MAT v1.0

Task 3.1 Multimodal and Accessible Travel (MAT) Use Case Review

Multimodal and Accessible Travel Use Case Review

Multimodal and Accessible Travel Standards and Vulnerable Road User Cybersecurity Support Project

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This document is produced by the MAT and Cybersecurity Subject Matter Experts (SMEs).

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Section 1 Introduction

1.1 Scope of Document

This document reviews the use cases that have been developed to describe aspects of Multimodal and Accessible Travel (MAT) in order to identify gaps that exist between the existing set of use cases and the scope of MAT. In addition to identifying use cases, the effort reviewed traditional and innovative projects from USDOT and other public deployments in order to track trends in traveler mobility services. Use cases were extracted from these projects and national and international standards documents that present constraints, actors, operational flow, information needs and accessibility considerations. The collected information is used to identify gaps and priorities of current development activities. The results of this effort will be used to prioritize use cases to develop in Task 3.2.

1.2 Background

In February 2021, the USDOT developed a *Roadmap for Multimodal and Accessible Travel Standardization Work* for the Multimodal and Accessible Travel Standards Assessment (MATSA) project. The project identified a gap in standardization in the areas of four **Complete Trip** categories -- On-Demand/Mobility Platform (OD) Application Programming Interfaces, Wayfinding and Navigation (WaN), Safety (S), and Integrated Payment (IP), and two **Complete Streets** categories -- Curb and Micromobility Vehicle Management (CM) and Public Right of Way/ Data Modeling for Indoor Navigation (PROW).

MATSA results described the need to add an “information layer” to the typical OSI model to incorporate a systems engineering approach to the discovery and development of message transactions among multimodal systems, as well as profiles that married the information layer to physical technology layer.

According to the **MATSA Standards Update Task 5 White Paper**:

“The artifacts that compose the information layer are typically published as technical specifications or reports by standards bodies, … trade associations, consortia, or grass roots organizations…The technical reports and specifications typically describe the following types of information:

- **Reference framework** – An architecture, typically role-based or functional that describes user roles and functions, as well as general interactions between entities.
- **Use Case** – Scenarios that detail the flow of control, functions, and data flow between components in the reference framework. The use case descriptions typically incorporate performance needs, exception handling, and policy and regulation drivers. For example, a payment system data exchange changes when a prepaid versus pay-as-you-go interaction is depicted.
- **Requirements** – Derived from the reference framework; these include specific data, message, and service specifications.**”**

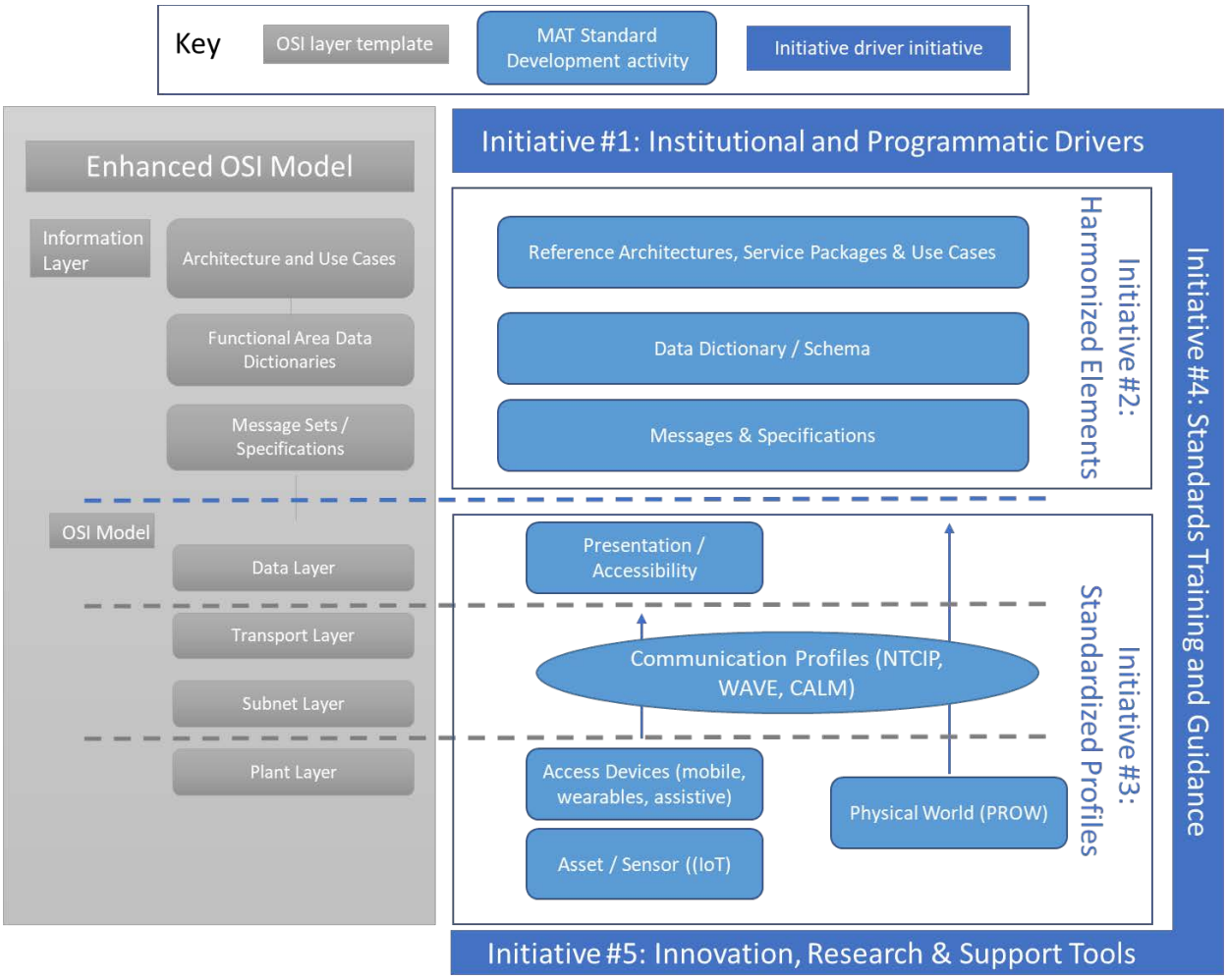

Figure 1. Strategic Framework for Roadmap Initiatives mapped to Enhanced OSI Model. *Source: MATSA Roadmap*.

This technical report follows the *MATSA Roadmap* Initiative #2 (see Figure 1) in drilling into the gaps in use cases that are needed to support standard message and specification development in the MAT areas.

The detailed assessment necessitated defining MAT by mobility services and functions (grouped by categories) in order to drill into the details needed by standard developers. MATSA identified several existing standards that expanded on the categories associated with the six areas. This effort used to prioritize areas where use cases are needed are based on existing efforts, as well as emerging MAT updates by the USDOT JPO ITS Architecture Development, Evolution, and Deployment Support.

Section 2 Scope of Multimodal and Accessible Travel

This section defines the scope of MAT. In particular, it creates descriptions of MAT mobility services (modes, services, and collaboration types) and functions (categories and detailed functions). The two classes are used as building blocks to compare MAT attributes between projects and use cases.

While there isn't a specific definition of MAT, examining the individual terms helps explain the scope of the effort. "The term multimodal means the combination of distinct functional and technical modes of transportation within a trip from origin to destination. By combining the strong points of specific forms of transportation in terms of their accessibility, space consumption, speed, efficiency, etc. for particular parts of a trip, an overall optimal travel performance might be attained." [2] Another definition is that multimodal travel uses different modes of transport to produce a seamless door-to-door travel experience. This definition is incorporated into the USDOT's definition of the Complete Trip, which also incorporates the term "accessibility," that has the following definition:

> "The accessibility of a transportation system can be described in terms of the ability of individuals to go from home to a destination without breaks or in terms of a complete trip with various links such as trip planning, travel to station, station/stop use, boarding vehicles, using vehicles, leaving vehicles, using the stop or transferring, and travel to destination after leaving the station or stop. If one link is not accessible, then access to a subsequent link is unattainable and the trip cannot be completed. Thus, the complete trip defines the scope of potential research and development in accessible transportation. The inability to get to and from destinations, i.e., from home to a transit station and from the station to a final destination (the first mile/last mile problem) and distance traveled are persistent problems in the complete trip. An accessible trip allows individuals with disabilities, especially those with severe disabilities, to have independent access to work sites, educational programs, health facilities, and social and recreational activities." [3]

The following subsections describe the scope of MAT mobility services and the functions associated with those services.

2.1 Mobility Services

The MAT is deployed through a variety of mobility services, which are defined in the following subsections.

2.1.1 Conveyances

This section describes different types of conveyances used as part of MAT.

2.1.1.1 Walking/running

Walking is "to advance or travel on foot at a moderate speed or pace; proceed by steps; move by advancing the feet alternately so that there is always one foot on the ground in bipedal locomotion and two or more feet on the ground in quadrupedal locomotion." Also, it can mean "to move about or travel on foot for exercise or pleasure."

Running is "to go quickly by moving the legs more rapidly than at a walk and in such a manner that for an instant in each step all or both feet are off the ground." Also, running is "to move with haste."

Source: (Dictionary.com)

2.1.1.2 Assistive Device, Stroller, or Cart

Assistive devices are "mobility aids, such as wheelchairs, scooters, walkers, canes, crutches, prosthetic devices, and orthotic devices."

Source: (https://www.nichd.nih.gov/health/topics/rehabtech/conditioninfo/device)

A stroller is “a chair on wheels, typically folding, in which a baby or young child can be pushed along.”

A cart is “a bag or basket on wheels for carrying shopping purchases.”

Source: (Oxford Languages)

2.1.1.3 Public transportation

Public transportation is a key category of conveyance for MAT. This section describes the different types of public transportation. “Public transportation service means the operation of a vehicle that provides general or special service to the public on a regular and continuing basis consistent with 49 U.S.C. Chapter 53.”

Source: (FTA)

2.1.1.3.1 Bus

“Bus means a rubber-tired automotive vehicle used for the provision of public transportation service by or for a recipient of FTA financial assistance.”

Source: (FTA)

2.1.1.3.2 Light Rail Transit (LRT)/Streetcar

“Light rail transit [is a] system of railways usually powered by overhead electrical wires and used for medium-capacity local transportation in metropolitan areas. Light rail vehicles (LRVs) are a technological outgrowth of streetcars (trams). Light rail transit lines are more segregated from street traffic than are tramways (particularly in congested urban areas) but less so than are rapid transit (heavy rail) lines.”

Source: (https://www.britannica.com/technology/light-rail-transit)

2.1.1.3.3 Heavy Rail / Subway

“Heavy rail (also called metro rail, subway, rapid transit, or rapid rail) is an electric railway on devoted rights-of-way that handles many passengers at once. Tracks may be placed in subway tunnels (like in New York City), on elevated structures (like in Chicago), or on fenced-off, ground-level tracks that do not crossroads. Heavy rail runs at high speeds and accelerates rapidly with the assistance of modern power systems and sophisticated signaling. Its passenger rail cars operate either singly or in multicar trains on fixed rail. Passengers generally pay a flat fare or a zone-based fare at fare gates in stations. Passengers board from high platforms that are even with the floor level of the car.”

Source: (https://policy.tti.tamu.edu/strategy/heavy-rail/)

2.1.1.3.4 Commuter Rail

“Commuter rail, also called suburban rail, is a passenger rail transport service between a city center, and outer suburbs and commuter towns or other locations that draw large numbers of commuters—people who travel on a daily basis. Trains operate following a schedule, at speeds varying from 50 to 200 km/h (30 to 125 mph). Distance charges or zone pricing may be used.”

Source: (http://railsystem.net/commuter-rail/)

2.1.1.3.5 Ferry

A ferry is “a boat or ship for conveying passengers and goods, especially over a relatively short distance and as a regular service.”

Source: (Oxford Languages)

2.1.1.3.6 Water Taxi

A water taxi is “a boat functioning (as within a harbor) as a taxi.”

Source: (https://www.merriam-webster.com/dictionary/water%20taxi)

2.1.1.3.7 Van

A van is “a medium-sized motor vehicle with a boxy shape and high roof, used for transporting goods or passengers.”

Source: (Oxford Languages)

2.1.1.4 Automated Vehicle

Automated vehicles are those in which at least some aspect of a safety-critical control function (e.g., steering, throttle, or braking) occurs without direct driver input. Automated vehicles may be autonomous (i.e., use only vehicle sensors) or may be connected (i.e., use communications systems such as connected vehicle technology, in which cars and roadside infrastructure communicate wirelessly). Connectivity is an important input to realizing the full potential benefits and broad-scale implementation of automated vehicles.

Source: (https://www.its.dot.gov/automated_vehicle/index.htm)

“The level of driving automation is based on the functionality of the driving automation system feature, as determined by an allocation of roles in dynamic driving task (DDT) and DDT fallback performance between that feature and the (human) user (if any).” The following subsections describe each level of automation.

Source: (SAE J3016™)

2.1.1.4.1 Level or Category 0 - No Driving Automation

“The performance by the driver of the entire DDT, even when enhanced by active safety systems.”

Source: (SAE J3016)

2.1.1.4.2 Level or Category 1 - Driver Assistance

“The sustained and operational design domain (ODD)-specific execution by a driving automation system of either the lateral or the longitudinal vehicle motion control subtask of the DDT (but not both simultaneously) with the expectation that the driver performs the remainder of the DDT.”

Source: (SAE J3016)

2.1.1.4.3 Level or Category 2 - Partial Driving Automation

“The sustained and ODD-specific execution by a driving automation system of both the lateral and longitudinal vehicle motion control subtasks of the DDT with the expectation that the driver completes the object and event detection and response (OEDR) subtask and supervises the driving automation system.”

Source: (SAE J3016)

2.1.1.4.4 Level or Category 3 - Conditional Driving Automation

“The sustained and ODD-specific performance by an automated driving system (ADS) of the entire DDT under routine/normal operation with the expectation that the DDT fallback-ready user is receptive to ADS-issued requests to intervene, as well as to DDT performance-relevant system failures in other vehicle systems, and will respond appropriately.”

Source: (SAE J3016)

2.1.1.4.5 Level or Category 4 - High Driving Automation

“The sustained and ODD-specific performance by an ADS of the entire DDT and DDT fallback.”

Source: (SAE J3016)

2.1.1.4.6 Level or Category 5 - Full Driving Automation

“The sustained and unconditional (i.e., not ODD-specific) performance by an ADS of the entire DDT and DDT fallback.”

Source: (SAE J3016)

2.1.1.5 Non-motorized Micromobility Vehicle (MMV)

A human-powered bicycle or other low-speed vehicle or device that provides travelers with short-term access on an as-needed basis.

Source: (SAE JA3163)

2.1.1.6 Motorized MMV

Vehicles and devices such as bicycles, scooters, mopeds or other low-speed vehicles propelled by power sources such as an engine or motor that provides travelers with short-term access on an as-needed basis. Micromobility vehicles and devices that are partially or fully powered by a motor or engine are defined in SAE J3194.

Source: (SAE JA3163)

2.1.1.7 Personal Vehicle/Driving

A “privately owned vehicle (POV)” is a motor vehicle not owned by the Government or private entity and used by an individual or his/her immediate family for the primary purpose of providing personal transportation. Personal driving is using a POV to provide transportation from one location to another without charging passengers for the transportation.

Source: (https://www.law.cornell.edu/cfr/text/41/302-9.1, in part)

2.1.2 Service Types

This section provides definitions of four different service types.

2.1.2.1 Fixed

"Fixed route transit services can be defined as services which operate on predefined routes according to a set schedule."

Source: (https://www.e-education.psu.edu/geog855/node/801)

2.1.2.2 Flexible (route- or point-deviation)

"Flexible public transportation services is a general term describing a range of strategies typically utilized in local public bus transportation. It is commonly applied to services which incorporate elements of but are not exclusively fixed-route or demand-responsive models.

"Route Deviation [is] a defined path and schedule used to define a service area, but the vehicle(s) may serve requests for pick-up or drop-off within a specified zone around the path. The deviation-zone may or may not be strictly bounded. According to a survey of service operators, the deviation is commonly between one-half and three-quarters of a mile from the route. Three-quarters of a mile from is the distance mandated by the Americans with Disabilities Act (ADA) for paratransit service complementing a fixed-route service. This service type is most effective in areas with enough density to support a predictable route and schedule but could benefit from the flexibility of serving origins and destinations that are otherwise off-route.

"Point Deviation [is] service provided within a defined zone with a set of specific stops, but the path between the stops is unspecified and the vehicle will serve locations within the zone on request. Point Deviation can be most effective in an area with specific trip destinations but dispersed origins, or vice-versa."

Source: (https://www.transitwiki.org/TransitWiki/index.php/Flexible_transportation_services)

2.1.2.3 Demand-response/ Mobility on Demand (MOD) Services

"Demand response is any non-fixed route system of transporting individuals that requires advanced scheduling by the customer, including services provided by public entities, nonprofits, and private providers."

Source:
(https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/Demand_Response_Fact_Sheet_Final_with_NEZ_edits_02-13-13.pptx)

"Mobility on Demand (MOD) is an innovative transportation concept where consumers can access mobility, goods, and services on demand by dispatching or using shared mobility, courier services, unmanned aerial vehicles (UAVs), and public transportation solutions."

Source: (Mobility on Demand Operational Concept Report)

2.1.2.4 Docked/Dockless MMV Services

Docked MMVs are "a fleet of vehicles or devices that can only be picked up and dropped off at designated physical or digital stations within the service area determined by the mobility provider and/or regulatory agency. [This] includes both one-way and roundtrip. Physical stations can include painted boundaries designating pick-up and drop-off locations, sometimes also referred to as 'corrals.'"

Dockless MMVs are “a fleet of vehicles or devices that can be picked up and dropped off anywhere in the service area determined by the mobility provider and/or regulatory agency. [This] can also be referred to as “one-way.” For shared micromobility, the ability to lock devices to street furniture (e.g., signs, bicycle racks, etc.) is another variation of [this] model. This variation of free floating shared micromobility is sometimes also referred to as the “lock to model.”

