Guidebook on Digital Tools to Facilitate Complete Trip Planning

Executive Summary
Guidebook on Digital Tools to Facilitate Complete Trip Planning

The Guidebook opens with an introduction to the concept of the complete trip in Chapter 1, explaining its components and providing an overview of related concepts including Mobility as a Service and One-Call/One-Click systems. The complete trip "synthesizes aspects of a person's trip from the time the individual begins to plan the trip, to when he or she leaves the originating location when starting a journey, to the doorstep of the final destination," as defined in the National Center for Mobility Management's (NCMM) "The Complete Trip: Helping Customers Make a Seamless Journey."[1] The concept centers on the customer experience of individuals within the mobility system, treating each trip as a unique event that takes into account how the person interacts with various aspects of the trip. These interactions have physical aspects, such as the presence of a bus stop or a bike route in a person's surroundings, but the interactions are psychological as well. Making complete trip-related improvements to the mobility system involves considering both of these aspects.

Chapter 1 goes into detail on how the complete trip can be broken down into individual trip segments based on trip milestones such as evaluating options, selecting an option, departing from the origin, entering/beginning use of the vehicle, exiting/ending use of the vehicle, and arriving at the destination. When strategizing improvements for the complete trip, professionals should consider the customer experience with the individual segments, the customer experience with the milestones, and how all of these parts work together for the complete trip. Factors influencing the feasibility for individuals to take certain journeys are explained; these fall into two categories: personal requirements and design of the surrounding environment. Personal requirements differ widely from person to person, especially due to considerations related to age and disability. The design of the surrounding environment can either help or hinder the customer experience, depending on an individual's personal requirements. The highlighted projects at the end of the chapter include projects focused on the physical aspects of the complete trip primarily, while highlighted projects in subsequent chapters focus mainly on digital aspects of the complete trip; the complete trip requires both physical and digital improvements. Focusing on digital improvements alone may run the risk of enabling problematic physical aspects to remain in place, which would be counterproductive in the larger picture of the complete trip.

Chapter 2 provides an overview that differentiates among related, but different, terms—trip planning vs. trip planner vs. trip plan—and explains how trip planning is often integrated with trip booking and trip payment within digital tools. In addition, key topics

[1] https://nationalcenterformobilitymanagement.org/wp-content/uploads/2013/11/1_Complete_Trip_Final.pdf

such as General Transit Feed Specification (GTFS) data and extensions, Open Trip Planner software, and on-demand transit/microtransit are detailed in Chapter 2 in preparation for the highlighted projects featured later in the chapter. In addition to the highlighted projects, transit agency initiatives that are important to consider for the complete trip are listed and explained. These initiatives include practices for using multiple tools together, innovative procurement processes, and embarking on GTFS data creation and maintenance.

In Chapter 3, best practices for the complete trip are summarized including 1) prioritizing customer input, 2) defining collaboration roles for various actors, 3) considering governance topics early, and 4) leveraging feedback loops between infrastructure types. Chapter 4 serves as an instructive chapter, building off of the information provided in Chapters 1-3. The chapter opens with two key topics to keep at the forefront when pursuing a complete trip-related effort—the overall aims of the complete trip in general and the shortcomings of digital trip planners specifically. A three-step approach for providing digital tools in order to improve the complete trip is provided: (1) clarify challenges related to digital tools for the complete trip, (2) consider potential tactics to address digital challenges, and (3) plan for providing digital tools. The Guidebook concludes with worksheets to guide the reader in the process of applying the information shared in Chapters 1-4 to their own unique situation.

Chapter 1: "Complete Trip" Concept Explained

1.1 Concept Introduction

The complete trip "synthesizes aspects of a person's trip from the time the individual begins to plan the trip, to when he or she leaves the originating location when starting a journey, to the doorstep of the final destination," as defined in the National Center for Mobility Management's (NCMM) "The Complete Trip: Helping Customers Make a Seamless Journey."[2] The concept centers on the customer experience, treating each trip as a unique event that takes into account how the person interacts with various aspects of the trip. These interactions have physical aspects, such as the presence of a bus stop or a bike route in a person's surroundings, but the interactions are psychological as well. Even if a trip appears successful on the surface, perhaps the person arrived at the destination more or less when they expected to, it is still possible for them to experience negative emotions throughout the trip experience. For example, an individual may feel stress and anxiety regarding certain trip components—they may wonder *will I get there on time*, *what alternatives do I have if things don't go as planned*, *am I safe*, and a litany of other questions. Further, when people have strong doubts regarding the safety and comfort level of a trip, they may avoid it altogether.

What this boils down to is the real or perceived threat of uncertainty throughout the trip. By leveraging the complete trip concept, professionals have a tool to help illustrate the experience that people go through—if not the unique experience of each person, then a general approximation of what people with similar characteristics and concerns encounter. The benefit of having this structure is that professionals can identify known or likely challenges individuals come into contact with, and with this knowledge, they can go about identifying tactics to address these challenges. Ultimately, addressing such challenges reduces the uncertainty of a trip; the less uncertain a trip becomes, the less psychological strain is placed on a person. When they set out from home, the individual will have more confidence and trust in the transit and mobility system. This could very well contribute to the individual taking more trips and, as collective awareness of the improvements expands more broadly, the encouragement of others to consider trying transit for the first time.

As shown in figure 1, components of the complete trip to take into account include:

- **Travel modes** – Travel modes span options including walking, cycling, fixed-route transit, on-demand transit, demand-response transit, Americans with Disabilities Act (ADA) paratransit/human services transportation (HST), micromobility such as shared bikes and e-scooters, and others. These options can be used separately for single-mode trips or used together during intermodal trips.
- **Collaboration** – Collaboration deals with how the actors involved in a complete trip-related effort work with each other. Formal collaboration could involve written agreements such as memorandums of understanding (MOU), but more often, collaboration happens informally.

[2] https://nationalcenterformobilitymanagement.org/wp-content/uploads/2013/11/1_Complete_Trip_Final.pdf

- **Physical infrastructure** – This encompasses all the fixed and rolling assets within the transit and mobility system such as sidewalks, bus stops, and buses.
- **Service infrastructure** – This involves important aspects of service such as bus routes and schedules as well as transit agency websites that communicate policies and service details. Included within service infrastructure are elements that support customer service such as all the touch points that occur directly between the customer and the transit agency staff when customers speak with the bus operator or call a customer service line.
- **Governance infrastructure** – Generally, governance can be thought of at three levels. The first level is at the level of a single transit agency, governing the relationship between the customer and the transit agency, which encompasses agency policies such as payment structures and passenger codes of conduct. The second level is the multi-transit agency level, governing the relationship between the customer and multiple transit agencies together, involving policies such as transfer agreements and reciprocity of ADA paratransit eligibility. The third level is the mobility system level, governing the relationship between the customer and the mobility system, which deals with policies such as monthly mobility subscription models for payment that offer a bulk discount of sorts in exchange for committing to several modes at one time and for a certain duration.
- **Technology infrastructure** – There are generally two types of technology infrastructure. The first is directed toward the customer and assists with planning, booking, paying, and completing other customer tasks online, on mobile devices, and over the phone. The second supports the transit system and the work of its staff more generally such as on-demand route generation, computer-aided dispatch, and automatic vehicle location. While the focus of this guidebook is on the former, trip planning in particular, it should be noted that in some cases these types of technology infrastructure and data can intersect and benefit each other. For example, real time bus location data became available to customers in part because transit agencies initially generated the data for their own operational purposes. Automatic vehicle location (AVL) data were commonly set up so that agencies could see where all the vehicles were in real time and the operation headquarters, for example, could know immediately when a bus was running behind schedule without any direct communication with the bus operator. In time, it became clear these data would also be useful for the customer, and currently this is a common type of data to make available to the customer—often available as real time vehicle alerts in apps. This can also work in the other direction, such as when the public reports on the crowding status of vehicles, either actively or passively through their phone's location, to give warning to other passengers on real time crowding conditions. By tracking public reports on vehicle crowding over time, a transit agency may gain insight into vehicle planning needs such as adding more cars onto a train or increasing the frequency of a busy bus route in order to reduce overall passenger crowding.

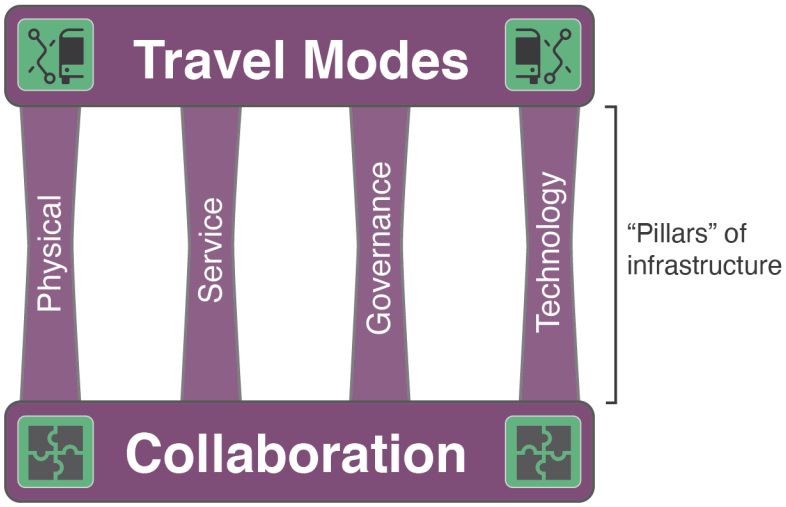

Figure 1

Actors typically involved in supporting these components include:

- Any organization directly responsible for planning and/or implementing physical, service, governance, and technology infrastructure for any of the travel modes in a mobility system.
- In addition to organizations that are directly responsible, others may be involved including regional organizations such as regional commissions and councils of governments, economic development organizations, and state-level organizations such as departments of transportation and human service organizations.

The "transit and mobility system" can differ widely from place to place and may be more of a conceptual grouping of the travel options available than a formal consortium of mobility providers that have agreed to combine their efforts. In highly rural areas, for example, it is common to have demand-response transit available as the only travel mode, outside of walking, cycling, and driving, in certain areas. In highly urban areas, it is common to have all of the travel modes listed above present. Although the overall goal for either area may be to fill in mobility gaps and make improvements, the challenges are very different. A common challenge for the former often involves improving and expanding the few options that are available, while the challenge for the latter often centers on better integrating all the available options—typically across the public and private sectors.

Depending on how the transit and mobility system is formally defined, actors will be involved in various roles. In highly urban areas with multiple transit agencies and many travel modes, for example, regional organizations are often heavily involved in coordinating activities across mobility providers and with those directly responsible for physical infrastructure. State-level organizations may also be involved in decision-making, particularly for federal and state funding decisions. Each geographic area is

unique in terms of how all the actors in the area work together. Figure 2 helps to illustrate how actors, complete trip components, and mobility system users interact.

