MAT v1.0

Task 3.2 Multimodal and Accessible Travel (MAT) Use Cases

Multimodal and Accessible Travel Use Cases

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

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1 Introduction

1.1 Scope of Document

Based on the results of Task 3.1, this document describes and expands on several use cases related to gaps in Multimodal and Accessible Travel standards. Task 3.1 analysis included a deep dive into existing use cases to identify gaps and contradictory use cases in the literature. Five topics were selected to describe and expand on existing literature. This document describes the methodology used to develop the use cases and the use cases covering the following five topics:

- Eligibility
- Reservations: Dispatch and Scheduling
- Product Rules for Mobility Payment Integration
- Path Costs for Personalized Trip Planning
- Pedestrian Intersection Crossing

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 the 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."

The Task 3 effort included a deep dive into the existing use case to identify gaps and contradictory scenarios in the literature. The Task 3.1 MAT Use Case Review document identified five areas where additional effort is warranted. These include the following:

- Eligibility to participate in specific mobility service programs
- Reservations: Dispatch and Scheduling
- Mobility Payment Integration specifically focused on Product Rules, Discounts/Benefits, Payment Methods
- Data Collection: Focused on collecting and generating Path Costs for Personalized Trip Planning
- Pedestrian intersection crossing

2 Use Case Methodology

2.1 Use Case Template

As noted in Section 1, a use case identifies the interactions—such as data flow and functions—among users (actors) and a system to enable the user to achieve a goal. The purpose of the use cases in the context of this project is to identify specific areas where standardization may have an impact on the capabilities and means of interaction among the different actors, such as travelers and mobility systems.

To address the five identified areas where additional effort is warranted, use cases were developed for specific scenarios in each of the five areas where the development of a standard may benefit travelers.

A use case template was defined to guide the development of the use cases in this document. The purpose of the use case template was two-fold:

- The developed use cases are presented in a consistent format to help understanding and use
- The developed use cases are complete

The use case template used, and their definitions, are presented in Section 2.1.1.

2.1.1 Use Case Definition

UC*n*: *Title*	***n* – *a unique identifier to reference the use case*** **Title – The name of the use case**
Goal	*The goal or purpose of the use case.*
Description	*A summary of the use case, defining the problem the system (or standard) aims to solve and proposed benefits.*
Primary Actor	*An enumeration of the actors (as described in Section 2.2) that participate and interact with other actors.*
Secondary Actors	*An enumeration of support actors (as described in Section 2.2).*
Illustration	*A figure or depiction of the actors and flows/transactions between the actors.*
Pre-conditions	*What must be true or happen before and after the use case runs.*
Triggers	*An event that initiates the use case.*
Post-conditions	*A condition that occurs following the events/activities related to the use case.*
Assumptions/ Constraints	*Any assumption or constraints associated with the use case.*
Trustworthiness	*Any privacy or cybersecurity provision that is assumed by the user as part of the use case.*
Accessibility	*Accommodations or challenges faced by underserved communities including people with disabilities, older adults, low income, LEP.*
Information Requirements	*Provision for information flows including data input, processed, generated, and output as part of this use case. The requirements may be at the data element level.*
Issues	*Any issues, challenges, or anomalies associated with the use case.*
Source Documents	*An enumeration of the references that informed the development of this use case.*

UCn: Title		
Pre-conditions		
Item	**Step**	**Description**
Main Flow	1	*The sequence of events or interactions that the actors perform to complete a process or transaction in pursuit of the goal.*
	2	
	3	
	4	
	5	
Alternate Flows		*Variations on the main theme above in pursuit of the goal.*
Exception Flows		*Exceptions are what happens when things go wrong at the system level.*
Extensions		*<None>*

3 Eligibility to Participate in Mobility Services Use Cases

3.1 Description

"The Americans with Disabilities Act (ADA) requires complementary paratransit in view of the fact that there will always be some people with disabilities who are unable to navigate the fixed route [transit] systems on their own. Public transit agencies that provide fixed route transportation to the general public must ensure the provision of paratransit service to people with disabilities who are unable to use the fixed route system.

"Because the ADA requires paratransit service only for people who are unable to use the fixed route service due to a disability, eligibility determination focuses solely on the person's functional ability to use the fixed route service."[1]

The use cases cover only the public transit-related modes since they focus on describing the process and information elements needed to determine eligibility for travelers to use specialized transportation (aka ADA paratransit). The use cases define the eligibility process for accessing this type of mobility service.

3.1.1 Eligibility Categories[2]

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

A. 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:

- An individual with a cognitive disability, if they do not 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)

Bus drivers (vehicle operators) are required to provide assistance with the use of accessibility equipment on the vehicle, such as lifts, ramps, securement devices, and so forth. The need for this assistance is not a basis for paratransit eligibility.

B. 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.

The ADA Part 37--Transportation Services for Individuals with Disabilities, 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.

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.

C. 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.

This has come to be called the "reasonable person" test. For example, an individual with an ambulatory disability may be able to go six blocks to a bus stop but doing so takes quite a while 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.

3.1.2 Types of Eligibility[3]

The ADA requires consideration of eligibility for trips that an applicant or rider makes or might make. For this reason, different types of eligibility that have developed in the transit industry, including the following:

1. Unconditional Eligibility (All Trips)

This is a person's eligibility category when it is not reasonable to use the fixed route service under any circumstances, regardless of weather, distance to the stop, and so on.

2. Conditional Eligibility (Some Trips)

In this type of eligibility, the person can be reasonably expected to make some trips on the fixed route service. For example, a person may be able to reach bus stops that are no more than three blocks away, and where there is a safe, accessible path of travel, but she may require paratransit if distances are greater than three blocks, or if there are path of travel obstacles such as steep hills, deep snow or ice, or other obstacles. Another person may have a variable health condition; on some days fixed route use is possible and on other days, it is not.

When transit agencies determine individuals conditionally eligible, they should identify all conditions that affect travel. Omitting any of the conditions that affect travel will inappropriately limit the rider's

eligibility. FTA has found in ADA compliance reviews that some transit providers did not adequately consider path-of-travel barriers, weather, and other possible issues when setting conditional eligibility.

Reports from transit systems that have relatively thorough eligibility determination processes suggest that approximately 30 to 45 percent of all eligible people require the service only under certain conditions. Moving a portion of these trips to the fixed route service can result in significant cost savings to transit providers, though this needs to be done in a manner that is consistent with the ADA requirements, and with best operational practices.

3. Temporary Eligibility

The ADA also includes temporary eligibility for people with disabilities that prevent them from using the fixed route system for a limited period of time.

3.1.3 Applying Conditional Eligibility: Trip-By-Trip Eligibility[4]

For riders who have conditional eligibility, for each trip they request, the transit agency may assess (or "screen") whether that particular trip's circumstances meet the conditions under which the rider is eligible. This is known as trip-by-trip eligibility (also called simply "trip eligibility").

Conditional eligibility and trip-by-trip eligibility form a two-stage process. First, in conditional eligibility, the transit agency assesses an individual's functional ability to use the fixed route transit system. Second, in trip eligibility, the transit agency applies the individual's conditions to his or her specific trips, one by one.

Neither conditional nor trip eligibility is required by the ADA. But when they are implemented properly, consistent with the best operational practices in the transit industry, it can save money for transit agencies while preserving the ADA rights of riders. It can also yield additional benefits, such as specific information on how to make the fixed route system more accessible.

In conducting trip eligibility, transit agencies consider environmental and other conditions, such as the path of travel to and from the bus stops, for every trip request, or for every request in certain categories, such as night trips or those taken during winter months. If the streets and barriers along the route of the trip request have not been assessed, the rider is given presumptive eligibility for that route until the completion of an environmental assessment.

A few transit agencies screen most or nearly all requested trips for their conditionally eligible riders; many more screen some percentage of trips, focusing on the most frequent trips or subscription trips. Transit agencies that do significant trip-by-trip screening include those in Pittsburgh, Seattle, Spokane, Salt Lake City, Dayton, Corpus Christi, and Philadelphia.

3.1.4 Eligibility Process[5]

Many different processes and types of materials are used by transit agencies across the country to make determinations of eligibility and to inform the public about ADA paratransit eligibility and accessible transportation services. These processes combine a variety of information sources in different ways to gather information about the functional abilities of applicants. The processes also involve different types of organizations, with some systems making determinations using in-house staff, and others contracting for assistance with the process.

No single process has emerged as the "best" model. Processes seem to develop over time to reflect local conditions and local expertise. It is therefore important to understand all the options and to design a process that best fits local conditions. Regardless of the exact process, there are certain types of information that are typically used to make determinations. Information can be gathered from applicants, professionals familiar with applicants, or through independent assessments.

There are also a number of ways that processes and staffing can be organized. There are three primary sources of information that can be used to make ADA paratransit eligibility determinations. There are also various ways that information can be gathered from each source.

- Information from applicants
  - Application forms
  - Telephone interviews
  - In-person interviews
- Verification of disability and information from programs and professionals familiar with applicants
  - Requesting information about professional(s) who can be contacted as needed
  - Requiring verification of disability as part of the application form
  - Inviting applicants to provide readily available information
  - Requiring information for certain types of disabilities
- In-Person Functional Assessments
  - Physical functional assessments
  - Assessments of cognitive abilities
  - Assessments of sensory skills

Table 1 shows some of the more common approaches and processes documented in a survey conducted for the Transit Cooperative Research Program (TCRP)[6]. Further, Figure 1 shows the recommended eligibility process.

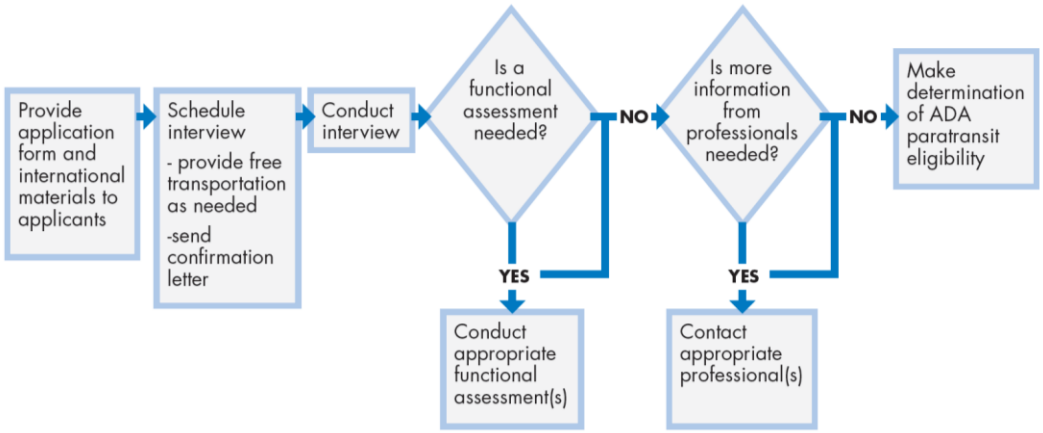


Figure 1. Recommended Eligibility Process.[7]

Table 1. Types of Information and Processes used by Transit Agencies[8]

Sources of Information/Process Elements						Number of Transit Systems	Percent of Transit Systems
Paper Application	Professional Verification	Interviews (As needed)	Interviews (All)	Functional Assessments (As needed)	Functional Assessments (All)		
Application form and/or professional verification. No in-person interviews or functional assessments.							
✓						16	
	✓					2	
✓	✓					35	
Subtotal						**53**	**43%**
Application form (and professional verification). In-person interviews as needed. No functional assessments.							
✓	✓	✓				8	
✓		✓				2	
Subtotal						**10**	**8%**
Application form and professional verification. 100% in-person interviews. No functional assessments.							
✓	✓		✓			13	
Subtotal						**13**	**10%**
Application form and professional verification. In-person interviews and/or functional assessments as needed.							
✓	✓	✓		✓		12	
✓	✓	✓		✓		1	
✓	✓			✓		6	
Subtotal						**19**	**15%**
No application form. 100% in-person interviews and/or functional assessments. Some professional verification.							
					✓	1	
			✓	✓		2	
	✓		✓		✓	2	
	✓		✓	✓		1	
			✓		✓	1	
Subtotal						**7**	**6%**
Application form (some professional verification). 100% in-person interviews and/or functional assessments.							
✓					✓	2	
✓	✓				✓	1	
✓			✓		✓	3	
✓			✓	✓		1	
✓	✓	✓			✓	4	
✓	✓		✓		✓	6	
✓	✓		✓	✓		9	
Subtotal						**23**	**18%**
Totals						**125**	**100%**

3.2 Eligibility Actors

As described above, the use cases describe the eligibility determination process for travelers to access specialized transportation services. The use case actors interact with each other to determine eligibility, communicate the eligibility status to agencies providing specialized transportation services, and grant access to specialized transportation services by eligible travelers.

3.2.1 Actors

The actors in the eligibility determination process are described in Table 2: Eligibility Actors.

Table 2: Eligibility Actors

Actor	Description
Mobility Service Manager (MSM)	Authority or agency that manages or contracts out the specialized transportation service(s).
Mobility Operator (MO)	Organization that operates the vehicles and facilities associated with the specialized transportation service(s). An MSM can be the same as the MO.
In-house Functional Assessment Staff (IFAS)	Staff within the agency who provide functional assessment services.
Contractor Functional Assessment Staff (CFAS)	Staff outside the agency who provide functional assessment services.
Product	An eligibility identification (ID) that allows a traveler to access one or more specialized transportation services.
Traveler	A person(s) traveling using specialized transportation services which require eligibility for access.

3.2.2 Actor Roles

According to Figure 1, Table 3 is a description of actor roles.

Table 3. Actor Roles

Actor	Roles
Mobility Service Manager (MSM)	• Provide information about ADA paratransit and other accessible transportation options and services • Send eligibility application to traveler • Schedule in-person interview with traveler • Provide transportation to eligibility interview, if necessary • If a photo ID is needed, take photo of traveler • Determine if functional assessment needs to be conducted • If a decision about eligibility is not made within 21 days, “presumptive eligibility” granted to traveler (traveler will be able to use the service until a decision can be made). • Review recommendations made by contractors and reserve the right to make the final eligibility decision
Mobility Operator (MO)	• Provide transportation to eligibility interview, if necessary • Provide specialized transportation service if contracted by MSM
In-house Functional Assessment Staff (IFAS)	• Review information provided by traveler • Disability verification provided for travelers known to staff • Additional information provided as needed for travelers with disabilities and functional abilities familiar to staff
Contractor Functional Assessment Staff (CFAS)	• Review information provided by traveler • Disability verification provided for travelers known to staff • Additional information provided as needed for travelers with disabilities and functional abilities familiar to staff

Actor	Roles
Traveler	• Complete application form • Participate in an in-person interview • Obtain written verification of disability from a professional or provide contact information for a professional familiar with his or her disability and functional abilities • Based on a review of the application and information collected in the interview, the traveler may undergo a physical functional assessment, a cognitive functional assessment, or both. • Identify mobility aid(s) they use to travel • Describe their travel abilities and needs in their own words in the interview

3.2.3 ARC-IT Physical Objects for Actors

The actors involved in the Eligibility Determination use cases are mapped to the most relevant ARC-IT physical objects in Table 4.

Table 4: ARC-IT Physical Objects for Eligibility Actors

Actor	ARC-IT Physical Object	Comment
Mobility Service Manager (MSM)	Transit Management Center (TRMC)	ARC-IT does not have a separate physical object for MSM, the functionality is included in the TRMC.
Mobility Operator (MO)	Transit Management Center/ Transportation Information Center (TIC)	While ARC-IT covers very well the transit aspects of MO, it currently doesn't address other types of MO as well (considering them TICs). The TRMC and TIC do not include MMV operators, for example.
In-house Functional Assessment Staff (IFAS)	Eligibility Certification Group*	ARC-IT does not currently have a physical object that relates to IFAS (or CFAS). A revision to ARC-IT is under development that would add a PO to cover this functionality.
Contractor Functional Assessment Staff (CFAS)	Eligibility Certification Group*	
Product	Payment Device	This PO covers all forms of payment, from smart cards to "general purpose devices like smart phones that support a broad array of services."
Traveler	Traveler	

The definitions of the Physical Objects from ARC-IT are shown below.