Source: (JA3163)

2.1.3 Cooperative Type

This section contains definitions for various cooperative types of mobility.

2.1.3.1 Sharing

2.1.3.1.1 Concurrent Sharing

Sharing of the same transportation vehicle, device, or service by travelers from different households and/or different traveling parties in a simultaneous manner.

Source: (SAE JA3163)

2.1.3.1.2 Sequential Sharing

Sharing of the same transportation vehicle, device, or service by travelers from different households and/or different traveling parties one after the other (i.e., in a sequential manner). Examples of sequential sharing modes are shown in the following subsections.

Source: (SAE JA3163)

2.1.3.1.2.1 Bikesharing

“A service that provides travelers on-demand, short-term access to a shared fleet of bicycles, usually for a fee. Bikesharing service providers may own, maintain, and provide charging (if applicable) for the bicycle fleet. Bikesharing includes pedal-only and powered bicycles such as e-bikes. Powered bicycles are defined in SAE J3194. Bikesharing is a service that is a form of shared micromobility.”

Alias: pedal-only and powered bicycles such as e-bikes.

Source: (SAE JA3163) SAE International, “Taxonomy of On-Demand and Shared Mobility: Ground, Aviation, and Marine,” JA3163™, issued June 2021, page 4.

2.1.3.1.2.2 Carsharing

“A service that provides the traveler with on-demand, short-term access to a shared fleet of motor vehicles typically through a membership and the traveler pays a fee for use. Carsharing service providers typically own and maintain the vehicle fleet and provide insurance, gasoline/charging, and parking.

Source: (SAE JA3163, p. 4)

2.1.3.1.2.3 Scooter Sharing

“A service that provides the traveler on-demand, short-term access to a shared fleet of scooters for a fee. Scooter sharing service providers typically own, maintain, and provide fuel/charging (if applicable) for the scooter fleet. Service providers may also provide insurance. Scooter sharing includes standing and seated scooters that are solely human powered and those that are partially or fully powered by a motor or engine, which are defined in SAE J3194. Scooter sharing is a service that is a form of shared micromobility.”

Source: (SAE JA3163, p. 4)

2.1.3.2 Pooling

This section describes different aspects of pooling services.

2.1.3.2.1 Carpooling

“The formal or informal sharing of rides between drivers and travelers with similar origin-destination pairings using vehicles of two to six passengers.”

Source: (SAE JA3163, p. 6)

2.1.3.2.2 Vanpooling

“The formal or informal sharing of rides between drivers and travelers with similar origin-destination pairings using vehicles of seven to 15 passengers who share the cost of a van and operating expenses, and may share driving responsibility.

Source: (JA3163, p. 6)

2.1.3.3 Peer-to-Peer

“A marketplace—typically an online platform—facilitates transactions among individual buyers and sellers of personally owned and operated mobility services, in exchange for a transaction fee.” An example for peer-to-peer sharing is Personal Vehicle Sharing, which is “a service that provides the traveler on-demand, short-term access to a fleet of personally owned motor vehicles and for a fee for use. Vehicle hosts own and maintain the vehicle fleet. Vehicle hosts and drivers broker transactions using an online-enabled application or platform (i.e., smartphone app) provided by a personal vehicle sharing company. The personal vehicle sharing company may provide resources and services to make the exchange possible (e.g., an online platform to facilitate the transaction, customer support, etc.). Personal vehicle sharing companies do not own or maintain a fleet of vehicles. Personal vehicle sharing is also referred to as ‘peer-to-peer carsharing.’

Source: (SAE JA3163, p. 4)

2.1.3.4 For-Hire Ride Services

This section describes various forms of for-hire ride services.

2.1.3.4.1 Taxi

“A service that provides the traveler pre-arranged and/or on-demand access to a ride service in a motor vehicle for a fee for use. The travelers can typically access this ride by scheduling trips in advance, by street hail, or by e-hail. Street hail is done by raising a hand on the street, standing at a taxi stand, or specified loading zone. E-hail entails dispatching a driver on-demand using a smartphone app. Taxi ride service typically uses sequential sharing (although taxi splitting—the sharing of a taxi ride and fare between two travelers—is allowed in some areas). The term compensation denotes a service that charges a fare above the actual cost of driving.”

Source: (JA3163, p., 5)

2.1.3.4.2 Water taxi

“Any vessel for hire on-demand that is operated between a point of origin and a destination point different from the point of origin.”

Source: (JA3163, p., 7)

2.1.3.4.3 Transportation Network Company (TNC)/ Ridehailing/Ridesourcing

“A service that provides the traveler with pre-arranged and/or on-demand access to a ride for fee using a digitally enabled application or platform (e.g., smartphone apps) to connect travelers with drivers using their personal, rented, or leased motor vehicles. Digitally enabled applications are typically used for booking, electronic payment, and ratings. TNCs are not allowed to street hail (on-demand does not include street hail). The term compensation shall denote a service that charges a fare above the actual cost of driving. Concurrently shared TNC ride service is referred to as “ridesplitting” as defined in Section 2.1.1.9. TNCs may also be used to provide goods delivery, known as courier network services.”

Source: (JA3163, p., 5)

2.1.3.4.4 Ridesplitting/Ridepooling

“A concurrently shared commercial ride service in a motor vehicle where the traveler is matched with other riders traveling along a similar or identical route.”

Source: (JA3163, p., 5)

2.1.3.4.5 Microtransit

“A technology-enabled transit service that typically uses shuttles or vans to provide pooled on-demand transportation with dynamic routing. Typically, microtransit services are operated by or provided on behalf of a government entity or nonprofit organization but privately operated microtransit programs may also exist. Variations could include fixed schedules and routes and larger or smaller vehicles”

Source: (JA3163, p., 6)

2.1.3.4.6 Informal Ride Service (e.g., jitneys)

“A concurrently shared unlicensed commercial ride service. Also referred to as ‘jitneys.’”

Source: (JA3163, p., 6)

2.1.3.4.7 Shuttle

“A service typically employed using vans or buses that connect travelers between a common origin or destination to public transit, retail, hospitality, or employment centers.”

Source: (JA3163, p., 6)

2.1.3.4.8 Pedicab

“A for-hire ride service in which a cyclist transports traveler(s) on a tricycle with a passenger compartment. Service may be concurrently or sequentially shared.”

Source: (JA3163, p., 6)

2.1.3.5 Rental

This section describes the car rental service.

2.1.3.5.1 Car Rental

“A service that provides the traveler with access to a shared fleet of commercially owned motor vehicles for short periods of time (typically one day to a few weeks) usually for a fee. Gasoline (and/or EV charging) and insurance may be provided for an additional fee. Car rental companies typically own and maintain the vehicle fleet.”

Source: (SAE JA3163, p., 4)

2.1.3.6 Personal (Owned)

Personal Vehicle Sharing is “a service that provides the traveler on-demand, short-term access to a fleet of personally owned motor vehicles and for a fee for use. Vehicle hosts own and maintain the vehicle fleet. Vehicle hosts and drivers broker transactions using an online-enabled application or platform (i.e., smartphone app) provided by a personal vehicle sharing company. The personal vehicle sharing company may provide resources and services to make the exchange possible (e.g., an online platform to facilitate the transaction, customer support, etc.). Personal vehicle sharing companies do not own or maintain a fleet of vehicles. Personal vehicle sharing is also referred to as ‘peer-to-peer carsharing.’”

Source: (SAE JA3163, p., 4)

This section creates a model and set of categories that describe mobility services.

2.2 MAT Functions

This section describes the set of functions that are included in MAT. The functions are used to characterize the projects and use cases and provide a consistent ontology to compare them and to identify gaps and overlaps in their deployments.

2.2.1 Trip Planning functions

Trip planning is one of the key functions of MAT. A good definition of this area is given below:

“A journey planner, trip planner, or route planner is a specialized search engine used to find an optimal means of travelling between two or more given locations, sometimes using more than one transport mode. Searches may be optimized on different criteria, for example fastest, shortest, fewest changes, cheapest. They may be constrained, for example, to leave or arrive at a certain time, to avoid certain waypoints, etc. A single journey may use a sequence of several modes of transport, meaning the system may know about public transport services as well as transport networks for private transportation. Trip planning or journey planning is sometimes distinguished from route planning, which is typically thought of as using private modes of transportation such as cycling, driving, or walking, normally using a single mode at a time. Trip or journey planning, in contrast, would make use of at least one public transport mode which operates according to published schedules; given that public transport services only depart at specific times (unlike private transport which may leave at any time), an algorithm must therefore not only find a path to a destination, but seek to optimize it so as to minimize the waiting time incurred for each leg.” (https://dbpedia.org/page/Journey_planner)

Given the definition of trip planning, the following parameters are included:

- Origin and destination(s)
- Typical optimization parameters (e.g., shortest distance, least cost, minimize transfers),
- Mobility service preferences (e.g., transit, carsharing, walking, bikesharing, ridehailing),
- Right of way preferences (e.g., cycle track, non-highway)
- Alert preferences (e.g., real-time alerts for a specific mobility service) including preferred communication channel (e.g., email, SMS), and presentation
- Other trip considerations such as walkability, safety, accessibility (e.g., curb cuts, audio crosswalk signal)

The trip planning function may be executed without saved parameters or may be based on user preferences saved in a trip planning account for which a traveler registers and accesses via secure login procedures.

A trip plan can include a map and/or text with turn-by-turn directions. The output may be printed, rendered as a digital image, or downloaded as a file that can be displayed by an online map application.

2.2.2 Wayfinding/Navigation functions

The next key area of MAT functions is Wayfinding/ Navigation. Wayfinding refers to "the process or activity of ascertaining one's position and planning and following a route." (Oxford Dictionary) Navigation is defined as "the process or activity of accurately ascertaining one's position and planning and following a route." (Oxford Dictionary)

In other words, wayfinding and navigation provide directions that guide people through a physical environment using maps, landmarks, paths, signs, and other decision points (hereafter referred to as waypoints). Wayfinding includes the execution of trip plans that include orienting the traveler to a location along a path through time and space waypoints. Various waypoints assume different time/space conditions and travelers are oriented using various notification technologies and detailed alerts.

Crosswalk includes (e.g., a pedestrian crossing or a bike queue jump):

- Travelers are guided through crosswalks depending on the traveler (e.g., with a visual impairment) and their conveyance (e.g., bicycle, pedestrian).
- Additional sensors or message transactions may be available to alert the signal controller to the presence and intention of a traveler to cross the intersection or flow in a specific direction (e.g., pedestrian crossing request).

Traveler notifications may be generated:

- Based on time or geographic triggers. For example, the traveler can be notified of the arrival of a bus or hailed vehicle, or to modify a traveler's journey
- For anomalies with the mobility services that are part of the traveler's trip plan (e.g., late bus arrival)
- For navigation purposes (e.g., turn-by-turn directions) or to alert the traveler that they are approaching a specific waypoint or landmark

Routing includes the following:

- Guides travelers to their destination by providing route directions while driving a car or riding a MMV, taking transit, locating and hailing mobility services, or walking.
- Preferences may be based on the inclusion or exclusion of specific public right of way types for walking (sidewalk, park, alley, parking lot), MMV (cycle tracks, bike lanes), or driving (toll roads, highway, arterials), and indoor navigation (elevator, escalator, stairs).
- Orientation to parking (e.g., lots, garages) and parking spaces.
- Transitions between mobility services including finding pickup/drop off locations and boarding/alighting vehicles.
- Destination finding supporting indoor to outdoor transitions (and vice versa) and locating destinations within a facility.

Time-based transitions (connections and detours)

    - Transitions between mobility services and obstacles to travel provide real time changes to expected journeys. These time based transitions include transfers between mobility services (e.g., transfer between buses, planes/bus, bus/train, etc.) and detours due to unplanned (incidents) or preplanned events (construction, special events).

- Predictive wayfinding information (dynamic space / time routing)

2.2.3 Reservations functions

The Reservations function includes two types of functions – user-facing booking and confirmation (including cancellation and change options), and backend dispatch, schedule, and operations functions

- User reservations – provide services for a traveler to book a mobility service for one or more travelers with specific preferences (origin-destination, pickup/dropoff time, accessibility, quality features, concierge services, and conditions such as luggage, buggy, number of passengers). The reservations may also include request for booking update, estimated time of arrival/departure, cancellation, postponement or detour.
- Dispatch and Scheduling – provides functionality to
  - Match and confirm vehicle and vehicle type availability, estimate pickup / dropoff places and times and user preferences
  - Schedule vehicle and driver based on reservation confirmation (may be on-demand)
  - Alert user on vehicle arrival / departure (based on their preferences) and current ETA (at origin and/or destination)
  - Provide driver with manifest of travel directions (pickup / dropoff locations and times, passenger information)
  - Manage travel plans based on unplanned events (incidents, detours)
  - Monitor passenger comfort and safety (esp. for AV)

2.2.4 Mobility Payment Integration

Multimodal, multi-agency (or provider) mobility service systems, usually relying on Electronic Fare Payment Systems (EFPS) and potentially combining two or more payment convergence, shared mobility, Mobility-as-a-Service, Payment-as-a-Service, or Software-as-a-Service elements, are growing in prevalence and popularity. These emerging and future payment integration strategies reflect a new model for public transportation agencies and are referred to in the literature as mobility payment integration (MPI) systems. As such, considerations of all these elements are discussed given their relevance across a diverse range of MPI deployments. Such deployments are driven by a consumer market that increasingly expects to pay for mobility services like any other good or service. (source: CTR-C MPI Task 2 Report. Internal document to FTA, May 2022). The functions across all the various payment systems depend on Product Rules driven by service, usage and commercial rules, benefits and discounts, and payment methods (i.e., the provision of access rights such as a ticket, proof of purchase or QR validation). The categories included for Mobility Payment Integration include the following:

- Product (service, usage and commercial)
  - Service Rules --Transit, parking, TNC, peer (carpooling), tolls (incl. dynamic pricing)
  - Usage Rules -- Pricing / Tariff (rules for usage)
  - Commercial rules for settlement among multi-agency sharing agreements (data, liabilities, refunds, etc.)
- Discounts/ benefits (including Guaranteed ride home vouchers, capping, free fare)
- Payment methods (e.g., media including virtual, card with NFC, QR, proprietary smartcard)

2.2.5 Eligibility Processes

Eligibility processes comprise the requirements for entitlement of travelers to participate in specific mobility service programs. In particular for public transportation, provisions are made for complementary paratransit service for people with disabilities or reduced or free fare for vulnerable travelers (low income, older adults, etc.). Other programs provide benefits and services for people from specific organizations (students, health transportation, and work transportation options).

“The ADA establishes three general eligibility categories, or three general criteria for determining which riders are eligible for ADA paratransit.

1. **Can't Navigate the System Independently.** A person who cannot navigate the transit system without assistance is eligible for ADA paratransit. Examples include the following:

- A person who cannot navigate the transit system without assistance is eligible for ADA paratransit.
- An individual with a cognitive disability, if he doesn't know where to get off the bus.
- A person with a vision disability who cannot travel in an unfamiliar location or cannot navigate complex transfers.
- A person whose lack of manual dexterity and lack of balance makes her unable to stand up and hang on, so she always needs a seat on the bus or train (since a seat cannot always be guaranteed).

2. **Needs an Accessible Vehicle.** Also eligible are people with disabilities who can use accessible buses—that is, vehicles with lifts, ramps, or other boarding assistance devices—when they want to travel on routes that are still not fully served by accessible buses, or when their bus stop is not accessible due to physical characteristics of the stop. Inaccessible bus routes or bus stops trigger eligibility.

The United States Department of Transportation (DOT) regulation Appendix D, which provides interpretive guidance on the regulation, states that a bus route as accessible when all buses scheduled on the route are accessible. A route with every other bus accessible is not fully accessible. So, a person in this eligibility category who travels in that route's corridor would have paratransit eligibility until every bus on every run is accessible.

A person is also eligible for paratransit when boarding or disembarking at a bus stop is not possible due to the inaccessibility of the stop. In addition, if the lift or ramp on a vehicle cannot be deployed at a particular stop, an individual with a disability who needs to use the lift or ramp at that stop is eligible for paratransit under this category. However, the ADA contains strict rules about buses serving every stop with the lift or ramp. The transit agency may not refuse to permit a passenger who uses a lift or ramp to board or disembark from a vehicle at any designated stop unless the lift cannot be deployed at the stop, or unless the lift will be damaged if it is deployed, or unless all passengers are precluded from using the stop due to temporary conditions at the stop that are not under the control of the transit agency.

People are also eligible if they can use accessible trains, but they want to travel on an inaccessible light rail or rapid rail line. A rail line is not considered accessible until a transit agency has made all key stations accessible and provided at least one accessible car per train. If an area is served by both bus and rail, even if the bus service is 100 percent accessible, riders have paratransit eligibility if they are traveling to and from stops where key stations are not accessible.

Some cannot use the fixed route system when the stops are not called.

Another key feature needed to make the fixed route system accessible to certain people with disabilities is stop announcements. Some people who are blind or have vision impairments and some people with cognitive disabilities are unable to use the fixed route system when the stops are not called. In these cases, such riders have paratransit eligibility until the problem is remedied and the fixed route system becomes accessible.

3. **Obstacles Prevent Reaching the Bus or Train**. Also eligible is anyone who, because of a disability, cannot travel to or from the bus stop or train station due to, for example, distance, terrain, weather, safety, or other obstacles that impede them due to their disability. To trigger eligibility, the obstacles must hinder the individual beyond simply being inconvenient. At the same time, it is not

necessary for independent travel to be completely impossible. As the DOT ADA regulation Appendix D states:

> Inevitably, some judgment is required to distinguish between situations in which travel is prevented and situations in which it is merely made more difficult. In the Department's view, a case of "prevented travel" can be made not only where travel is literally impossible (e.g., someone cannot find the bus stop, someone cannot push a wheelchair through the foot of snow or up a steep hill) but also where the difficulties are so substantial that a reasonable person with the impairment-related condition in question would be deterred from making the trip.[10] This has come to be called the "reasonable person" test.