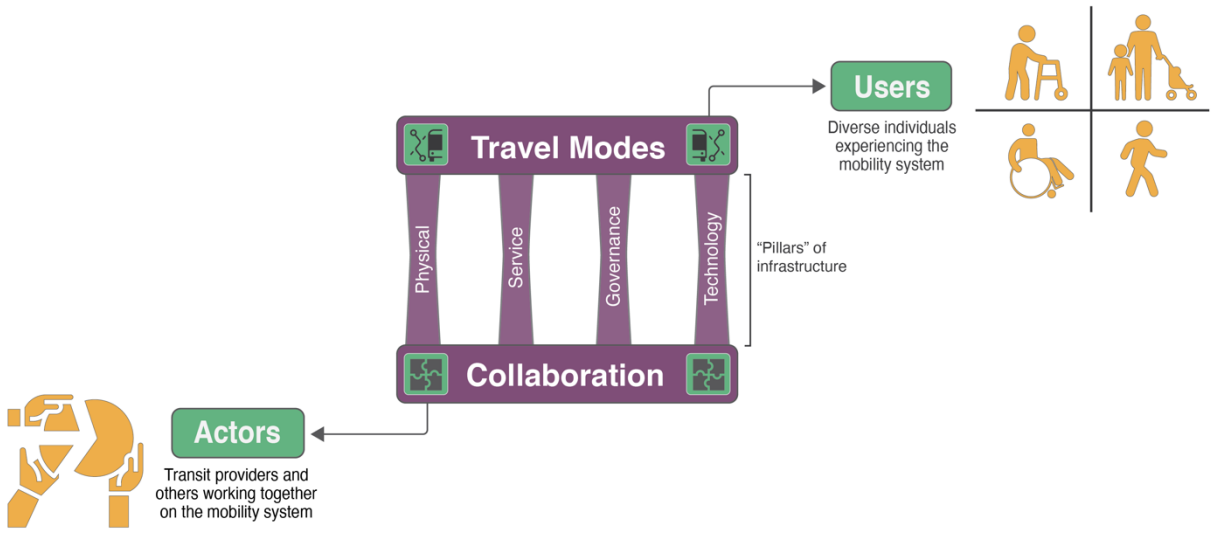

Figure 2

The federal government has become involved in contributing to innovation for the complete trip concept. In early 2020, the U.S. Department of Transportation (USDOT) announced a funding effort called the "Complete Trip - ITS4US Deployment Program." More than $38 million was awarded to five grantees[3] across three phases of activity with the purpose to "identify ways to provide more efficient, affordable, and accessible transportation options for underserved communities that often face greater challenges in accessing essential services. The program aims to solve mobility challenges for all travelers with a specific focus on underserved communities, including people with disabilities, older adults, low-income individuals, rural residents, veterans, and limited English proficiency travelers."[4] The five grantees are currently working on the first phase of their projects, which is focused on concept development. More details about the current projects and future plans are available on the Complete Trip - ITS4US Deployment Program website.[5]

The complete trip concept relates to, and in some ways has overlap with, two other concepts including Mobility as a Service (MaaS) and One-Call/One-Click (OC/OC) systems. MaaS is "an integrated mobility concept in which travelers can access their transportation modes over a single digital interface. MaaS primarily focuses on passenger mobility allowing travelers to seamlessly plan, book, and pay for travel on a pay- as-you-go and/or subscription basis."[6] One way of comparing the complete trip concept to MaaS is to point out that while they both involve including all of the travel

[3] https://www.transportation.gov/briefing-room/us-department-transportation-announces-over-41-million-awards-innovative-technologies
[4] https://www.its.dot.gov/its4us/index.htm
[5] https://www.its.dot.gov/its4us/index.htm
[6] https://n-catt.org/resources/mobility-as-a-service-now-and-in-the-future/

modes in a geographic area, MaaS is much more focused on the "technology infrastructure" component—digital technology that is online and on mobile devices in particular—while leveraging physical, service, and governance infrastructure to its ends.

OC/OC systems "inform the public about most, if not all, available transportation options for all populations in a given geographic area" and "enable users to access trip information; where required, confirm eligibility for and book trips; and pay for trips. This allows community members to plan and implement travel within a single system or seamlessly across multiple systems."[7] The same type of comparison between the complete trip and MaaS also applies to OC/OC systems (i.e., a focus on the "technology infrastructure" component), with the main difference that the technology for OC/OC systems does not necessarily depend on digital technology; call-based technology is an explicit part of the concept.

The Guidebook includes seven "highlighted projects" in chapter 1 and chapter 2; each project is a window into specific types of improvements for the complete trip. Figure 3 shows the locations of these US-based projects. In chapter 1, the projects deal more with *physical* infrastructure improvements, while the projects in chapter 2 involve improvements in *technology* infrastructure—both types contributing to progress for the complete trip.

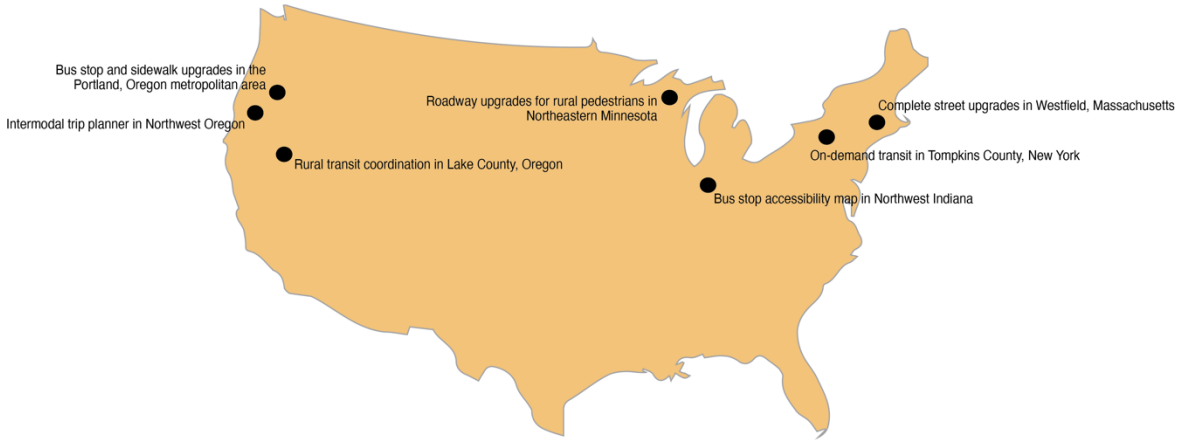

Figure 3

1.2 Milestones and Segments of the Complete Trip

Travel modes such as walking, cycling, fixed-route transit, on-demand transit, demand-response transit, Americans with Disabilities Act (ADA) paratransit/human-services transportation (HST), and micromobility (e.g., shared bikes and e-scooters), used separately for single-mode trips or used together during intermodal trips, each have their own distinct trip process. The "journey diagram" graphics (figures 4 and 5) provide a generalized illustration of typical end-to-end journeys, but do not address the full range of all journey possibilities. Most end-to-end journeys have similar "milestones" including:

[7] https://nationalcenterformobilitymanagement.org/one-call-one-click-resource-center/

- Evaluate options
- Select option (with booking and payment as required)
- Depart from origin
- Enter/begin use of vehicle
- Exit/end use of vehicle
- Arrive at destination