The **Transit Management Center** manages transit vehicle fleets and coordinates with other modes and transportation services. It provides operations, maintenance, customer information, planning, and management functions for the transit property. It spans distinct central dispatch and garage management systems and supports the spectrum of fixed route, flexible route, paratransit services, transit rail, and bus rapid transit (BRT) service. The physical object's interfaces support communication between transit departments and with other operating entities such as emergency response services and traffic management systems.

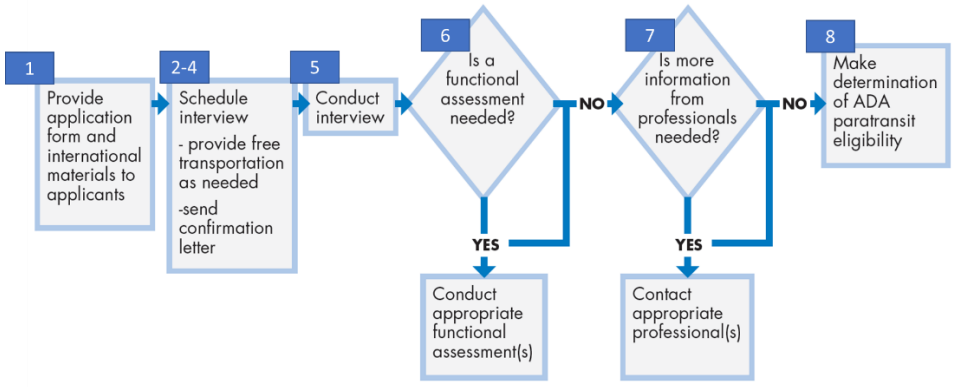
The **Transportation Information Center** (TIC) collects, processes, stores, and disseminates transportation information to system operators and the traveling public. The physical object can play several different roles in an integrated ITS. In one role, the TIC provides a data collection, fusing, and repackaging function, collecting information from transportation system operators, and redistributing this information to other system operators in the region and other TICs. In this information redistribution role, the TIC provides a bridge between the various transportation systems that produce the information and the other TICs and their subscribers that use the information. The second role of a TIC is focused on delivery of traveler information to subscribers and the public at large. Information provided includes basic advisories, traffic and road conditions, transit schedule information, yellow pages information, ride matching information, and parking information. The TIC is commonly implemented as a website or a web-based application service, but it represents any traveler information distribution service.

The **Traveler** represents any individual who uses transportation services. The interfaces to the traveler provide general pre-trip and en route information supporting trip planning, personal guidance, and requests for assistance in an emergency that are relevant to all transportation system users. It also represents users of a public transportation system and addresses interfaces these users have within a transit vehicle or at transit facilities such as roadside stops and transit centers.

3.3 Use Cases

3.3.1 Use Case 1 Eligibility Determination with no Automation

Use Case Definition

UC 1	**Eligibility Determination Process with no Automation**
Short Description	This use case consists of functions for the determination of Traveler eligibility to access and use specialized transportation services such as ADA paratransit.
Goal	The goal of this use case is to illustrate the eligibility determination process for the Traveler to access specialized transportation services.
Constraints	MSM or MO eligibility process (the process illustrated here is the recommended process – every agency has their own process).
Actors	• Mobility Service Manager (MSM) • Mobility Operator (MO) (there will be at least one MO per mobility service) • Traveler
Illustration (example)	
Preconditions	None

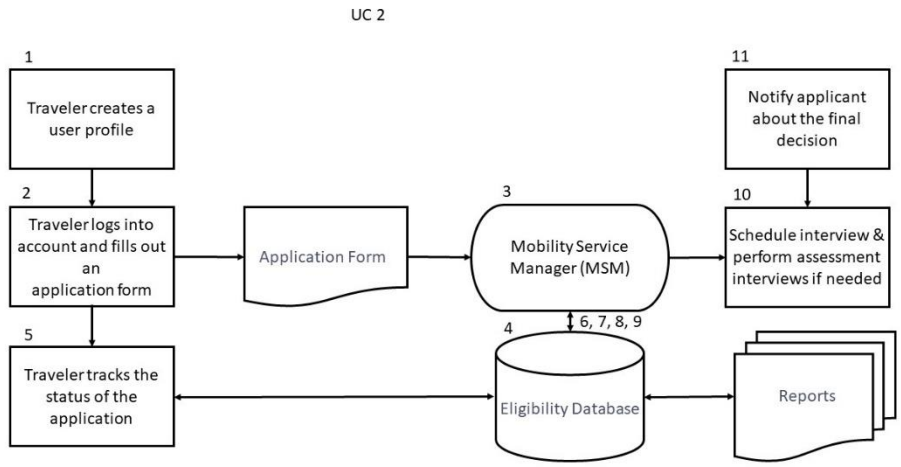
Post-conditions	Once eligibility is determined, the applicant shall be notified of the determination making it possible for the Traveler to make a reservation for a trip using specialized transportation services.
Assumptions / Constraints	The use case considers eligibility to use types of specialized transportation based upon the traveler's qualification to be a part of a specific group. Each group has its own eligibility requirements that the traveler must meet in order to qualify. Some of the groups for which this may apply are: • Persons with disabilities who qualify under ADA eligibility • Seniors • Low-income travelers • Veterans
Information Requirements	There are three primary manual sources of information that can be used to make ADA paratransit eligibility determinations: • Information from applicants can be obtained from an application form, follow-up telephone conversations, and in-person interviews • Verification of disability and information from programs and professionals familiar with applicants, which can be obtained from requesting information about professional(s) who can be contacted as needed, requiring verification of disability as part of the application form, inviting applicants to provide readily available information, and requiring information for certain types of disabilities • In-person functional assessments from physical functional assessments, assessments of cognitive abilities, and assessments of sensory skills

UC 1 Eligibility Determination Process with no Automation		
Pre-conditions		
Item	**Step**	**Description**
Main Flow	1	Provide application form and materials to applicants (potential Travelers): The MSM or MO will provide the eligibility application to a potential Traveler who requests specialized transportation service if they are not already eligible for these services.
	2	Schedule interview with the applicant: The MSM or MO will schedule an eligibility interview with the applicant.
	3	If requested, provide free transportation to the applicant: The MSM or MO will provide transportation for the applicant to travel to the interview if requested by the applicant.
	4	Once the interview is scheduled, send a confirmation letter: The MSM will send a letter to the applicant confirming the date, time, and location of the eligibility interview.
	5	The MSM conducts an interview with the Traveler to assess the eligibility of the applicant for specialized transportation services.
	6	If a functional assessment is needed, conduct appropriate functional assessment(s): The IFAS or CFAS will conduct the appropriate assessment(s). Once these are conducted, go to step 7.
	7	If more information from professionals is needed, contact appropriate professional(s): The MSM will determine if more information is needed from appropriate professionals and if so, will contact those professionals.

	8	Make determination of ADA paratransit eligibility: The MSM will determine whether or not the applicant is eligible for specialized transportation services.
	9	Inform applicant of eligibility decision.
Alternate Flows		None
Exception Flows		None
Extensions		<None>

3.3.2 Use Case 2 Eligibility Determination with Automation

Use Case Definition

UC 2	**Eligibility Determination Process with Automation**
Short Description	This use case consists of functions, some of which are automated, for the determination of Traveler eligibility to access and use specialized transportation services such as ADA paratransit.
Goal	The goal of this use case is to illustrate a partially automated eligibility determination process for the Traveler to access specialized transportation services.
Actors	• Mobility Service Manager (MSM) • Mobility Operator (MO) (there will be at least one MO per mobility service) • Traveler
Illustration (example)	Figure 1. Recommended Eligibility Process. 
Preconditions	None
Post-conditions	Once eligibility is determined, the applicant shall be notified of the determination making it possible for the Traveler to make a reservation for a trip using specialized transportation services.
Assumptions/ Constraints	The use case considers eligibility to use types of specialized transportation based upon the traveler's qualification to be a part of a specific group. Each group has its own eligibility requirements that the traveler must meet in order to qualify. Some of the groups for which this may apply are the following: • Persons with disabilities who qualify under ADA eligibility • Seniors • Low-income travelers

	• Veterans A constraint on this use case is the existing MSM or MO eligibility processes.
Information Requirements	The eligibility application form shall have at least the following fields and be protected as SPII applying the NIST Privacy Protection Framework and cyber security protocols that are applicable to HIPPA: 1. Name 2. Street Address 3. Day and evening phones 4. Emergency Contact 5. Disability conditions 6. Disability type (short term, permanent); 7. If short term disability, then a. Recovery time b. Is it recurring? 8. Checklist of mobility aids used 9. Need of a personal care attendant? 10. Specific questions on accessibility/functional disability such as: a. Can take the stairs? b. Can walk in adverse weather (snow/ice)? c. Can walk more than a specific (e.g., one block) distance? d. Can transfer across vehicles/routes)? e. Can wait at a stop? f. Can follow driver instructions /passenger information? g. Other (to be discussed with (PennDOT and individual agencies) 11. Use of regular fixed route modes: a. frequency of use b. If yes, three most traveled destinations c. Purpose of the above trips d. Time and days of the above trips 12. Specific problems in riding fixed route system 13. Contact information of the personal physician/medical professional

UC 2 Eligibility Determination Process with Automation		
Pre-conditions		
Item	**Step**	**Description**
Main Flow	1	Travelers create a user profile with a valid login and password using a web browser-based application form.
	2	Traveler logs into account and fills out an application form.
	3	Application is submitted to the MSM where its information is used to populate a database of all customers applying for paratransit services.
	4	A database (“eligibility database”) will be maintained for all customers applying for paratransit services to track the workflow of the eligibility determination process, as described in the next section. The applicant will be notified about all possible steps in the process determination beforehand.
	5	On the website the traveler can track the status of the application. The traveler will be notified over the phone or email about the rejection and will also be told about the reason of the rejection.

	6	The designated agency staff access the eligibility system to view all submitted applications in a workflow queue and will be able to review any application form by selecting one of those.
	7	The eligibility system can store any additional form, certificate, or document mailed/emailed/faxed by the applicant. These additional documents are linked to the applicant's record in the database.
	8	The designated agency staff can access the eligibility system to obtain reports regarding the status and operation of the eligibility system including the following: a. Number and details of all submitted applications b. Number and details of all rejected applications c. Number and details of all incomplete applications d. List and count of applications submitted by disability type e. Reasons of not able to ride the fixed route service by applicants and disability type f. List and count of applications waiting to be scheduled for an interview by disability type g. Number of applicants scheduled for an interview by date/time and disability type h. List and count of applicants scheduled for functional assessment by date time and disability type i. List of applicants that need help with transportation to appear for the interview/assessment j. List and count of applicants that need to submit further certificates/forms for verification k. Status and details of pending interviews/assessments l. Details of interview/assessment by application ID m. List of completed interviews/assessments with the name of interviewer/assessor n. List of applicants for who the follow up (e.g., contact with professional medical references) is required o. List of applications within "x" (e.g., 3) days of the end of application 21-day processing period (starting from the time of interview) p. Approved candidates by eligibility type ("unconditional," "conditional," and "temporary") q. List of candidates granted "presumptive" eligibility r. List of candidates that need to be recertified
	9	The designated agency performs verification on the application a. Determine if verification is required: i. What kind of verification is required ii. Is there a need for additional documents from the applicant b. Determine if an in-person interview is needed; if yes, then i. What needs to be covered in the interview ii. Is the applicant required to bring anything

		iii. If the customer needs transportation to appear c. Determine if a functional assessment is needed i. The type of functional disability (e.g., physical, cognitive, sensory) ii. The resources needed to conduct the assessment d. If application is OK then create a record in the "client eligibility management system/module"
	10	Schedule interview and perform assessment interviews if needed a. Notify the applicant about all details by email/phone b. Conduct interview and update the details in the system c. Conduct functional assessment and update the details in the system d. Determine if verification is required with the professional contact provided by the applicant e. Update the system with final decision
	11	Notify the applicant about the final decision by email/phone
Alternate Flows		n/a
Exception Flows		n/a
Extensions		<None>

3.4 Linking of Eligibility Database to Reservations System

The following discussion shows how the system for trip-by-trip ADA eligibility determinations can be used to provide a link between data in the eligibility module and the trip reservations module.

Approved applicants shall be coded as being either "Unconditionally eligible," "Conditionally eligible," or "Not eligible" in the eligibility module. The date of initial eligibility as well as the date of eligibility expiration shall also be included for each approved rider.

The eligibility code (Unconditional, Conditional, Not eligible) of each rider shall appear as a pop-up box on the initial trip booking screen once a reservationist enters the name (or ID number) of a calling rider. The date of expiration of eligibility shall also appear in the same pop-up box.

If a rider is listed in the pop-up box as being "Conditionally eligible," the reservationist shall be able to call-up certain information about the rider's trip eligibility. This shall include: any dates of "seasonal eligibility" (e.g., eligible only from November 1 to March 31), any time-of-day eligibility conditions (e.g., dusk to dawn), any weather-related conditions of eligibility (e.g., snow or icy conditions), and a list of trips that have been evaluated for eligibility. The list of evaluated trips shall include the origin and destination addresses and a statement whether the trip is "eligible" or "not eligible." For example: "10 Main Street to 50 Elm Street – eligible," or "10 Main Street to 200 Oak Street – not eligible." Trip eligibility information will be determined by on-street environmental assessments (outside of the reservations and scheduling process) and trip eligibility information shall be entered into the rider eligibility file.

In addition, the software shall include the ability to define geocoded buffers around fixed routes (or other geocoded polygons depicting the formal ADA service area) and compare these service area buffers to the requested paratransit trip origin and destination to determine if the trip is within the ADA paratransit service area and eligible. Further, the service area polygons shall be able to have time-of-day attributes associated with them (separately) to reflect when fixed route service is operating in each buffer zone. The system shall then compare not only paratransit origins and destinations to the service area buffer zones, but also determine if the requested times of the trip are within the formal ADA service days and hours for the areas

of travel. When comparing requested paratransit travel times to service area buffer times, the system shall compare the requested pick-up times and the appointment times rather than the "scheduled" times selected by the automated scheduling system. If a going trip is requested based on an appointment/desired arrival time, the pick-up time that will be compared to the service area time shall be the appointment time minus the direct, shortest path travel time from the origin to the destination based on the travel speed parameters in the system for that time of day.

3.5 Available Standards[9]

Under a grant from the Federal Transit Administration's Mobility for All Pilot Program (M4A), the Oregon Department of Transportation (ODOT) took a "solid first step" toward filling a pressing need for standardized and computer-readable data that describes rider eligibility (characteristics that qualify a rider to use a specialized transportation service; service capability (ability to meet rider needs); and trip purpose eligibility (trip intent matches service requirements).

GTFS-eligibilities[10] and GTFS-capabilities[11] are new data standards in development. When complete, they will describe the many factors that can determine access to transit services, particularly specialized transportation services.

GTFS-eligibilities will deal with how a person's individual characteristics (e.g., age, disability status, residence, employment, or registration in a program) may affect their access to public transportation services.

GTFS-capabilities will describe a transportation provider's ability to meet a rider's needs (e.g., whether the provider offers services such as door-to-door service, door-through-door service, stretcher service, mobility device accommodation, and bariatric capability).