Travel is "prevented" if a reasonable person with the disability would be deterred from making the trip.

For example, an individual with an ambulatory disability may be able to go six blocks to a bus stop but doing so takes so long and is so physically difficult that it affects him for the rest of the day. While not physically impossible, a reasonable person would be deterred from making this trip." (Marilyn Golden and Russell Thatcher, "Topic Guides on ADA Transportation: Eligibility for ADA Paratransit," prepared for the Federal Transit Administration, June 2010, © 2010 DREDF and TranSystems Corporation, https://dredf.org/ADAtg/elig.shtml#:~:text=A%20person%20who%20cannot%20navigate,to%20get%20off%20the%20bus)

The Eligibility category goes beyond the ADA eligibility categories by including eligibility processes for the following services:

- Services restricted for vulnerable communities
- Services restricted for specific populations
- Service restricted for special programs (e.g., work, health, students, employers)

2.2.6 Data Collection and Distribution

Collecting, curating, and distributing information on places, paths, and routes is a critical element of the multimodal and accessible travel platforms and services. The functions apply to public right of ways (PROW) of a variety of modal pathways – pedestrian (by accessibility, and indoor/outdoor), MMV (by class), and vehicle (by class). And the PROW characteristics include both temporal and location attributes whose currency may be static, periodic, or dynamic. Dynamic pathways may refer to microtransit and vanpool paths that are based on ordered stops between pickup and drop-off places (that may trigger traveler alerts). They also include information on events that impact static paths such as obstacles to travel or conditions related to travel (e.g., congestion, blocked sidewalks). The range of modal pathways include the following:

- Collect Information (places, links, junctions, and attributes) on **Static Modal Pathways**
- Generate Information on **Dynamic Modal Pathways**
    - Ad hoc modal paths (places, links, junctions, and attributes)
    - Obstacles to travel (changes to places, links, junctions, and attributes)
    - Conditions that impact travel (changes to attributes)
    - Generation of triggers that alert travelers (change to event trigger based on arrival based on travel rate of change)
- Generate **Path Cost** based on static and dynamic conditions and attributes of each place, link and junction along a route.
- **Transfer map** data -- general and personalized path information (Map places, links, junctions and attributes and Path Cost) from map server to map server including the following:
    - Indoor map transfer and update
    - ROW map transfer and update
    - PROW map transfer and update
    - MMV (by class) path map transfer and update
- Institutional / Portal – provides governance and access over collections of data

2.2.7 Hardware and Physical Elements

Although not a function, projects and use cases explore hardware and physical elements that are needed for MAT functions. The three main elements that enable MAT include the following:

- **Traveler securement** of MMVs and mobility scooters in conveyances. These include the following:
  - Wheelchair/mobility scooters securement in buses, rail cars, vans, and automated vehicles
  - Bike racks that transport bikes of all types on buses and other conveyances
- **Indoor navigation sensors** and systems used to enable wayfinding and orientation for travelers navigating in indoor or closed facilities not easily navigable using Global Navigation Satellite System (GNSS). In addition to indoor facilities, outdoor transit hubs surrounded by concrete structures or underground parking garages are examples of facilities that may be of need of fielded navigation sensors. Types of sensors include Bluetooth, WiFi, NFC, LiDAR. The indoor navigation area may also include optimization of message transmission, message content and format, and other best practices with deploying the sensors to support MAT.
- **Payment equipment and systems** varies depending on the validation method and access rights, e.g., QR code, NFC, flash pass, cash, ticket. It also depends on the payment architecture whether the system is card- or account-based or open payment (e.g., merchant using bank card).

Section 3 MAT Projects and Use Cases

This section describes the variety of Projects and Use Cases that have been considered for the analysis of use case gaps.

3.1 MAT Projects

Many USDOT-sponsored projects provide insight into the use and adoption of MAT standards. The projects also identify concepts that are ready for deployment while pushing the edge of innovation. Most of the projects are using standards, emerging standards and open specifications in their design. The results of these projects, (even without related use cases), provide insight into the requirements, lessons, and priorities of the industry. The projects were reviewed against the same mobility services and functions as the use cases. Most of the projects included USDOT-sponsored programs as well as international projects of significant interest.

3.1.1 USDOT Sponsored Programs

The USDOT sponsored programs include the following:

Integrated Mobility Innovation (IMI), a program led by FTA which "supports the transit industry's ability to leverage and integrate mobility innovations with existing services, while examining the impact of innovations on agency operations and the traveler experience." (Extracted from https://www.transit.dot.gov/IMI on 4/13/2022.) This program includes 23 projects, 20 of which are included in the assessment. Information for the analysis was derived from USDOT published descriptions and internal discussions and documents for the IMI Demonstration Program. Details of these deployments are described in Annex C.

Accelerating Innovative Mobility (AIM), a program led by FTA which drives "innovation by promoting forward-thinking approaches to improve transit financing, planning, system design and service. The AIM Initiative also supports innovative approaches to advance strategies that promote accessibility, including

equitable and equivalent accessibility for all travelers." (Extracted from https://www.transit.dot.gov/AIM on 4/13/2022). Information for the analysis was derived from USDOT published descriptions and internal discussions and documents for the AIM Demonstration Program. This program includes 25 projects, 11 of which are included in the assessment. Annex C.

Mobility on Demand (MOD) Sandbox— The MOD Sandbox program "[a]dvanc[es] … the vision of MOD and carefree mobility; the Sandbox allows communities to creatively leverage a range of mobility options from bike- and car-sharing systems to demand-responsive bus services. The program integrates payment systems as part of a suite of concepts, technologies, and solutions with the potential to advance the Complete Trips for All vision that sits at the center of FTA's mobility innovation research efforts." (Extracted from https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program on 7/21//2022). Information for the analysis was derived from USDOT published documents. This assessment includes 11 projects described in Annex C.

Complete Trip ITS4US, a program led by the ITS JPO which "identifies ways to provide more efficient, affordable, and accessible transportation options for underserved communities that often face greater challenges in accessing essential services." (Extracted from https://www.its.dot.gov/its4us/index.htm on 4/13/2022). During the Phase 1 Deployment Conceptual, five deployments develop Concept of Operations documents that included use cases. These use cases were used in the evaluation of this Use Case Review. The five project descriptions, adopted from https://www.its.dot.gov/its4us/index.htm, are described below:

- **Health Connector for the Most Vulnerable** (Heart of Iowa Regional Transit Agency) -- this project will 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 to barriers with the use of advanced technologies. Further, this solution will include information and wayfinding services to guide users for every step of their trip. This deployment will provide enhanced access to healthcare options for "all travelers" in Dallas County.
- **Safe Trips in a Connected Transportation Network (ST-CTN)** (Atlanta Regional Commission) – this project will provide Gwinnett County residents with detailed information and step-by-step navigation tailored for users' specific needs along with a range of other features geared to improve trip efficiency and safety. This concept is comprised of an integrated set of advanced transportation technology solutions including connected vehicles, transit signal priority, machine learning, and predictive analytics to support safe and complete trips, with a focus on accessibility for those with disabilities, aging adults, and those with limited English proficiency. The ST-CTN system includes a mobile application that will provide users with the ability to create a personalized trip plan with information regarding the navigation of physical infrastructure, the ability to provide safe alternative trip routes when encountering unexpected obstacles and ensuring users safety throughout the trip.
- **Trip Planning for All** (California Association of Coordinated Transport (CALACT)) – this project will deploy in an area covering California, Oregon, and Washington. The project will improve underserved travelers' access to information about available transportation modes and to streamline their ability to book and pay for multimodal trips. The project will define extensions to the General Transit Feed Specification (GTFS) in response to the trip planning needs of underserved riders and develop new data standards related to demand responsive booking integration. Implementation assistance will include developing guidelines for data producing systems and providing technical assistance to agencies and vendors in order to encourage use of these new standards.
- **Transportation Data Equity Initiative,** (University of Washington) – this project aims to create the foundational data tools necessary for both public and private entities to collect, share, manage, and use transportation data that provide equitable outcomes to all travelers regardless

of location, income, or disability. This effort includes: 1) working with existing standards committees to extend and update three existing, early-stage international data standards: OpenSidewalks, GTFS-Flex, and GTFS-Pathways; 2) developing a series of tools that help agencies, jurisdictions, and other stakeholders collect the data that can be stored with these refined data standards; and 3) using three unique accessible mobility applications to demonstrate these three very different uses of the data.

- **Complete Trip Deployment in Buffalo, NY** (ICF) – this project will deploy new and advanced technologies focused on addressing existing mobility and accessibility challenges. The project integrates an accessible trip planning tool with current transit services, indoor/outdoor wayfinding, community-based on-demand shuttle services that include a fleet of fully autonomous shuttles, and intersection pedestrian safety technologies aimed at providing complete trip support to travelers with disabilities in BNMC and neighboring communities. Central to the project is a complete trip platform that is able to factor in travelers' preferences and accessibility-related needs in providing comprehensive trip planning and execution support to registered users. The platform, accessed both offline and online via multiple interfaces including an app, will integrate with multiple enabling technologies and services including fixed route transit, community shuttles, smart intersections that use tactile and mobile technologies that assist travelers with disabilities navigate intersections safely, and wayfinding Infrastructure such as smart signs and information hubs to support outdoor and indoor navigation.

Of the five projects, four were awarded Phases 2 and 3 (Deployment and Evaluation) contracts. They include the Health Connector, ST-CTN, Transportation Data Equity Initiative, and Complete Trip Deployment Buffalo, NY. In addition, two of the projects changed "ownership." The Buffalo, NY project is now lead by the Niagara Frontier Transportation Authority (NFTA) and the ST-CTN project is now led by the Georgia Department of Transportation (GDOT).

Several **Connected Vehicle pilots** include technologies that support vulnerable road users including pedestrian crossing (PED-X) that included priority requests by pedestrians from their mobile phones. The pilots include New York City DOT and Tampa Hillsborough Expressway Authority (THEA).

One older USDOT initiative, the **Accessible Transportation Technologies Research Initiative** (ATTRI), is relevant in this effort. ATTRI was a joint USDOT initiative, co-led by the Federal Highway Administration (FHWA), Federal Transit Administration (FTA), and Intelligent Transportation Systems Joint Program Office (ITS JPO), with support from the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR), and other federal partners. This program is leading efforts to develop and implement transformative applications to improve mobility options for all travelers, particularly those with disabilities. ATTRI research focuses on removing barriers to transportation for people with visual, hearing, cognitive, and mobility disabilities. Emerging technologies and creative service models funded by ATTRI are offering all Americans enhanced travel choices and accessibility at levels. The USDOT has awarded application development funding for Wayfinding and Navigation, Pre-trip Concierge & Virtualization, Safe Intersection Crossing with NIDILLR awarding a grant in the Robotics and Automation technology area.

Within the ATTRI, the following projects are included in this review:

- **pathVu is developing AccessPath**, a pedestrian wayfinding app tailored towards wheelchair users and people with visual impairments. Typical pedestrian wayfinding apps do not use the sidewalk network to provide navigation, nor do they know the quality of the routes that they direct their users. In addition, these apps are not user-friendly for people with disabilities. AccessPath considers the pathway network, quality of routes, and user settings when suggesting pedestrian routes to travel. AccessPath can be used for pre-trip planning or real-time navigation.

- **The Specialized Media for Assisting Route Travel (SMART)** is a new standardized approach for communicating travel instructions to individuals who can benefit from person-centered instructions designed to meet their specific information access needs. The SMART Wayfinding Specification is provided as an open source application programming interface (API) and defacto standard for transportation related app developers to interface with new or existing travel related applications, with the goal of promoting increased independence in transportation for travelers with disabilities and others with special travel needs. The foundation of the SMART Wayfinding Specification is built upon a transportation application initially developed by AbleLink Smart Living Technologies, LLC. that has been successfully used since 2010 to enable more independent travel for individuals with cognitive disabilities.
- **The Smart Living Concierge System (SLCS) project** is aimed at creating a series of cognitively accessible tools designed to support pre-trip assessment, training, planning, and virtualization to promote greater access to fixed route transportation services for individuals who may otherwise be reliant on paratransit. This resulted in the SLCS, comprised of four subsystems designed to support self-assessment of current transportation skills, general training on those skills, personalized tools to support timely and accurate completion of pre-trip preparation activities, and to virtually experience trips prior to actual engagement in travel.
- **The PedPal project** aims to develop a mobile app that enables pedestrians with disabilities to more safely and more efficiently cross signalized intersections. The proposed technology concept is a smart phone app that interacts directly with a real-time, adaptive traffic signal control system at the intersection via 3G/4G wireless ration technology or via Dedicated Short Range Communication (DSRC) radio technology. Basic capabilities will enhance safety by allowing the user (1) to communicate crossing intent and required crossing time, and receive an extended crossing duration, (2) to receive feedback if movement outside of the crosswalk is detected during crossing, and (3) to dynamically extend the crossing duration if slower than expected crossing progress is observed. Advanced capabilities will include anticipation of the user's arrival at the intersection and minimizing wait time and (2) utilizing real-time bus information to better synchronize user arrival times at bus stops.
- The Mobility Assistance for People with Cognitive Disabilities (MAPCD) project is one (1) of eight (8) projects in the Smart Columbus portfolio. The project is meant to enable people with cognitive disabilities to travel more independently on fixed-route bus service. The project team includes City of Columbus staff, subject matter experts with the Central Ohio Transit Authority (COTA) and The Ohio State University (OSU), and participating individuals with cognitive disabilities. The goals of the MAPCD project are the following:
    - Allow travelers with cognitive disabilities to transition from using paratransit services to independent travel using fixed-route bus service
    - Provide caregivers with an interface to create individual routes for travelers and be able to view traveler's progress on a map
    - Collect anonymized data on app usage and travel behavior in the Smart Columbus Operating System (OS) for performance measures and analytics

3.1.2 Other Projects

MAT projects that are of significant interest, but are outside of the USDOT grant programs include the following:

asSIsted Mobility for Older aNd impaired users (SIMON) (Simon) is a demonstration project with four large scale pilots in Madrid, Parma, Lisbon and Reading aiming to use Information, Communications, and Technology (ICT) services to promote the independent living and social participation of mobility impaired people in the context of public parking areas and multiple transport modes. It focuses on the reduction of fraud in the pre-ICT implementation of the European Disabled Badge for public parking areas and the use

of specific navigation solutions for elderly and people with disabilities. SIMON services are classified into the following:

- Validation services: SAYS and OPENS deal with the user authentication and validation. Two main situations have been considered: validation at the parking spaces and access to restricted areas. Several security tokens are combined in different ways: mainly personal enhanced ID card (blue badge), smartphones, standard mobile phones or park meters.
- Navigation services: SIMON ANSWERS enable multimodal as well as hybrid (outdoor-indoor) navigation in the cities by exposing several service end-points to the citizen application, namely geographic services and navigation services. The setting up of different user profiles determines how the routes will be computed, based on walking speed or accessibility needs.
- Information services: SIMON BOOKS provides the functions to determine availability of parking places, by offering an end point with methods that allow querying the available parking spaces near a given position. Occupancy status (free, occupied, all) is provided to the users in the map of parking places. SIMON ANSWERS also provides information services about city elements, accessibility, etc. that are closely related to the navigation functions.

SIMON applications act as human interface within these services:

- SIMON Mobile app enables users to navigate through the target cities in a multimodal fashion that is adapted to their preferences and abilities, also allowing validation of authorized parking cards. Towards this end, it integrates navigation services, validation services, and information services related to mobility in a single application that is adapted to the needs of mobility-impaired persons.
- SIMON CONTROLS is the mobile application used by the authorized controller to check the validity of parking rights of end users. It is responsible for verifying that a user has been correctly validated in the system for occupying or leaving a parking space. In case of not validation or fraud, the controller is able to notify and impose a penalty to the user through the application.
- SIMON Authority Operator Tool is the web-based application that allows the Public Authority the management of authorized parking badgeholders as well as to obtain statistics and reports of the use drivers do of reserved parking places.

EuTravel Project. The EuTravel vision is to contribute towards the realisation of a sustainable and open single European market for mobility services by: 1. enabling travel users (both businesses and private) to easily organise a door-to-door pan-European multimodal trip in accordance with their own set of criteria including environmental performance; 2. providing multimodal travel service providers an easy and cost-effective way to deliver optimal customised services to cater for any type of specialised multimodal travel needs; 3. supporting policy decision making by contributing to the implementation of standards and regulations and facilitating fact-based EU policy making. For each user group [1], two use cases are reported:

- Traveller inserting his / her profile information in the EuTravel system, showing how the user can insert his profile data and travel preferences into the EuTravel system;
- Traveller planning a door-to-door trip for one of the cross-border travel itineraries through the EuTravel system

Service Provider's perspective Use Cases (for Rail transport operator, Ferry GDS Provider), aimed to show how the EuTravel system interacts with the systems (e.g., API) of transport operators and or GDS in order to:

- Request and gather necessary transport services data to plan a multi-modal travel itinerary requested by the user
- Question the transport operators / GDSs systems to perform booking and payment transactions, in order to allow the user to reserve and purchase his / her preferred travel solution

Leicester City Council journey planner for the 'Choose How You Move' website, part of the Council's 'Enhanced Behaviour Change Programme' which is funded by the Joint Air Quality Unit. The programme aims to improve air quality and encourage people to use more sustainable modes of transport, such as walking and cycling. By integrating SkedGo's technology into the website, residents and visitors can visualise their current and new journeys and understand the benefits of active travel and sustainable transport to move around the city.

Empresa Municipal de Transportes de Madrid (EMT) is a not-for-profit public company owned by the City Council of Madrid, charged with the management of the bus service, public e-bikesharing service (BiciMAD), cable car, and underground parking facilities. The aim of MaaS is to provide sustainable mobility solutions and a reliable alternative to private cars. Given the large number of services and operators present in Madrid, MaaS facilitates the users' experience, raising awareness regarding the wide choice (AriasMolinares & García-Palomares, 2020). The app, Madrid Mobility 360, is innovative because it offers information on free floating services (including battery level for e-vehicles), as well as user information on bus occupancy levels.