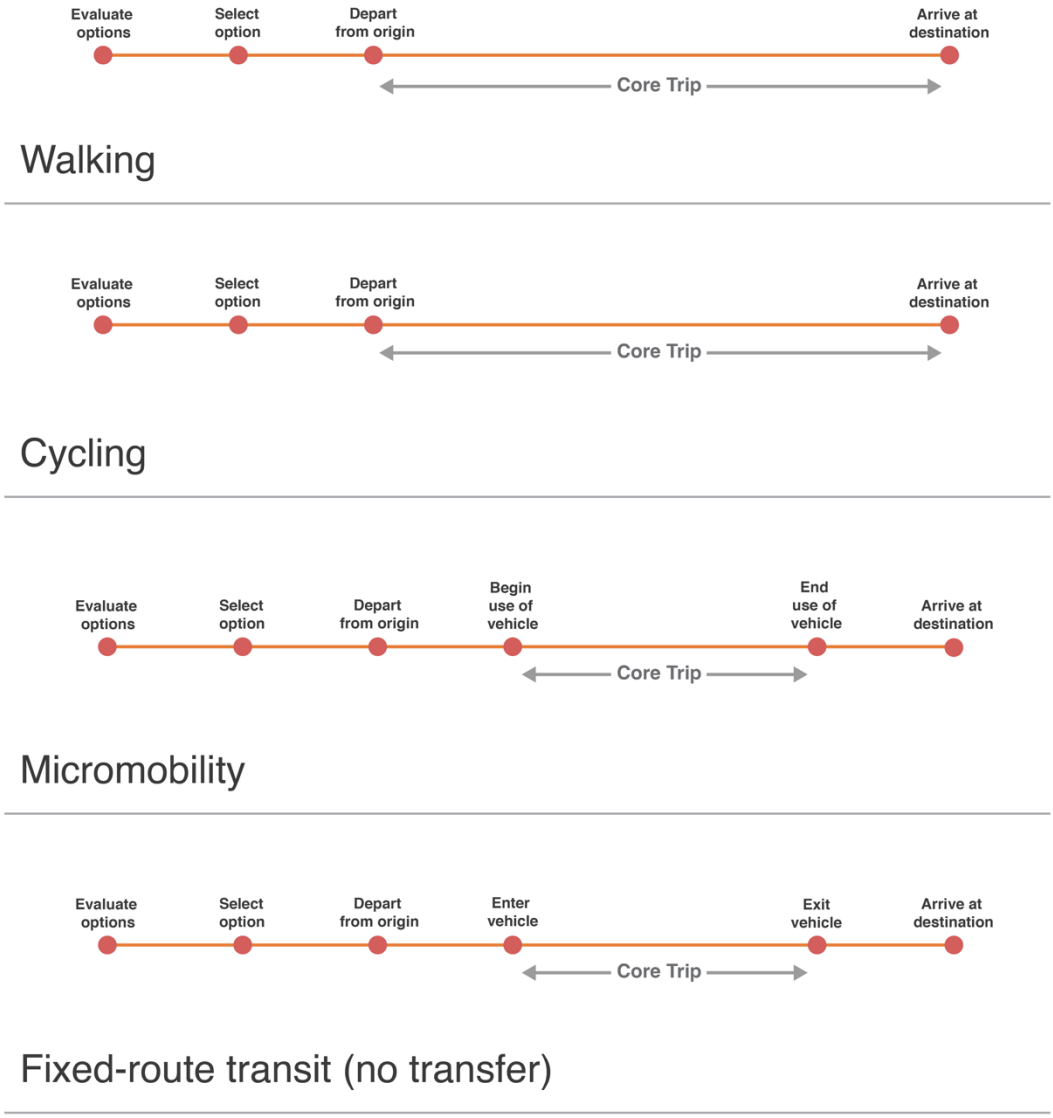

Figure 4

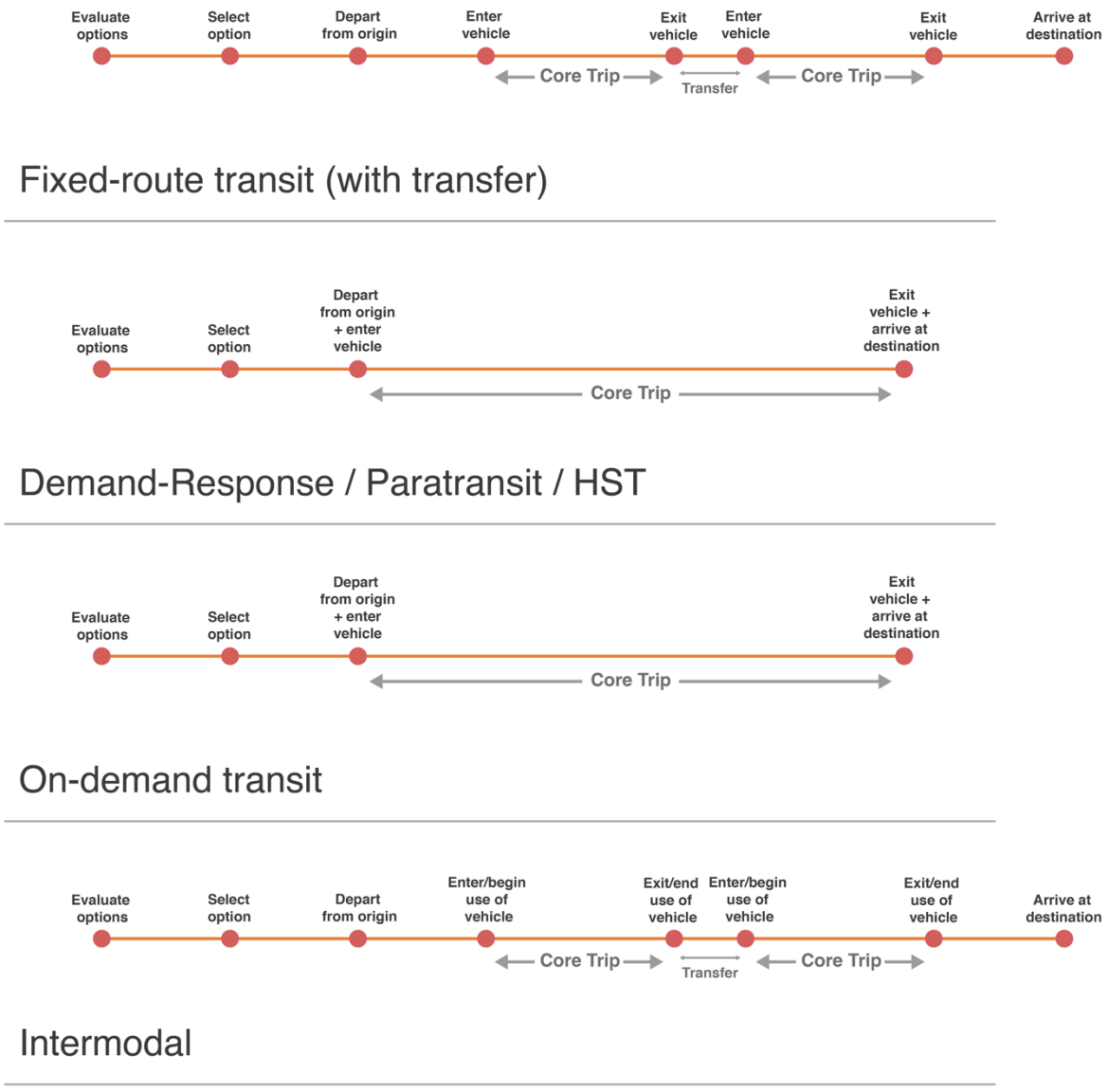

Figure 5

A journey "segment" refers to the customer experience between two milestones. For modes involving a vehicle, the segment that exists between the *enter/begin use of vehicle* and *exit/end use of vehicle* milestones is the "core trip"—the period of the journey that involves the customer riding in/on the vehicle. When an intermodal trip takes place, there are actually two core trips, one for each mode, and the segment between ending one core trip and beginning the other is the transfer. By adding more variables, intermodal end-to-end journeys become more complex. Payment reconciliation among various actors may also occur after the journey is complete, for some intermodal or multi-jurisdictional trips.

The main innovation of the complete trip concept is that it calls upon professionals to give just as much attention to all the other journey segments as is often given to the core trip. By considering each end-to-end journey type, with all its milestones and segments, how each journey works in reality becomes more transparently displayed—its gaps and shortcomings for the customer experience are less likely to remain hidden.

1.3 Factors Influencing Journey Feasibility for Individuals

Understanding the challenges that people face during their end-to-end journeys involves considering each segment separately and how the segments connect to each other to comprise the end-to-end journey. A potential tactic to address challenges may apply to a single segment (i.e., improved sidewalks encountered between "depart from origin" and "enter/begin use of vehicle"), or even multiple segments, but will rarely be able to address challenges for the entire end-to-end journey. Therefore, when developing ideas to improve the complete trip, it is important to consider many tactics that address specific journey segments. Ultimately, it is how all of these tactics are applied in unison that determines how successful an overall complete trip effort will be in reducing challenges for individuals.

Journey diagrams are helpful because they illustrate the customer experience in a simplified format, giving a bird's eye view of the situation. They can also help with another key step in understanding the complete trip—clarifying the diversity of individual experiences across modes. How an individual experiences an end-to-end journey primarily deals with two factors, their personal requirements and the design of the surrounding environment as shown in Figure 6.

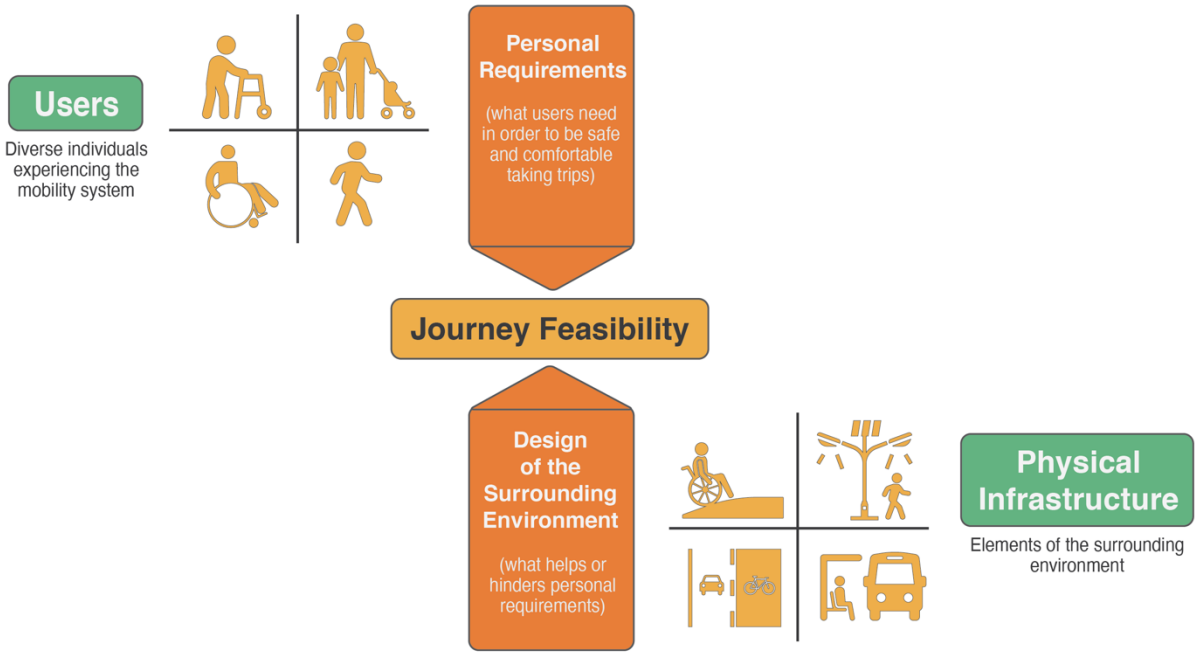

Figure 6

1.3.1 Personal requirements

Personal requirements influence the ability of an individual to access certain end-to-end journeys; they can even determine if a mode is feasible at all. While some personal requirements are related to an individual's disability, other requirements are related to how an individual perceives their travel experience more generally; both may involve a complex mental calculation to assess the levels of uncertainty for factors such as safety and comfort.

One category of personal requirements pertains to disabilities, such as cognitive, hearing, mobility, and visual impairments, as well as medical conditions. For example, while poor sidewalk conditions could potentially be navigated by some, those with mobility devices may have a very difficult time. While the "core trip" on a vehicle might be accessible, other journey segments for a fixed-route transit trip (i.e., getting from the origin to the vehicle) would not be—rendering the journey infeasible. As another example, if an individual has asthma, experiencing poor air quality while walking to catch the bus, while unpleasant yet bearable for some, could mean that the journey becomes infeasible for them.

In these situations, when a journey segment has been deemed infeasible, the individual eliminates the whole journey as an option. It cannot be assessed further considering factors such as safety, comfort, cost, and time; it is eliminated entirely.

Another category of personal requirements involves an individual's perception of the travel experience, which can vary widely depending on the person. Before an individual sets out on a certain travel mode, they first try to anticipate what the journey will be like based on past personal experience, the experience of others they may have heard about, and other bits of incoming information such as the weather, known traffic jams, and the like. From this, they may mentally construct an image of what could happen as they take the journey, taking various scenarios into account.

Everyone—each mobility customer—performs this mental calculation to some extent, particularly when embarking on a new mode. The factors they consider (i.e., safety, comfort, cost, and time), and the conclusions they arrive at, determine if a travel option is deemed infeasible (and eliminated) or feasible. And even if it is feasible, there are still levels of desirability to take into account. In some cases, the person may decide to try it, even though they find it risky or have concerns. In other cases, they may proceed with confidence, thinking that the trip should go smoothly.

Cycling, for example, involves a level of skill to operate the vehicle, navigate it through a variety of spaces (some with dedicated cycling infrastructure and some without), and the ability to avoid potential obstacles such as other cyclists, cars, and uneven pavement. When other elements in the surrounding environment are taken into consideration, cycling gets even more complicated. The weather and time of day are some elements to consider. Cycling in rain, of course, can make the activity more dangerous due to slippery conditions as can snow and ice, while cycling at night presents its own set of vision-related challenges.

It requires a certain amount of mental focus to cycle as well as some level of physical ability. Cycling is a learned skill, so someone who began cycling in earnest three years ago may have much more advanced capabilities in the present day. After three years, for example, it is typical that a cyclist can much more easily navigate a familiar route. The cyclist has learned what they might encounter through years of experience; there are fewer unknowns, less stress, and less fear as they cycle. Of course, cycling is not always taken as a stand-alone mode, it is often combined with transit for an intermodal journey. The distances that a bike can travel are impressive, which widen the coverage area for transit significantly.

In short, based on their perception of the travel experience, a new cyclist would likely have a very different mental calculation pertaining to safety when compared to an experienced cyclist. Because of that, a new cyclist might have much more stringent personal requirements in order to be convinced the journey would be safe enough to attempt. If certain elements were not in place, and their personal requirements were not met, a new cyclist could easily decide that a potential journey is not feasible.

Every individual interacting with the transit and mobility system has their own unique requirements for each travel mode; these requirements fluctuate based on external factors like the weather and internal factors such as disability, age, and even their own skill level. In order to provide feasible options, transit and mobility professionals must deeply understand the range of personal requirements of their customers.

The transit and mobility system should be designed with the explicit goal of providing options that are viable for the greatest number of people possible—regardless of their disabilities, medical conditions, skill levels, or age. The concept of the complete trip helps professionals better understand how to go about setting up a mobility system with options that are feasible for everyone.