Such information is currently available to the public in analog or one-off digital formats only. The absence of this information creates a range of unnecessary difficulties such as the following:

- Discovering services is labor-intensive, often with the burden falling on riders themselves to figure out what exists, whether they qualify for a specific type of transportation, and whether a provider can meet their service needs
- It's difficult for transit agencies to communicate about their services, especially specialized services, to the public
- It adds barriers to planners, policymakers, and researchers understanding how eligibility factors and agencies' ability to provide specialized services affect different populations' mobility

To ensure that this effort was worthwhile and didn't duplicate existing work, ODOT requested that its consultant, Full Path Transit Technology (Full Path), conduct research into completed and in-process efforts to define and enumerate these three areas. There is a well-established transit data standard (the General Transit Feed Specification or GTFS) as well as several "extensions" to the GTFS that expand its utility to the complex world of transportation data. However, this research indicated that no existing efforts address the need for data standards relating to rider eligibility, service capability, and trip purpose eligibility.

To develop an initial proposal for two extensions to the GTFS, Full Path convened an advisory group. This group was made up of experts in the fields of human services transportation, disability advocacy, public transit, data standards development, and transit-related software development to provide input and guidance to this project overall. The panel's work centered on ensuring that the standards being defined meet the needs of riders and the agencies that serve them, while also being technically sound.

A Technical Working Group, a subset of the advisory group, worked on the very detailed technical work of developing the proposed standards. Once complete, the draft extensions will be made available for continued refinement and ultimately adoption by implementers and ongoing oversight by the appropriate standards body.

The project's budget and timeline required focusing on an achievable result. Accordingly, it was decided that the scope would be limited to the discovery stage of the trip lifecycle, despite early discussions of possibly including registration/booking stages. Another key decision was emphasizing the ease of creating a data feed over completeness and exactness of data. For example, the group determined that it was more important for this early version of GTFS-capabilities to provide service-level information about capabilities, rather than requiring service providers to supply detailed information about every vehicle in their fleet. The advisory group also chose to emphasize flexibility in describing eligibility categories rather than imposition of definitions. The resulting proposal for GTFS-eligibilities introduces Universal Resource Names (URNs) as a structured way of developing unique identifiers for eligibility categories.

Because this project was intended to offer a foundation in the development of GTFS-eligibilities and GTFS-capabilities, several next steps and opportunities were identified:

- Supporting cross-institutional conversations to develop agreement on common goals and processes
- Inclusive engagement with riders during the development of applications that use the proposed standards
- Inclusive governance for the standards that entities that are accountable to the public interest
- Engaging people and agencies from throughout the world (to get beyond the United States focus of this project); sustained funding for data production and consumption
- Ongoing development and support around URNs as a concept that is new to the transit world
- Developing ability to track real-time information about seating area configuration changes through GTFS-capabilities
- Support for multiple languages under all scenarios

The effort is a continuation of ODOT's ongoing work to support the accessibility and usefulness of transit services through open data and address equity goals laid out in the Oregon Public Transportation Plan.

4 Reservations, Scheduling, and Dispatch of On-Demand Services Use Case

4.1 Description

Making a reservation for using a specific mobility service consists of trip booking, management of standing orders or subscription trips, and modifying or cancelling a trip. Another term that is often used as a substitute for reservation is booking, which "allows reservation of specific assets for a specific place, time and date."[12]

Scheduling mobility service trips consists of using multiple criteria or parameters to deliver the service using specific vehicles (with specific drivers if it is a public transit trip) taking specific routes for public transit service. Criteria/parameters used in scheduling can include the following:

- Actual street network in the mobility services' service areas, including parameters associated with street network segments (e.g., physical barriers, running speed by time of day, and appropriate dwell times for the boarding and alighting of passengers)
- Dwell time
- On-board capacity
- Average vehicle speed profile for street segments
- Grouping based on geographic location of origin and destination of trips
- Avoidance of street segments with detours/road closures
- Accessibility needs/mobility aids

Scheduling must set priority levels on all ADA complementary paratransit trips, which require higher service standards. Scheduling for paratransit or demand-response transit trips includes the generation of daily manifests for each run, indicating pull-in and pull-out times, the projected arrival time of a vehicle at each pickup and drop-off location, and listing the trip events in chronological order.

When creating a daily manifest, scheduling must take into account any vehicle assignment restrictions. For example, certain vehicles can provide only a specific type of trip (e.g., buses with wheelchair ramps).

Dispatching "refers to an operations management function which involves assigning vehicle, tracking fleet location, managing schedule adherence, managing trip manifests and other operational functions."[13] Dispatching consists of multiple functions, particularly when it is done for public transit service[14], and every transit agency does not dispatch service in the same way. In the dispatching use case, the following high-level dispatch functions are taken into account:

- Dispatching and scheduling of transit vehicles in accordance with established policies and procedures
- Operation of a two-way radio and/or other communication system and/or phone system to dispatch transit vehicles and drivers
- Performance of preparatory work at the beginning of each shift, such as assigning vehicles to drivers, distributing keys and on-board (e.g., tablet) computers, coordination of repair work and vehicle substitution to maintain service levels, and monitoring and reporting of driver tardiness, attendance, and situational occurrences to supervisors
- Directs drivers regarding the timely and efficient routing of transit services
- Troubleshooting computer-aided dispatch (CAD)/automatic vehicle location (AVL) system issues and resolving operating problems
- Coordinating schedules and preparation of recommended routes in the event of a service disruption
- The possible need to receive and respond to customer inquiries or complaints regarding service
- Maintaining log of radio transmissions and other operational data
- Advising staff and other concerned agencies of emergency situations, weather conditions, road closures and other matters relevant to mobility service
- Receipt and verification of drivers' paperwork to ensure accuracy

Typical depictions of reservation, scheduling, and dispatching are shown in Figure 2 and Figure 3, along with other functions that are not included in the use cases in this section.

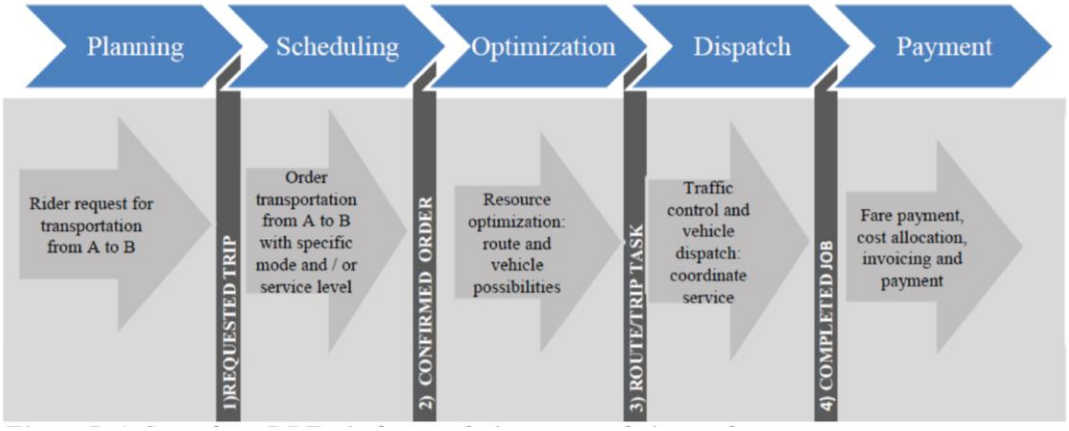


Figure 2. Reservation, Scheduling, and Dispatching within the Steps for a DRT trip.[15]

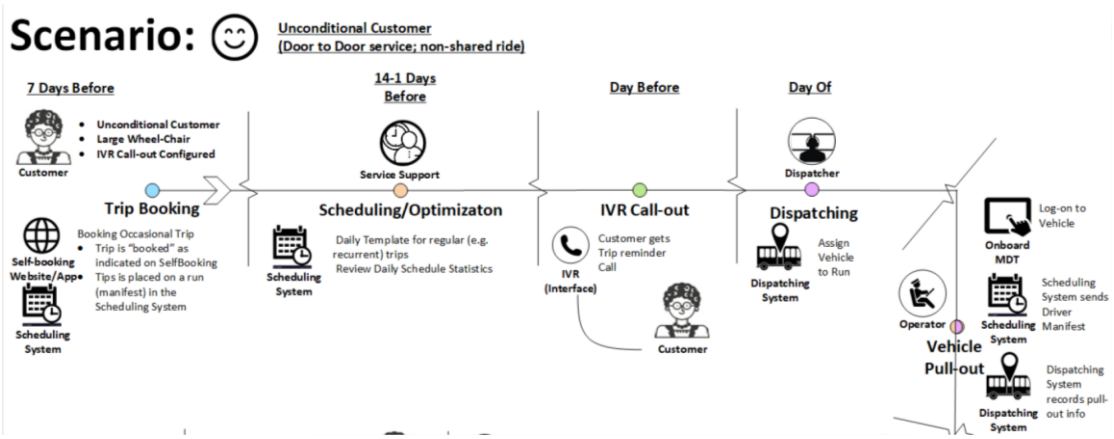


Figure 3. Typical Reservation, Scheduling, and Dispatching Flow[16]

4.2 Reservation, Scheduling and Dispatching Actors

As described above, these use cases describe the reservation, scheduling, and dispatching processes for travelers to access specialized transportation services. The use case actors interact with each other to take reservations, schedule the specialized transportation trips, and dispatch the trips for eligible travelers.

4.2.1 Actors

The actors in the eligibility determination process are described in Table 5.

Table 5: Reservation, Scheduling, and Dispatching Actors

Actor	Description
Mobility Service Manager (MSM)	Authority or agency that manages or contracts out the specialized transportation service(s).
Mobility Operator (MO)	Organization that operates the vehicles and facilities associated with the specialized transportation service(s). An MSM can be the same is the MO.
Call taker/reservationist	Staff within the MSM or MO who take reservations for specialized transportation trips.

Actor	Description
Scheduler	Staff within the MSM or MO who schedule the specialized transportation trips.
Dispatcher	Staff within the MSM or MO who dispatch the specialized transportation trips.
Traveler	A person(s) traveling using specialized transportation services which require registration and eligibility for access.

4.2.2 Actor Roles

Table 6 is a description of actor roles.

Table 6. Reservation, Scheduling, and Dispatching Actor Roles

Actor	Roles
Mobility Service Manager (MSM)	• Provides reservation, scheduling, and dispatching of specialized transportation services • Receives calls from Travelers to reserve/book a specialized transportation trip • Determines if Traveler is eligible for the requested trip(s) • Schedules specialized transportation trips based on trip reservations • Confirms trips with Travelers either manually or in an automated way (using an interactive voice response system integrated with paratransit scheduling and dispatching software) • Dispatches specialized transportation trips • Operates specialized transportation services
Mobility Operator (MO)	• If contracted by MSM, may provide reservation, scheduling and dispatching of specialized transportation services • If contracted by MSM, may receive calls from Travelers to reserve/book a specialized transportation trip • If contracted by MSM, may determine if Traveler is eligible for the requested trip(s) • If contracted by MSM, may schedule specialized transportation trips based on trip reservations • If contracted by MSM, may confirm trips with Travelers either manually or in an automated way (using an interactive voice response system integrated with paratransit scheduling and dispatching software) • If contracted by MSM, may dispatch specialized transportation trips • If contracted by MSM, may operate specialized transportation services
Call taker/Reservationist	• Take calls from Travelers who wish to make trip reservations • Verify the eligibility of Travelers to make the requested trip • Request trip details from Traveler (e.g., origin and destination, mobility aids, appointment time) • Enter required information to confirm the reservation

Actor	Roles
Scheduler	• Use scheduling software to schedule reservations according to driver and vehicle availability, Traveler characteristics and other factors, such as pick-up window (e.g., Traveler must be ready to travel 30-minutes prior to the reservation time). • Once trips are scheduled initially, optimize the results of the initial schedules • Once schedules are finalized, provide Drivers with their manifests at least the evening before the Driver's next service day
Dispatcher	• Take note of vehicles available and their location for service prior to pull-out • If necessary, assign vehicle(s) to particular trips or routes • Monitor location of vehicles in revenue and non-revenue service • Monitor and manage schedule adherence of vehicles in revenue service • Manage specialized transportation service trip manifests • Manage other operational functions as needed
Traveler	• Request trip(s) on specialized transportation service

4.2.3 ARC-IT Physical Objects for Actors

The actors involved in the Reservation, Scheduling, and Dispatch use cases are mapped to the most relevant ARC-IT physical objects in Table 7.

Table 7: ARC-IT Physical Objects for Reservation, Scheduling and Dispatch Actors

Actor	ARC-IT Physical Object	Comment
Mobility Service Manager (MSM)	Transit Management Center (TRMC)	ARC-IT does not have a separate physical object for MSM, the functionality is included in the TRMC.
Mobility Operator (MO)	Transit Management Center/ Transportation Information Center (TIC)	While ARC-IT covers very well the transit aspects of MO, it currently doesn't address other types of MO as well (considering them TICs). The TRMC and TIC do not include MMV operators, for example.
Call taker/reservationist	TIC Operator	Reservations are done through the Transportation Information Center (TIC). The only human PO attached to the TIC is the TIC Operator. Currently the definition of this does not include reservationist.
Scheduler	Transit Operations Personnel	The TRMC has a single human PO; the Transit Operations Personnel, that addresses both roles here.
Dispatcher	Transit Operations Personnel	
Traveler	Traveler	

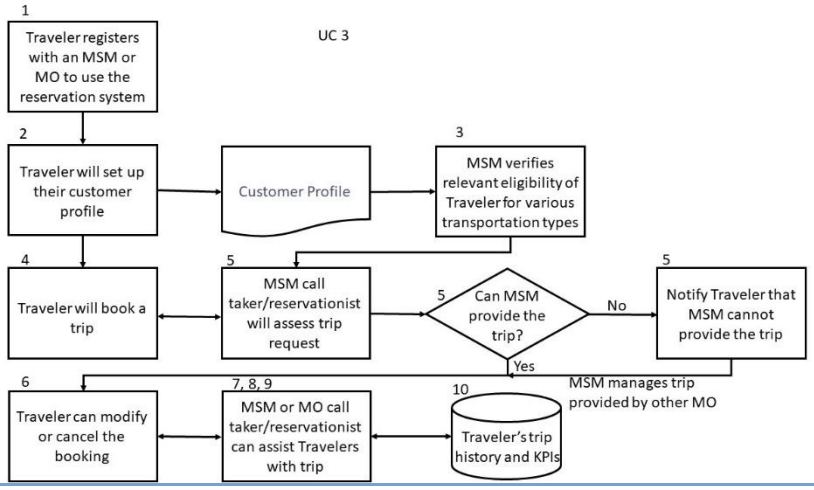
The ARC-IT definitions for TRMC, TIC, and Traveler are in section 3.2.3. The additional Physical Object definitions are shown below:

The '**TIC Operator**' represents the person or people that monitor and manage traveler information services provided by the Transportation Information Center.

'Transit Operations Personnel' represents the people that are responsible for fleet management, maintenance operations, and scheduling activities of the transit system. These different roles represent a variety of individuals in the transit industry. Within the transit industry the person responsible for fleet management is known by many names: Street Supervisor, Starter, Dispatcher, Supervisor, Traffic Controller, Transportation Coordinator. This person actively monitors, controls, and modifies the transit fleet routes and schedules on a day-to-day basis (dynamic scheduling). The modifications will take account of abnormal situations such as vehicle breakdown, vehicle delay, detours around work zones or incidents (detour management, connection protection, and service restoration), and other causes of route or schedule deviations. Transit operations personnel are also responsible for demand responsive transit operation and for managing emergency situations within the transit network such as silent alarms on board transit vehicles, or the remote disabling of the vehicle. In addition, the Transit Operations Personnel may be responsible for assigning vehicle operators to routes, checking vehicle operators in and out, and managing transit stop issues. This object also represents the personnel in the transit garage that are responsible for maintenance of the transit fleets, including monitoring vehicle status, matching vehicles with operators, and maintenance checking of transit vehicles. Finally, it represents the people responsible for planning, development, and management of transit routes and schedules.

