for user communities yet.	Y	An integrated healthcare transportation as planned (combination of Routematch and Uber) has not been deployed for user communities yet.	Users have been introduced to RMPay but not Uber Transit.	An integrated healthcare transportation as planned (combination of Routematch and Uber) has not been deployed for user communities yet.	Y	No

Table 5 provides assessment of ET# 8- ET12 that are used by central applications for transportation management. This includes both the existing application from Routematch by Uber and planned upgrade from Uber Transit.

Table 5. Technologies for TMS Subsystem (ET#8- ET#12)

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
1	**Basic principles and research**	Do basic scientific principles support the concept?	Y	Y	Y	Y	Y
1	**Basic principles and research**	Has the technology development methodology or approach been developed?	Y	Y	Y	Y	Y
2	**Application formulated**	Are potential system applications identified?	Y	Y	Y	Y	Y
2	**Application formulated**	Are system components and the user interface at least partly described?	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
2	**Application formulated**	Do preliminary analyses or experiments confirm that the application might meet the user need?	Y	Y	Y	Y	Y
3	**Proof of concept**	Are system performance metrics established?	Y	Y	Y	Y	Y
3	**Proof of concept**	Is system feasibility fully established?	Y	Y	Y	Y	Y
3	**Proof of concept**	Do experiments or modeling and simulation validate performance predictions of system capability?	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
3	**Proof of concept**	Does the technology address a need or introduce an innovation in the field of transportation?	Y	Y	Y	Y	Y
4	**Components validated in laboratory environment**	Are end-user requirements documented?	Y	Y	Y	Y	Y
4	**Components validated in laboratory environment**	Does a plausible draft integration plan exist, and is component compatibility demonstrated?	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
4	**Components validated in laboratory environment**	Were individual components successfully tested in a laboratory environment (a fully controlled test environment where a limited number of critical functions are tested)?	Y	Y	Y	Y	Y
5	**Integrated components demonstrated in a laboratory environment**	Are external and internal system interfaces documented?	Y	Y	Y	Y	Y
5	**Integrated components demonstrated in a laboratory environment**	Are target and minimum operational requirements developed?	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
5	**Integrated components demonstrated in a laboratory environment**	Is component integration demonstrated in a laboratory environment (i.e., fully controlled setting)?	Y	Y	Y	Y	Y
6	**Prototype system demonstrated in a relevant environment**	Is the operational environment (i.e., user community, physical environment, and input data characteristics, as appropriate) fully known?	Y	Y	Y	Not yet implemented	Y

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
6	**Prototype system demonstrated in a relevant environment**	Was the prototype tested in a realistic and relevant environment outside the laboratory?	Y	Y	Y	Not yet implemented	Y
6	**Prototype system demonstrated in a relevant environment**	Does the prototype satisfy all operational requirements when confronted with realistic problems?	Y	Y	Y	Not yet implemented	Y
7	**Prototype demonstrated in operational environment**	Are available components representative of production components?	Y	Y	Y	Not yet implemented	Y

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
7	**Prototype demonstrated in operational environment**	Is the fully integrated prototype demonstrated in an operational environment (i.e., real-world conditions, including the user community)?	Y	Y	Routematch and Uber Transit applications both provide scheduling and optimization but are not integrated. There are likely scenarios when both applications may need to be utilized for Health Connector (e.g., when requests for specialized mobility needs cannot be accommodated in Uber Transit).	Not yet implemented	Y

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
7	**Prototype demonstrated in operational environment**	Are all interfaces tested individually under stressed and anomalous conditions?	Y	Y	N/A	Not yet implemented	Y
8	**Technology proven in operational environment**	Are all system components form-, fit-, and function-compatible with each other and with the operational environment?	Level of details required in completing registration and customer data management functions is different in Routematch and Uber Transit applications.	Routematch and Uber Transit applications use different mapping technologies. This may cause issues when data is being exchanged between both systems and will have to be verified.	Routematch and Uber Transit applications both provide scheduling and optimization but are not integrated.	Not yet implemented	Vehicle tracking using proposed application for Health Connector has not been proven for HIRTA. Currently, Routematch by Uber application is used on Driver terminals.