1.3.2 Design of the surrounding environment

Personal requirements have a counterpart that can work with, or against, them—the design of the surrounding environment. While the weather and time of day cannot be changed, nor can the fact that people have differing levels of ability or skill, in some cases design can take these factors into account to ensure greater levels of safety and comfort and less uncertainty, in order to better meet personal requirements for everyone.

Related to disability, the pedestrian and transit system can be designed not only to meet the minimum of Americans with Disabilities Act (ADA) requirements, but can include digital tools, in-person services, and physical infrastructure that make using the system truly comfortable. This could mean, for example, that bus stops have shelters with plenty of space for multiple wheelchairs and that the sidewalks leading to bus stops, as well as the areas around them, allow for easy access. In the “Research Brief” for Transit Cooperative Research Program (TCRP) Report 163, *Strategy Guide to Enable and Promote the Use of Fixed-Route Transit by People with Disabilities*, the following is mentioned, “accessibility requirements for bus stops are defined through the ADA

Standards for Transportation Facilities. However, accessible connections to and from the stop are not always provided, often because the transit agency does not have control over sidewalks or other parts of the rights-of-way where bus stops are located. Incomplete or poorly maintained sidewalks, difficult street crossings, lack of curb ramps, and obstacles in the pathway such as utility poles create barriers for people with disabilities, limiting or preventing access to fixed-route transit service."[8]

In some cases, the surrounding environment can be designed to meet diverse needs. For example, having a sizeable bus stop shelter to keep customers out of the rain and wind can make a big comfort difference in certain climates on certain days. For people with mobility devices, keeping some devices out of downpours in the same bus stop may be an absolute requirement for safety. Repairing the sidewalk in an area frequently trafficked on the way to a bus stop improves safety for all users. But for a wheelchair user, the same repaired sidewalk may be required—more fundamentally—to ensure a route is feasible.

Increasing visibility at night for areas commonly trafficked by pedestrians and cyclists, as stand-alone trips or in combination with transit, is key. Street lighting and other tactics play an important role in enabling a safer area to transit through, "safer" not only from the risk of pedestrian and vehicle collisions but from crime events in general. Having a more thorough approach to physical infrastructure of this sort can have major impacts on ridership; the safer the area is, the more likely people are to transit through at all times of the day regardless of natural light levels.

The availability and quality of cycling infrastructure can be the main determinant for an individual considering it as a viable option. In places where bike lanes are separated from traffic, intersections are designed with cyclists in mind, and overall traffic speeds are slower, someone with little experience cycling might consider trying it. In places where bikes are forced to be in direct contact with cars, where bike lanes suddenly end with no warning, and vehicles are travelling at higher speeds, someone new to cycling will likely deem the area not feasible for cycling, based on their skill level. Someone new to cycling could easily imagine the stress and fear they would experience if they were to embark on a cycling trip with poor infrastructure.

Whether related to disability or a more general perception of the travel experience, the design of the surrounding environment directly determines if an individual deems a particular journey feasible or not. Therefore, for certain modes and certain journey segments, professionals should consider how the surrounding environment could be better designed to take personal requirements into account. Figure 7 helps illustrate how actors, complete trip components, mobility system users, and physical infrastructure interact to support journey feasibility for the complete trip.

[8] https://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_163IBBusStop.pdf

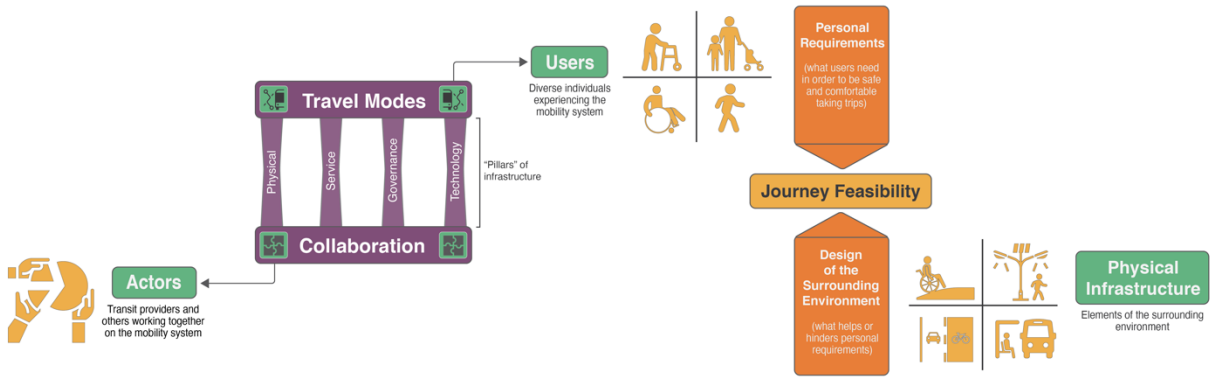

Figure 7

1.4 Highlighted Projects

Highlighted projects are provided below, serving as illustrations for the complete trip concept. Each project involves implementing improvements for the customer experience of end-to-end journeys. The projects are compared and contrasted across a number of factors including:

- Place and purpose – This section covers the geographic context, travel modes involved, and details about what the project team hoped to accomplish through the project.
- Process and people – This section covers the ways in which the project team approached the project, what steps were taken, and who was involved in the effort. For projects with a documented public input component, this aspect is explained.
- How this project could improve the complete trip – A brief summary is provided to explain how the project seems to have contributed to complete trip-related improvements.

1.4.1 Roadway upgrades for rural pedestrians in Northeastern Minnesota

Place and purpose

This project involves implementing countermeasures to mitigate safety risks for rural pedestrians who are crossing roadways on tribal reservations. The project centered on ten roadway sites across rural areas of Northeastern Minnesota known to have safety risks for pedestrians; the ten sites are within four rural tribal reservations. The Advocacy Council for Tribal Transportation (ACTT), a group that supports tribal transportation advocacy in Minnesota and includes tribal representation, helped to identify viable sites based on their personal knowledge of areas where safety concerns were known to be present and where they believed monitoring pedestrian activity could help identify countermeasures to improve safety. The purpose of the project was not only to address pedestrian safety risks on the ten sites selected, but also to more widely influence future roadway and highway projects in Minnesota, essentially developing best practices for the state to follow.

Process and people

The ten roadway sites were equipped with video cameras to enable the gathering of statistics on the usage of the site as well as details on how pedestrians interacted with roadway traffic. In addition, site analysis was conducted including "the number of lanes, lane width, bike and pedestrian facilities or networks, vegetation, motor vehicle speeds, lighting, pedestrian origins and destination, and the area's population distribution."[9] After viewing the video recordings, the project team drafted a set of potential countermeasures, including "crosswalks, signage, pedestrian crossing signs, pedestrian education, improved lighting, line of sight improvement, warning lights, and access ramps,"[10] and considered ways to fund such countermeasures. These countermeasures were implemented by early 2021.

Project collaborators included the ACTT and other tribal members, University of Minnesota researchers, the Minnesota Department of Transportation (MnDOT), as well as MnDOT district engineers and county engineers. The project's Technical Advisory Panel was comprised of ACTT members. Said of the engagement process, "an overarching goal was to work closely and collaboratively with the Native American populations toward improving safety along high-speed rural roads where most Native American pedestrians walk… This project's combination of the tribes' intimate knowledge of their pedestrian risks with robust and clear data showed that collaborative efforts can produce evidence that matters."[11] Representatives from four reservations were a part of the project including those from the Bois Forte Band of Chippewa, Fond du Lac Band of Lake Superior Chippewa, Grand Portage Band of Ojibwe, and Mille Lacs Band of Ojibwe.

MnDOT plays a major role in pedestrian planning for the state and has been leading the Statewide Pedestrian System Plan since late 2019. In addition, MnDOT and the Minnesota Department of Health collaborate on a wider effort, Minnesota Walks.[12] The policy framework of Minnesota Walks has specified that Native Americans are one of six priority user groups, since their daily lives are more likely to include walking when compared with other groups.

As of early 2021, phase 2 of the project was already in progress, which involves broadening the project by considering appropriate countermeasures for pedestrian safety risks in four additional tribal reservations. The countermeasures that have been implemented at the original 10 sites during phase 1 are also being evaluated for effectiveness.

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[9] https://mntransportationresearch.org/2021/01/13/understanding-rural-pedestrian-travel-behavior-and-safety-issues/
[10] https://mntransportationresearch.org/2021/01/13/understanding-rural-pedestrian-travel-behavior-and-safety-issues/
[11] https://mntransportationresearch.org/2021/01/13/understanding-rural-pedestrian-travel-behavior-and-safety-issues/
[12] https://www.dot.state.mn.us/peds/documents/planning-research/minnesota-walks-2017-final.pdf

How this project could improve the complete trip

- By working directly with representatives of the target user group, in this case **pedestrians living on tribal reservations in Northeastern Minnesota**, the project team was able to gain valuable information about how to best focus the project.
- Based on the project documentation, it appears that **pedestrian safety** on the ten sites should have improved as a result of the project. By considering personal requirements for pedestrians, the surrounding environment was better designed for safety taking these into account. By improving safety, the feasibility of pedestrian journeys in the area should have improved.
- The complete trip components that were involved include:
    - **Travel modes** such as walking.
    - **Collaboration** in the form of University of Minnesota researchers, MnDOT, district-level and county engineers, and ACTT all working together to support the research, analysis, planning, and implementation aspects the project required.
    - **Physical infrastructure** in the form of crosswalks, signage, pedestrian crossing signs, improved lighting, line of sight improvement, warning lights, and access ramps.
    - **Service infrastructure** in the form of pedestrian education. It appears that a new service is now being provided as a result of the project. The project team opted to couple physical infrastructure improvements with direct education to the people impacted locally for a more holistic approach.
- The end-to-end **journey segment impacted** is the "core trip" segment between the *depart from origin* and *arrive at destination* milestones for pedestrian trips as well as the walking element of transit journeys.