4.3 Use Cases

4.3.1 Use Case 3 Reservation/ Booking Process

UC 3	Reservations/Booking Process
Short Description	This use case consists of functions for a Traveler with eligibility for specialized transportation service to reserve a trip using mobility services such as ADA paratransit, including reservations and confirmation with the specialized mobility service(s).
Goal	The goal of this use case is to illustrate the traveler's ability to book travel through either an application or MSM, based on their eligibility for specialized transportation service.
Actors	• Mobility Service Manager (MSM) • Mobility Operator (MO) (there will be at least one MO per mobility service) • Call taker/reservationist • Traveler
Illustration (example)	Figure 2. Reservation, Scheduling, and Dispatching within the Steps for a DRT trip.Figure 3. Typical Reservation, Scheduling, and Dispatching Flow 

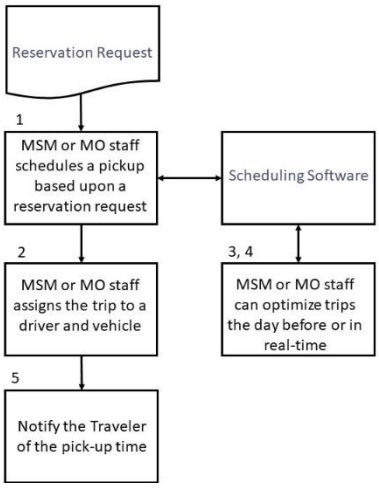
Preconditions	If a Traveler is logged into their account, specialized mobility service providers for which the Traveler is eligible will be made available for use by the Traveler
Post-conditions	• Once a reservation is confirmed, trips will be scheduled using the scheduling process described in Use Case 2
Assumptions/Constraints	• Only the MSM or registered and eligible Travelers will be able to use the reservations services to book a trip • Traveler must be eligible for and registered to use specialized transportation services.
Information Requirements	• Customer information • Reservations details

UC 3 Reservation/Booking Process		
Pre-conditions		
Item	**Step**	**Description**
Main Flow	1	The Traveler registers with an MSM or MO to use the reservation system. Registration can be done through web or mobile-based tools or through a call-taker/ reservationist.
	2	Upon registration, the Traveler will set up their customer profile, including eligibility for various types of transportation. The customer profile can be set up (or updated) web or mobile-based tools or through a call-taker/ reservationist.
	3	The MSM will verify relevant eligibility of the Traveler for various types of transportation. See Use Cases 1 and 2 for a discussion of eligibility verification.
	4	The Traveler will book a trip using the online system (or through a call-taker/reservationist. There are three types of trips that could be booked: a trip in advance (according to the MSM or MO policy of advanced trip booking), a recurring trip (also known as a subscription or standing order trip), or an ad-hoc/same day trip (according to the MSM or MO policy). The MSM call taker/reservationist will have the capability to view the requested reservation time and date in order to determine pick-up and/or drop off times.
	5	The MSM call taker/reservationist can identify other MOs and notify Travelers when the MSM is not able to provide services for the requested trip (e.g., origin/destination location not in MSM's service area).
	6	Following the initial booking, the Traveler can modify or cancel the booking. This can be done through web or mobile-based tools or via an MSM call taker/reservationist as requested and per the MSM's policy.
	7	The MSM or MO call taker/reservationist can assist Travelers with trips that were booked by the MSM and are being delivered by the MO.
	8	The MSM call taker/reservationist can assist travelers that need assistance with web or mobile-based tools available to them but are having difficulty. The assistance could include any needed translation services in order to assist the Travelers with their trip.
	9	The MSM call taker/reservationist will provide tools to connect with Travelers according to their preference to assist with any aspect of their trips.
	10	The MSM call taker/reservationist can use the reservation system to view the Traveler's trip history and any relevant KPIs (e.g., number of no-shows, number of cancellations, number of completed trips against the quota identified by the funding source).
Alternate		Cancellation and Modification Functions Performed by the Traveler.

Flows	1	Traveler selects their reservation from the website or application menu.
	2	The website or application includes a button to view, edit, or cancel the reservation.
	3	Traveler selects one of the three buttons a. If View: The website or application will show a summary of the reservation(s). Traveler will select okay to flow back to main screen. b. If Modify: Traveler is presented a form to change one or more of the fields (date/time, origin and destination, number of passengers, mobility aid). c. If Cancel: Traveler is presented a form to cancel their reservation(s). The form is pre-filled by the system. The Traveler reviews and submits it. The system sends the form to the MSM's application and receives a confirmation.
Exception Flows		None
Extensions		<None>

4.3.2 Use Case 4 Scheduling Process

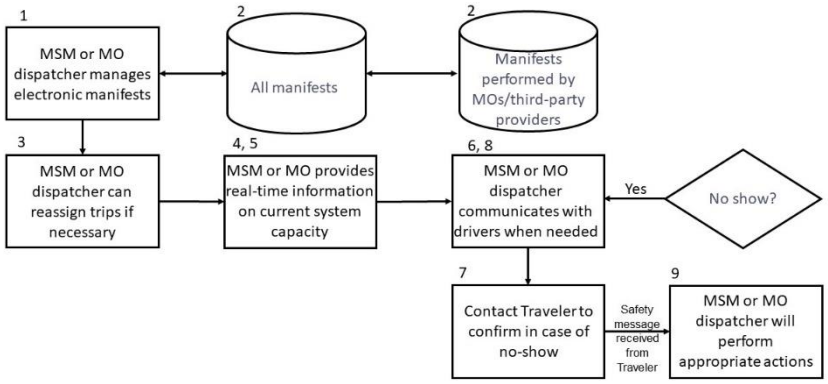
UC 4	**Scheduling Process**
Short Description	This use case consists of functions for scheduling specialized transportation trips that have been reserved by the Traveler or by the MSM call taker/reservationist on behalf of the Traveler.
Goal	The goal of this use case is to illustrate the MSM's ability to schedule reserved trips through automated scheduling software, including the assignment of drivers and vehicles, and vehicle routing based on the MSM's labor and work rules.
Constraints	Only the MSM or MO will be able to use the scheduling process to assign reserved trips to specific drivers and vehicles and route the vehicles accordingly.
Actors	• Mobility Service Manager (MSM) • Mobility Operator (MO) (there will be at least one MO per mobility service) • Scheduler • Traveler

Illustration (example)	Figure 2. Reservation, Scheduling, and Dispatching within the Steps for a DRT trip.Figure 3. Typical Reservation, Scheduling, and  Dispatching Flow
Preconditions	Reservations and Booking process use case
Post-conditions	Once the scheduling is finalized the day before service, the manifests are provided to Drivers the day before service begins.
Information Requirements	• Travelers' reservations • Driver information • Vehicle information

UC 4 Scheduling Process		
Pre-conditions		
Item	**Step**	**Description**
Main Flow	1	MSM or MO staff schedules a pickup based upon a reservation request (see Use case 3).
	2	MSM or MO staff assigns the trip to a driver and vehicle per labor and work rules (e.g., driver work hours and breaks).
	3	MSM or MO staff can optimize trips booked in advance the day before for appropriate utilization of driver/vehicle resources. Parameters to be used for such optimization (e.g., grouping, on-board travel time, dwell time, modification of travel time for street segments) will be configurable.
	4	MSM or MO staff can optimize trips in real-time to better utilize the driver/vehicle resources.
	5	Once scheduled, notify the Traveler of the pickup time.
Alternate Flows		*<None>*
Exception Flows		*None*
Extensions		*<None>*

4.3.3 Use Case 5 Dispatching/Operations Management Process

UC 5	**Dispatching/Operations Management Process**
Short Description	This use case consists of functions for dispatching specialized transportations trips that have been scheduled by the MSM or MO scheduler.

Goal	The goal of this use case is to illustrate the MSM or MO dispatcher(s) to operate the specialized transportation service according to the schedules generated by the scheduler(s).
Constraints	Only the MSM or MO will be able to use the dispatching process to manage the operation of specialized transportation services.
Actors	• Mobility Service Manager (MSM) • Mobility Operator (MO) (there will be at least one MO per mobility service) • Dispatcher • Traveler
Illustration (example)	Figure 2. Reservation, Scheduling, and Dispatching within the Steps for a DRT trip.Figure 3. Typical Reservation, Scheduling, and Dispatching Flow 
Preconditions	Scheduling process
Post-conditions	
Information Requirements	• Vehicle schedules/manifests • Vehicle routes • Driver and vehicle availability/schedules

UC 5 Dispatching Process		
Pre-conditions		
Item	**Step**	**Description**
Main Flow	1	The MSM or MO dispatcher manages electronic manifests to be performed by MSM or MO drivers in real time.
	2	Manifests performed by MOs/third-party providers are managed in separate systems owned by those MOs but the operational status on those are accessible to the MSM Dispatching/Operations staff.
	3	The MSM or MO dispatcher can reassign trips to another vehicle in the event of an incident/crash if needed.
	4	The MSM or MO provides real-time information on current system capacity across all MSM vehicles and MO/third-party providers to accommodate real-time requests or better utilization of resources.
	5	The MSM or MO provides real-time status on trips with appropriate level of details based on MSM or MO policies.
	6	The MSM or MO dispatcher communicates with the driver when needed using one or more communication devices (e.g., land-mobile radio, cellular/mobile phone, on-board mobile data terminal/ tablet).

	7	When a no-show is reported by the driver, the MSM or MO dispatcher/operations staff will attempt to contact the Traveler to confirm.
	8	The MSM or MO dispatcher assists the Driver with any translation service needs while a trip is in progress.
	9	If a safety message is received from the Traveler, the MSM or MO dispatcher will perform appropriate actions per the MSM's or MO's safety protocol(s).
Alternate Flows		<None>
Exception Flows		None
Extensions		<None>

4.4 Available Standards

4.4.1 GTFS-Flex v2[17]

GTFS-Flex v2 is composed of two extensions that aim to model the variety of demand responsive services that do not always follow the same fixed stops. The following two extensions address this need:

GTFS-FlexibleTrips: Flexible services that operate according to some schedule but are responsive to on-demand requests of individual riders.
GTFS-BookingRules: Booking information for rider-requested services using GTFS-FlexibleTrips, such as how far in advance booking should occur or a phone number that should be called.

GTFS-FlexibleTrips describes services that operate according to a schedule, but also include one or more flexible features, such as the following:

- **Dial-a-ride service**: The vehicle serves a zone where pickups and drop offs are allowed during certain service hours.
- **Route deviation services**: The vehicle serves a fixed route and ordered set of stops and may detour to pick up or drop off a passenger between stops.
- **Point-to-zone service**: The rider can board at a fixed stop such as a train station, and then alight anywhere within an area, or vice versa. Departures from some locations are scheduled or timed with other services.
- **Point deviation or checkpoint service**: The rider can board at a fixed stop, and then alight anywhere among an unordered list of stops, or the opposite. The driver only serves stops at which a request is made.
- **Hail-and-ride services**: The vehicle stays along a fixed path, but the rider can request a stop anywhere along the path to board or alight.

GTFS-FlexibleTrips describes the times when and locations where flexible service can be requested.

GTFS-BookingRules: Many flexible services included in the GTFS-FlexibleTrips extension must be booked in advance and/or by using a phone or the Internet. This extension provides the rider with information about how to request service.

4.4.2 Transactional Data Specifications[18]

A transactional data specification sets forth the vocabulary and syntax for how information about individual DRT trips can be transmitted from one computer system to another. This information includes the essential details about the traveler(s), the logistics of the trip, and any other information required to successfully order, schedule, and execute each trip.

The DRT transactional data specification developed by the Transportation Research Board (TRB) spans the entire trip lifecycle, from the initial ordering of the trip to its execution and subsequent delivery of data

to all relevant parties about how the service was performed (e.g., when the passenger was picked up and dropped off), all the way back to the entity that originated the trip order. This means that multiple organizations can participate in the trip ordering and delivery process with the assurance that each will have access to the complete set of data it needs to perform its specific function(s) properly. Every step in the process is recorded, and the data details are available—in a standardized data format—for subsequent reporting and analysis, including for financial transactions. In addition, the transactional data specification developed for this study includes a recommended data communication mechanism to allow software systems from various service providers to exchange specification-compliant trip-related data.

Once implemented, these transactional data specifications will improve the availability, cost-effectiveness, and quality of demand-responsive transportation services. These specifications have been implemented on a very limited basis as of September 2022. When they are used more commonly, the primary beneficiaries include the following :

- *Travelers,* who will benefit because transactional data specifications can help increase availability of demand-responsive services
- *Demand-responsive service providers,* which will benefit because they can better utilize their vehicles, serving more customers at a lower cost per trip, and more seamlessly interoperate with public transportation organizations and others that fund these services
- *Publicly supported transportation organizations,* which can benefit from improved cost effectiveness of DRT services as it becomes possible to use multiple transportation providers for a single service program, while also fostering competition among them
- *Government transportation funding programs,* which will benefit by using public resources more efficiently and effectively to fund transportation services and by improving mobility services to local communities

Transactional data is the data created for each ride occurring in a DRT service spanning a trip lifecycle that begins with a trip-booking request and ends when a customer is delivered and the financial settlement information for the trip has been exchanged among the customer, service provider, and any third-party funding entity. Transactional data contains all pertinent trip details in a reservations and scheduling system, including the following:

- Origin
- Destination
- Requested time (pickup/arrival)
- Passenger attributes (e.g., wheelchair)
- Actual pickup time
- Actual arrival time
- Trip fare (to passenger)
- Trip cost (to provider)
- Fare, payment, or funding information

5 Mobility Payment Integration Product Rules Use Case

5.1 Description

The use cases focus on defining and using **Product Rules** for integrated mobility services. These use cases do not cover the individual modes, rather they focus on describing the process and information elements needed to exchange product rules for travelers to purchase, access and use multi-agency, multimodal system mobility services in a federated environment.

The purpose of these product rules is to facilitate and expedite the seamless travel from origin to destination using one payment, acquired from one sales channel that can provide one customer service venue for cancellations, refunds and other sales services. In addition, the electronic rules will provide a language for mobility operators/managers to franchise the sales of these combined products to the growing MaaS marketplace managers. These rule sets will make it easier to build, manage, and update products and agreements among operators, and with MaaS marketplace managers.

5.1.1 Mobility Payment Integration

Mobility Payment Integration (MPI) provides an integrated approach for combining fare, tariff, or fee-based pricing, linked to a token (or encrypted number) that is accepted to access mobility services by more than one mode, operator, or authority. According to the FTA Complete Trips Research and Coordination Mobility Payment Integration (MPI) Strategy and Scenario Analysis for Mobility Payment Integration (ICF, unpublished June 2022),

> "Multimodal, multi-agency (or provider) mobility service systems, usually relying on EFPS [Electronic Fare Payment Systems] and potentially combining two or more payment convergence, shared mobility, MaaS, PaaS, or SaaS elements, are growing in prevalence and popularity. These emerging and future payment integration strategies reflect a new model for public transportation agencies and [other modes],…Such deployments are driven by a consumer market who increasingly expects to pay for mobility services like any other good or service." (MPI, p., 13)

There are several standards, specifications, and data models that represent individual modes (e.g., parking, GTFS Fares), or products that are governed by a cooperative, regional fare authority, such as ORCA. However, there are no standards that contain a language to specify federated products that can combine multi-agency, multimodal and cooperative services that include transit fares (rail, ferry, bus, subway, etc.), parking tariffs, tolling and dynamic pricing fees, and emerging MaaS mode pricing models.