This information regarding the projects will be used to identify priority services and functions and compared against the use cases to identify overlap and gaps in use case development. A summary of the related mobility services and functions are included below.

3.1.3 Analysis of MAT Projects

This section provides an analysis of the projects that summarizes the MAT categories included in the projects reviewed for this summary. Fifty-five (55) projects were reviewed. They varied in the state and sustainability of the project. For example, the ITS4US projects just completed their concept phase, while many of the international projects have been piloted or are operational.

Several assumptions were made in entering data for the projects for mobility services and functions.

A single **MAT Function** entry was entered for each project.

MAT Mobility Services (vehicle types and services) were entered for each conveyance type paired with a service or cooperative type for projects and use cases. If more than one conveyance was deployed (or included in a use case), then it was coded as a single entry with its paired service or cooperative type. For example, the Buffalo ITS4US project includes three conveyance types (i.e., pedestrian/pedestrian with assistive device, van, and CAV); the pedestrian/pedestrian with assistive device is entered without any service or cooperative types, the van is implemented as demand responsive /shared ride, and the CAV as a flex/shared ride. The three conveyances were counted as three types of mobility services.

3.1.3.1 Summary of Project Conveyance, Service, and Cooperative Types

One hundred twenty-nine (129) mobility services of varying combined conveyances, service and cooperative types are being deployed by the projects (meaning that many of the 55 projects apply to more than one mobility service). The discrete types for conveyances (Figure 2) service types (Figure 3) and cooperative types (Figure 4) are summarized below. Not surprisingly, the highest density of conveyance types falls into public transportation types – Bus, Van, and Commuter Rail (CR). Pedestrians are also covered, but still less than a quarter of the number of projects. Interesting, micromobilty vehicles (MMV) – both motorized and non-motorized (e.g., e-bikes, e-scooters, bikes) are not included in many projects. This might be expected given that most of the projects were sponsored by FTA. Cars are included in a significant

number of projects. In most cases, cars are paired with DR service and/or Shared/Peer cooperative types (see analysis in Section 4).

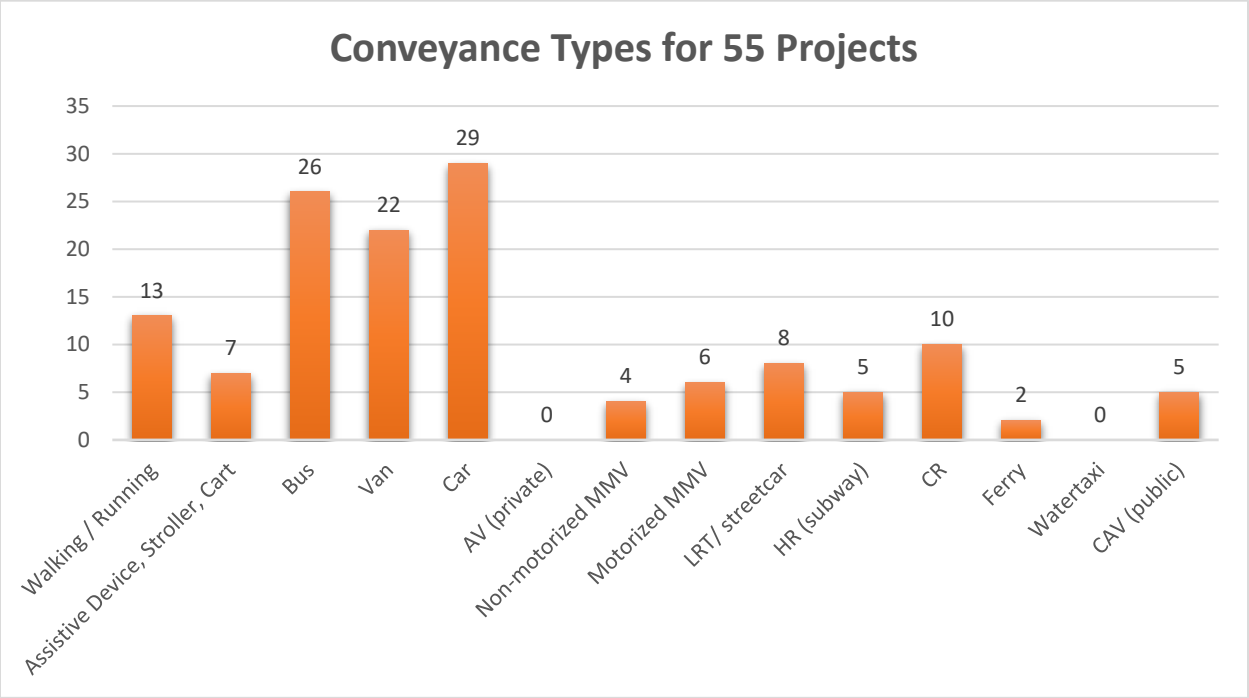

Figure 2. Project Summary: Conveyance Types

Fixed and demand-responsive services are a part of most of the projects. The other types of services (flex or microtransit services or shared use MMV docked / dockless) show up in only about 20 percent of the projects.

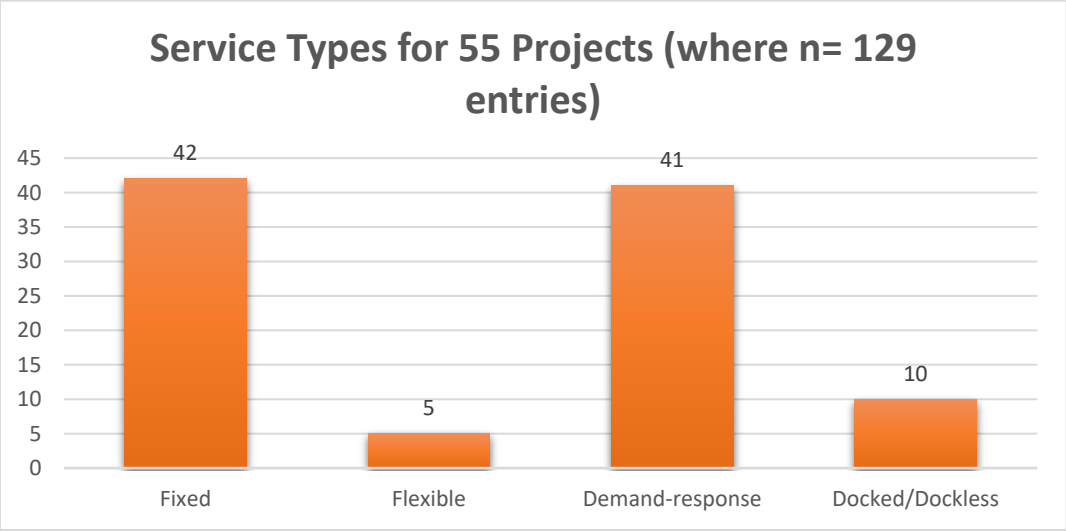

Figure 3. Project Summary Service Types

Finally, shared use (concurrent and sequential) cooperative services were deployed more often than any other cooperative type (a total of 87 of 129 entries). Pooled cooperative types accounted for less than half the number. Traditional cooperative type deployments were minimal.

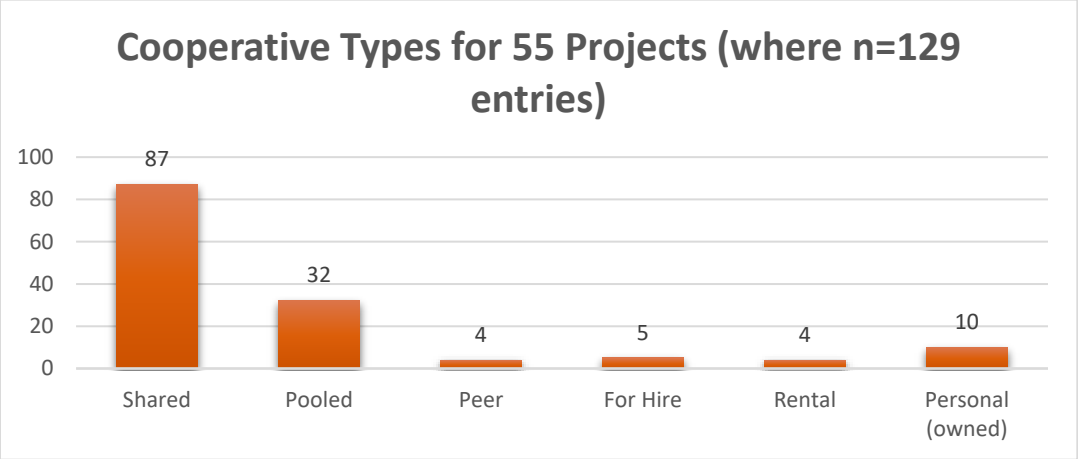

Figure 4. Project Summary Cooperative Types.

3.1.3.2 Summary of Project Mobility Services

A cross correlation of the Mobility Services data was conducted to identify the combination of conveyances, service and cooperative types. Table 1 shows the set of categories that were defined. The correlation of projects to these categories is summarized in Figure 5.

Table 1. Mobility Service Types (Combination of Conveyance, Service and Cooperative Types)

Code	Conveyance Type	Service / Cooperative Type
VRU0	Ped (ped / asst device)	if Ped without any service/coop type
VRU1	MMV (motorized / non-motorized)	if (MMV) then Service type =docked
VRU2	MMV	if (MMV) then Coop Service = shared
VRU3	MMV	if (MMV) then Coop Service = pooled
VRU4	MMV	if (MMV) then Coop Service = peer
VRU5	MMV	if (MMV) then Coop Service = for hire
VRU6	MMV	if (MMV) then Coop Service = rental
VRU7	MMV	if (MMV) then Coop Service = owned
FixedRail	rail (lrt, hr, cr, ferry)	if (Rail) then Service Type = fixed
Fixed (tire)	multiride (Bus, van, car, CAV)	if (multiride) then Service Type = fixed
Flex	multiride	if (multiride) then Service Type = Flex
DR	multiride	if (multiride) then Service Type = DR
Shared	multiride	if (multiride) then Mobility Type = shared
Pooled	multiride	if (multiride) then Mobility Type = pooled
Peer	multiride	if (multiride) then Mobility Type = peer
Hire	single ride (water taxi, AV, car)	if (single ride) then Mobility Type = for hire
Rental	single ride	if (single ride) then Mobility Type = rental
Personal	single ride	if (single ride) then Mobility Type = personal

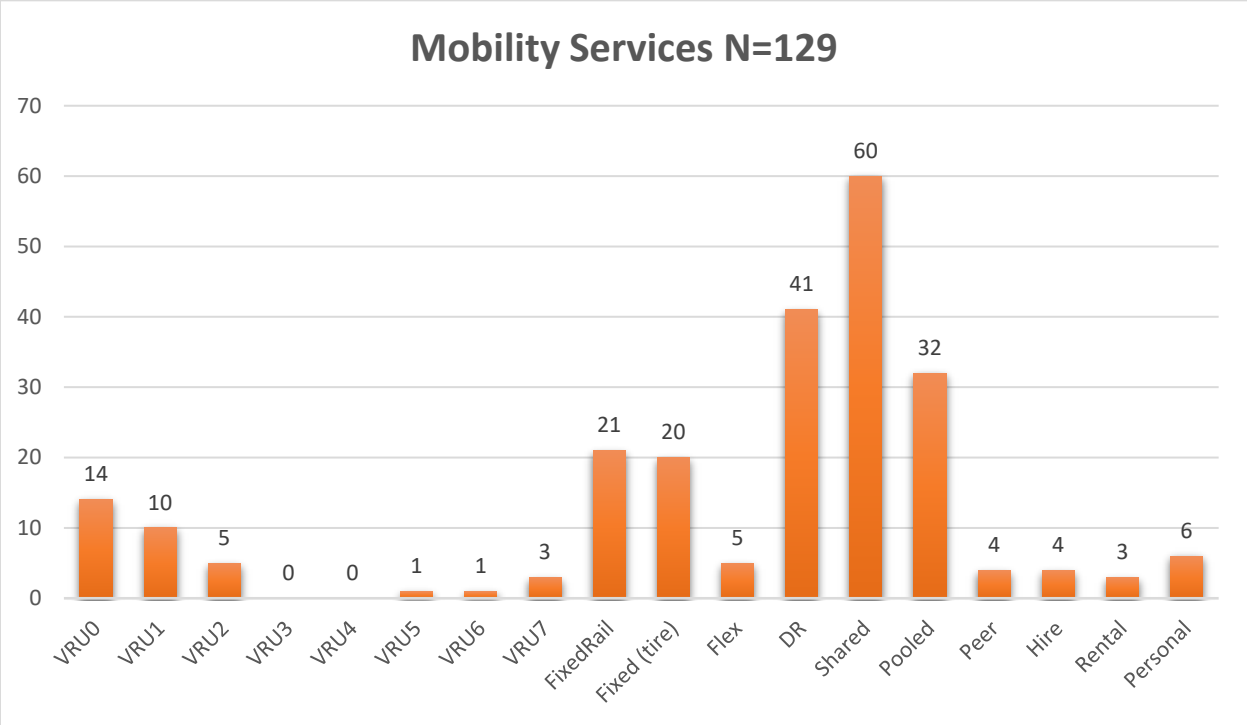

Figure 5. Summary of Project Mobility Service Types.

Observations from the mobility services include the following:

- Few projects include **Pedestrians** with and without assistive devices (less than 11 percent -- VRU0)
- Few projects include **MMVs** (less than 8 percent -- VRU1-VRU7)
- **Fixed rail** and **fixed bus** are still conveyances that are included in MAT related projects (over 15 percent)
- Demand responsive (which include on-demand services) provides a significant number of the project services types (just under 32 percent)
- The majority of projects include **Shared** use (concurrent or sequential) services (about 47 percent) while **Pooled** services only contribute about 25 percent of mobility services.
- Finally, traditional mobility services – **peer**, for **hire**, **rental,** and **personal** vehicle use cover less than 5 percent each.

3.1.3.3 Summary of Project Functions

The functions deployed by the projects are summarized below. This summary was done in two levels, a high level associated with broad categories of functions (Figure 6), and more detailed summaries where specific functions were identified (Figure 7). The summary of high level functions shows that the projects provide widespread coverage of all the categories, with wayfinding, reservations, and data collection being address in over 60 percent of projects while pre-trip planning, payment, eligibility and other physical devices are covered by at least 50 percent of the projects.

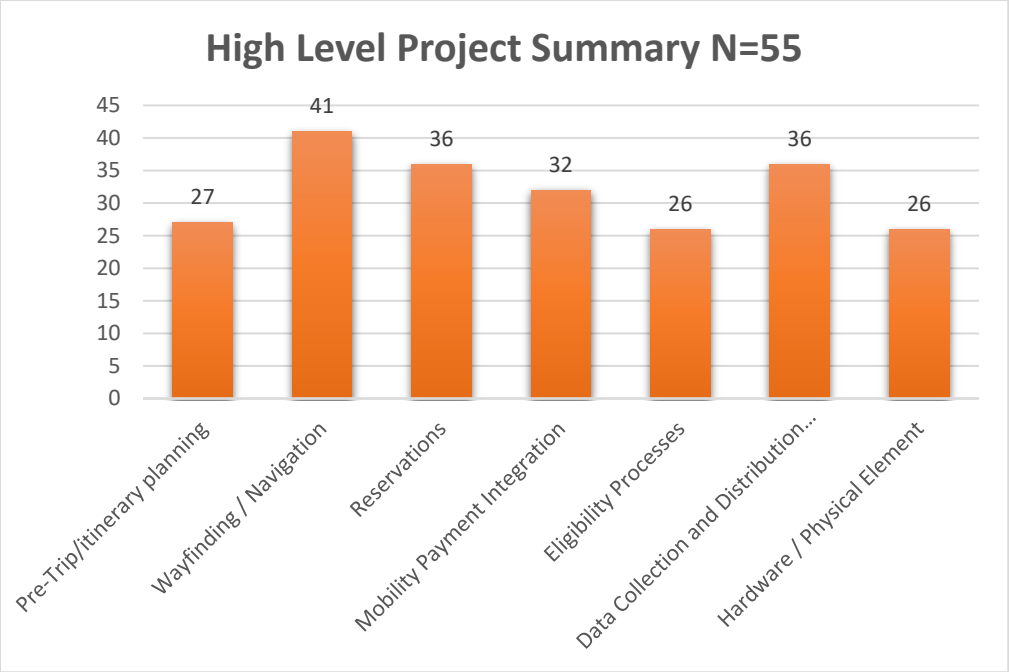

Figure 6. Project Summary Function Categories

The detailed function summary provides additional details about how many projects address individual functions within the categories. When viewed at the detail level, user reservations (under the Reservations category) is included in the highest number of projects with real time information addressed by notifications and routing being a close second and third highest level of coverage in the projects.

Additionally, although over 60 percent of projects addressed the category of Data Collection, the majority of the projects addressed only the static (20) and dynamic (19) data collection functions.