1.4.2 Complete street upgrades in Westfield, Massachusetts

Place and purpose

Westfield is embarking on a complete streets project in order to increase safety for people walking, cycling, and taking transit along the Route 20/Main Street corridor. The project area is shown on the map image (Figure 8); Westfield is part of the Springfield, Massachusetts Metropolitan Statistical Area (MSA). The US Department of Transportation (USDOT) explains that complete streets are "streets designed and operated to enable safe use and support mobility for all users. Those include people of all ages and abilities, regardless of whether they are travelling as drivers, pedestrians, bicyclists, or public transportation riders. The concept of Complete Streets encompasses many approaches to planning, designing, and operating roadways and rights of way with all users in mind to make the transportation network safer and more efficient."[13]

[13] https://www.transportation.gov/mission/health/complete-streets

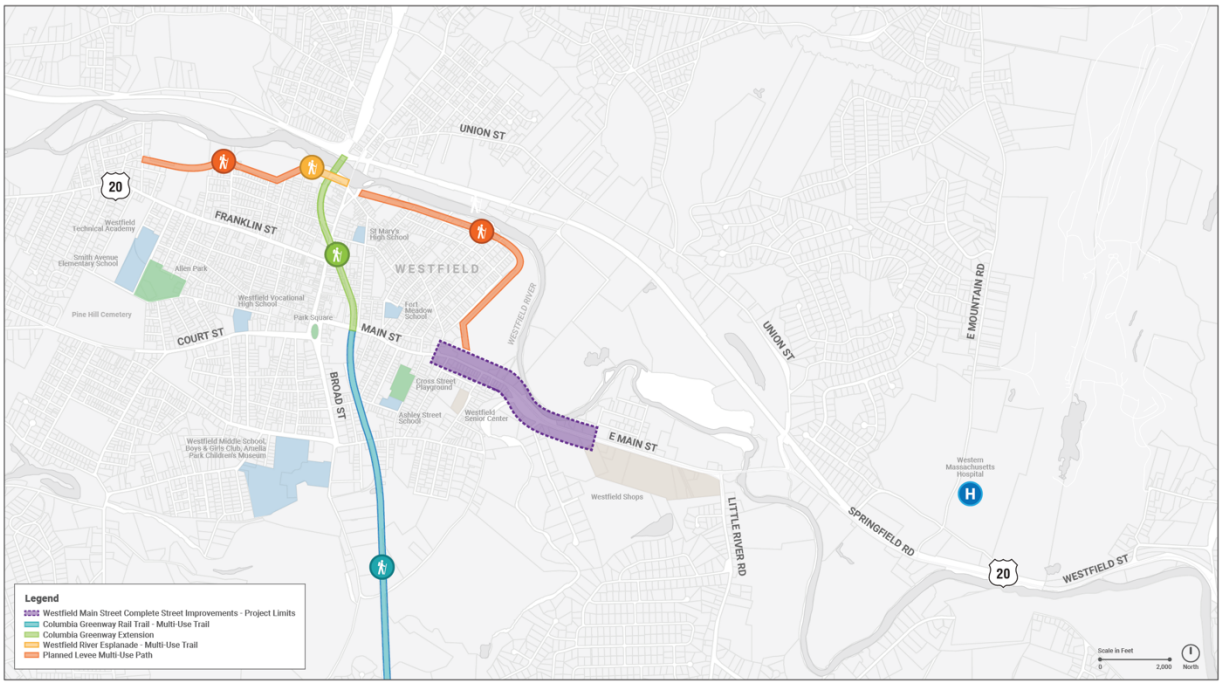

Image Source: MassDOT Project Page for the Westfield Main Street (Route 20) Complete Street Improvements, https://www.mass.gov/info-details/about-the-westfield-main-street-route-20-complete-street-improvements#project-background-

Figure 8

This project has been prioritized by the Massachusetts Department of Transportation (MassDOT), because the corridor was identified as having a high potential for daily walking and cycling. The corridor runs along Route 20/Main Street. As stated by MassDOT, "The purpose of this project is to improve pedestrian safety, transit accommodations, and provide connectivity for people walking and cycling on existing and planned shared use paths and trails in Westfield, MA."[14]

Process and people

This project is being led by the MassDOT Highway Division. As of November 2021, the project team is currently gathering online feedback from stakeholders. An image from this information gathering process is shown (figure 9). An interest in feedback related to accessibility and the Americans with Disabilities Act (ADA) is mentioned specifically. In terms of the types of outcomes that can be expected from the project, these include better connections between travel modes, vehicles travelling at slower speeds, and the addition of sidewalks—currently the corridor has a sidewalk on only one side of the roadway.

[14] https://www.mass.gov/info-details/about-the-westfield-main-street-route-20-complete-street-improvements#project-background-

Image Source: MassDOT Interactive Online Map and Comment Form for the Westfield Main Street (Route 20) Complete Street Improvements, https://pima.massdotpi.com/public/comment/project-comment-dynamic?project_id=13987

Figure 9

How this project could improve the complete trip

- By asking for the input of **people living in Westfield**, the project team should be able to gain valuable information about which parts of the Route 20/Main Street corridor would benefit from complete street upgrades.
- Based on the project documentation, it appears that **pedestrian, cyclist, and transit user safety** along the corridor should improve as a result of the project. By considering the personal requirements of these groups, the surrounding environment could be better designed for safety taking their input into account. By improving safety, the feasibility of pedestrian, bike, and transit journeys in the area should be improved.
- The complete trip components that appear to be involved include:
    - **Travel modes** such as walking, cycling, and transit.
    - **Physical infrastructure** to be determined but could take the form of redesigned intersections and signaling, sidewalk additions and repairs, bike lane upgrades, and other measures.
    - **Governance infrastructure** may be considered on this project in addition to physical infrastructure. MassDOT announced grant availability of $12.5

million for “Shared Streets and Complete Streets” in July 2021.[15] Massachusetts also has a Complete Streets Funding Program; in order to be eligible, municipalities must have a Complete Streets policy in place and develop a plan for prioritizing such projects.[16] While funding is a significant supportive measure, Smart Growth America tracks a wide range of governance-related efforts across the country for Complete Streets through its “policy atlas.”[17] These efforts include resolutions, policies, laws/ordinances, plans, design manuals/guides, internal policies/executive orders, and tax ordinances. A number of municipalities within the Springfield, Massachusetts MSA are identified on the Complete Streets “policy atlas” as having governance-related efforts in place.

- The end-to-end **journey segment impacted** for this project is the “core trip” segment between the *depart from origin* and *arrive at destination* milestones or between the *enter/begin use of vehicle* and *exit/end use of vehicle* milestones, depending on the travel mode.

1.4.3 Bus stop and sidewalk upgrades in the Portland, Oregon metropolitan area

Place and purpose

A bus stop and sidewalk improvement project in the Portland, Oregon metropolitan area, including some bus stops along a highway, succeeded in providing ADA-compliant features while enabling all transit customers travelling in high-traffic areas to get to bus stops more safely. The project also seems to have contributed to some ADA paratransit customers being more able to use fixed-route options in places where the bus stop upgrades were completed, instead of using paratransit only.

This project was led by TriMet, a local public transit agency. In 2008, TriMet completed project implementation, in partnership with the Oregon Department of Transportation (ODOT), of substantial upgrades to 17 bus stops and nearby sidewalks along a high-ridership fixed-route transit corridor in the TriMet service area. Some bus stops were located along a highway. The overall purpose was to increase safety for transit customers as they access bus stops. The project also focused on additional outcomes for customers with disabilities.

Process and people

This project, a collaboration between TriMet, ODOT, and local authorities in charge of sidewalk management, involved the construction and repair of sidewalks alongside the 17 bus stops that were missing or in disrepair. In addition, ten bus shelters were added, and concrete pads were constructed. Figure 10 provides before and after photos of one of the bus stops.

[15] https://mass.streetsblog.org/2021/07/21/massdot-announces-12-5-million-in-shared-streets-complete-streets-grants/
[16] https://www.mass.gov/complete-streets-funding-program
[17] https://smartgrowthamerica.org/program/national-complete-streets-coalition/publications/policy-development/policy-atlas/

Image Source: TCRP Report 163, Strategy Guide to Enable and Promote the Use of Fixed-Route Transit by People with Disabilities, https://www.trb.org/Publications/Blurbs/170626.aspx

Figure 10

After the implementation of the project, TriMet conducted an assessment of its results. Of interest to TriMet was a multi-modal understanding of how the upgrades influenced the ridership of customers with disabilities—not only for fixed bus routes, but also ADA paratransit within a .25-mile radius of the upgraded bus stops.

The usage of fixed bus routes by customers with disabilities was tracked by TriMet. TriMet used the deployment of a lift on a fixed bus route as an indicator that a customer with a disability took a trip. In the year following the upgrades (from fall 2008 to fall 2009), lift deployments nearly doubled. In order to track the usage of ADA paratransit, TriMet used paratransit trips taken by customers with "conditional eligibility" as an indicator. Conditional eligibility is applied when "an individual may be able to use the fixed route system for *some* trips. Transit agencies can establish conditional eligibility for those individuals, and would only be obligated to provide complementary paratransit for those trips that the individuals cannot make using fixed route, based on the conditions of the particular trip."[18]

TriMet found that when comparing the year 2011 to the year prior to making the upgrades, paratransit ridership by conditionally eligible customers decreased by 12%. TriMet also found that there was no change during the same time period for fully eligible paratransit customers taking paratransit; bus stop upgrades did not appear to have a

[18] https://www.nationalrtap.org/Toolkits/ADA-Toolkit/Service-Type-Requirements/ADA-Complementary-Paratransit-Requirements#1448768802

measurable impact on fixed-route bus ridership by fully eligible paratransit customers. Explained in TCRP Report 163, *Strategy Guide to Enable and Promote the Use of Fixed-Route Transit by People with Disabilities*, regarding this outcome, "it is conditionally eligible riders who will most benefit from stop and infrastructure accessibility improvements, as these are the riders who are able to use fixed-route transit in some cases. Regarding costs, if one assumes that the new lift/ramp trips at the 17 bus stops can be attributed to the improvements, and that without the improvements those trips would be on TriMet's ADA paratransit service, then TriMet is saving nearly $60,000 per year by accommodating additional lift/ramp-using riders on fixed-route transit as a result of the improvements installed in 2009 (using the FY 2012 operating cost per ADA paratransit trip of $29.87)."[19]

One takeaway from the TCRP report that may be of interest to other transit agencies is that a cost-benefit analysis could be conducted to compare the implementation of bus stop accessibility projects against the cost of providing additional ADA paratransit trips for those who are conditionally eligible; the costs of the latter might become reduced if projects such as the former are implemented—and could incur lower overall costs to the agency over time.

It is important to note that, due to the limitations of the data indicators used, the ridership patterns of customers with disabilities who do not need to use the lift, such as those with vision impairments, were not tracked. In short, it is possible that the benefits of the project were further-reaching than was quantified in TriMet's analysis.

How this project could improve the complete trip

- Based on the project documentation, it appears that **transit user safety, for customers with disabilities in particular,** to the 17 bus stops should have improved as a result of the project. The bus stops and the environment surrounding them was better designed for safety, which should also improve the feasibility of taking transit trips in the area.
- The complete trip components that were involved include:
    - **Travel modes** such as walking and fixed-route transit.
    - **Collaboration** in the form of TriMet, ODOT, and the local authorities in charge of sidewalk management working together to conduct analyses and address construction and maintenance needs.
    - **Physical infrastructure** in the form of the construction and repair of sidewalks, additions of new bus shelters, and the addition of new concrete pads at bus stops.
    - **Governance infrastructure** *potentially* in the form of modifications to conditional eligibility agreements between TriMet and ADA paratransit customers. As TriMet makes significant upgrades to its bus stops and the areas surrounding them, it may lead to conditionally eligible paratransit customers no longer being eligible, at least in areas where fixed bus routes have been made more accessible.

[19] https://www.trb.org/Publications/Blurbs/170626.aspx

- The end-to-end **journey segments impacted** are the segments between the *depart from origin* and *enter vehicle* milestones and *exit vehicle* and *arrive at destination* milestones for fixed-route transit.

Chapter 2: Digital Tools and the "Complete Trip"

2.1 Overview

The focus of the Guidebook is on how digital tools can aid in facilitating the complete trip and, within that, primarily the role that trip planning plays. Digital tools, as an element of technology infrastructure, operate within a wider framework of other types of complete trip components including physical, service, and governance infrastructure. Therefore, while focusing on digital tools and technology infrastructure, it is important to always consider how they will interact within the wider framework, as shown in figure 11.