5.1.2 Product Rules

In December 2019, the International Standards Organization (ISO) conducted a workshop that reviewed specifications and standards in development or in use internationally (ISO Pricing Rules Workshop). The Workshop presenters, from tolling, public transport, on-demand/shared use services, and parking domains, discussed the product rule concept first promoted by the ISO Technical Report (TR) 24014-1 Interoperable Fare Management System (IFMS) (ISO 24014-1:2020). The document is composed of use cases that describe the ecosystem of integrated fare systems, and has been expanded to include emerging mobility services. In the Workshop report, Product Rules are defined by three sub-rule sets:

Usage rules: Focus on service provisions for access, …information about time, geographic area, user type and types of services offered.

Pricing rules: Focus on rules related to customer payment …information about pricing, billing and payment rules related to customer media, methods, calculation, verification, and reporting.

Commercial rules: Focus on rules exchanged between businesses…information that is typically included in a memorandum of understanding or contract including refunds, interchange fees, liabilities (seller vs. token owner).

These sub-rule sets are interrelated and framed by security, legal, technical, and commercial policies and requirements.

Workshop presenters were asked to describe their product rules and data models that support the product rules. Across the board, usage rules modeled time, geographic area, user types and type of services. Pricing rules describe fare/tariff tables. Some pricing rules also cover payment methods and media, and calculations (i.e., processing APIs and services). Models for these two areas are well represented, though the various modes employ different (and sometime incompatible) models.

None of the individual mode models describe refunds, payment between organizations, interchange fees, microtransactions, liabilities (e.g., who holds the sales for a monthly card or an unused ticket). The content of last area differs not only from organization to organization, but also state to state and country to country. However, a specification language or logical calculus may be developed to electronically communicate the commercial rules between business, thus lowering the barrier to participate in a MaaS Marketplace.

5.1.3 MPI Products and Rules

The three sub-rule categories are related. Given a set of rules, as defined in reference model adapted from Transmodel[19] , information categories for **pricing rules** are listed below.

Pricing Rules

- Structure Element MODEL
  - Tariff
  - Fare Structure
    - Common, geographic, distance, time, quality
  - Fare Structure Elements in sequence
  - Fare Structure Element Price
- Pricing Rules
  - Standard Pricing Rules
  - Limiting Rules (capping)
  - Discounting Rules
  - Pricing Service (dynamic pricing)
  - Price Group
- Validity Limitation Rules
  - Any of the above that limit price by fare structure for example, day type (only on Saturday), line (excluding express) or operator (not ferry operated by XY agency)

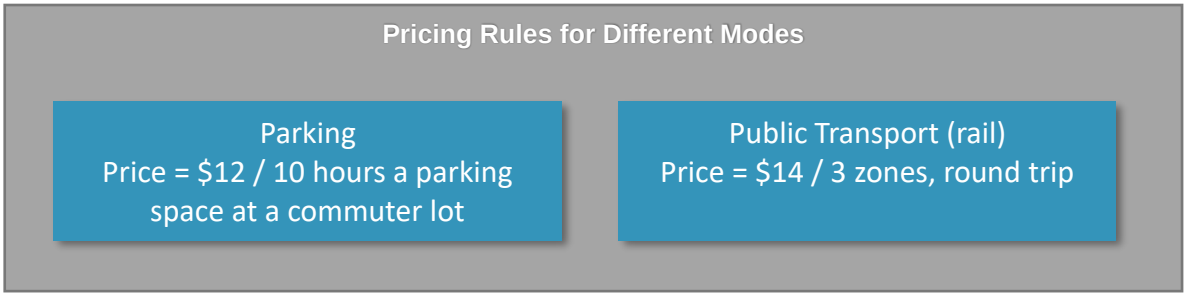


Figure 4: Pricing Rules Example.

Pricing rules are typically represented as a tariff table.

Information categories for **service usage rules** are listed below.

Service Usage Rules

- Travel Usage
  - Step limit (zones, # stops), minimum stay, round trip, routing, frequency, etc.
- Eligibility Usage
  - User profile, residential qualification, companion profile, commercial (e.g., business) profile, group ticket
  - Proof required
  - Entitlement
- Luggage Allowance
- Booking Usage
  - Reservations, purchase timing, policies, reservation moment
- After Sales Usage
  - Transferability, exchanging, reselling (and sell by), replacing, rebating, refunding, suspending
- Charging Usage
  - Charging policy, penalty policy, subscribing, (reentry, credit)
- Validity Limitation Rules
  - Any of the above that limit usage for example, user profile, luggage allowance, booking, entitlement document

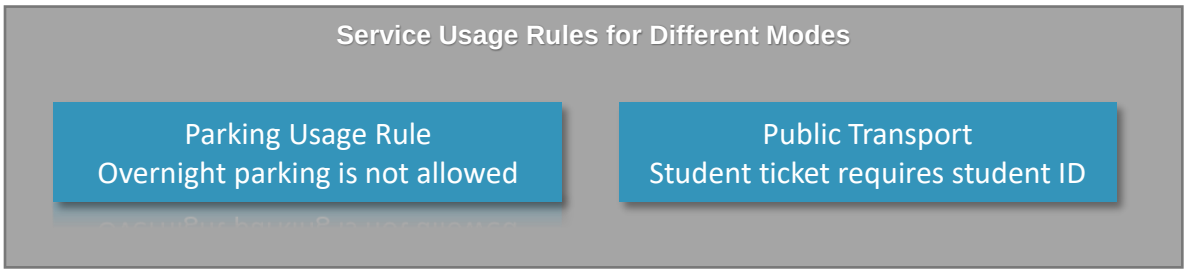


Figure 5: Service Usage Rules Example.

Currently, there are no existing information categories for Commercial Rules.

A multimodal product will be a list of rules that apply to the multiple services. For example, a Park and Ride product may include a discount for parking and then taking transit (see Figure 6). The rule set will also include commercial or contractual rules between the businesses / operators. For example, in a park and ride product, the usage and pricing rules (on the left) include a single price and usage rules for the product. In addition, as multiple agencies, there are commercial rules contracted between the organizations (on the right).

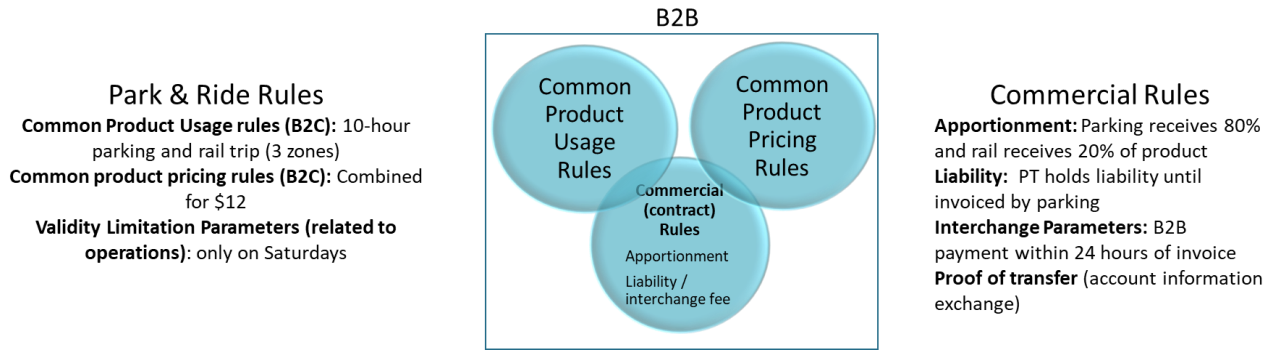


Figure 6: Product Rules for multimodal / multiagency environment.

5.1.4 Limitations of Tariff Management Toolsets

Most payment vendors offer tariff management tools for agencies to specify their pricing and usage rules. These tools typically are prime-organization centric, that is, all rule sets require either single agency product definitions or a product that is related to the prime. For example, if two independent organizations develop a product, the toolset will not be capable of defining a joint multimodal product that can be integrated in a MaaS Marketplace. The use cases attempt to address this.

There are hundreds of rule descriptions and permutations that can be described related to Product Rules using the Use Case methodology. Individual vendors develop tools for their deployments, but they are tied to their sales and validation equipment.

5.2 Multimodal Actors in Product Scenarios

As described above, the use cases deal with MPI product rules, that is, products that combine mobility services in a multimodal, multi-agency environment. The use cases involve actors who interact with each other to generate the product, agree to product terms, and grant access to sales channels to conduct commerce with travelers.

5.2.1 Actors

The key actor categories are described in Table 8.

Table 8: MPI Product Actors

Actor	Description
Mobility Service Manager (MSM)	Authority that manages or contracts mobility operator
Mobility Operator (MO)	Organization that operates the vehicles/facilities and services
Common Service Account Manager (CSAM)	Organization that provides product sales and manages traveler accounts
Product Media (PM)	Physical or virtual secureID (token) used to gain access rights to mobility operator services. The secureID (embedded in the media) associates one or more products stored in an account or held by the traveler (e.g., on their smart phone or paper ticket).
Product	A proof of payment travel document that allows access to one or more mobility operator services.
Product Owner	The owner(s) of a product. In this case, the owners are typically more than one MSM or MO that generated, distribute, accept, and gain revenue from a product.

Actor	Description
Traveler	A person(s) traveling using mobility services which require payment for access.
Financial Service Providers (FSP)	The authority that issues and validates electronic payment media and authenticates and settles payment transactions. Each party involved in payment for public transport service may include their FSP in the process. For example, when a credit card is used for payment, the card may be issued by one brand, the payment may be authenticated through another merchant acquirer, and the settlement may be executed through a third provider. (Source: ISO TR 21724-1:2020)

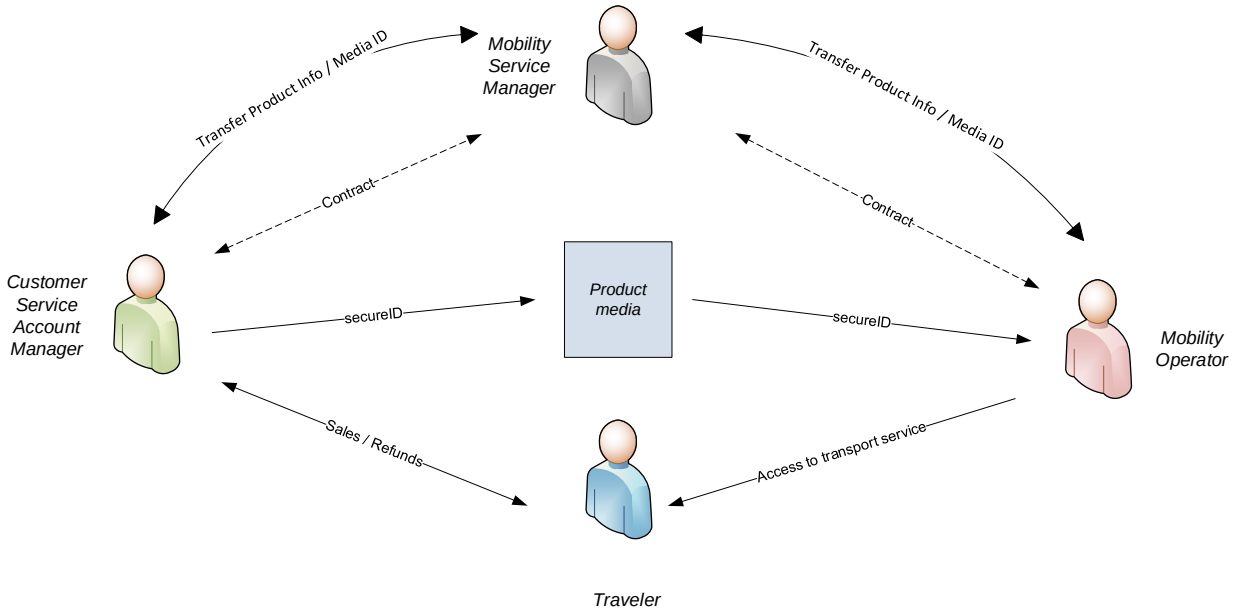
The mobility operators use various types of vehicles and service as listed in Table 9.

Table 9: Mobility Operator Service Types

Vehicle / Facility	Service Type	Payment Method
Transit		
Commuter rail	Fixed	
Intercity rail	Fixed	with / without reservations (ticket)
Commuter bus (intercity)	Fixed	
Subway/Light rail (streetcar)	Fixed	
Paratransit	Demand-Responsive	reservations
Ferry	Fixed	
Local/Regional Bus	Fixed, flex, microtransit, express	
Personal / Shared Use Vehicles		
Car / Accessible	Owned, Ridehailing, Pooled	
Van / Accessible	Owned, Ridehailing, Pooled	
Mircomobility Vehicles		
Bicycle, e-bike	Owned, shared-use	
E-scooter	Owned, shared-use	
Parking		
On-street		Pay in advance
Lot (indoor, outdoor, multilevel)	concierge services	Reservation, Pay upon entrance, Pay upon exit, concierge services
Roads		
Any Vehicle type		Pre or usage charge via account

5.2.2 Actor Roles

The roles of the four major actors in distribution of product rules as illustrated in Figure 7 and described in the paragraphs below.



Adopted from ISO TR 21724-1:2020 Common Transport Service Account (CTSA) concept

Figure 7: Actors involved in Mobility Payment Processes.

Mobility Service Manager perspective. The MSM manages product and media information. In particular, the MSM manages and provisions information about the product state (e.g., active, refunded, inactive, consumed, blocked) to the CSAM and MO.

Mobility Operator perspective: The MO provides access to the traveler when media is validated against valid product. The MO accesses the existence and state of the combine media ID and product state through the MSM.

Customer Service Account Manager perspective: The CSAM provides a sales channel to acquire, purchase, refund, and manage traveler products including single operator and MPI products. This role may be viewed as a MaaS marketplace provider. The purchased mobility product may be stored in a secure environment in the CSAM or transferred to the traveler as a paper ticket or virtual token (e.g., smart card or mobile app).

Traveler perspective: A traveler procures products from the Customer Service Account Manager and uses the product which is represented by product media to gain access rights to the mobility operator (who operates services as shown in Table 9).

The focus of this use case is on the exchange of contracts (product rules) between the major actors as shown in Figure 8.

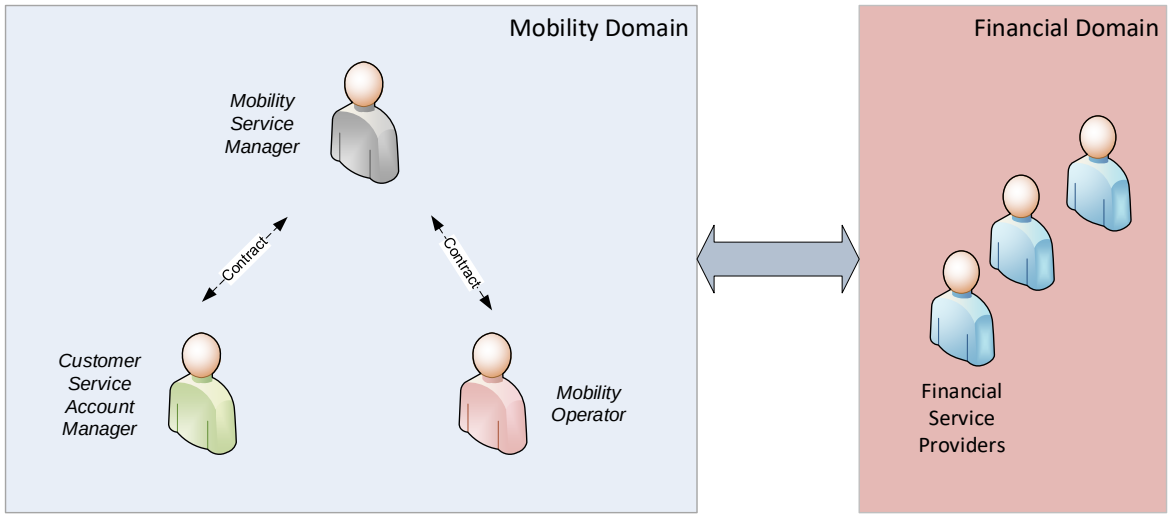


Figure 8: Use Case Actors in the Generation and Exchange of Product Rules.