Other observations include the following:

- Payment Methods function, which include the priority to deploy mobile payment apps and virtual payment media, was covered by 29 projects
- Trip Planning function, which include the deployment of additional functionality that covers mobility services in the trip planning tools was covered by 27 projects
- Dispatch and scheduling function, which covers the back office of the reservations system was covered by 31 projects

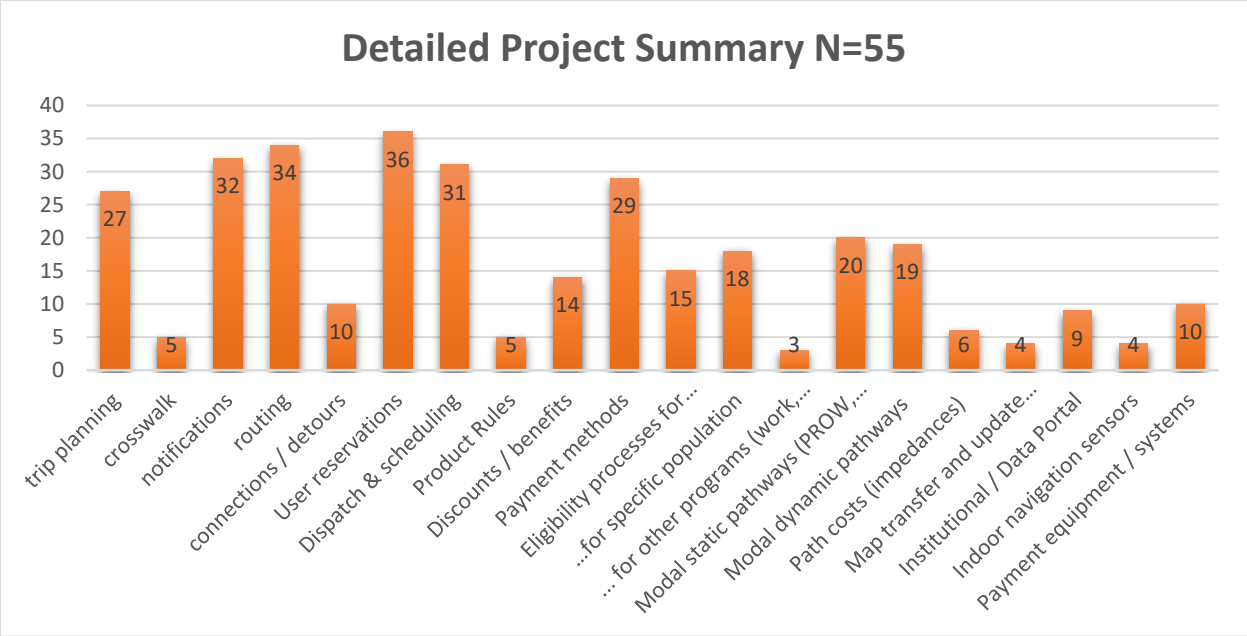

Figure 7. Project Summary Detailed Functions.

3.2 MAT Use Cases

3.2.1 Use Case Summary

This effort has reviewed 92 use cases that have been developed as part of some of the MAT Projects described in 3.2.3. In addition, a set of consolidated use cases recently developed by the ARC-IT program are included in the gap analysis. For each project, the number of use cases relevant to the functions of MAT defined in Section 2 is shown in parentheses after the project name.

Program	Project Name	Use Cases No.
ITS4USProjects	Health Connector for the Most Vulnerable (Heart of Iowa Regional Transit Agency)	14
	Safe Trips in a Connected Transportation Network (ST-CTN) (Atlanta Regional Commission)	2
	Trip Planning for All, (California Association of Coordinated Transport (CALACT))	14
	Transportation Data Equity Initiative, (University of Washington)	13
	Complete Trip Deployment in Buffalo, NY (ICF)	10
ARC-IT	Vulnerable Road Users	6
	Wayfinding	6
	Payment Integration	6
ATTRI	Safe Intersection Crossing	15
CV Pilot	New York City	2
	Tampa	4
	Total Number of Use Cases	**92**

Appendix D provides a detailed list of the 92 use cases that have been analyzed to help identify the gaps in the description of MAT. For each use case the table in Appendix D identifies the following:

- The project from which the use case is drawn
- The title of the use case
- A short description of the use case
- The source of the use case

While most of the use cases in the above table relate to specific projects, the ARC-IT MAT use cases are a consolidation and generalization of a variety of inputs. The ARC-IT MAT use cases cover the following three specific areas:

- Wayfinding/ Navigation
- Vulnerable Road Users
- Payment Integration

Each of these efforts reviewed a wide array of use cases, some of which are included in Appendix D, and some relating to standards efforts. The VRU use cases considered the following use cases in the development (the projects in italics are included in Appendix D):

- ISO/TR 22085-1 ITS Nomadic device service platform for micromobility - 16 use cases
- ISO/TR 13184-1 ITS Guidance protocol via personal ITS station for advisory safety systems - 13 use cases
- Updating BSM to communicate VRU Information using Bluetooth 5 - A Tome Software WP from the 2019 B2V Workshop - two use cases
- SAE J2945/9 VRU Safety Message Minimum Performance Requirements - four use cases
- ISO 24317 ITS Mobility Integration - C-ITS for light mode conveyances and accessibility travel standards gap assessment - 1 use case
- ISO 13111-1 ITS Use of personal ITS station to support ITS service provision for travelers - 10 use cases
- *Phase 1 CALCT (ITS4US) ConOps - 9 use cases*
- *Phase 1 HIRTA (ITS4US) ConOps - 10 use cases*
- *Phase 1 Buffalo (ITS4US) ConOps - 10 use cases*
- *Phase 1 ARC (ITS4US) ConOps - two use cases*
- *THEA Connected Vehicle Pilot - four use cases*
- *NYC Connected Vehicle Pilot - two use cases*

The Wayfinding/ Navigation use cases developed by the ARC-IT effort considered the following source:

- *Phase 1 Buffalo (ITS4US) ConOps - eight use cases*
- ISO 22085-1 - one use case
- ISO 17438-1 - four use cases

Finally, the Payment Integration use cases are primarily based on real world systems for payment integration (e.g., MTA, MTC, DART, and SF Go).

The 92 use cases described in Appendix D.

3.2.2 Analysis of Use Cases

This section summarizes the MAT mobility services and functions included in the 92 use cases reviewed for this effort and considers what gaps exist between the use cases developed so far and the range of mobility services and functions that describe MAT.

3.2.2.1 Summary of Use Case Conveyance, Service, and Cooperative Types

Figure 8 shows the numbers of use cases that cover each of the mobility types. Note that a single use case may cover several different mobility types. The largest number of use cases cover pedestrians (72 of 92) and persons using assistive devices (51 of 92). Every mobility type is covered by the use cases, although some coverage is only in a couple use cases. Additionally, there was a use case that included workers (an additional VRU category).

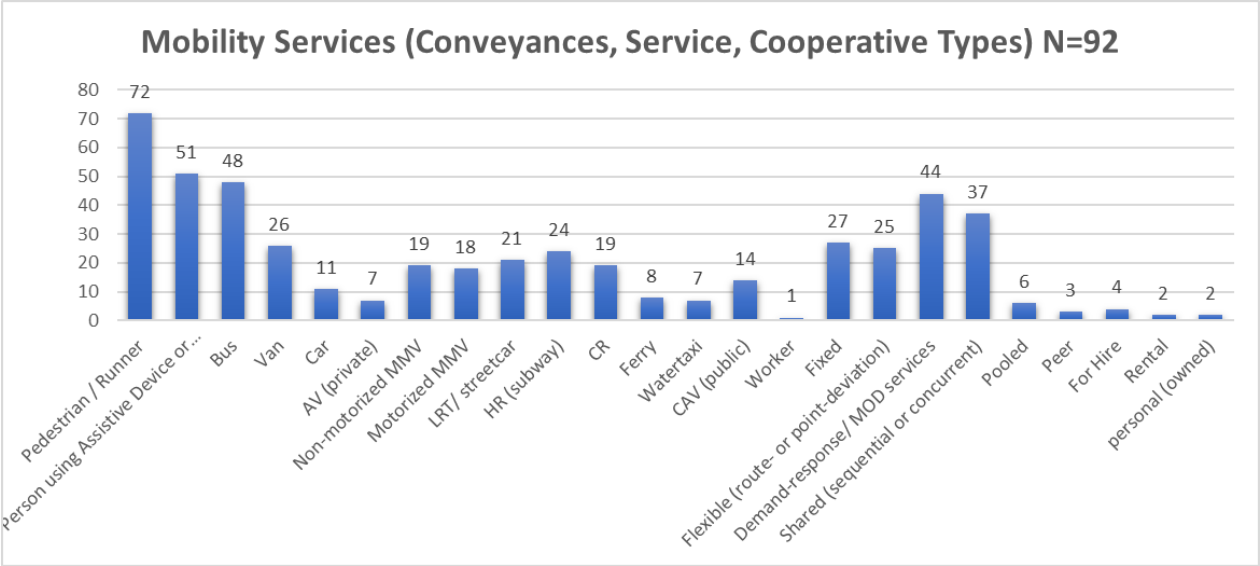

Figure 8. Use Case -- Mobility Services.

3.2.2.2 Summary of Use Case Functions

Figure 9 shows the number of use cases that address each of the high-level function categories. Note, a single use case usually addresses more than one of the categories. As shown in the figure, Wayfinding is represented in the largest number of use cases, with Eligibility Processes being the category that has the least coverage across the range of use cases.

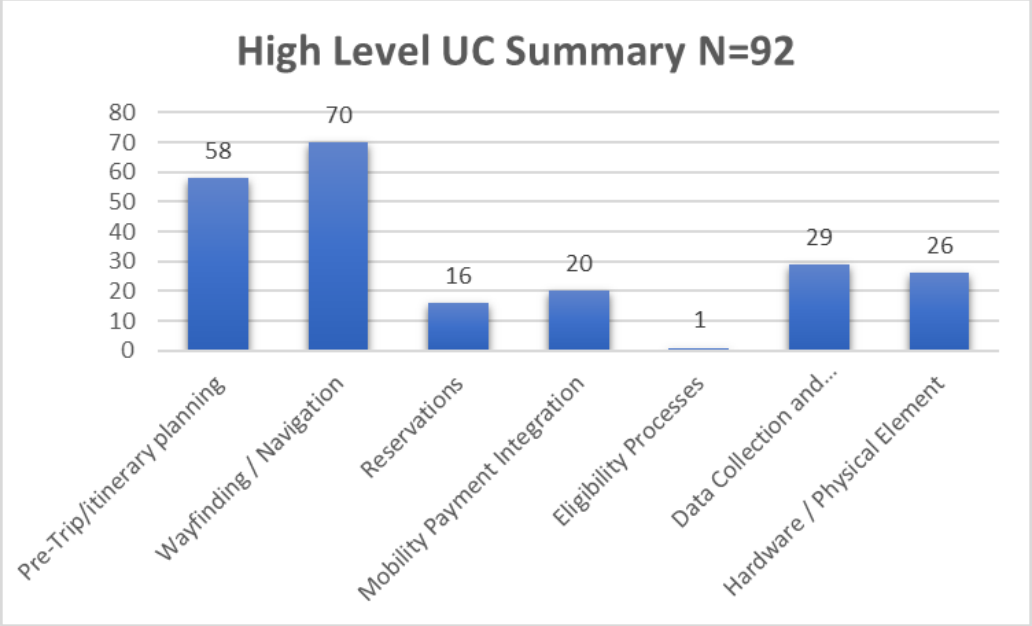

Figure 9. Use Case -- High Level MAT Functions.

Figure 10 shows the mapping of use cases to each of the detailed functions defined as the overall scope of MAT. The same high-level observation, that Eligibility is lightly covered, are viable in this diagram. In addition, there are a couple of functions within different areas that have very light coverage:

Under Payment Integration, there are only five use cases that address for product rules. In addition, under Data Collection and Distribution Methods, there are only five use cases that address Path costs (impedances).

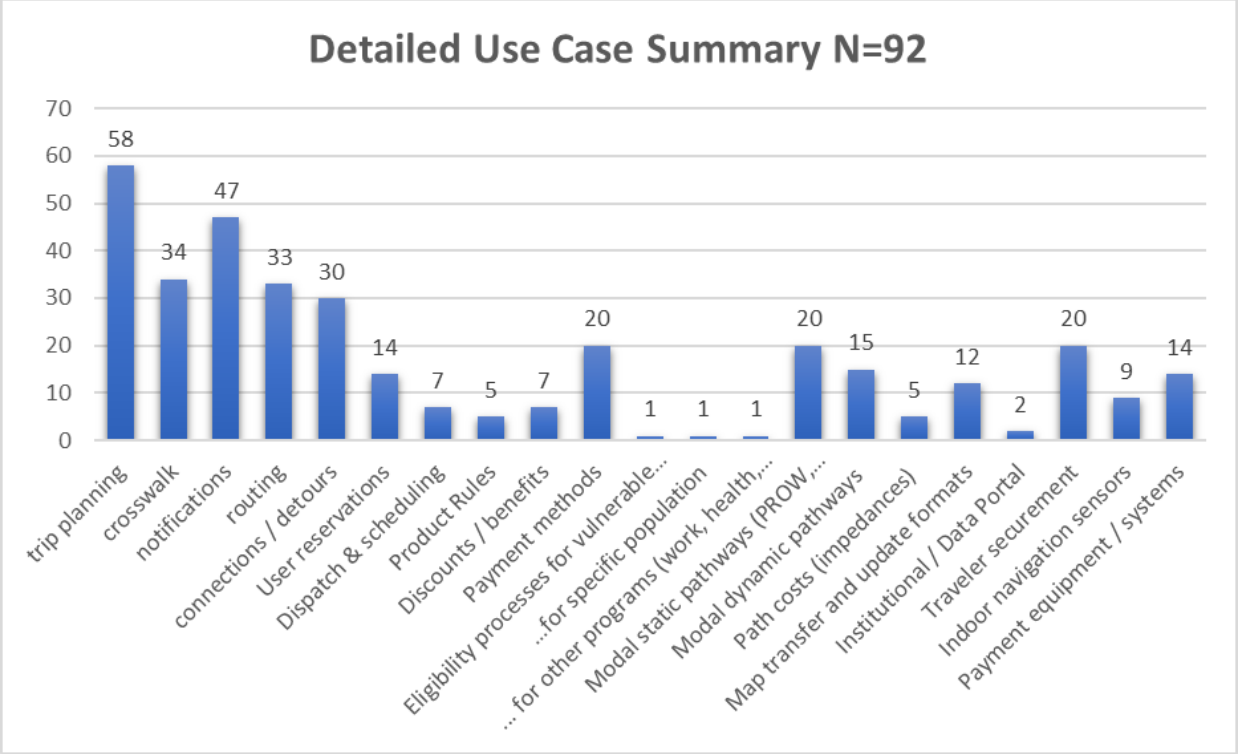

Figure 10. Use Case -- Detailed MAT Functions.

3.2.3 Analysis of Use Case Detail

In addition to considering how many use cases apply for each category or related function, another consideration is whether these use cases have sufficient details to support standardization. To address this question, an analysis was performed of whether the use cases have detailed information requirements that could be used to support standardization. The following four cases were considered relating to the use cases (with the results for the 92 use cases shown in Figure 11).

- Have information requirements that could be used to support standards (Yes)
- Use Case references standards to support the interfaces in the use case (Reference Standards)
- Have only a high-level description of information requirements (Not Detailed)
- Does not contain information requirements (No)

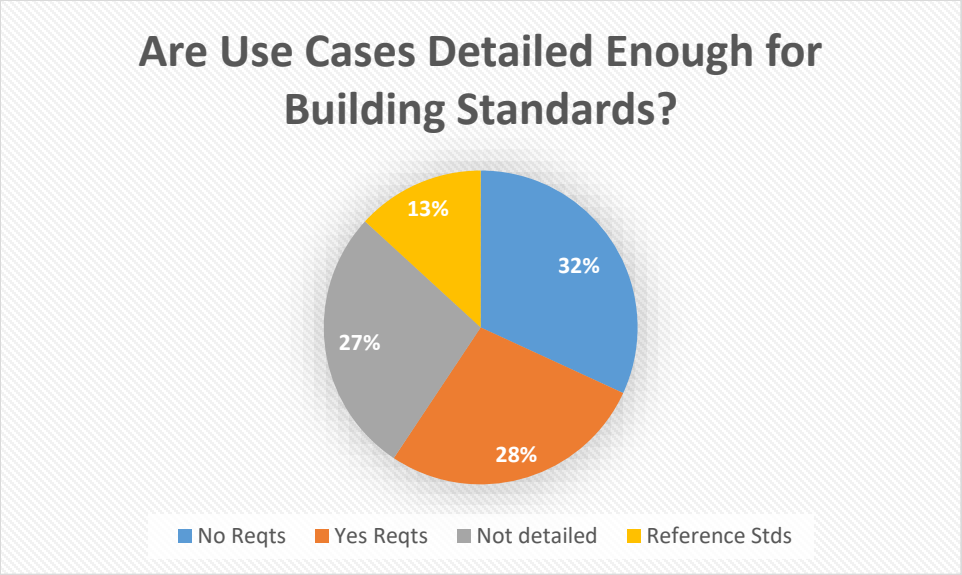

Figure 11. Are Use Cases Detailed Enough for Building Standards?

The next level of detail is to consider the question of information requirements at the function level. To simplify this discussion, the two categories indicating standards references and information requirements will be combined (Identified as Yes), and the two categories of no or not detailed information requirements will be combined (identified as No). Table 2 shows the number of use cases that define information requirements or standards for each category and related function.

Table 2. Information requirements/ standards defined for each category and function

Category	Function	Yes	No
Pre-Trip/Itinerary planning	**Trip Planning**	22	36
Wayfinding / Navigation	**Crosswalk**	12	22
	Notifications	20	27
	Routing	17	16
	Connections / Detours	13	17
Reservations	**User reservations**	4	10
	Dispatch & Scheduling	1	6
Mobility Payment Integration	**Product Rules**	0	5
	Discounts / Benefits	1	6
	Payment methods	1	19
Eligibility Processes	**Eligibility processes** for vulnerable communities	0	1
	…for specific population (this is a new column)	0	1
	… for other programs (work, health, students, employers)	0	1

Category	Function	Yes	No
Data Collection and Distribution Methods	**Modal static pathways (PROW, indoor, bikes)**	16	4
	Modal dynamic pathways	13	2
	Path costs (impedances)	3	2
	Map transfer and update formats	10	2
	Institutional/ Data Portal	0	2

The functions within Eligibility and Payment Integration have only a single use case with information requirements or standards details. Other functions with little or no coverage include Dispatch and Scheduling, Path Costs, and Data Portal.