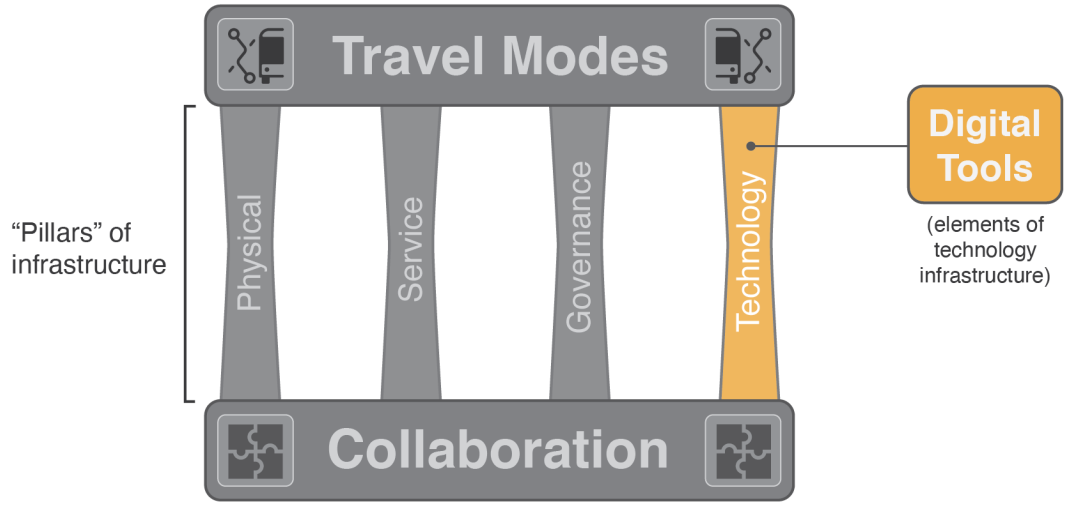

Figure 11

While the Guidebook primarily deals with digital tools for trip *planning*, it is important to keep in mind that trip *booking*, trip *payment*, and trip *navigation* functions are often tightly connected to trip planning. For this reason, the Guidebook does not exclusively deal with trip planning alone; it makes mention of trip booking, payment, and navigation functions as relevant. As shown in figure 12, the end-to-end journey milestones and segments correspond to typical functions supported by digital tools—trip planning, booking, payment, and navigation.

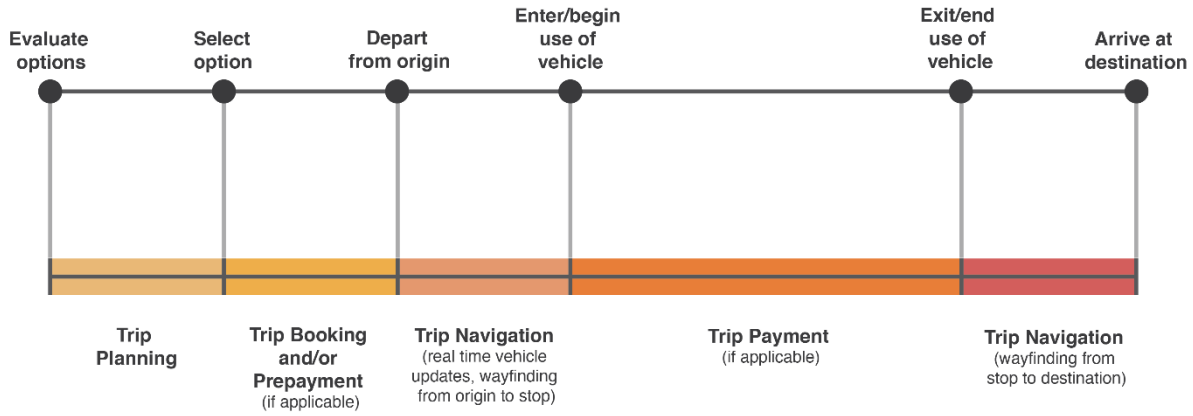

Figure 12

2.1.1 Trip planning vs. trip planner vs. trip plan

For the purposes of this Guidebook, three terms will be used:

- Trip planning – General reference to the process of preparing to take a trip on one or more travel modes.
- Trip planner – Specific reference to map-based software applications that ingest data from one or multiple travel modes and produce itineraries from which users select the final trip plan to take. Decision-making criteria typically displayed within trip planners include time (i.e., trip duration), cost (i.e., total trip cost), and distance (i.e., total distance to cross), though other factors may be included.
- Trip plan – Specific reference to the itinerary for the selected trip.

Trip planning is a process that may or may not involve digital tools. Section 1.3 of the Guidebook refers to a "mental calculation" that all mobility system users perform to some extent, especially when embarking on a new mode. This process involves evaluating different options, by anticipating the travel experience and considering criteria (e.g., time, cost, and safety), and finally, selecting an option. These activities help to describe the process of trip planning. Prior to the availability of digital tools such as trip planning apps and websites, people performed these calculations mentally if the travel modes and options warranted consideration. They simply had less precise information at their fingertips in order to do so.

With the advent of trip planners, mobility system users have been given a digital tool to aid in their mental calculation. Users of trip planners are typically able to organize information better than they could otherwise from a mental calculation alone. Take the Google Maps transit trip planner, for example. By having information on all the streets and their dimensions, the estimated walking time to the bus is likely much more precise in Google Maps than through a mental calculation. Some trip planners even have information on calories expended, so that decisions can be made according to exercise potential. Others can compare options according to estimated carbon dioxide emissions, so that a user can better understand their carbon footprint implications.

Some of the most common trip criteria that people consider are cost and time; both of these tend to be well estimated in current trip planners as of November 2021. Other criteria that are commonly considered—but are not necessarily easy to assess in trip planners—are safety and comfort. While much of the transit industry's energy is put into improving the safety of getting to and taking transit, transit customers using trip planners and other digital tools still typically need to perform a personal safety assessment through their own mental calculation.

This is, in part, why section 1.3 of the Guidebook gives so much attention to how people go about determining the feasibility of the journey. Assessing personal requirements for a travel mode, safety in particular, is indeed a personal process that involves a number of factors including a person's past experience, their own appetite for risk, and the information they have at hand—all contributing to their perception of the experience.

There are, at present, no trip planners that allow for all safety-related information to be considered at one time. There are some digital tools that have pieces of safety-related information, but the information overall is incomplete. To check the street and intersection conditions for a pedestrian trip in an unfamiliar area in the US, the best way to gain information is often to check Google Street View. Though this is a helpful digital tool, the information it provides is still just one input into a broader and more complex mental calculation an individual performs to consider their personal requirements. The reality of this situation is that people live with a great deal of ambiguity in the trip planning process.

In short, trip planning is a complex process supported by mental calculations with the aid of trip planners and other digital tools. Trip planners are certainly helpful in reducing uncertainty for some decision-making criteria in the trip planning process; at the same time, they have their limits.

2.1.2 Introduction to projects and initiatives

In order to provide context around how digital tools can support the complete trip for various travel modes, a table is provided in section 2.3 with information on projects. Each project is framed in terms of the journey segment with which it most closely aligns. By considering how each segment is supported through digital tools, it becomes clearer how the complete trip, as a whole, can best be supported.

In addition to the table in section 2.3, there are also four highlighted projects provided in Section 2.4, allowing for greater detail to be covered. Section 2.5 explains how specific types of initiatives can support the adoption of new digital tools for the Complete Trip. These initiatives include practices for using multiple tools together, innovative procurement processes, and embarking on General Transit Feed Specification (GTFS) data creation and maintenance projects.

For transit agencies considering their own approaches, these projects and initiatives provide valuable examples. Mobility professionals can adopt multiple digital tools, or a single tool that supports multiple functions, to support a) the travel modes that are

present in their system, b) the journey segments most in need of support, and c) the personal requirements of individuals. Through these examples, mobility professionals can see how digital tools can improve the customer experience for each journey segment as well as the complete journey.

2.2 Key Topics

There are a number of data and technology-related trends referenced throughout the projects and initiatives. While this list is not exhaustive, information on key topics provides an informational base that is needed to understand some of the project details.

2.2.1 GTFS data and extensions

The General Transit Feed Specification (GTFS) is a data specification that began as a way to communicate static fixed route transit schedules and routes, primarily used in trip planners. On that foundation, extensions have been added over the years that impact GTFS data, such as GTFS-RT (real time) which can now show real-time route details based on the location of vehicles, as opposed to relying on static schedule data alone, thus improving the accuracy of trip planners. GTFS-RT can also be used on a stand-alone basis to display wait times for approaching vehicles. Other extensions include GTFS-flex, which displays flexible transit options such as demand-response transit, flag stops, and route deviations.[20] There are also emerging areas for GTFS, such as GTFS-eligibilities[21] and GTFS-pathways.[22] The former enables services that have eligibility requirements such as age, veteran status, or disability to be displayed with relevant details, while the latter provides navigation details that are important to customers with disabilities. GTFS and its extensions are commonly used across the US and the world to standardize transit information, so that apps and other services, once developed, can more easily support users across the globe. More details on GTFS-related efforts are provided in N-CATT's *Data Practices Guidebook*;[23] the table on "Important Transportation Data Specifications" in a Shared-Use Mobility Center (SUMC) case study provides further detail on GTFS and other data standards.[24]

2.2.2 Open Trip Planner

Open Trip Planner (OTP) is an open source software that has provided a code base for a few of the projects explained in this chapter. To learn more about open source software and open data, see the N-CATT white paper, "Open Source Software and Open Data: What Are They and How to Use Them."[25] As explained on the OTP website,[26] "OTP is an open source multi-modal trip planner, focusing on travel by

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[20] https://n-catt.org/resources/gtfs-flex-what-is-it-and-how-is-it-used/
[21] https://nationalcenterformobilitymanagement.org/blog/open-data-part-4/
[22] https://docs.google.com/document/d/1qJOTe4m_a4dcJnvXYt4smYj4QQ1ejZ8CvLBYzDM5IyM/edit#heading=h.edxt3s6om1lm
[23] https://n-catt.org/wp-content/uploads/2021/06/Final-Data-Practices-Guidebook.pdf
[24] https://learn.sharedusemobilitycenter.org/casestudy/the-role-of-data-specifications-in-creating-an-integrated-transportation-system/
[25] https://n-catt.org/resources/open-source-software-and-open-data-what-are-they-and-how-to-use-them/
[26] http://docs.opentripplanner.org/en/latest/

scheduled public transportation in combination with bicycling, walking, and mobility services including bike share and ride hailing… It builds its representation of the transportation network from open data in open standard file formats (primarily GTFS and OpenStreetMap). It applies real-time updates and alerts with immediate visibility to clients, finding itineraries that account for disruptions and service changes… As of 2020, the codebase has been in active development for over ten years, and is relied upon by transportation authorities and travel planning applications in deployments around the world."

2.2.3 On-demand transit/microtransit

On-demand transit/microtransit is a travel mode that has become more common over the past five years as an option provided by transit agencies. Once transportation network companies (TNCs) such as Lyft and Uber became more common, it also became clear in the transit industry that the type of technology TNCs use could have broader implications. By connecting the geolocation in mobile phones, which identifies a transit customer's location, with the automatic vehicle location (AVL) data that identifies a transit vehicle's location, more dynamic trips can be provided that are available in near real time across service areas that have no fixed routes. This is in striking contrast to demand-response transit services, which typically require trip booking and reservations to be handled the day prior to the travel day due to limitations of the enabling technology.