This is a generic model of the exchange which does not show the complexity of the different MPI products. The actors are generalized into categories of players. For example, the Mobility Operators represent multiple operators providing mobility services including ferry, tolling, transit, transportation network companies, MMV shared use providers and more (see Figure 9).

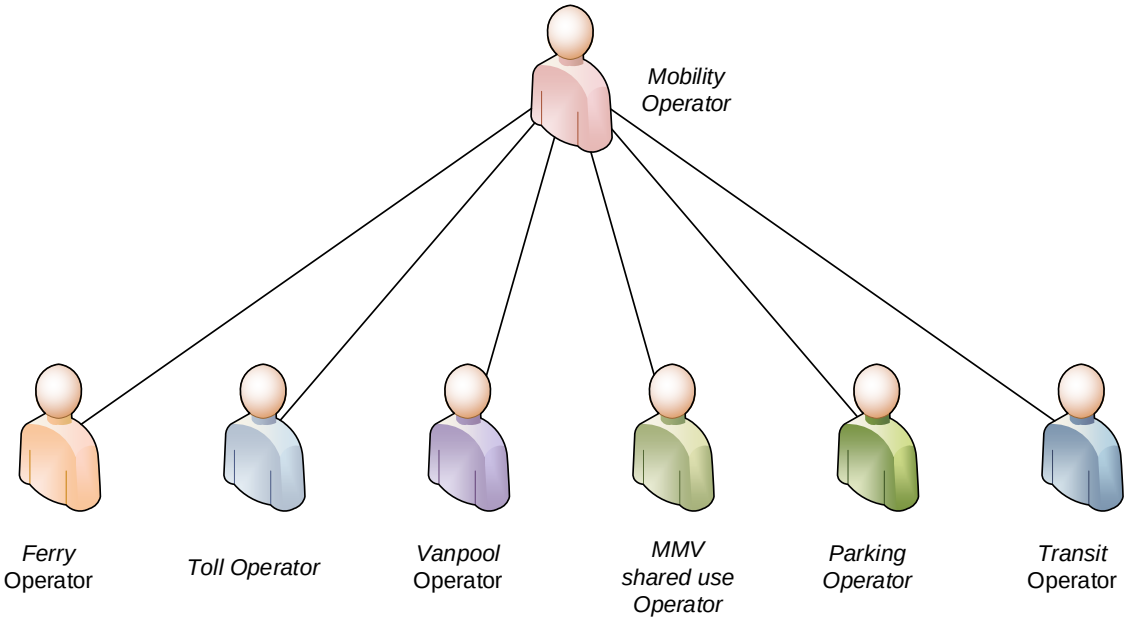


Figure 9: Actors Generalized under the Mobility Operator Category.

5.2.2.1 Multimodal Product Actors

For an integrated payment product, the **product owner** is composed of multiple MSMs and/or MOs that agree on terms and conditions for providing access to services, distribution methods, and financial management of the product sales and management. In addition, the product owners have a relationship with CSAM and Travelers that are conveyed in a similar way as the single authority product rules.

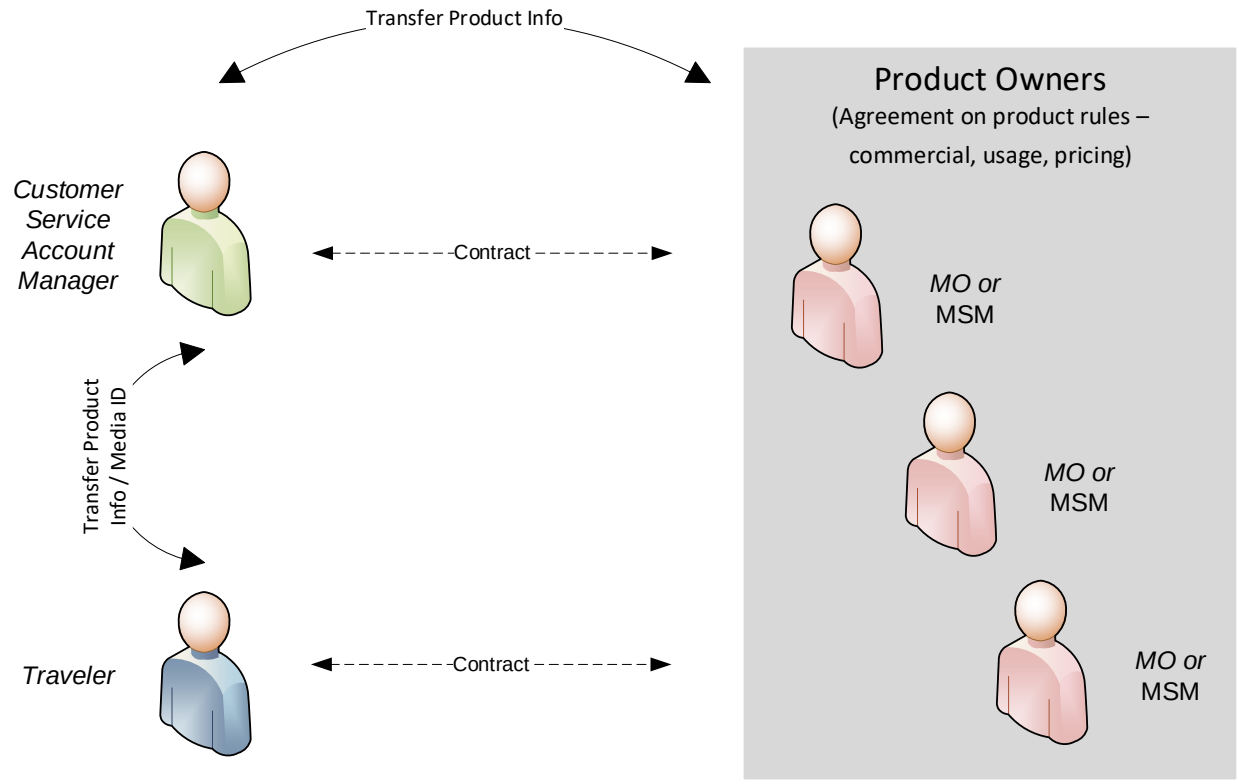


Figure 10: Product Owner and relationship with CSAM and Traveler.

5.2.3 ARC-IT Physical Objects for Actors

This section reviews the key MPI actors and how they relate to ARC-IT physical objects (PO). While actors can represent organizations, ARC-IT is focused on centers (and other classes of systems) that carry out the services. That's because ARC-IT is based around services. ARC-IT does have an Enterprise layer, but this largely considers the roles of the agencies that are responsible for the Pos.

Below is the closest mapping we can make between the key actors and ARC-IT:

Table 10: ARC-IT Physical Objects for MPI Actors

Actor	Description	ARC-IT Physical Object	Comments
Mobility Service Manager (MSM)	Authority that manages or contracts mobility operator	Transit Management Center	ARC-IT does not break the functionality into to Physical Objects- they are contained within TRMC.
Mobility Operator (MO)	Organization that operates the vehicles/facilities and services	Transit Management Center/ Transportation Information Center	While ARC-IT covers very well the transit aspects of MO, it currently doesn't address other types of MO as well (considering them TICs). The TRMC and TIC do not include MMV operators, for example.
Common Service Account Manager (CSAM)	Organization that provides product sales and	Payment Administration Center	This PO manages traveler accounts for most of ARC-IT.

Actor	Description	ARC-IT Physical Object	Comments
	manages traveler accounts		

The ARC-IT Physical Object definitions for Transit Management Center and Transportation Information Center are shown in Section 3.2.3 . The definition of the addition object is given below:

Th **Payment Administration Center** provides general payment administration capabilities and supports the electronic transfer of funds from the customer to the transportation system operator or other service provider. Charges can be recorded for tolls, vehicle-mileage charging, congestion charging, or other goods and services. It supports traveler enrollment and collection of both pre-payment and post-payment transportation fees in coordination with the financial infrastructure supporting electronic payment transactions. The system may establish and administer escrow accounts depending on the clearinghouse scheme and the type of payments involved. It may post a transaction to the customer account, generate a bill (for post-payment accounts), debit an escrow account, or interface to a financial infrastructure to debit a customer designated account. It supports communications with the ITS Roadway Payment Equipment to support fee collection operations. As an alternative, a wide-area wireless interface can be used to communicate directly with vehicle equipment. It also sets and administers the pricing structures and may implement road pricing policies in coordination with the Traffic Management Center.

5.3 Use Case

5.3.1 Use Case 6: Document Product Rules

Use Case Description

UC6: Document Product Rules	
Goal	The purpose of this use case is to describe the process for generating a contract between Product Owners to form a multimodal product.
Description	Once the provisions and conditions of the joint product rules are agreed upon, the multimodal providers document the rules in a formal electronic contract language to convey the commercial, usage and pricing rules that are communicated to the MO, CTSM and traveler as needed.
Primary Actor	• Product Owner MSM MO
Secondary Actors	• CSAM • Traveler
Illustration	See Figure 10.
Pre-conditions	• Product owners agree on rules for commercial, pricing, and usage files.
Triggers	Not applicable
Post-conditions	• In some scenarios, product owners may certify product rules into contract documents.
Assumptions/ Constraints	A set of specifications are developed that represent the data required for Product Rules – pricing, usage and commercial (hereafter referred to as **Product Rule specifications**).
Trustworthiness	• Once published, these documents are open to review except confidential agreements (such as commercial rules).
Accessibility	Not applicable
Information Requirements	See Section 5.1.2 Product Rules

Issues	The use case should accommodate MPI products including the following: 1. Transfers between transit modes operated by different agencies 2. Park and ride services (for owned vehicle or MMV) 3. First mile/last mile transfers between transit and ridehailing/MMV services 4. Carpooling and vanpooling (including toll and parking) 5. Guaranteed Ride Home

UC6: Document Product Rules		
Item	**Step**	**Description**
Main Flow	1	Product owners encode the product pricing, usage and commercial rules using Product Rule specifications.
	2	Product Rule specification is validated using a specification validation tool to ensure the data is encoding correctly.
	3	Product Rule specification is reviewed by product owners to verify that the rules agree with the negotiated terms and conditions.
	4	Product is released to Sales channels (e.g., CTSM, MO, MSM) for distribution and sales.
	5	Product rule specifications are implemented in validation systems to enforce rules.
Alternate Flows		<None>
Exception Flows		<None>
Extensions		<None>

5.4 Available standards

ISO/TR 21724-1:2020 Intelligent transport systems — Common Transport Service Account Systems — Part 1: Framework and use cases

ISO 24014-1:2021 Public transport — Interoperable fare management system — Part 1: Architecture

ISO Workshop on Concept Development for Pricing [Product] Rules. [unpublished, held 2020-Dec 13 and 14, Report published 2021-January-03]

6 PROW Data Collection of Path Impedance Use Case

6.1 Description

Since the effort required by one person to traverse a length of public right of way (PROW) differs by their ability and circumstances, the designation of the accessibility score assigned to a path may differ significantly. For example, a wheelchair or person pushing a buggy may have a major obstacle to traveling on a graveled ROW while the effort required would be minimal for a practiced runner. Accessibility score or impedances are typically assigned to paths based on their component elements. The PROW network is typically described as a topological series of ordered links connected via nodes.

A PROW network in this use case is described for modes other than vehicles on the right of way (roadway). To that end, the PROW network supports vulnerable road users (VRU) including people riding bicycles, electric bikes (e-bikes), and e-scooters, as well as pedestrians, runners, people using wheelchairs, and assistive devices (e.g., hearing aids, walkers, canes, etc.). (Note, motorbikes and motorcycles are not included in the definition of VRU).

Collection and assignment of path impedances on links and nodes can be defined as a layer on a graph or as a set of attributes that can be used to generate an impedance value associated with the link or node. Regardless of how the impedances are shared or transmitted, the approach to collecting the characteristics is critical.

The general process for collecting, attributing, generating, and distributing network PROW impedance data to downstream systems (e.g., trip planner) are composed of five major steps (as shown in Figure 11).

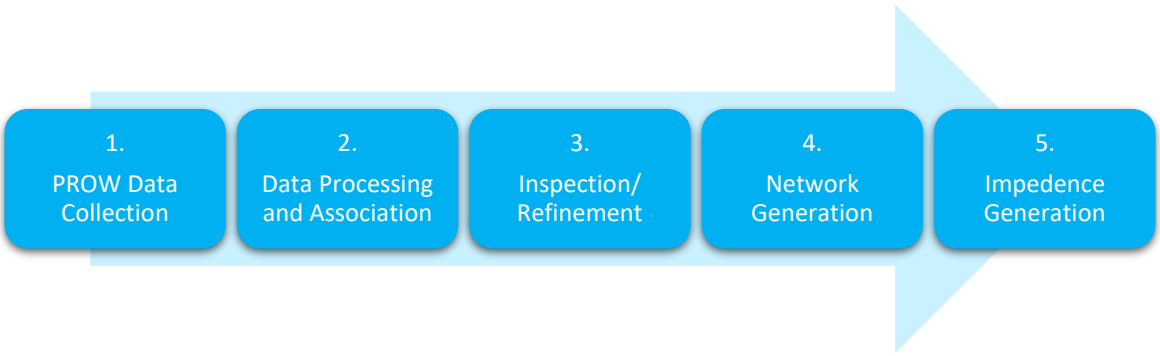


Figure 11: Public Right of Way Network accessibility process.

PROW Data Collection. The physical collection of the data can occur through one or many methods:

Crowdsourcing through walking path using physical tools and observation (manual or via sensors)
Visual detection through street or aerial photography (either manually or automated machine learning techniques).

“Flythrough” with sensors (camera or video technology) mounted on vehicles to record image in high definition and detect object distances.

Data Processing and Association. Once collected, the PROW data will be associated with the road network. The discontinuity of sidewalk data and specialized paths that traverse along or through non-roadway data (e.g., bike trails, walking paths through parks and facilities) may require the PROW features be associated with parcel level data. The specific network graph will be significant for the presented accuracy of the accessibility, for example, link length, points along the

link that obstruct travel, details of the node(s) that connect multiple links. This second step results in the PROW graph that is associated with a road network and optionally parcel data as well.

Inspection / Verification. All of these data collection and analysis techniques are prone to error, so many methods require an audit function using observers to confirm the presence of the attributes. The verification may be manual or through visual inspection of high-resolution aerial photography.

PROW Network Generation. Once the Quality Assurance / Quality Control (QA/QC) verification is performed, the PROW network can be stored and posted for distribution.

Impedance Generation. When the PROW network is available, impedance layers can be generated from the data. For example, if a link includes a post that narrows the width to obstruct the passage of a person using a wheelchair and person pushing a buggy, the link should be assigned an impedance of 100 percent[1]; for a person with visual disabilities, the link may receive an impedance close to 100 percent because the post will create a barrier to passage.

The last step – *Impedance Generation*, is critical to enable all travelers to actively move through the built environment. The use cases will walk through these steps. Specific technologies, and collection, association and inspection processing will not be covered in the use cases.

6.2 PROW Actors

6.2.1 Actors

The PROW Data Collection of Path Impedance use case covers the data collection and processing of PROW data, so it has just the single actor shown below:

- Data Collection staff: Company or agency that collects and processes PROW data.

6.2.2 ARC-IT Physical Objects for Actors

The PROW actor has the mapping to ARC-IT physical objects shown in Table 11.

Table 11: ARC-IT Physical Objects for PROW Actors

Actor	ARC-IT Object	Comment
Data Collection staff	Map Update System (MUS)	Describing the PROW is a function of the MUS, so the data collection and processing would be a part of the functionality.