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
8	**Technology proven in operational environment**	Is the technology proven in an operational environment (i.e., meet target performance measures)?	N/A	Y	Capabilities to meet the needs for booking, vehicle assignments and reassignments in real-time for all underserved users should be tested.	Not yet implemented	Application has been used in similar environment but not in the same operating environment.
8	**Technology proven in operational environment**	Was a rigorous test and evaluation process completed successfully?	System as proposed has not yet been tested.	System as proposed has not yet been tested.	System as proposed has not yet been tested.	Not yet implemented	System as proposed has not yet been tested.
8	**Technology proven in operational environment**	Does the technology meet its stated purpose and functionality as designed?	System as proposed has not yet been tested.	System as proposed has not yet been tested.	System as proposed has not yet been tested.	Not yet implemented	System as proposed has not yet been tested.

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
9	**Technology refined and adopted**	Is the technology deployed in its intended operational environment?	Technology has not been deployed as proposed where both Routematch by Uber and Uber Transit are deployed and work in conjunction.	Technology has not been deployed as proposed where both Routematch by Uber and Uber Transit are deployed and work in conjunction.	Technology has not been deployed to meet the needs of real-time scheduling for underserved groups.	Not yet implemented	Vehicle tracking capability per needs of real-time responsiveness will be required.

TRL Rating	TRL Description	Questions	ET#8	ET#9	ET#10	ET#11	ET#12
9	**Technology refined and adopted**	Is information about the technology disseminated to the user community?	Only Routematch by Uber application is deployed and known to user community.	N/A	Only Routematch by Uber application is deployed and known to user community.	Not yet implemented	N/A
9	**Technology refined and adopted**	Is the technology adopted by the user community?	Only Routematch by Uber application is deployed and known to user community.	N/A	Only Routematch by Uber application is deployed and known to user community.	Not yet implemented	N/A

Table 6 provides assessment of ET# 13- ET16 that are used by central applications for transportation management. This includes both the existing application from Routematch by Uber and planned upgrade from Uber Transit.

Table 6. TRL Assessment for Technologies for TMS (ET#13- ET#16)