Since on-demand transit/microtransit service is built around the core technology of dynamic route scheduling, a complex software that relies on real-time customer and vehicle locations, the customer processes of trip planning, booking, payment, and navigation are typically handled within a single platform or app that interfaces with the core technology. In its current iteration, this often results in on-demand transit not being displayed as an option within multi-modal trip planners. Instead, it is more common for the digital components of this mode to be handled by customers in a separate, dedicated app. More details on how on-demand transit works are provided in the N-CATT Guidebook, *New Software Adoption for Small Transit Agencies*.[27] Other resources that help explain this topic include TCRP Synthesis 141, *Microtransit or General Public Demand–Response Transit Services: State of the Practice*,[28] SUMC's Learning Module on Microtransit,[29] and a list provided by APTA[30] of various microtransit projects.

While on-demand transit/microtransit is generally supported within a single app for booking and payment, it is sometimes possible to connect these platforms with a broader multi-modal trip planning application as has been done in the Denver metro area.[31]

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[27] https://n-catt.org/resources/new-software-adoption-for-small-transit-agencies/
[28] https://www.nap.edu/catalog/25414/microtransit-or-general-public-demand-response-transit-services-state-of-the-practice
[29] https://learn.sharedusemobilitycenter.org/learning_module/microtransit/
[30] https://www.apta.com/research-technical-resources/mobility-innovation-hub/microtransit/
[31] https://www.kyyti.com/demandtrans-partner-kyyti-group-integrates-trip-plans-in-flexride-app/

2.3 Table of Projects

Figure 13, the table of projects, organizes projects for digital tools according to travel mode (y-axis) and the most relevant journey segments (X-axis) with the project title indicating if it involves a more specific digital solution for personal requirements such as related to a disability. Highlighted projects, which are covered in greater depth in Guidebook Section 2.4, are shown with a dark grey background. All other projects are listed below with links to more information.

Travel Mode	End-to-End Journey Segments				
	Trip Planning	Trip Booking (if applicable)	Trip Navigation (real time vehicle updates)	Trip Payment (if applicable)	Trip Navigation (wayfinding from origin to stop and from stop to destination)
Multi/Intermodal	Intermodal Trip Planner in Northwest Oregon				
	Intermodal Trip Planner in Portland, OR				
	Intermodal Trip Planner in Vermont				
	Intermodal Trip Planner and Navigator in Helsinki, Finland				
	Intermodal Trip Planner and Navigator in Pinellas County, FL				
Walking	AccessMap in Seattle, WA				
	Accessibility Mapping Project for the University of Pennsylvania				
	Open Sidewalks				
	Project Sidewalk				
Cycling	Komoot Trip Planner and Navigator				
	RideWithGPS Trip Planner and Navigator				
	Strava Trip Planner and Navigator				
Micromobility	Adaptive Bikeshare Pilot in Oakland, CA				
	Adaptive Micromobility Vehicles with Lime				
	Bikeshare Program in Pocahontas, Northwest IA				
	Bikeshare System Expansion into Adaptive Bikes in Milwaukee, WI				
	E-Scootersharing Program in Burlington, IA				
Fixed-route transit	Bus stop accessibility map in Northwest Indiana		OneBusAway app for Real Time Transit Info	Integrated trip payment in Denver, CO	Wayfinding for individuals with vision impairments/blindness in Kansas City, KS and MO
	Multi-modal trip planner in Tulare County, California			Multi-Agency Mobile Ticketing in Ohio	
	Step-Free Trip Planning in Chicago, IL			Trip payment in Gwinnett County, GA	
	Trip Planner with Bus Stop Accessibility Details in Washington, D.C.				
	Wheelchair-accessible Trip Planning in Boston, MA				
Demand-Response / Paratransit / HST		Rural Transit Coordination in Lake County, Oregon			
		HST Trip Coordination in Denver, CO			
		Online Booking for Paratransit in Orlando, FL			
	On-Demand Paratransit Pilot Program in Boston, MA				
	On-Demand Paratransit Pilot Program in Kansas City, KS and MO				
	Online Booking Tool for Paratransit in Las Vegas, NV				
	Paratransit Mobility on Demand Demonstration in Pinellas County, FL				
On-demand transit	On-Demand Transit in Tompkins County, New York				
	On-Demand Transit Pilot in Johnson County, KS				
	On-Demand Transit Pilot in Traverse City, MI				
	On-Demand Transit Program Expansion in Dallas, TX				
	Rural On-Demand Transit Pilot in Gloucester and Wise Counties, VA				

Figure 13

Each project is shown in relation to the trip segment, or segments, it most closely supports; the table is a general approximation. Showing that a project or tool spans

multiple segments does not necessarily indicate it supports all the segments in all situations, but that the capability to support the segments is possible. Some of the multi/intermodal tools also support individual travel modes once selected, such as walking and cycling, but this is not noted in the table. Modes that tend to have all the complete trip segments handled in the same digital tool (e.g., walking, cycling, micromobility, and on-demand transit) are shown as such (i.e., not broken down by segment).

None of the tools mentioned in the table have been evaluated in terms of how well they perform. Neither N-CATT nor the author of this Guidebook endorses the use of the tools mentioned in the table. The table is not intended to provide an exhaustive or complete list of all digital tools that may support the Complete Trip.

Multi/intermodal

- Intermodal Trip Planner in Portland, OR
  - https://learn.sharedusemobilitycenter.org/overview/trimet-trip-planner-adds-uber-share-now-and-biketown-portland-oregon-2019/
- Intermodal Trip Planner in Vermont
  - https://nationalcenterformobilitymanagement.org/resources/oc-oc-state-of-vermont/
  - https://govermont.agilemile.com
- Intermodal Trip Planner and Navigator in Helsinki, Finland
  - https://www.cerema.fr/system/files/documents/2020/04/cerema_parangonnage_maas_synthesis_eng.pdf
- Intermodal Trip Planner and Navigator in Pinellas County, FL
  - https://learn.sharedusemobilitycenter.org/overview/psta-partners-with-the-transit-app-pinellas-county-fl-2017/

Walking

- AccessMap in Seattle, WA
  - https://www.washington.edu/news/2017/02/01/new-route-finding-map-lets-seattle-pedestrians-avoid-hills-construction-accessibility-barriers/
- Accessibility Mapping Project for the University of Pennsylvania
  - https://web.sas.upenn.edu/access-map/
- Open Sidewalks Project
  - https://www.opensidewalks.com
- Project Sidewalk
  - https://www.washington.edu/news/2019/04/18/project-sidewalk/

Cycling

- Komoot Trip Planner and Navigator
  - https://www.komoot.com
- Ride with GPS Trip Planner and Navigator
  - https://ridewithgps.com
- Strava Trip Planner and Navigator
  - https://www.strava.com

Micromobility

- Adaptive Bikeshare Pilot in Oakland, CA
  - https://learn.sharedusemobilitycenter.org/overview/ford-gobike-adaptive-bikeshare-pilot-oakland-california-2019/
- Adaptive Micromobility Vehicles with Lime
  - https://learn.sharedusemobilitycenter.org/overview/lime-seeks-to-provide-new-adaptive-vehicles-new-york-new-york-2021/
- Bikeshare Program in Pocahontas, Northwest IA
  - https://learn.sharedusemobilitycenter.org/overview/small-bikeshare-system-launched-in-pocahontas-northwest-ia-2018/
- Bikeshare System Expansion into Adaptive Bikes in Milwaukee, WI
  - https://learn.sharedusemobilitycenter.org/overview/milwaukee-incorporates-adaptive-bikes-into-public-bikeshare-system-milwaukee-mi-2019/
- E-Scootersharing Program in Burlington, IA
  - https://learn.sharedusemobilitycenter.org/overview/bird-launches-e-scootersharing-program-burlington-ia-2021/

Fixed-route transit

- Multi-modal trip planner in Tulare County, California
  - https://www.transitwiki.org/TransitWiki/index.php/GTFS-flex#Tulare_County.2C_California
- Step-Free Trip Planning in Chicago, IL
  - https://www.transitchicago.com/planatrip/accessiblegoogletrip/
- Trip Planner with Bus Stop Accessibility Details in Washington, D.C.
  - https://www.wmata.com/schedules/trip-planner/
  - https://www.wmata.com/service/accessibility/metrobus.cfm
- Wheelchair-accessible Trip Planning in Boston, MA
  - https://medium.com/@karti.subramanian/investing-in-accessibility-technology-pays-off-for-mbta-riders-f555c1b0456e
  - https://techcrunch.com/2018/03/15/google-adds-a-wheelchair-accessible-option-for-transit-maps/
- OneBusAway app for Real Time Transit Info
  - https://onebusaway.org
- Integrated trip payment in Denver, CO
  - https://learn.sharedusemobilitycenter.org/casestudy/denver-rtd-and-uber-app-development/
- Multi-Agency Mobile Ticketing in Ohio
  - https://www.apta.com/ohio-neoride-ezfare/
- Trip payment in Gwinnett County, GA
  - https://atltransit.ga.gov/xpress-and-gwinnett-county-transit-launch-token-transit-mobile-ticketing-program-to-help-prevent-the-spread-of-covid-19/
- Wayfinding for individuals with vision impairments/blindness in Kansas City, KS and MO
  - https://ridekc.org/rider-guide/navigator

Demand-Response/Paratransit/HST

- HST Trip Coordination in Denver, CO
  - https://nationalcenterformobilitymanagement.org/resources/oc-oc-denver-metro-area/
- Online Booking for Paratransit in Orlando, FL
  - https://nationalcenterformobilitymanagement.org/resources/oc-oc-central-florida/
- On-Demand Paratransit Pilot Program in Boston, MA
  - https://learn.sharedusemobilitycenter.org/overview/on-demand-paratransit-pilot-program-boston-massachusetts-2016/
- On-Demand Paratransit Pilot Program in Kansas City, KS and MO
  - https://learn.sharedusemobilitycenter.org/casestudy/ridekc-freedom-on-demand-pilot-leveraging-existing-contracts-for-on-demand-paratransit/
- Online Booking Tool for Paratransit in Las Vegas, NV
  - https://learn.sharedusemobilitycenter.org/overview/transportation-agency-launches-online-booking-tool-for-paratransit-las-vegas-nv-2021/
- Paratransit Mobility on Demand Demonstration in Pinellas County, FL
  - https://learn.sharedusemobilitycenter.org/overview/paratransit-mobility-on-demand-demonstration-pinellas-county-florida-2017/

On-demand transit

- On-Demand Transit Pilot in Johnson County, KS
  - https://n-catt.org/resources/emerging-transit-tech-connecting-low-density-regions-through-microtransit/
- On-Demand Transit Pilot in Traverse City, MI
  - https://learn.sharedusemobilitycenter.org/casestudy/modernizing-mobility-on-demand-at-bata-traverse-city-mi/
- On-Demand Transit Program Expansion in Dallas, TX
  - https://learn.sharedusemobilitycenter.org/overview/dart-microtransit-program-pilots-service-in-new-area-dallas-tx-2021/
- Rural On-Demand Transit Pilot in Gloucester and Wise Counties, VA
  - https://learn.sharedusemobilitycenter.org/overview/rural-virginia-transit-agencies-pilot-microtransit-services-gloucester-and-wise-counties-va-2021/

2.4 Highlighted Projects

In addition to being included in the table, a few projects are highlighted to call out specific details.