The ARC-IT definition for this object is the following:

> The '**Map Update System**' represents a provider of map databases used to support ITS services. It supports the provision of the map data that are used directly by vehicles (e.g., roadway and intersection geometry data sets), travelers (e.g., navigable maps used for route guidance and display maps used at traveler information points), system operators (e.g., map data used by Traffic Operators to monitor and manage the road network, and map data used by Fleet Managers to manage a vehicle fleet). It may represent a third-party provider or an internal organization that produces map data for agency use. In the latter case, the 'Map Update System' is typically included as part of the center (e.g., a Traffic Management Center) of the infrastructure owner/operator that manages map data. Products may include simple display maps, map data sets that define detailed road network topology and geometry, or full geographic information system databases that are used to support planning and operations.

[1] Or equivalent score. The higher the impedance the greater the obstacle to passage. Examples of physical barriers that are assigned a high impedance include fences, bodies of water, and highways.

6.3 Use Cases

6.3.1 Use Case 7: PROW Data Collection and Path Impedance

Use Case Description

UC7: PROW Data Collection and Path Impedance	
Goal	Provide multimodal and accessible travel directions from end-to-end including modes used by VRUs. Accessibility varies by traveler ability and their mode (e.g., walking, cycling, scootering, mobility aid). As such, accessibility for one traveler may differ for another based on the impedance or cost of travel by a person's personal preferences. Modes such as micro mobility vehicles (MMV), walking, and running are universal. In particular, every trip includes pedestrian travel.
Description	This use case describes a generic process to collect and assign costs to the PROW network data that augments and supports seamless trip plans for multimodal and accessible travel.
Primary Actor	• Data Collection staff
Secondary Actors	• GIS • Vehicle with sensors
Illustration	See Figure 11 for business process to collect and assign cost to PROW networks.
Pre-conditions	• Levels of accessibility algorithms defined • Collection methods collect attributes required to generate levels of accessibility • Parcel data • Road network data
Triggers	• n/a
Post-conditions	• Generation of PROW network data associated with road network and parcel data • Generation of Impedance level graphs associated with PROW network. • Metadata related to the provenance, collection tools, processing, related network and parcel data, etc. are stored and associated with the generated datasets.
Assumptions/ Constraints	
Trustworthiness	• Videos with residences, vehicles, vehicle licenses and people will be retained in encrypted storage.
Accessibility	• Define different levels of accessibility based on data collected and barrier scores associated with levels of abilities.
Information Requirements	Information Requirements for barriers include the following: • PROW dimensions (e.g., width, length) • PROW type (e.g., cycletrack, bike lane, bike path, sidewalk) • Leveled ground • Surface type • Curb ramp • Gradient • Narrow or obstructed path (for example, posts, protrusions, debris, overhead foliage, tree roots, change of surface type or leveled ground on path/link) • Presence of PROW path (sidewalk, bike lane)

	• Connections and conveyances between levels (e.g., floors), i.e., elevator (dimensions), escalator (direction), stairs. • Distance • Accessible entrances to facilities including buildings, transit stops / boarding locations, rail platforms, etc.
Issues	This use case
Source Documents	Hara, Kotaro. Scalable Methods to Collect and Visualize Sidewalk Accessibility Data for People with Mobility Impairments. Computer Science Theses and Dissertations UMD Theses and Dissertations (2016). https://doi.org/10.13016/M2RZ4N Phase 1 Enabling Technology Readiness Assessment— University of Washington ITS4US Deployment Project. Published 2022-02-02, FHWA-JPO21-889. https://rosap.ntl.bts.gov/view/dot/62479

UC7: PROW Data Collection and Path Impedance		
Pre-conditions		Prepare network and parcel data for data collection process (e.g., to geocode PROW network path to data).
Item	**Step**	**Description**
Main Flow	1	Collect data.
	2	Associate data with road network (and optionally parcel data).
	3	Perform QA/QC on collected PROW data and validate association with road network and parcel data.
	4	Store and make PROW network accessible.
	5	Apply link / node attributes to accessibility levels for different VRU types and user preferences.
Alternate Flows		n/a
Exception Flows		n/a
Extensions		<None>

6.4 Available standards

Standards for pathway information

- OpenStreetMap (OSM) enumerated attributes
  - Bikes paths
  - sidewalk
- OpenSidewalk
  - Sidewalk
  - conveyances
- GTFS-Pathways
  - For transit hubs and stations
- CurbLR
  - Linear referencing and curb space
- Open GeoSpatial Consortium (OGC) Indoor Mapping Data Format (IMDF)

There are no standards/specifications for assigning impedances to different pathways. There are standards and reference architectures for disseminating the data once developed.

7 Pedestrian Intersection Crossing

7.1 Description

As noted in the document, *Multimodal and Accessible Travel Use Case Review,* many crosswalk use cases exist and cover an array of scenarios (center to center, center to point, point to point) with several connectivity options (direct, C2C, detection, via third party). However, there are several crosswalk scenarios that are not described at all.

Section 7 adds three use case scenarios that were either implemented as part of a Connected Vehicle Pilot, proposed to be implemented by an ITS4US site, or is identified as a gap. The focus of these use cases is to allow vulnerable road users, such as pedestrians or bicyclists, to safely traverse signalized intersections.

7.2 Pedestrian Intersection Crossing Actors

7.2.1 Actors

The key actor categories are described in Table 12.

Table 12: Pedestrian Intersection Crossing Actors

Actor	Description
Traffic Management Agency	Agency that performs traffic and pedestrian control at the intersection.
Traveler Information Organization	Organization that operates the traveler information application that interfaces with the traveler.
Traveler	A person(s) traveling through the intersection not in a vehicle.

7.2.2 ARC-IT Physical Objects for Actors

Mapping of Actors to ARC-IT Physical Objects is shown in Table 13.

Table 13: ARC-IT Physical Objects for Pedestrian Intersection Crossing Actors

Actor	Physical Object	Comments
Traffic Management Agency	Traffic Management Center, ITS Roadway Equipment, Connected Vehicle Roadside Unit	The TMC manages devices at the intersection- traffic signals, detection devices, and RSUs.
Traveler Information Organization	Transportation information Center	
Traveler	Traveler, Personal Information Device (PID)	The interface to the traveler may be through a PID, or directly at the intersection.

The ARC-IT definitions for Transportation Information Center and Traveler are in Section 3.2.3. The definition of the new physical objects above are the following:

The '**Traffic Management Center**' monitors and controls traffic and the road network. It represents centers that manage a broad range of transportation facilities including freeway systems, rural and suburban highway systems, and urban and suburban traffic control systems. It communicates with ITS Roadway Equipment and Connected Vehicle Roadside Equipment (RSE) to monitor and manage traffic flow and monitor the condition of the roadway, surrounding environmental conditions, and field equipment status. It manages traffic and transportation resources to support allied agencies in responding to, and recovering from, incidents ranging from minor traffic incidents through major disasters.

'**ITS Roadway Equipment**' represents the ITS equipment that is distributed on and along the roadway that monitors and controls traffic and monitors and manages the roadway. This physical object includes traffic detectors, environmental sensors, traffic signals, highway advisory radios, dynamic message signs, CCTV cameras and video image processing systems, grade crossing warning systems, and ramp metering systems. Lane management systems and barrier systems that control access to transportation infrastructure such as roadways, bridges, and tunnels are also included. This object also provides environmental monitoring including sensors that measure road conditions, surface weather, and vehicle emissions. Work zone systems including work zone surveillance, traffic control, driver warning, and work crew safety systems are also included.

'**Connected Vehicle Roadside Equipment**' (CV RSE) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short Range Communications (DSRC) or other alternative wireless communications technologies. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.

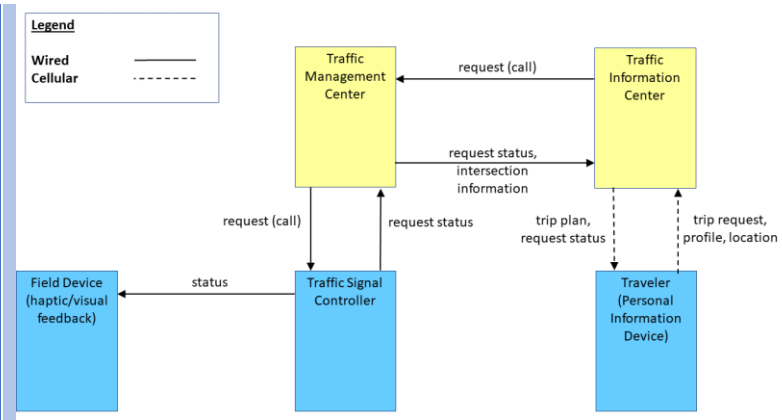
The '**Personal Information Device**' provides the capability for travelers to receive formatted traveler information wherever they are. Capabilities include traveler information, trip planning, and route guidance. Frequently a smart phone, the Personal Information Device provides travelers with the capability to receive route planning and other personally focused transportation services from the infrastructure in the field, at home, at work, or while en route. Personal Information Devices may operate independently or may be linked with connected vehicle on-board equipment.

7.3 Use Cases

7.3.1 Use Case 8: Pre-Planned Trip

This use case addresses a scenario where the projected route of a traveler across a signalized intersection is known because the traveler has created a trip plan with a trip planner. As the traveler approaches the signalized intersection, the trip planner sends a request for service to the traffic signal controller via the traffic management center to allow the traveler to cross the signalized intersection. Infrastructure devices at the signalized intersection provide haptic or visual feedback to the traveler on whether it is safe for the traveler to traverse the signalized intersection.

UC8 Pre-Planned Trip	
Goal	This use case addresses the information gap for the feedback system that occurs in the steps between a Traveler requesting signal actuation and the Traveler crossing an intersection.
Description	When a Traveler requests hands-free signal actuation, a series of messages are exchanged among an application, the traffic management center and the traffic signal before providing the Traveler feedback for their request. The feedback tells the Traveler whether or not it is safe to cross the intersection.
Primary Actor	Traveler Traffic Management Center (TMC) Traffic Signal Controller (TSC) Transportation Information Center (TIC)
Secondary Actors	

Illustration	
Pre-conditions	Traveler has put in a trip request in the trip planner application located at the TIC and received a trip plan from the TIC with turn-by-turn directions. The trip planner has a record of the Traveler's nominal speed (e.g., walking speed for pedestrians). • Traveler is carrying a Personal Information Device (PID) The trip planner application is tracking the location of the Traveler via the PID at regular intervals (e.g., every 5 – 15 seconds). • Wearables are "docked" with a PID.
Triggers	Traveler is approaching a signalized intersection as part of their trip plan and is a pre-determined distance (seconds or feet) away.
Post-conditions	Traveler has safely traversed the signalized intersection.
Assumptions/ Constraints	The positional accuracy of the Traveler, via the PID, is relatively high, i.e., with enough confidence and accuracy such that the TIC can determine which lane or path the Traveler is currently in. The communications latency between the components is low (less than approximately 5 seconds). The TIC has security clearance to request actuations to the TMC. The signal actuation request includes information (e.g., MAP data (SAE J2735)) to identify the signal indication associated with requested path through the intersection.
Trustworthiness	The PID may contain personally identifiable information (PII) but should be kept confidential and private. The TIC authenticates that the PID is valid and is authorized to signal a hands-free request to the TSC.
Accessibility	Users with disabilities will need to have PIDs equipped with appropriate accessibility features.
Information Requirements	Trip Request Profile (default speed, restrictions, preferences) Trip destination Desired time of departure/arrival Services available If the TSC accept requests Road geometry information (location of lanes/crossing) Mapping of signal indications to lanes/crossings Can the time for a crossing be extended Request for Actuation Movement (crossing) Call (actuation) Request identifier Estimated time of arrival Estimated time of departure

	Cancel existing request Confirmation if a Traveler is present Status of request Status of request and reason Request identifier Current signal indication Countdown for the current interval (how much time before the current interval ends) or time of change (when the interval will change)
Issues	
Source Documents	Phase 1 Concept of Operations (ConOps) Atlanta Regional Commission: ITS4US Deployment Project

UC8: Pre-Planned Trip		
Pre-conditions		
Item	**Step**	**Description**
Main Flow	1	The trip planner (TIC) is tracking the Traveler and determines the Traveler is approaching a signalized intersection as part of their trip plan and is a pre-determined distance (seconds or feet) away.
	2	The trip planner confirms it is authorized to transmit a request for that movement (crossing) at the signalized intersection. The trip planner also confirms what services are provided by the signalized intersection (e.g., can the traffic signal controller accept service requests, including requests for extensions if needed (e.g., for slower moving pedestrians)).
	3	The trip planner generates a request to the TMC. The request contains the traveler type requesting service (e.g., pedestrian, bicyclist, micromobility vehicle), a request identifier, the movement (crossing) requested, estimated time of arrival, estimated time of departure, Traveler's default speed and preference for notification for the service request status.
	4	The TMC forwards a service request to the TSC at the appropriate time, if needed. The service request is an actuation request (call).
	5	The TMC logs all transactions (including timestamps) including the request received from the trip planner, and the service request transmitted to the TSC (including any external entities).
	6	The TSC receives the service request from the TMC and determines if it can service the request with the information in the request.
	7	The TSC transmits a service request status message to the TMC on whether it has accepted or rejected the service request. If the TSC rejects the service request, the service request status message will also contain information on why the service request was rejected.
	8	If the TSC accepts the service request, the TSC notifies the Traveler through a haptic/visual feedback device at the signalized intersection that the service request has been accepted and that it is safe to cross the intersection. The haptic feedback may be an audible signal, a visual signal (such as a sign), or vibrations on a pad at the signalized intersection.
	9	The TSC receives and logs all transactions to and from the TMC, including the service requests (and times) received from TMC, and the service request status messages (and times) transmitted to the TMC.
	10	Steps 3-9 repeat continuously as the trip planner continues transmitting requests to the TMC; the trip planner continually tracks the traveler and calculates the Traveler's estimated time of arrival. Updated request and service request messages, to inform the TMC and TSC of changes to the traveler's anticipated arrival, are generated and transmitted to the TMC and TSC on an as-needed basis.
	11	The TSC services the Traveler with the appropriate signal indication (e.g., WALK) and at the appropriate time.

Alternate Flows	1	Alternatively, the Traveler may manually request from their PID, but needs to identify the movement (crossing) requested.
	4	The service request contains the movement (crossing) requested, the pedestrian (or vehicle as appropriate) call, estimated time of arrival, estimated time of departure, and a request for extension time if needed. (For example, for slower moving pedestrians.)
	7	The TSC transmits a service request status message to the TMC on whether it has accepted or rejected the service request. The TMC then forwards the service request status message to the TIC, which then sends the service request status information to the Traveler via the PID.
	8	The PID notifies the Traveler via haptic/visual feedback if the request was rejected and thus it is not safe to cross, if the request has been accepted with a wait time thus the traveler has to wait, or if the request has been accepted and it is safe to cross.
Exception Flows		
Extensions	<None>	

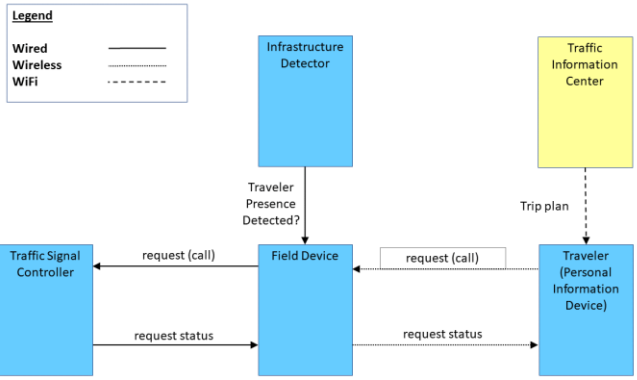
7.3.2 Available Standards

NTCIP 1202, Object Definitions for Actuated Signal Controllers. Supports requests (calls) for pedestrian or vehicle movements (including bicyclists).
NTCIP 1211, Object Definitions for Signal Control and Prioritization. Supports requests for priority at signalized intersections.