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
1	**Basic principles and research**	Do basic scientific principles support the concept?	Y	Y	Y	Y
1	**Basic principles and research**	Has the technology development methodology or approach been developed?	Y	Y	Y	Y
2	**Application formulated**	Are potential system applications identified?	Y	Y	Y	Y
2	**Application formulated**	Are system components and the user interface at least partly described?	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
2	**Application formulated**	Do preliminary analyses or experiments confirm that the application might meet the user need?	Y	Y	Y	Y
3	**Proof of concept**	Are system performance metrics established?	Y	Y	Y	Y
3	**Proof of concept**	Is system feasibility fully established?	Y	Y	Y	Y
3	**Proof of concept**	Do experiments or modeling and simulation validate performance predictions of system capability?	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
3	**Proof of concept**	Does the technology address a need or introduce an innovation in the field of transportation?	Y	Y	Y	Y
4	**Components validated in laboratory environment**	Are end-user requirements documented?	Y	Y	Y	Y
4	**Components validated in laboratory environment**	Does a plausible draft integration plan exist, and is component compatibility demonstrated?	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
4	**Components validated in laboratory environment**	Were individual components successfully tested in a laboratory environment (a fully controlled test environment where a limited number of critical functions are tested)?	Y	Y	Y	Y
5	**Integrated components demonstrated in a laboratory environment**	Are external and internal system interfaces documented?	Y	Y	Not yet implemented	Not yet implemented
5	**Integrated components demonstrated in a laboratory environment**	Are target and minimum operational requirements developed?	Y	Y	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
5	**Integrated components demonstrated in a laboratory environment**	Is component integration demonstrated in a laboratory environment (i.e., fully controlled setting)?	Y	Y	Not yet implemented	Not yet implemented
6	**Prototype system demonstrated in a relevant environment**	Is the operational environment (i.e., user community, physical environment, and input data characteristics, as appropriate) fully known?	Y	Y	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
6	**Prototype system demonstrated in a relevant environment**	Was the prototype tested in a realistic and relevant environment outside the laboratory?	Y	Y	Not yet implemented	Not yet implemented
6	**Prototype system demonstrated in a relevant environment**	Does the prototype satisfy all operational requirements when confronted with realistic problems?	Y	Y	Not yet implemented	Not yet implemented
7	**Prototype demonstrated in operational environment**	Are available components representative of production components?	Y	Y	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
7	**Prototype demonstrated in operational environment**	Is the fully integrated prototype demonstrated in an operational environment (i.e., real-world conditions, including the user community)?	HIRTA plans to utilize Uber Transit for dispatching health Connector applications but that is currently not used and has not been tested in HIRTA service area. Also, capability to dispatch third party services has not been validated yet.	Y	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
7	**Prototype demonstrated in operational environment**	Are all interfaces tested individually under stressed and anomalous conditions?	All conditions as relevant to HIRTA and various underserved group needs may not have been tested.	Y	Not yet implemented	Not yet implemented
8	**Technology proven in operational environment**	Are all system components form-, fit-, and function-compatible with each other and with the operational environment?	Proposed application has not been used for HIRTA.	Capabilities as available from Uber Transit application have not been validated in the similar operating environment (e.g., shared ride or accommodation of unique needs of underserved groups in the project)	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
8	**Technology proven in operational environment**	Is the technology proven in an operational environment (i.e., meet target performance measures)?	Application has been used in similar environment but not in the same operating environment.	Application has been used in similar environment but not in the same operating environment.	Not yet implemented	Not yet implemented
8	**Technology proven in operational environment**	Was a rigorous test and evaluation process completed successfully?	System as proposed has not yet been tested.	System as proposed has not yet been tested.	Not yet implemented	Not yet implemented
8	**Technology proven in operational environment**	Does the technology meet its stated purpose and functionality as designed?	System as proposed has not yet been tested.	System as proposed has not yet been tested.	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
9	**Technology refined and adopted**	Is the technology deployed in its intended operational environment?	New application must support the capabilities within existing application and also support real-time responsiveness. That has not been verified yet.	ETA accuracy needs to be verified in the HIRTA service area and by accommodating the needs of the underserved population under consideration.	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#13	ET#14	ET#15	ET#16
9	**Technology refined and adopted**	Is information about the technology disseminated to the user community?	N/A	N/A	Not yet implemented	Not yet implemented
9	**Technology refined and adopted**	Is the technology adopted by the user community?	N/A	N/A	Not yet implemented	Not yet implemented

Table 7 provides assessment of technologies to be utilized by vehicle-end subsystem which primarily includes the application to be used by the Driver. These technologies have been used by proposed applications in similar environment but all use cases as identified for this project have not been tested yet.

Table 7. TRL Assessment for Vehicle-end Subsystem

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
1	**Basic principles and research**	Do basic scientific principles support the concept?	Y	Y	Y	Y	Y
1	**Basic principles and research**	Has the technology development methodology or approach been developed?	Y	Y	Y	Y	Y
2	**Application formulated**	Are potential system applications identified?	Y	Y	Y	Y	Y
2	**Application formulated**	Are system components and the user interface at least partly described?	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
2	**Application formulated**	Do preliminary analyses or experiments confirm that the application might meet the user need?	Y	Y	Y	Y	Y
3	**Proof of concept**	Are system performance metrics established?	Y	Y	Y	Y	Y
3	**Proof of concept**	Is system feasibility fully established?	Y	Y	Y	Y	Y
3	**Proof of concept**	Do experiments or modeling and simulation validate performance predictions of system capability?	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
3	**Proof of concept**	Does the technology address a need or introduce an innovation in the field of transportation?	Y	Y	Y	Y	Y
4	**Components validated in laboratory environment**	Are end-user requirements documented?	Y	Y	Y	Y	Y
4	**Components validated in laboratory environment**	Does a plausible draft integration plan exist, and is component compatibility demonstrated?	Y	Y	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
4	**Components validated in laboratory environment**	Were individual components successfully tested in a laboratory environment (a fully controlled test environment where a limited number of critical functions are tested)?	Y	Y	Y	Y	Y
5	**Integrated components demonstrated in a laboratory environment**	Are external and internal system interfaces documented?	Y	Y	Y	Not yet implemented	Y
5	**Integrated components demonstrated in a laboratory environment**	Are target and minimum operational requirements developed?	Y	Y	Y	Not yet implemented	Y