Section 4 Analysis of Use Cases and Projects

4.1 Gap Analysis

This section compares the 92 use cases and 55 projects identified in the previous section with the MAT Conveyances and Functions defined in section 2.1.1 and 2.1.2. The comparison shows the magnitude of use case scenarios against project deployments as an engineering assessment of stakeholder priorities. The two types of analyses are divided into two distinct categories:

1. **Gap:** A MAT Functional area is not covered at all, or only partially covered by existing use cases and / or projects
2. **Overlap:** A MAT Functional area which is supported by multiple use cases and projects with conflicting implementations or supported by multiple reference standards / specifications

4.2 Comparison of Use Cases and Project to MAT Conveyances

Figure 12 shows the comparison between the conveyance types represented by use cases versus those deployed in projects. Table 2 shows the difference between the number of conveyances represented by a Use Case versus those that are implemented or proposed to be implemented by a project. Except for cars (which are associated with cooperative and demand responsive service types), ***the number of use cases exceed, by significant percentages, the number of implementations.***

Of specific interest is the significant magnitude of use cases which include Pedestrians and Pedestrians with Assistive Devices versus the limited number of projects. The Complete Trip scenarios all include the transition between vehicle and pedestrian modes. In this case, one can assume that the Use Cases are ahead of the project implementations for pedestrians.

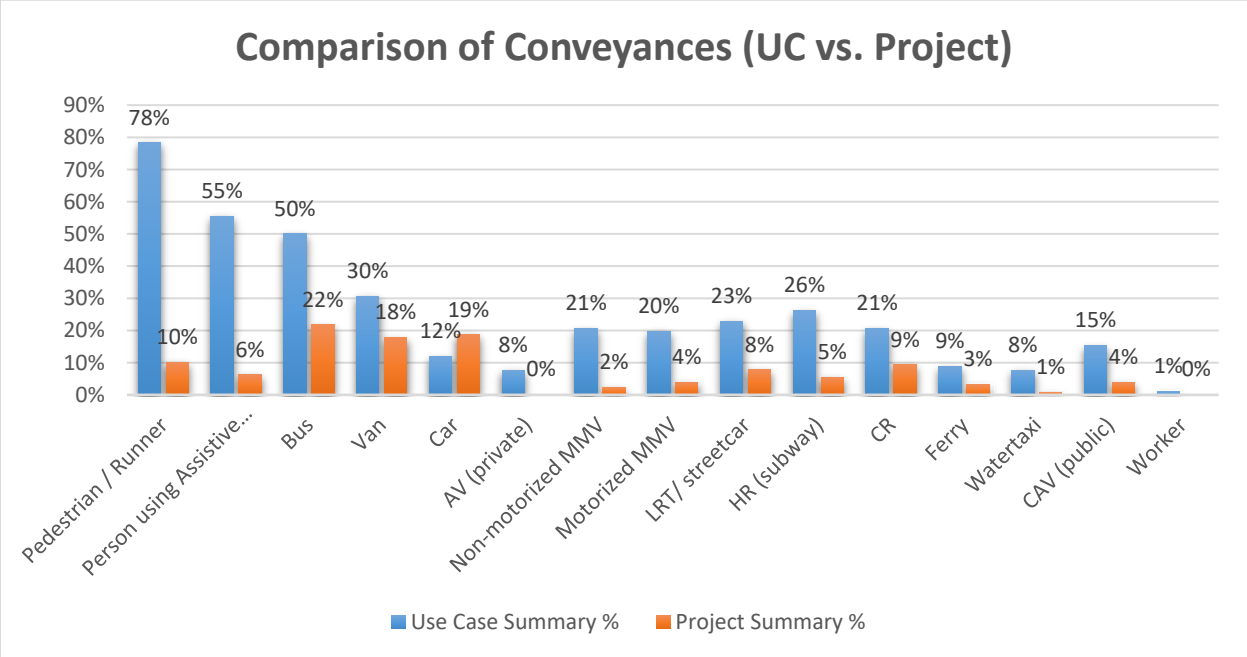

Figure 12. Comparison of Conveyance Types.

Table 3. Difference between Use Case and Project

Conveyance Type	Magnitude of Difference (Difference between Use Cases and Projects)
Pedestrian / Runner	68%
Person using Assistive Device or Cart (buggy)	49%
Bus	28%
Van	13%
Car	-7%
AV (private)	8%
Non-motorized MMV	18%
Motorized MMV	16%
LRT/ streetcar	15%
HR (subway)	21%
CR	11%
Ferry	6%
Water taxi	7%
CAV (public)	11%
Worker	1%

4.3 Comparison of Use Cases and Projects for MAT Functions

Figure 13 shows a comparison between the percentage of use cases that cover a high level function and the percentage of projects that cover the function.

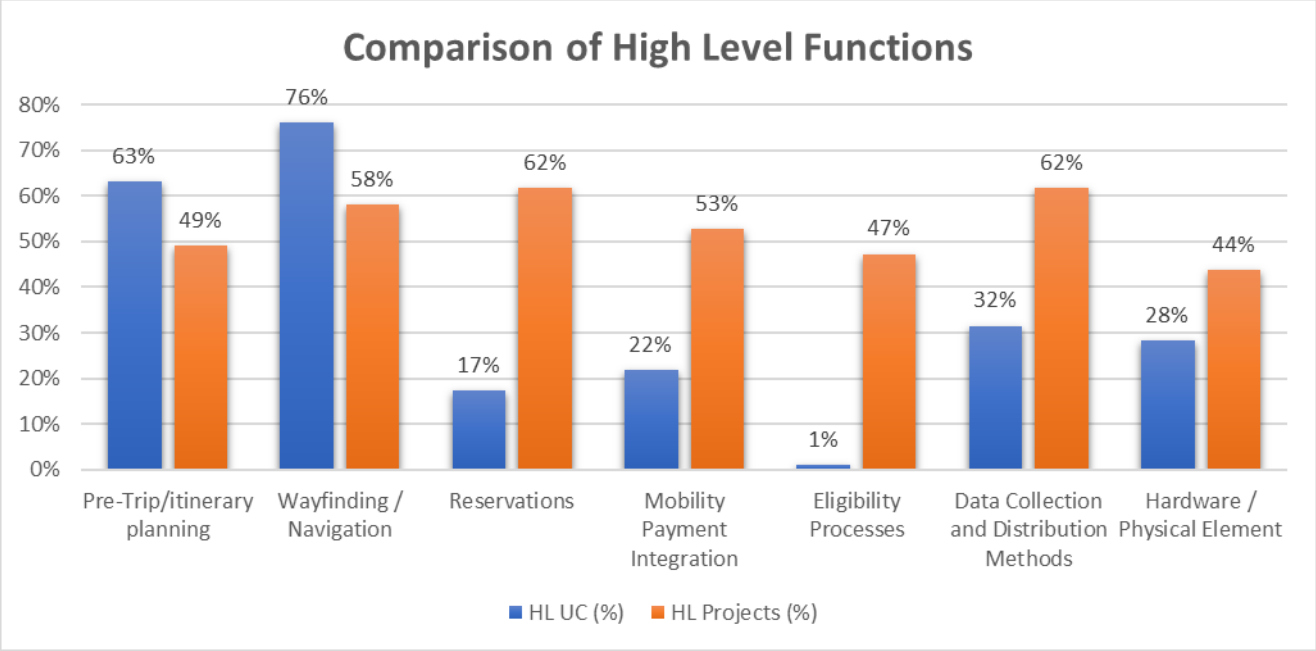

Figure 13. Comparison of UC and Project MAT Categories.

An analysis of this figure shows the following:

- A significant number of use cases and projects are associated with **Pre-trip planning** and **Wayfinding and Navigation**.
- **Eligibility Processes** is an area with few use cases relative to the number of project deployments.
- There are far more projects deploying **Mobility Payment** function than there are use cases describing it.
- The number of projects implementing **Reservation** services far exceed the number of use cases describing the function.

Figure 14 provides a similar comparison (of use cases to projects) for the detailed set of MAT functions. Reviewing this figure provides the following observations:

- **Pre-trip planning** (trip planning) are well covered by both use cases and projects.
- **Crosswalk** use cases far exceed the number of projects. These use cases use an array of scenarios (center to center, center to point, point to point via proxy) and standards to implement pedestrian signal crossing. Other crosswalk scenarios such as bike queue jump are not described at all.
- **Static and real time travel information** (Wayfinding and Navigation) including notifications and routing are also well represented in both use cases and projects as befits the fact that these functions are priorities for projects funded by the USDOT.
- The number of use cases that cover Reservation functions -- **User Reservations** and **Dispatch and Scheduling,** are small compared to the number of projects that are implementing the functionality. Even with the number of use cases, the deeper dive into the use cases (Section 3.2.3) show that the use case details may not be sufficient to develop standards. There are several standards that cover parts of the flow control, data exchange and operational performance related to the functionality. For example, the GTFS On-Demand Feed Specification (GOFS) covers some user reservation interfaces but does not include detailed functional or information requirements or guidance about using the standards. In addition, GOFS does not include schedule and dispatch functions, the back-office functions needed to match customer needs to vehicle/driver capabilities. The Transactional Data Specifications (TDS) that emerged from TCRP Project G-16 include a small number of transactions that support the back-office processes. However, the specification is not sufficient to support the majority of functions.
- In the Mobility Payment Integration (MPI) area, new **Payment Methods** are being deployed in significant numbers, these include mobile fare payment apps. Open MPI specifications and taxonomies that describe tariff/fare tables are limited. In particular. Use cases that describe multimodal and integrated mobility service **Product Rules** are limited.
- Automated and electronic validation of **Eligibility Processes** are gaining significant recognition as a critical function among projects. There is only a single existing use cases that depicts the process. One of the difficulties with developing use cases are the various ways each state and even each jurisdiction provides and stores credentials (e.g., driver's licenses) that can be used to validate a person's eligibility. This category may need additional research to identify a generic method that can be cover a variety of credential types and implementations.
- In the Data Collection category, both **Static** and **Dynamic Pathway** data collection are covered by use cases and projects. Less covered by both projects and use cases are how the data are translated to information about the **Path Cost** (impedance) to traverse the path. There are several projects that are in the process of developing tools to develop the cost models, fewer use cases that detail requirements. Access to the pathway data is important as well. So many projects are developing data portals or institutional repositories to provide access to the datasets.
- Finally, functions related to using physical hardware and devices are well covered by both the projects and use cases.

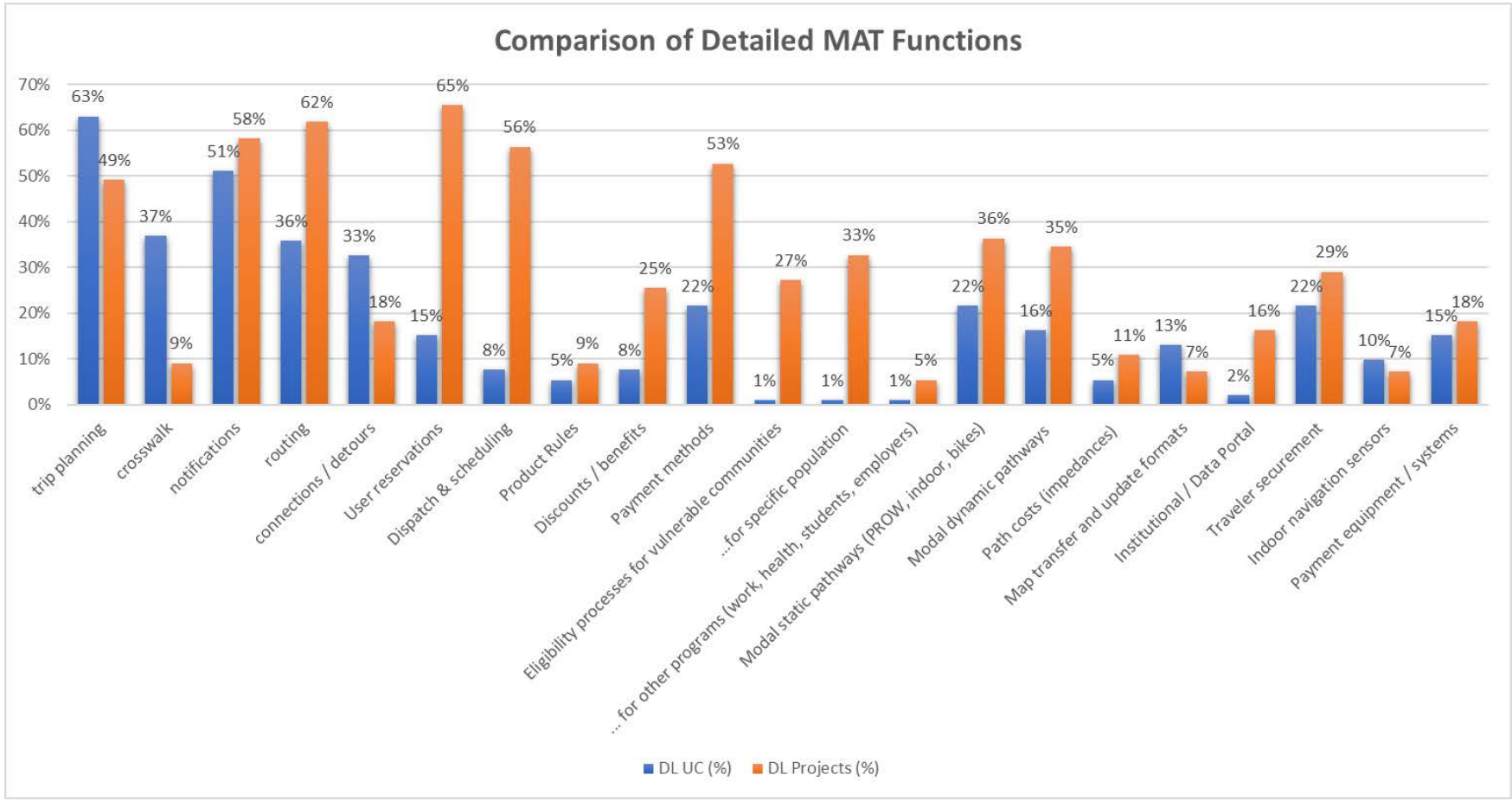

Figure 14. Comparison of UC and Project Detailed MAT Functions.

4.3.1 Gaps

When considering gaps based on the number of use cases already created to address the category/function, the most obvious use case gap to consider relates to the category **Eligibility Processes**, which have little or no coverage in the use cases. Some of the other areas that require additional review based upon this high-level analysis are the following:

- Reservations: User Reservations
- Reservations: Dispatch and Scheduling
- Mobility Payment Integration: Product Rules
- Mobility Payment Integration: Discounts/Benefits
- Data Collection: Path Costs

When considering the more detailed review of information requirements/ standards defined within the use cases the same gaps mentioned above again stand out:

- Eligibility processes (which have no information requirements/ standards defined)
- Mobility payment integration (which have only a single use case that provides any definition of information requirements or standards (in two of three functions, and no mapping in the third function)
- Reservations (which has only one use case defining information requirements or standards in the function of Dispatch and schedules and four use cases in the function of reservations)
- Data Collection: Path Costs (which has only three use cases with any details about information requirements or standards

4.3.2 Overlaps

The overlap consideration is where there are conflicts between existing use cases. The **connected intersection for VRUs** is an example of this category, specifically as it related to MMVs and Pedestrian crossing:

1. Pedestrian signal crossing. There are multiple implementations of this capability defined in the use cases. These include implementation with several connectivity options (direct, C2C, detection, via third party), which reference two different standards.

2. Bike queue jump. This also has multiple implementations with varied connectivity (direct, C2C, detection).

Section 5 Recommendations

Based on the analysis presented in Section 4, most of the functional areas of MAT are well covered by a wide range of existing use cases. The following set of use cases are recommended to be developed:

1. Eligibility to participate in specific mobility service programs for various communities (e.g., vulnerable groups and specific populations)- expand on the existing ARC-IT PI use case to cover information requirements.
2. Reservations: Dispatch and Scheduling- consolidate existing use cases into a single set that expands on current information requirements.
3. Mobility Payment Integration: Product Rules, Discounts/Benefits, Payment Methods- expand on the existing use cases to create a coherent set that includes information requirements.
4. Data Collection: Path Costs- consolidate the three existing use cases into a coherent set that addresses the information requirements.
5. Pedestrian signal crossing- create scenarios within a use case that highlights the alternate approaches (flows and configurations) to performing this function. Consideration of bike queue jump could be added to this use case as well since it is a related intersection issue.

Section 6 Appendices

Annex A: Acronyms / Glossary

Term	Meaning
ADA	Americans with Disabilities Act
AIM	Accelerating Innovative Mobility
ATTRI	The Accessible Transportation Technologies Research Initiative
ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
AV	Autonomous Vehicle
B2B	Business To Business
BNMC	Buffalo Niagara Medical Campus
CALACT	California Association of Coordinated Transport
CM	Curb and Micromobility Vehicle Management
DOT	Department of Transportation
EFPS	Electronic Fare Payment Systems
ETA	Estimated Time of Arrival
EV	Electronic Vehicle
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GNSS	Global Navigation Satellite System
GTFS	General Transit Feed Specification
IMI	Integrated Mobility Innovation
ITS JPO	Intelligent Transportation Systems Joint Program Office
LiDAR	Light Detection and Ranging
MAT	Multimodal and Accessible Travel
MaaS	Mobility As a Service
MMV	Micro-Mobility Vehicle
MPI	Mobility Payment Integration
MATSA	Multimodal and Accessible Travel Standards Assessment
NFC	Near Field Communication
NIDILRR	National Institute on Disability, Independent Living, and Rehabilitation Research
OSI	Open Systems Interconnection
PROW	Public Rights of Way
QR	Queensland Rail

ROW	Rights of Way
ST-CTN	Safe Trips in a Connected Transportation Network
TfNSW	Australia's Transport for NSW
TMaaS	Traffic Management as a Service
TNC	Transportation Network Company
USDOT	United States Department of Transportation
WaN	Wayfinding and Navigation
WiFi	Wireless Fidelity

Annex B: Resources

B.1 References

SAE International, “Taxonomy of On-Demand and Shared Mobility: Ground, Aviation, and Marine,” JA3163™. June 2021.