7.3.3 Use Case 9: Trip Planner Application - WiFi

Description – Localized Mobile Applications
This use case addresses a scenario where the projected route of a traveler across a signalized intersection is known because the traveler has a trip plan in a mobile application. As the traveler approaches the signalized intersection, the mobile application transmits a wireless request for service to the traffic signal controller to allow the traveler to cross the signalized intersection. Other infrastructure devices at the signalized intersection that may be used to confirm the presence of the traveler provide haptic or visual feedback to the traveler on whether it is safe for the traveler to traverse the signalized intersection.

UC9: Trip Planner Application - WiFi	
Goal	This use case addresses using a trip planner application on a Traveler's Personal Information Device (PID) to broadcast a call or request for signal actuation using local wireless communications, such as WiFi.
Description	A Traveler requests hands-free pedestrian signal actuation using WiFi communications, using a trip planner application on the Traveler's PID, based on a trip plan stored on the trip planner application and the GNSS location and kinematics (speed, direction) of the Traveler. However, the GNSS location may not always be accurate or reliable, so field devices such as CCTV cameras may provide verification that a Traveler is in a crossing.
Primary Actor	• Traveler • Field devices (e.g., external processing device, etc.) Traffic Signal Controller (TSC)
Secondary Actors	• Transportation Information Center (TIC) • Infrastructure Device

Illustration	
Pre-conditions	Traveler has received a trip plan from a TIC with turn-by-turn directions. The trip plan includes the Traveler's nominal travel speed (e.g., walking speed for pedestrians). • Traveler is carrying a Personal Information Device (PID) A trip planner application on the PID is tracking the location of the Traveler via the PID at regular intervals (e.g., every 5-15 seconds). • Wearables are "docked" with a PID.
Triggers	• Traveler is approaching an intersection as part of their trip plan and is a pre-determined distance (seconds or feet) away.
Post-conditions	• Traveler has safely traversed the signalized intersection.
Assumptions/ Constraints	The positional accuracy of the Traveler, via the PID, is relatively high, i.e., with enough confidence and accuracy such that the trip planner application can determine which lane or path the Traveler is currently in. The communications latency between the components is low (less than approximately 5 seconds). The trip planner application or the field device has information from MAP data (SAE J2735) to identify the desired path across the intersection to the appropriate signal indication controlling that path.
Trustworthiness	• The PID may contain personally identifiable information (PII) but should be kept confidential and private. • The TIC authenticates that the PID is valid and is authorized to broadcast a hands-free request to the TSC. • The communication of information regarding the location of the Traveler and their destination should be transmitted via an encrypted protocol between the TSC and the Traveller's PID. • The communication of information regarding the location of the Traveler and their destination should be transmitted via an encrypted communication between the TSC and the Traveler's PID and/or or the RSE to the Traveler's PID. Recommendations for cybersecurity are in the "Multimodal and Accessible Research Paper,"[20] under the sections for "ITS4US Atlanta," "ITS4US Buffalo," and "NYC-THEA." • SPII and PII that is stored should follow data storage and destruction policies as outlined in the "Multimodal and Accessible Research Paper," under the section "NYC-THEA."
Accessibility	• Users with disabilities will need to have PIDs equipped with appropriate accessibility features.
Information Requirements	• Services available If the TSC accept requests. Road geometry information (location of lanes/crossing). Mapping of signal indications to lanes/crossings.

	If time for a crossing be extended. • Request Movement (crossing). Call (actuation). Request identifier Estimated time of arrival. Estimated time of departure. Cancel existing request. Confirmation if a Traveler is present Status of request Status of request and reason. Request identifier. Current signal indication. Countdown for the current interval (how much time before the current interval ends) or time of change (when the interval will change).
Issues	
Source Documents	• Phase 1 Concept of Operations (ConOps) – Buffalo NY ITS4US Deployment Project

UC9: Trip Planner Application - Wifi		
Pre-conditions		
Item	**Step**	**Description**
Main Flow	1	The trip planner application is tracking the Traveler and determines the Traveler is approaching a signalized intersection as part of their trip plan and is a pre-determined distance (seconds or feet) away.
	2	The trip planner application confirms it is authorized to transmit a request via WiFi for that movement (crossing) at the signalized intersection. The trip planner also confirms what services are provided by the signalized intersection (e.g., can the traffic signal controller accept service requests, including requests for extensions if needed (e.g., for slower moving pedestrians)).
	3	The trip planner application generates a request to the TSC (or a field device in the TSC cabinet) via WiFi for the appropriate movement (or phase) based on the trip plan. The request may contain only a request for actuation (call).
	4	If a field device in the TSC cabinet receives the request, the field device checks the output from other available infrastructure detectors at the signalized intersection to confirm the presence of the Traveler. Examples of infrastructure detectors include pedestrian or bicycle detectors or involve processing of CCTV video images to detect travelers.
	5	If a field device in the TSC cabinet receives the request, and confirms the presence of a Traveler, the field device forwards a request for actuation (call) to the TSC.
	6	The TSC transmits a service request status message to the field device (or Traveler) on whether it has accepted or rejected the service request. If the TSC rejects the service request, the service request status message will also contain information on why the service request was rejected.
	7	The field device notifies the Traveler via WiFi if the request or service has been accepted or rejected.
	8	The PID notifies the Traveler via haptic/visual feedback if the request was rejected and thus it is not safe to cross, if the request has been accepted with a wait time thus the traveler has to wait, or if the request has been accepted and it is safe to cross.
	9	The TSC services the Traveler with the appropriate signal indication (e.g., WALK) and at the appropriate time.

	10	Steps 3-9 repeat continuously as the trip planner application continues transmitting requests to the field device; the trip planner application continually tracks the traveler and calculates the Traveler's estimated time of arrival and departure, until the Traveler has completely traversed the signalized intersection.
Alternate Flows	3	The request contains a request identifier, the movement (crossing) requested, estimated time of arrival, estimated time of departure, traveler's default speed and preference for notification for the service request status.
	3	The Traveler may manually request from their PID but needs to identify the movement (crossing) requested.
	5	The request may just be an actuation request or be a service request containing the movement (crossing) requested, the pedestrian (or vehicle as appropriate) call, estimated time of arrival, estimated time of departure, and a request for extension timeif needed. (For example, for slower moving pedestrians.)
	5	The field detector detects that a pedestrian has arrived at the intersection and sends a message to the TSC or the field device in the cabinet to forward to the TSC.
	10	The trip planner application generates a cancel request to the TSC (or field device in the TSC cabinet) if the Traveler stops, or changes directions (compared to the trip plan).
Exception Flows		
Extensions		<None>

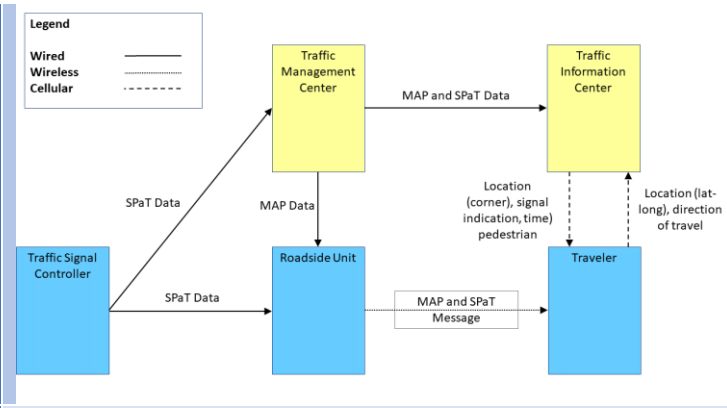
7.3.4 Use Case 10 Connected Traveler via a Cellular Network

Mobile Application via Cellular Network

This use case addresses a scenario where the projected route of a traveler across a signalized intersection is deduced and a trip planning system informs the traveler via a cellular network whether they can safely cross the signalized intersection. As the traveler approaches the signalized intersection, the trip planner system checks if the system has current signal timing data for the signalized intersection, and if available, transmits the signal timing data to the traveler's mobile application via the cellular network. The mobile application may provide haptic or visual feedback to the traveler on whether it is safe for the traveler to traverse the signalized intersection.

Use Case Description

UC10: Connected Traveler via a Cellular Network	
Goal	This use case outlines the process of a pedestrian receiving information about crossing a signalized intersection through a cellular network.
Description	A Traveler equipped with a PID with the appropriate mobile application approaches an intersection and receives information via the cellular network about the crossing location, indication and timing, and whether they are off path. No pre-loaded trip planner or signal actuation request is required/involved.
Primary Actor	• Traveler • Transportation Information Center (TIC)
Secondary Actors	• Traffic Signal Controller (TSC) • Traffic Management Center (TMC)

Illustration	
Pre-conditions	• The TIC has road geometry information (MAP) and current SPaT information for the signalized intersection from the TMC. • Traveler is carrying a Personal Information Device (PID) with the mobile application loaded and in use. • The PID tracks the location of the Traveler at regular intervals (e.g., every 5-15 seconds). • Wearables are "docked" with a PID.
Triggers	• A Traveler equipped with the mobile application open / in use on the PID approaches a signalized intersection.
Post-conditions	• Traveler has safely traversed the signalized intersection.
Assumptions/ Constraints	• The positional and directional accuracy of the Traveler, via the PID, is relatively high, i.e., with enough confidence and accuracy such that the TIC can determine which lane, path, and direction of travel the Traveler is currently in. • The communications latency between the components is low (less than approximately 5 seconds).
Trustworthiness	• The PID may contain personally identifiable information (PII) but should be kept confidential and private. • The communication of information regarding the location of the Traveler and their destination should be transmitted via encrypted communications between the TSC and the Traveler's PID and/or or the RSE to the PID. Recommendations for cybersecurity are in the "Multimodal and Accessible Research Paper," under the sections for ITS4US Atlanta, ITS4US Buffalo, and NYC-THEA. • SPII and PII that is stored should follow data storage and destruction policies as outlined in the "Multimodal and Accessible Research Paper,"[21] under the sections "NYC-THEA."
Accessibility	• Users with disabilities will need to have PIDs equipped with appropriate accessibility features.
Information Requirements	
Issues	
Source Documents	• Savari System Overview and Functional Specifications – SmartCross Pedestrian Safety Enhancement System.

UC10: Connected Traveler via a Cellular Network		
Pre-conditions		
Item	**Step**	**Description**
Main Flow	1	The mobile application on the PID is tracking the Traveler location and direction and uploads the information to the TIC via a cellular network upon request from the TIC.
	2	The Traveler approaches a signalized intersection. The TIC assumes the intended crossing direction of the Traveler based on the heading of travel of the PID.
	3	The TIC provides SPaT and MAP information (the location (corner), indication and timing) for the assumed crossing direction to the mobile application.
	4	The mobile application displays the information on the PID screen or communicates it to the Traveler through audio/haptic.
	5	The Traveler crosses the intersection if the mobile application indicates that the Traveler has the WALK signal. If the mobile application indicates otherwise, the Traveler will wait to cross until the mobile application indicates a WALK signal.
	6	While the Traveler crosses the intersection, the TIC monitors the PID location to check if they are off path.
	7	If the Traveler is off path, the TIC will send an alert to the mobile application to notify the Traveler that they are off path [along with a direction to get back on path].
	8	Steps 7-8 repeat continuously until the Traveler has cleared the intersection.
Alternate Flows	4	If the Traveler enters the intersection while they do not have the WALK signal, the mobile application will send an audio/haptic alert to the PID.
		If the system is unreliable, the mobile application will notify the Traveler that the mobile application should not be used.
		If the Traveler does not complete crossing the intersection at the end of the clearance interval, the TSC may delay displaying a conflicting green signal indication, subject to agency determination.
Exception Flows		
Extensions		<None>

7.3.5 Available Standards

SAE J2735, V2X Communications Message Set Dictionary. Supports providing current signal phase and timing information; and roadway geometry information (I.e., MAP data).

Annex Acronyms

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	Micromobility 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 A End Notes

[1] Disability Rights Education and Defense Fund (DREDF) and TranSystems Corporation, ***Eligibility for ADA Paratransit***, prepared for the Federal Transit Administration, Topic Guide 3, June 2010, page 5, https://dredf.org/ADAtg/elig.pdf

[2] Ibid, pages 6-8

[3] Ibid, pages 8-9

[4] Ibid, page 10

[5] TranSystems and ACCESS Transportation Systems, Determining ADA Paratransit Eligibility: An Approach, Recommendations and Training Materials, prepared for Easter Seals ProjectACTION, December 14, 2014, page 3-7, https://www.nadtc.org/wp-content/uploads/Determining-ADA-Paratransit-Eligibility.pdf

[6] TranSystems Corporation, ***TCRP Project B-40: Strategy Guide to Enable and Promote the Use of Fixed- Route Transit by People with Disabilities, Draft Interim Report***, Transit Cooperative Research Program, Washington, DC, July 3, 2012.

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[8] TranSystems and ACCESS Transportation Systems, Determining ADA Paratransit Eligibility: An Approach, Recommendations and Training Materials, prepared for Easter Seals ProjectACTION, December 14, 2014, page 3-15, https://www.nadtc.org/wp-content/uploads/Determining-ADA-Paratransit-Eligibility.pdf

[9] "GTFS-eligibilities and -capabilities Project Summary," https://github.com/ODOT-PTS/gtfs-eligibilities/blob/main/project_summary.md

[10] https://github.com/ODOT-PTS/gtfs-eligibilities

[11] https://github.com/ODOT-PTS/gtfs-capabilities

[12] Blueprint for an Application Programming Interface (API) from Transport Operator to MaaS Provider, Version Dragonfly (1.0), 30-09-2020, page 4, https://dutchmobilityinnovations.com/fileattachment?file=0HTF4lMkS2Zn11qtOi49kg%3D%3D&v=1&zip=true&isDownload=true

[13] Santosh Mishra, et al. ***Phase 1 Concept of Operations (ConOps): Heart of Iowa Regional Transit Agency ITS4US Deployment Project***, prepared for USDOT ITS JPO, August 4, 2021, Report No. FHWA-JPO-21-859, page 4

[14] "Extra-Help Transit Dispatcher Job Description," El Dorado Transit, https://eldoradotransit.com/jobs/extra-help-transit-dispatcher-filing-date-ongoing/

[15] Roger Teal, et al.***Development of Transactional Data Specifications for Demand-Responsive Transportation***, prepared for Transportation Research Board, Transit Cooperative Research Program (TCRP) Research Report 210, Project G-16, © 2020 National Academy of Sciences.

[16] Santosh Mishra, Steve Wilks, Brooke Ramsey, Tom Coogan, and Chris Zeilinger, ***Phase 1 Concept of Operations (ConOps): Heart of Iowa Regional Transit Agency ITS4US Deployment Project***, prepared for USDOT ITS JPO, August 4, 2021, Report No. FHWA-JPO-21-859, page 21

[17] "GTFS-eligibilities and -capabilities Project Summary," https://github.com/ODOT-PTS/gtfs-eligibilities/blob/main/project_summary.md

[18] Roger Teal, et al. ***Development of Transactional Data Specifications for Demand-Responsive Transportation***, prepared for Transportation Research Board, Transit Cooperative Research Program (TCRP) Research Report 210, Project G-16, © 2020 National Academy of Sciences, page 99.

[19] A European data standard available from https://www.transmodel-cen.eu/overview/d

[20] Rad, Tiffany. Task 2 Multimodal and Accessible (MAT) Research Paper. September 2022, Institute of Transportation Engineers. Pp. 26.

[21] Ibid.