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
5	**Integrated components demonstrated in a laboratory environment**	Is component integration demonstrated in a laboratory environment (i.e., fully controlled setting)?	Y	Y	Y	Not yet implemented	Y
6	**Prototype system demonstrated in a relevant environment**	Is the operational environment (i.e., user community, physical environment, and input data characteristics, as appropriate) fully known?	Y	Y	Y	Not yet implemented	Y

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
6	**Prototype system demonstrated in a relevant environment**	Was the prototype tested in a realistic and relevant environment outside the laboratory?	Y	Y	Y	Not yet implemented	Y
6	**Prototype system demonstrated in a relevant environment**	Does the prototype satisfy all operational requirements when confronted with realistic problems?	Y	Y	Y	Not yet implemented	Y
7	**Prototype demonstrated in operational environment**	Are available components representative of production components?	Y	Y	Y	Not yet implemented	Y

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
7	**Prototype demonstrated in operational environment**	Is the fully integrated prototype demonstrated in an operational environment (i.e., real-world conditions, including the user community)?	Y	Y	HIRTA plans to utilize Uber Transit for dispatching Health Connector applications but that is currently not used and has not been tested in HIRTA service area. Also, capability to dispatch third-party services has not been validated yet.	Not yet implemented	Y

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
7	**Prototype demonstrated in operational environment**	Are all interfaces tested individually under stressed and anomalous conditions?	Y	Y	All conditions as relevant to HIRTA and various underserved group needs may not have been tested.	Not yet implemented	Y
8	**Technology proven in operational environment**	Are all system components form-, fit-, and function-compatible with each other and with the operational environment?	Vehicle tracking using proposed application for Health Connector has not been proven for HIRTA. Currently, Routematch by Uber application is used on Driver terminals.	Y	Proposed application has not been used for HIRTA.	Not yet implemented	Y

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
8	**Technology proven in operational environment**	Is the technology proven in an operational environment (i.e., meet target performance measures)?	Application has been used in similar environment but not in the same operating environment.	Y	Application has been used in similar environment but not in the same operating environment.	Not yet implemented	Y
8	**Technology proven in operational environment**	Was a rigorous test and evaluation process completed successfully?	System as proposed has not yet been tested.	Y	System as proposed has not yet been tested.	Not yet implemented	Y
8	**Technology proven in operational environment**	Does the technology meet its stated purpose and functionality as designed?	System as proposed has not yet been tested.	Y	System as proposed has not yet been tested.	Not yet implemented	Y

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
9	**Technology refined and adopted**	Is the technology deployed in its intended operational environment?	Vehicle tracking capability per needs of real-time responsiveness will be required.	Y	New application must support the capabilities within existing application and also support real-time responsiveness. That has not been verified yet.	Not yet implemented	Y

TRL Rating	TRL Description	Questions	ET#17	ET#18	ET#19	ET#20	ET#21
9	**Technology refined and adopted**	Is information about the technology disseminated to the user community?	N/A	Y	N/A	Not yet implemented	Y
9	**Technology refined and adopted**	Is the technology adopted by the user community?	N/A	Y	N/A	Not yet implemented	Y

Table 8 provides assessment of technologies being considered for wayfinding subsystem. These technologies have very limited footprint in the transit industry as reflected in the assessment.