(Simon) https://trimis.ec.europa.eu/sites/default/files/project/documents/simon_publishablesummary-def.pdf

Susan Shaheen, et al. “Mobility on Demand Operational Concept Report,” prepared for the USDOT Intelligent Transportation Systems Joint Program Office. Report No. FHWA-JPO-18-611, September 2017.

Rob van Nes and Piet H.L. Bovy. "Multimodal traveling and its impact on urban transit network design." *Journal of Advanced Transportation*, January 2010. https://doi.org/10.1002/atr.5670380302

B.2 End Notes

[1] User groups are (1) Urban and Suburban able adult travelers (business travelers and a group of university students), (2) Family of adults and two children, and (3) Travelers with limited mobility or other special needs (a pregnant mother with small child (e.g., in baby carriage) travelling alone, an infirm couple, and a wheelchair-bound person with caregiver. From EuTravel deliverable D3.1: Modelling and Experiment plans – Scenarios and Use Cases, November 30, 2017. http://www.eutravelproject.eu /Deliverables-page

[2] van Nes 2010.

[3] Sheehan 2017, page 108

Annex C: List of Projects

Information for AIM/IMI derived from USDOT published descriptions and internal discussions and documents for the AIM/IMI Demonstration Program.

Information for MOD Sandbox, ITS4US, CV Pilots, and ATTRI projects derived from USDOT published documents.

Information for other programs derived from published reports.

Project	Project Title	PROJECT DESCRIPTION
AIM	Transforming Public Transit in Wilson with Rural On-Demand Microtransit	The City of Wilson in Rural central North Carolina will receive funding to replace its fixed-route transit service with on-demand, Rural microtransit to provide more targeted service and solve first/last mile connections. The microtransit system will include accessible vehicles, phone booking, and lower fares.
AIM	Creating the World's First Integrated Mobility Solution	Delaware Transit Corporation will receive funding to partner with the private mobility service, Via, to develop software that integrates fixed-route bus service, paratransit, and microtransit in Georgetown. With dynamic fare pricing and trip planning available on one platform, the software will expand limited bus service and create more efficient transportation to jobs and healthcare in rural Sussex County.
AIM	Implementing App-Based, Inter-Agency Fare Purchase and Trip Planning in the Rocky Mountain West	The Regional Transportation District (RTD) in Denver will receive funding for a multimodal trip platform to integrate RTD bus and rail with inter-city bus and microtransit travel services, allowing riders to plan for multimodal trips with integrated fare options.
AIM	Transits First/Last Mile Solution: the EZ Zeus, a zero-emission, Level 4, FMVSS, ADA, and Buy America-compliant Automated Shuttle Bus	The Metropolitan Transit Authority of Harris County (Houston Metro) will receive funding for an automated electric shuttle bus that will serve Texas Southern University, the University of Houston and Houston's Third Ward community. The shuttle will connect to Metro buses and light rail and be studied for potential use in urban, suburban, and rural environments.
AIM	Travel Rewards Research Pilot	The Los Angeles County Metropolitan Transportation Authority (LA METRO) will receive funding to work with researchers and technology firms to encourage new ways to travel, including transit, rideshare and vanpooling under FTA's Accelerating Innovative Mobility (AIM) program.
AIM	Memphis Integrated Mobility Framework	The Memphis Area Transit Authority will receive funding to implement a microtransit on-demand project in the Boxtown/Westwood neighborhood of Memphis, a low-density, suburban neighborhood

Project	Project Title	PROJECT DESCRIPTION
		with a large elderly population and infrequent transit service. Riders will be able to request rides using a mobile application or call center to destinations such as healthcare, grocery stores or government services, as well as connect to the existing transit network.
AIM	Southern Minnesota Mobility as a Service (MaaS) Platform	The Minnesota Department of Transportation will receive funding for a regional platform to enable multimodal trip planning and payment for residents in a 13-county area in southern Minnesota. The project will integrate transportation services across rural, small urban and large urban communities and inform strategies for increasing transit ridership and improving service quality, especially in rural areas.
AIM	Transit Integration: PSTA Direct Connect Service	The Pinellas Suncoast Transit Authority will receive funding to integrate its Direct Connect program, which connects riders in areas with low-frequency transit service to subsidized on-demand trips, into its mobile app. This project will offer riders a simple way to plan and book multimodal trips.
AIM	Installation of On-Bus Mobile Ticket Validators and Development of an Origin-Destination-Transfer (ODX) Model	The Pioneer Valley Transit Authority in western Massachusetts will receive funding to install on-bus technology to modernize fare payment and data collection. In addition to improving the rider experience, the new fare system will include interactive dashboards to track rider travel patterns to support service planning and other modeling efforts.
AIM	Enhancing Life with Automated Transportation for Everyone (ELATE)	Western Reserve Transit Authority will partner with the Santa Clara Valley Transportation Authority to deploy automated electric vehicles designed for accessibility in Mahoning Valley, Ohio, and Santa Clara Valley, California to augment fixed-route bus and paratransit services. The two locations will test the ability of the AVs to provide more efficient and cost-effective service under different climates and operating conditions.
IMI	BRATS On Demand	The Baldwin County Commission will receive funding to create a mobility-on-demand platform to automate routing, scheduling, and dispatching technology. It will enhance transit access for all residents of the Mobile area while increasing efficiency, reducing wait times and improving reliability.
IMI	CHARTS: Comprehensive Healthcare Access with Rural Transit Solutions	The Bay Area Transportation Authority (BATA) in northwest Michigan will receive funding to implement an integrated technology suite spanning four departments. The grant will support technology that consolidates dispatch scheduling, asset condition reports, and security systems across the agencies and will support the implementation of a mobility on demand solution.

Project	Project Title	PROJECT DESCRIPTION
IMI	Roadway to Recovery: Driving Transformational Change and Removing Barriers for the Recovery Community	Cecil County, Maryland, will receive funding to expand on-demand transit service to increase accessibility and provide more mobility options to people in substance recovery. The project will create a complete trip service model providing access to jobs, school, shopping, legal services and other vital services.
IMI	Arlington RAPID (Rideshare, Automation, and Payment Integration)	The City of Arlington will receive funding to integrate autonomous vehicles into its existing on-demand system operated with the Via car-sharing service. The service will include a wheelchair accessible vehicle and allow University of Texas at Arlington students to ride fare-free.
IMI	Atlanta-Region Rider Information and Data Evaluation System (ATL RIDES)	The Georgia Regional Transportation Authority on behalf of Atlanta-Region Transit Link Authority will receive funding to develop a multimodal journey planning application to include live navigation and integrated mobility payment options to provide a seamless passenger experience throughout the Atlanta region.
IMI		The Grand Gateway Economic Development Association will receive funding to introduce an integrated, on-demand shared-ride service in 21 rural communities in eastern and central Oklahoma. Using intelligent transportation systems, the project will connect four regional rural public transit partners with predictive scheduling and routing technology that helps riders tailor trips to meet their needs.
IMI	GHPIM Mobility Platform	The Greater Hartford Transit District will receive funding to develop a responsive, 24/7 transportation option for older adults and people with disabilities to fill gaps in service throughout Connecticut. The District will partner with a paratransit provider and use technology and "smart" routing to improve response times and the traveler experience.
IMI	ITNCountry: Transportation for Rural and Small Communities	The Independent Transportation Network will receive funding to expand its mobility-on-demand transit model designed for older adults and people with disabilities in Portland, Maine, to new rural communities in Maine, Kentucky, and California. Using an automated routing and scheduling platform, it will increase access to trips.
IMI	Kootenai Regional Mobility Platform	Kootenai County will receive funding to explore an open architecture fare payment system. The project will close gaps in transportation services in Idaho's second-most populous region, while determining costeffective and efficient transportation options and solutions for riders.
IMI	Centralized Mobility Management Software	The Matanuska-Susitna Borough will receive funding on behalf of four rural transit providers to implement a platform that centralizes dispatch, fleet management, call-taking, and payment across

Project	Project Title	PROJECT DESCRIPTION
		providers. The system will assign trips to the lowest-cost eligible provider and allow riders flexible request and payment options.
IMI	Bowtown/Westwood Microtransit Pilot	Memphis Area Transit Authority (MATA) will receive funding to develop a pilot microtransit service and an accompanying mobile app with multimodal trip planning capabilities. It will support customers without smartphones with a call center for trip planning activities.
IMI	Rural Integrated Payments Program	The Crawford Area Transportation Authority in rural Northwestern Pennsylvania will receive funding to develop a unified system for riders taking fixed route and paratransit by combining rider validation for paratransit services with mobile ticketing. The platform will streamline the experience of taking a multimodal trip for riders on either mode.
IMI	Expanding Rural Access to Non-Emergency Medical Transportation	River Cities Public Transit will receive funding to expand a program that provides transportation for oncology patients to a large hospital in central South Dakota to all types of patients within a 60-mile radius. The project will feature an integrated single payment system and allow Avera St. Mary's Hospital to hire a full-time transportation coordinator to advocate the service.
IMI	Developing Standardized Payment Integration and Institutional Capacity for Rural Mobility-as-a-Service	The San Joaquin Regional Transit District will receive funding to create standard payment integration and trip planning apps across local and regional transit providers. Riders will be able to access and pay for services by multiple providers on the same trip. The project will include marketing and rider-education strategies.
IMI	EZfare: The Gateway	The Stark Area Regional Transit Authority will receive funding to develop an innovative alternative payment system for mobility, business, and personal applications targeted to low-income, disadvantaged, disabled, student, elderly, and other underserved populations.
IMI	Steps to MOD and MIPI	TriMet will receive funding to develop a mobility payment system that integrates payment for multiple modes into a single transaction. The project will build on TriMet's multimodal trip planner to reduce travel stress with better real-time arrival predictions.
IMI	Virginia Rural Microtransit Deployment Initiative	The Virginia Department of Rail and Public Transportation will receive funding to provide microtransit in rural communities in the Tidewater region. The project will augment existing transit resources by leveraging mobile technology for real-time trip booking and vehicle routing, providing real-time, demand-response microtransit service.
IMI	GoWake Access Microtransit	Wake County Human Services will receive funding to initiate an on-demand service to provide residents in rural areas with greater access to jobs, school, healthcare, and other services. The

Project	Project Title	PROJECT DESCRIPTION
		organization will launch microtransit services that provide a “first five-mile, last five-mile” approach to connect rural residents with more distant services.
IMI	Serving a Small City with Vans on Demand	The Whatcom Transportation Authority will receive funding to provide on-demand transit service to residents in the small city of Lynden in northwest Washington. A new on-demand mobile app will allow seniors, school-aged children, people with disabilities, and people with limited income to hail an accessible van to any destination within the city.
MOD Sandbox	Integration of Shared-Ride Services into GoPass Ticketing Application	Releases updated version of Dallas Area Rapid Transit’s (DART) existing trip planning app. Updated version incorporates shared-ride services to provide first/last-mile (FMLM) connections to public transit stations and allows users to pay for services within the app.
MOD Sandbox	Two-Region Mobility on Demand	Establishes partnership between Via and LA Metro. Via provides FMLM connections for passengers going to or leaving from transit stations. There is a companion project in Seattle, WA.
MOD Sandbox	Smart Phone Mobility Platform	Releases updated version of Valley Metro’s existing trip planning app. New version updates trip planning features and enables payments.
MOD Sandbox	Paratransit Mobility on Demand	Improves paratransit service by combining services from taxi, ridesourcing/TNCs, and traditional paratransit companies.
MOD Sandbox	Open Trip Planner Share Use Mobility	Releases updated version of TriMet’s existing multimodal app. New version provides more sophisticated functionality and features, including options for shared mobility.
MOD Sandbox	Bay Area Fair Value Commuting (Palo Alto)	Reduces single occupancy vehicle use within Bay Area through commuter trip reduction software, a multimodal app, workplace parking rebates, and FMLM connections in areas with poor access to public transit.
MOD Sandbox	Integrated Carpool to Transit (BART System)	Establishes partnership between Scoop and BART. Scoop matches carpoolers and facilitates carpooling trips for passengers going to or leaving from BART stations with guaranteed parking.
MOD Sandbox	Limited Access Connections	Establishes partnerships between local ridesourcing companies/TNCs and Pierce Transit. Ridesourcing companies provide FMLM connections to public transit stations and park-and-ride lots with guaranteed rides home.
MOD Sandbox	Adaptive Mobility with Reliability and Efficiency	Built integrated data platform that incorporates ridesourcing/TNC and carpooling services to support FMLM connections and reduce congestion.
MOD Sandbox	Statewide Transit Trip Planner	Releases new multimodal app for VTrans that employs fixed and flexible (non-fixed) transportation modes to route trips in cities and rural areas.

Annex D: List of Use Cases

Index	Project	UC#	Use Case Title	Use Case Description	UC Source
1	ITS4US Washington	1	Sidewalk Data Generation, Collection, and Vetting	This use case is about collecting sidewalk information	ITS4US - Phase 1 ConOps
2	ITS4US Washington	2	Vetting of Sidewalk Data and Street Crossing Identification	This use case is about vetting above sidewalk information	ITS4US - Phase 1 ConOps
3	ITS4US Washington	3	Generation and Vetting of GTFS for Pathways Linking Together Locations within Stations Data	This use case is about mapping stations	ITS4US - Phase 1 ConOps
4	ITS4US Washington	4	Generation and Vetting of GTFS for Demand-Responsive or Paratransit Service Data	This use case is about generating GTFS-Flex data	ITS4US - Phase 1 ConOps
5	ITS4US Washington	5	Individual with Mobility Disability Uses Verified Sidewalk and Transit Data to Navigate Through Several Cities	This use case is about an individual with mobility disability using sidewalk and transit data to navigate through a city	ITS4US - Phase 1 ConOps
6	ITS4US Washington	6	Veteran with Mobility Disability Traveling from a Rural Home to the Veterans Affairs Hospital for a Medical Appointment	This use case is about getting a rural traveler on a paratransit service	ITS4US - Phase 1 ConOps
7	ITS4US Washington	7	Blind, Vision Disabled, or Deafblind Individual Uses Verified Sidewalk and Transit Data	This use case is about vision disabled users using sidewalk and transit data	ITS4US - Phase 1 ConOps
8	ITS4US Washington	8	Multilingual Tourist Tries to Conduct Pre-Trip Planning for a Multilevel Transit Station	This use case is about aiding multilingual traveler in pre-trip planning for complex transit station	ITS4US - Phase 1 ConOps
9	ITS4US Washington	9	Low-Income Traveler Utilizes a Third-Party Application (One-Call/One-Click	This use case is about providing a low-income traveler a third-party application to help reach a destination	ITS4US - Phase 1 ConOps

			Service) to Reach a Destination		
10	ITS4US Washington	10	Travelers with Sidewalk Preferences Utilize Data Generated by a City Government	This use case is about city government providing sidewalk data to travelers with sidewalk preferences	ITS4US - Phase 1 ConOps
11	ITS4US Washington	11	Travelers with Sidewalk Preferences Utilize Data Generated by a Civic Organization	This use case is about a civic organization providing sidewalk data to travelers with sidewalk preferences	ITS4US - Phase 1 ConOps
12	ITS4US Washington	12	Travelers with Sidewalk Preferences Utilize Data Generated by an Aerial Mapping Company's Analytics Engine for Aerial Images	This use case is about aerial mapping companies generating sidewalk data	ITS4US - Phase 1 ConOps
13	ITS4US Washington	13	Transit Users Utilize GTFS for a Demand-Responsive or Paratransit Service and for Pathways Linking Together Locations within Stations Extensions Through a Navigation Application	This use case is about providing GTFS-Flex and GTFS-Pathway data to transit users	ITS4US - Phase 1 ConOps
14	ITS4US Buffalo	1	Register and Select Profile	This use case is about enabling the traveler to register their travel preferences on CPT	ITS4US - Phase 1 ConOps
15	ITS4US Buffalo	2	Generate Trip Plan and Book a Trip	This use case is about the functions for a traveler to plan a trip by inserting their origin and destination	ITS4US - Phase 1 ConOps
16	ITS4US Buffalo	3	Public Transport Services	This use case is about information provisions associated with accessing public transit mode options	ITS4US - Phase 1 ConOps
17	ITS4US Buffalo	4	Navigation	This use case is about providing turn by turn navigation to travelers	ITS4US - Phase 1 ConOps
18	ITS4US Buffalo	5	Reporting and History	This use case is about providing information to travelers about trips they completed and forms for feedback on the trips	ITS4US - Phase 1 ConOps
19	ITS4US Buffalo	6	Ride-hailing Reservations and Dispatch	This use case is about describing the process of user reservation and dispatch of shuttles	ITS4US - Phase 1 ConOps

20	ITS4US Buffalo	7	Passenger Pick-up, Securement, and Drop-off	This use case is about describing the processes and functions on shuttles during pickup/drop-off and securement	ITS4US - Phase 1 ConOps
21	ITS4US Buffalo	8	En-route Services and Information	This use case is about describing the processes and functions on shuttles during drive	ITS4US - Phase 1 ConOps
22	ITS4US Buffalo	9	Manage Incidents	This use case is about handling incidents in the shuttle network	ITS4US - Phase 1 ConOps
23	ITS4US Buffalo	10	PedX Request	This use case is about sending a hands-off PedX Signal Actuation Request	ITS4US - Phase 1 ConOps
24	ITS4US Atlanta	1	Traveler's Complete Trip with ST-CTN	This use case is about the process of a traveler planning and navigating their complete trip with the ST-CTN system	ITS4US - Phase 1 ConOps
25	ITS4US Atlanta	2	Connected Vehicle	This use case is about the way the CV subsystem will operate to provide functionality and support for system actions	ITS4US - Phase 1 ConOps
26	ITS4US HIRTA	1	Overarching Scenario-Normal Operations	This use case is about a person with disability traveling to an appointment, then family member home, then home with a companion	ITS4US - Phase 1 ConOps
27	ITS4US HIRTA	2	Scenario 2-Degraded Operation	This use case is about a person trying to book a transportation appointment for a medical appointment using Health Connector when HIRTA TMS is down	ITS4US - Phase 1 ConOps
28	ITS4US HIRTA	3	Scenario 3-System Failure Mode	This use case is about a person who scheduled an appointment where Health Connector system is non-operational day of but HIRTA TMS still accessible but without real-time updates	ITS4US - Phase 1 ConOps
29	ITS4US HIRTA	4	Scenario 4-Traveler looking for Transportation for a Recurring Medical Appointment	This use case is about a person who has a scheduled recurring trip to a medical appointment and uses on-demand service for return trips	ITS4US - Phase 1 ConOps
30	ITS4US HIRTA	5	Scenario 5-Traveler looking for Transportation for a Recurring Medical Appointment on Irregular Schedule	This use case is about a person who has recurring medical appointments on an irregular schedule, LEP, and requires assistance	ITS4US - Phase 1 ConOps
31	ITS4US HIRTA	6	Scenario 6-Traveler Looking for a Preventative Care Appointment	This use case is about a rural veteran looking for an ad-hoc appointment for preventative care	ITS4US - Phase 1 ConOps

32	ITS4US HIRTA	7	Scenario 7-Traveler looking for an Appointment for an ad-hoc Procedure where a Companion is needed for Return Leg of the Trip	This use case is about a traveler who needs a personal companion on the return home from a medical appointment	ITS4US - Phase 1 ConOps
33	ITS4US HIRTA	8	Scenario 8-Traveler looking for more than one Person as Accompaniment for a Medicaid-funded Trip	This use case is about a person going to a medical appointment with a group of accompaniments	ITS4US - Phase 1 ConOps
34	ITS4US HIRTA	9	Scenario 9 (DCHD)-A New Dallas County Resident Looking for Information and Referral for Medical Care	This use case is about an elderly traveler using Health Navigator to get help with their medical and transportation needs	ITS4US - Phase 1 ConOps
35	ITS4US HIRTA	10	Scenario 10 (Healthcare Provider)-Healthcare Provider Assists with Transportation Needs after the Appointment	This use case is about a blind traveler requesting hospital staff for return transportation	ITS4US - Phase 1 ConOps
36	ITS4US HIRTA	11	Scenario 11 (Healthcare Provider)-Healthcare Provider Arranges Return Transportation for Patient prior to Discharge	This use case is about a traveler whose transportation after discharge is arranged by healthcare provider	ITS4US - Phase 1 ConOps
37	ITS4US HIRTA	12	Scenario 12 (HIRTA)-HIRTA to be aware of Medical Appointment Status to arrange the Return Trip	This use case is about a situation where HIRTA has to coordinate services since traveler does not use smart devices	ITS4US - Phase 1 ConOps
38	ITS4US HIRTA	13	Scenario 13 (HIRTA)-HIRTA to Coordinate regarding Return Trip since Outbound Trip to Healthcare Facility a No-Show	This use case is about a situation where a traveler is a no-show for a trip to a medical appointment and coordination may be needed for return leg before cancellation	ITS4US - Phase 1 ConOps
39	ITS4US HIRTA	14	Scenario 14 HIRTA to Contract with a Non-dedicated Service Provider (Taxi, TNC, Volunteer driver) to	This use case is about a traveler being dispatched a volunteer driver network vehicle when HIRTA service not available	ITS4US - Phase 1 ConOps

			Provide Trips During After Hours (TBD)		
40	ATTRI	1	Intersection Crossing - Signal Control is Red	Intersection Crossing - Signal Control is Red	Safe Intersection Crossing - Concept of Operations - Year 2
41	ATTRI	2	Intersection Crossing - Signal Control is Green (Enough Time)	Intersection Crossing - Signal Control is Green (Enough Time)	Safe Intersection Crossing - Concept of Operations - Year 2
42	ATTRI	3	Intersection Crossing - Signal Control is Green (Not Enough Time)	Intersection Crossing - Signal Control is Green (Not Enough Time)	Safe Intersection Crossing - Concept of Operations - Year 2
43	ATTRI	4	Intersection Crossing - Multiple Pedestrians -Signal Control is Green	Intersection Crossing - Multiple Pedestrians -Signal Control is Green	Safe Intersection Crossing - Concept of Operations - Year 2
44	ATTRI	5	Intersection Crossing - System Communications Failure	Intersection Crossing - System Communications Failure	Safe Intersection Crossing - Concept of Operations - Year 2
45	ATTRI	6	Intersection Crossing - Unsafe Trajectory Detected	Intersection Crossing - Unsafe Trajectory Detected	Safe Intersection Crossing - Concept of Operations - Year 2
46	ATTRI	7	Intersection Crossing - Unexpected User Delay	Intersection Crossing - Unexpected User Delay	Safe Intersection Crossing - Concept of Operations - Year 2
47	ATTRI	8	Intersection Crossing - Dual Crosswalk During All Pedestrian Walk Phase	Intersection Crossing - Dual Crosswalk During All Pedestrian Walk Phase	Safe Intersection Crossing - Concept of Operations - Year 2
48	ATTRI	9	Pre-Crossing - Notifying Pedestrian that Upcoming Traffic Signal is Red	Pre-Crossing - Notifying Pedestrian that Upcoming Traffic Signal is Red	Safe Intersection Crossing - Concept of

					Operations - Year 2
49	ATTRI	10	Pre-Crossing - Assisting Pedestrian to Prepare for Crossing	Pre-Crossing - Assisting Pedestrian to Prepare for Crossing	Safe Intersection Crossing - Concept of Operations - Year 2
50	ATTRI	11	Pre-Crossing - Pedestrian Requires Replay of Instructions	Pre-Crossing - Pedestrian Requires Replay of Instructions	Safe Intersection Crossing - Concept of Operations - Year 2
51	ATTRI	12	Pre-Crossing - Pedestrian Decides Not to Cross	Pre-Crossing - Pedestrian Decides Not to Cross	Safe Intersection Crossing - Concept of Operations - Year 2
52	ATTRI	13	Pre-Crossing - Approach of an Emergency Vehicle	Pre-Crossing - Approach of an Emergency Vehicle	Safe Intersection Crossing - Concept of Operations - Year 2
53	ATTRI	14	Pre-Crossing - Pedestrian Crossing Synchronized with Bus Arrival	Pre-Crossing - Pedestrian Crossing Synchronized with Bus Arrival	Safe Intersection Crossing - Concept of Operations - Year 2
54	ITS4US CALACT	1	Individual with a mobility disability who uses a mobility device is looking for a demand response service for the first time	Individual with mobility disability using mobility device looking for demand response service for first time	ITS4US - Phase 1 ConOps
55	ITS4US CALACT	2	Person who uses a wheelchair planning a trip to work using fixed-route service near their home	This use case is about a person who uses a wheelchair planning to use fixed-route service	ITS4US - Phase 1 ConOps
56	ITS4US CALACT	3	A rider with a vision disability uses an agency's website to determine what times the local train stops near their house and receives alert en route to station	Blind individual navigates website to get updates on train that is delayed	ITS4US - Phase 1 ConOps

57	ITS4US CALACT	4	A rider with a vision disability boards a demand responsive vehicle on a busy street and knows the right vehicle to board because the mobile application directs them to it in a line of vehicles	Individual with vision disability navigates to the correct vehicle on a busy street	ITS4US - Phase 1 ConOps
58	ITS4US CALACT	5	Person with a developmental disability wants to schedule paratransit services online to pick them up at home and drop them off at their new job	This use case is about a person with a developmental disability setting up trips to work and back using paratransit services	ITS4US - Phase 1 ConOps
59	ITS4US CALACT	6	A rider who is a veteran and currently on a low fixed-income is researching transit in her area to see what options are available for her to go to the VA Hospital in a nearby urban center in the most efficient and economical way possible	Low-income veteran needs to find fare and transportation information to get to hospital	ITS4US - Phase 1 ConOps
60	ITS4US CALACT	7	An older rider who has a hearing disability is taking a long bus ride but realizes they need to alight early to find a restroom	This use case is about an older rider who has to alight early to access a bathroom and continues the trip home after	ITS4US - Phase 1 ConOps
61	ITS4US CALACT	8	A rider with limited English proficiency is navigating to the correct bus stop in a transit mall	This use case is about a rider with limited English proficiency navigating to the correct bus stop in a transit mall	ITS4US - Phase 1 ConOps
62	ITS4US CALACT	9	A rider in a rural area without consistent internet needs to book a trip into the closest urban area for a shopping trip	This use case is about providing users without consistent access to internet a way to make trips	ITS4US - Phase 1 ConOps
63	ITS4US CALACT	10	A rider who is a victim of stalking is planning a trip home from work at night using transit and their bike	This use case is about a rider who wants to safely travel home with their bike and transit	ITS4US - Phase 1 ConOps

64	ITS4US CALACT	11	A state DOT analyst is supporting a social service agency in identifying the transportation services available in a new operational region and their service parameters	This use case is about an analyst gathering info online about transit agencies in area	ITS4US - Phase 1 ConOps
65	ITS4US CALACT	12	A small demand response operator is transitioning to a new scheduling system	This use case is about the process of procuring a new scheduling system	ITS4US - Phase 1 ConOps
66	ITS4US CALACT	13	A rider advocacy group is working with a specialized transportation provider to present an analysis to the DOT and legislature regarding the need for investment in underserved communities	This use case is about the gathering of data that allows level of service analysis	ITS4US - Phase 1 ConOps
67	ITS4US CALACT	14	A vendor is calculating the potential return on investment from building a new software product for the transit market	This use case is about the gathering of data that allows ROI analysis for a new transit tool	ITS4US - Phase 1 ConOps
68	ITS4US CALACT	15	A state DOT is trying to add additional depth of information on mobility devices to the GTFS specification	This use case is about the process of standardizing the addition of information to GTFS specification	ITS4US - Phase 1 ConOps
69	ARC-IT MAT: Wayfinding	1	Customize User Profile	This use case describes the processes and interactions travelers apply to set up a wayfinding user profile. The use case allows the traveler to configure their default travel preferences for (1) types of notifications and alerts, (2) their modal preferences, (3) their accessibility needs, and (4) linking to other accounts.	ARC-IT Wayfinding and Navigation Use Cases
70	ARC-IT MAT	2	Trip Planning	This use case consists of functions for a traveler to plan a trip by inserting their origin and destination. The planning algorithm may consider expected conditions at the time of planned travel. Travelers may customize the trip by selecting	ARC-IT Wayfinding and Navigation Use Cases

				general preferences (e.g., modes, shortest trip, fewest transfers), or use an existing trip plan or set of preferences for travel and notification. The traveler can also adjust their trip preferences and save the updated trip plan.	
71	ARC-IT MAT	3	Personal Wayfinding	This use case describes wayfinding by walking or using self-directed micromobility vehicles to complete a portion of a trip plan that uses a single mode of travel from the point at which use of the mode starts to the point at which use of the mode ends. This use case includes wayfinding along a range of indoor and outdoor facilities.	ARC-IT Wayfinding and Navigation Use Cases
72	ARC-IT MAT	4	Transition To or From Driver Mode	This use case describes the process of transitioning to or from a driver mode.	ARC-IT Wayfinding and Navigation Use Cases
73	ARC-IT MAT	5	Transition to Passenger Mode	This use case describes the information provisions associated with transitioning to a passenger mode of travel.	ARC-IT Wayfinding and Navigation Use Cases
74	ARC-IT MAT	6	Passenger Wayfinding	This use case describes the process of navigating while a passenger and transitioning back to a non-passenger mode of passenger travel.	ARC-IT Wayfinding and Navigation Use Cases
75	ARC-IT MAT	1	Setup and Maintain Customer Account	This use case describes the processes and interactions travelers apply to set up an integrated payment user profile. The use case allows the traveler to configure their default payment preferences for (1) payment method (Smart Cards, Account-based, and Bank Credit Cards), (2) Linking to various mobility preferences by approving the exchange of data with each Mobility Service Provider offered in the app.	ARC-IT Payment Integration Use Cases
76	ARC-IT MAT	2	Integrated Multi-Modal Trip Planning integration with Payment application	This use case consists of functions for a traveler to plan, book, and pay for a trip using mixed modes of transportation. The use case is based around use of an applications that will act as a one-stop shop for	ARC-IT Payment Integration Use Cases

				payment and planning for multiple account-based transportation options.	
77	ARC-IT MAT	3	Address Income Inequality using Trip Planning/Payment Application	This use case describes the types of programs and promotions put in place via an on-line application to allow all Travelers equal opportunity to use all modes of Transportation. These modes of transportation can include Mobility on Demand to travel across all modes of travel.	ARC-IT Payment Integration Use Cases
78	ARC-IT MAT	4	Back-end Processing of Payment for Trips using account-based system (Pre-Payment)	This use case consists of the workflow used to process the payment made by the Traveler to plan and pay for a trip using mixed modes of transportation. The application will act as a one-stop shop for payment and planning for multiple account-based transportation options. The account-based system enables the Traveler to simply tap or scan a secure “token” using a contactless bank card, phone, or smartcard which is linked to an account in the back office.	ARC-IT Payment Integration Use Cases
79	ARC-IT MAT	5	Back-end Processing of Payment for Trips using Card-based system (Closed Loop)	This use case consists of the workflow used to process the payment made by the Traveler to plan and pay for a trip using mixed modes of transportation with a card. The trip payment application and it’s back-end will act as a one-stop shop for payment and planning for multiple account-based transportation options.	ARC-IT Payment Integration Use Cases
80	ARC-IT MAT	6	Back-end Processing of Payment for Trips using Open Payment Systems (Pay as you Go)	This use case consists of the workflow used to process the payment made by the Traveler to plan and pay for a trip using mixed modes of transportation. The trip payment application and its back-end will act as a one-stop shop for payment and planning for transportation options.	ARC-IT Payment Integration Use Cases
81	ARC-IT MAT	1	Transition Between Modes of Travel	This use case describes the processes and interactions as a traveler boards or alights from a "vehicle." The use case allows a traveler's personal information device (PID) (or Personnel	ARC-IT VRU Use Cases

				Device (PD)) to "adopt" the characteristics and profile of the vehicle the traveler is riding on. This "adoption" consists of coordination between the traveler's device and the vehicle equipment to avoid interference and conflicts between the two.	
82	ARC-IT MAT	2	VRU Clustering	This use case describes how VRUs interact with other VRUs. This may include warnings and alerts to avoid collisions or provide suggestions so VRUs may travel in platoons or traverse a path or open area.	ARC-IT VRU Use Cases
83	ARC-IT MAT	3	Public Right of Way Compliance	This use case describes the processes and interactions to allow a traveler to determine if they are permitted to use a lane or path based on its current traveler profile. Lane restrictions may be based on vehicle type, parking, stopping, or direction of travel.	ARC-IT VRU Use Cases
84	ARC-IT MAT	4	Cooperative Perception	This use case describes how a traveler broadcasts information about potentially hazardous conditions, hazards, incidents, and events with other travelers to support the safety and mobility of the traveler. The roadside communications infrastructure, if available, can extend the situational awareness range to other travelers within its communications range. In addition, the infrastructure may detect an event or an incident along the potential path of a traveler, then share the information about the event or incident with other travelers.	ARC-IT VRU Use Cases
85	ARC-IT MAT	5	Trajectory Prediction	This use case describes how a VRU determines and shares its predicted path trajectory with other VRUs.	ARC-IT VRU Use Cases
86	ARC-IT MAT	6	Workzone Workers	This use case describes how a VRU, such as a workzone worker, may interact with other vehicles. This may include warnings and alerts to be aware of potential collision, such as by intrusions of vehicles into the workzone.	ARC-IT VRU Use Cases

87	CV Pilot Deployment Program	5.3.8	Pedestrian in Signalized Crosswalk Application	This application will use the pedestrian detection information to indicate the presence of pedestrians in a crosswalk at a signalized intersection.	Connected Vehicle Pilot Deployment Program Phase 1, Concept of Operations (ConOps) - New York City
88	CV Pilot Deployment Program	5.3.9	PED-SIG Application	The NYC CVPD will deploy an application to support visually impaired (blind) crossing the street.	Connected Vehicle Pilot Deployment Program Phase 1, Concept of Operations (ConOps) - New York City
89	CV Pilot Deployment Program	UC3-S1	Pedestrians at Courthouse - CV Normal Conditions	This scenario describes the normal conditions where there is a “no problem” or “no issue” with the Pedestrians crossing Twiggs Street at the Courthouse or with Drivers on Twiggs Street proceeding through the site.	Connected Vehicle Pilot Deployment Program Phase 1, Concept of Operations (ConOps) - Tampa (THEA)
90	CV Pilot Deployment Program	UC3-S2	Pedestrians at Courthouse - CV Activation Conditions	This scenario describes the activation conditions where conditions will activate or trigger the CV apps for the Pedestrians crossing Twiggs Street at the Courthouse and Drivers on Twiggs Street driving through the crosswalk.	Connected Vehicle Pilot Deployment Program Phase 1, Concept of Operations (ConOps) - Tampa (THEA)
91	CV Pilot Deployment Program	UC3-S3	Pedestrians at Courthouse - CV Failure /Anomaly /Exception Conditions	This scenario describes the failure/anomaly/exception conditions that could require temporarily “turning off” the CV technology /system /device(s) of the CV apps for the Pedestrians crossing Twiggs Street at the Courthouse and Drivers on Twiggs Street driving through the crosswalk.	Connected Vehicle Pilot Deployment Program Phase 1, Concept of Operations (ConOps) - Tampa (THEA)
92	CV Pilot Deployment Program	UC3-S4	Pedestrians at Courthouse - CV Maintenance Conditions	This scenario describes the maintenance conditions that could require temporarily “turning off” the CV technology/system/device(s) of the CV apps for the Pedestrians	Connected Vehicle Pilot Deployment Program Phase 1, Concept of

				crossing Twiggs Street at the Courthouse and Drivers on Twiggs Street driving through the crosswalk, as well as related RSUs and TMC functions.	Operations (ConOps) - Tampa (THEA)