Table 8. TRL Assessment for technologies for Wayfinding Subsystem

TRL Rating	TRL Description	Questions	ET#22	ET#23	ET#24
1	**Basic principles and research**	Do basic scientific principles support the concept?	Y	Y	Y
1	**Basic principles and research**	Has the technology development methodology or approach been developed?	Y	Y	Y
2	**Application formulated**	Are potential system applications identified?	Y	Y	Y
2	**Application formulated**	Are system components and the user interface at least partly described?	Y	Y	Y
2	**Application formulated**	Do preliminary analyses or experiments confirm that the application might meet the user need?	Y	Y	Y
3	**Proof of concept**	Are system performance metrics established?	Y	Y	Y
3	**Proof of concept**	Is system feasibility fully established?	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#22	ET#23	ET#24
3	**Proof of concept**	Do experiments or modeling and simulation validate performance predictions of system capability?	Y	Y	Y
3	**Proof of concept**	Does the technology address a need or introduce an innovation in the field of transportation?	Y	Y	Y
4	**Components validated in laboratory environment**	Are end-user requirements documented?	Y	Y	Y
4	**Components validated in laboratory environment**	Does a plausible draft integration plan exist, and is component compatibility demonstrated?	Y	Y	Y
4	**Components validated in laboratory environment**	Were individual components successfully tested in a laboratory environment (a fully controlled test environment where a limited number of critical functions are tested)?	Y	Y	Y

TRL Rating	TRL Description	Questions	ET#22	ET#23	ET#24
5	**Integrated components demonstrated in a laboratory environment**	Are external and internal system interfaces documented?	Not yet implemented	Not yet implemented	Not yet implemented
5	**Integrated components demonstrated in a laboratory environment**	Are target and minimum operational requirements developed?	Not yet implemented	Not yet implemented	Not yet implemented
5	**Integrated components demonstrated in a laboratory environment**	Is component integration demonstrated in a laboratory environment (i.e., fully controlled setting)?	Not yet implemented	Not yet implemented	Not yet implemented
6	**Prototype system demonstrated in a relevant environment**	Is the operational environment (i.e., user community, physical environment, and input data characteristics, as appropriate) fully known?	Not yet implemented	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#22	ET#23	ET#24
6	**Prototype system demonstrated in a relevant environment**	Was the prototype tested in a realistic and relevant environment outside the laboratory?	Not yet implemented	Not yet implemented	Not yet implemented
6	**Prototype system demonstrated in a relevant environment**	Does the prototype satisfy all operational requirements when confronted with realistic problems?	Not yet implemented	Not yet implemented	Not yet implemented
7	**Prototype demonstrated in operational environment**	Are available components representative of production components?	Not yet implemented	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#22	ET#23	ET#24
7	**Prototype demonstrated in operational environment**	Is the fully integrated prototype demonstrated in an operational environment (i.e., real-world conditions, including the user community)?	Not yet implemented	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#22	ET#23	ET#24
7	**Prototype demonstrated in operational environment**	Are all interfaces tested individually under stressed and anomalous conditions?	Not yet implemented	Not yet implemented	Not yet implemented
8	**Technology proven in operational environment**	Are all system components form-, fit-, and function-compatible with each other and with the operational environment?	Not yet implemented	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#22	ET#23	ET#24
8	**Technology proven in operational environment**	Is the technology proven in an operational environment (i.e., meet target performance measures)?	Not yet implemented	Not yet implemented	Not yet implemented
8	**Technology proven in operational environment**	Was a rigorous test and evaluation process completed successfully?	Not yet implemented	Not yet implemented	Not yet implemented
8	**Technology proven in operational environment**	Does the technology meet its stated purpose and functionality as designed?	Not yet implemented	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#22	ET#23	ET#24
9	**Technology refined and adopted**	Is the technology deployed in its intended operational environment?	Not yet implemented	Not yet implemented	Not yet implemented
9	**Technology refined and adopted**	Is information about the technology disseminated to the user community?	Not yet implemented	Not yet implemented	Not yet implemented

TRL Rating	TRL Description	Questions	ET#22	ET#23	ET#24
9	**Technology refined and adopted**	Is the technology adopted by the user community?	Not yet implemented	Not yet implemented	Not yet implemented

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

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