2.4.1 Intermodal trip planner in Northwest Oregon

Place and purpose

This project, based in Northwest Oregon, includes cities along the coast of Oregon as well as the Portland metro area, Corvallis, Albany, and Salem. More details are shown on the map (Figure 14). The project is led by the NW Connector, a coordinated regional transit system, including five transit agencies in Northwest Oregon: Columbia County

Rider, Sunset Empire Transportation District, Tillamook County Transportation District, Benton County Transit, and Lincoln County Transit. The partnership aims to "improve transit connections between northwestern Oregon communities, brand and market the NW Connector transit service in all five counties, build community partnerships to increase transit ridership while promoting regional business and economic development opportunities, and implement sustainable funding strategies for continued transit system development."[32]

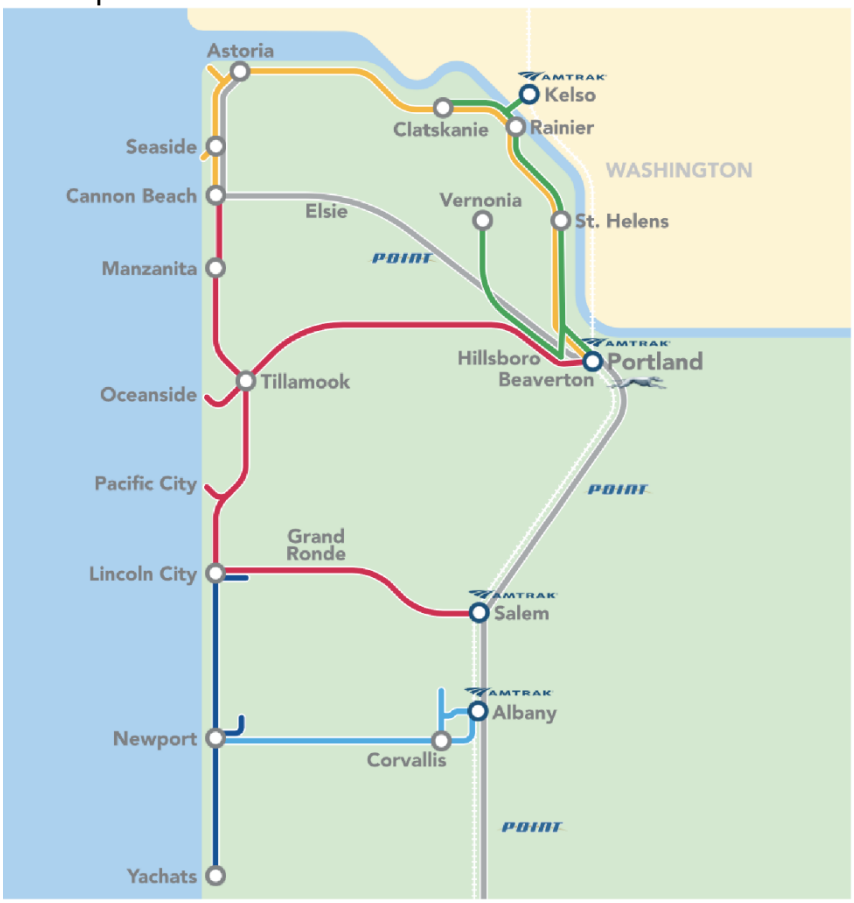


Image Source: NWConnector Website, https://www.nworegontransit.org

Figure 14

One project this partnership has implemented is the intermodal trip planner, which integrates both fixed-route transit, through GTFS data feeds, and demand-response transit (DRT), through GTFS-flex data feeds, into a single interface (Figure 15).[33]

[32] https://www.nworegontransit.org/nw-connector/
[33] https://www.nworegontransit.org/trip-planner/

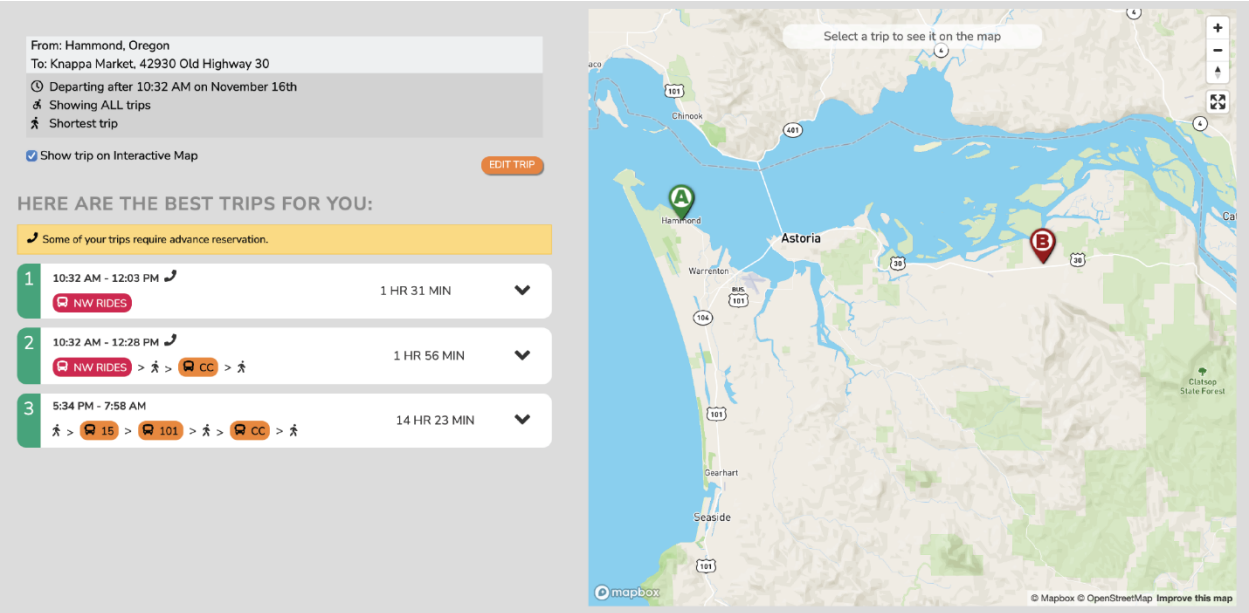


Image Source: NWConnector Trip Planner, https://www.nworegontransit.org/trip-planner/

Figure 15

One example of local DRT service is NW Rides, provided by Tillamook County Transportation District (TCTD).[34] As shown in Figure 16, more information is provided for this DRT trip, "NW Rides is reserved for people who qualify for Medicaid insurance benefits and need transportation to and from their Oregon Health Authority (OHA) covered medical appointments. Call 503-861-0657 or 888-793-0439 at least 2 hours ahead of your desired trip to request a ride or to determine eligibility." This particular option was displayed because the following checkboxes were selected, "include trips requiring reservations" and "include trips with eligibility requirements." Other DRT services, such as TCTD's Dial-A-Ride for the general public, do not have eligibility requirements but recommend advance reservations.[35] As mentioned in the transcript for a GTFS-flex webinar provided by N-CATT, the NW Connector trip planning software is based on the Open Trip Planner.[36]

[34] https://www.nworegontransit.org/nw-rides/
[35] https://www.nworegontransit.org/dial-a-ride-tctd/
[36] https://n-catt.org/resources/webinar-gtfs-flex/

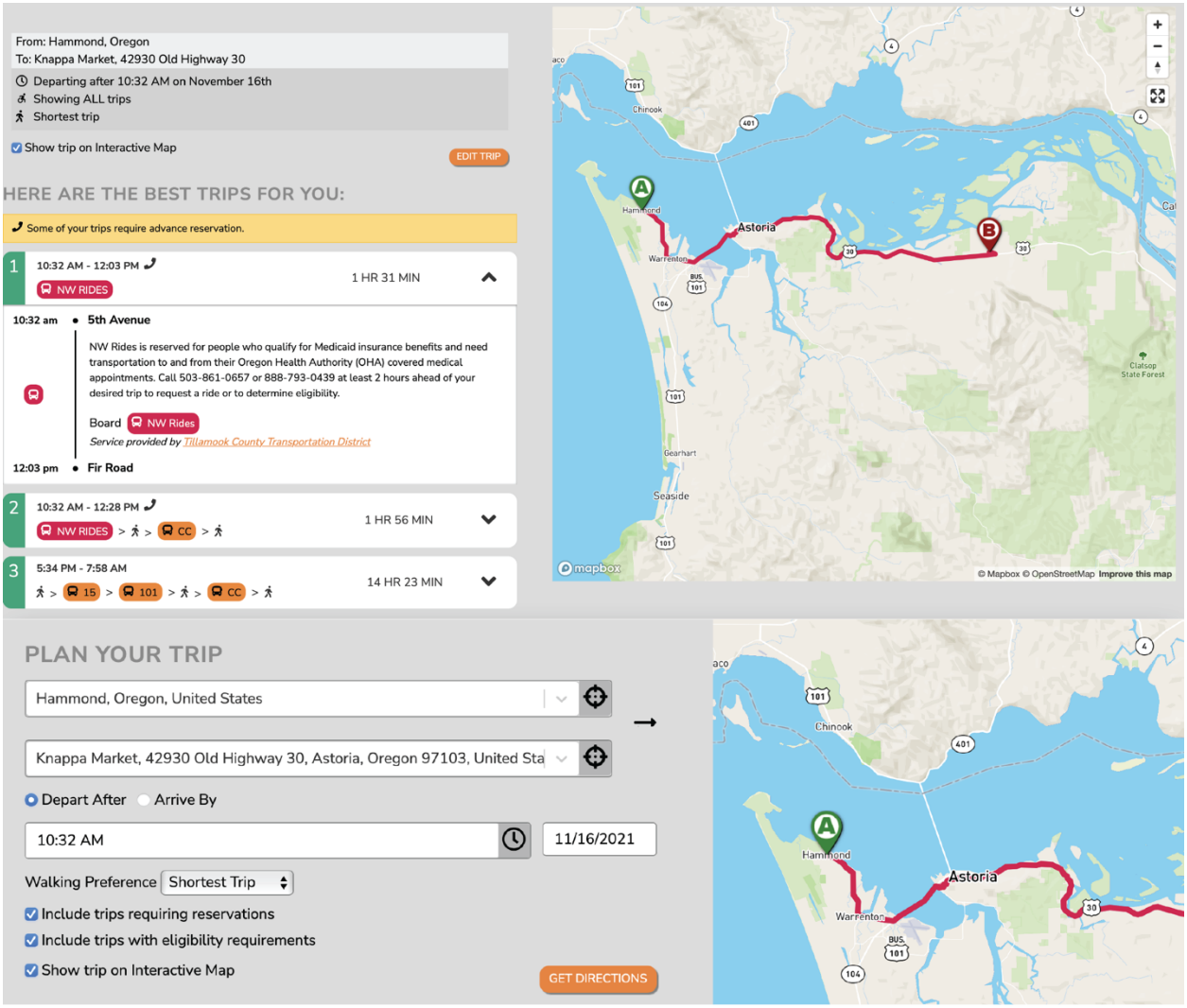


Image Source: NWConnector Trip Planner, https://www.nworegontransit.org/trip-planner/

Figure 16

Trips are possible between the Portland metro area and the coast via fixed route options, such as the trip shown in Figure 17. An interactive map is included with the trip planner to let the user know what services are available.[37] On the interactive map, a "trip ideas" feature is included that highlights points of interest for the user such as wildlife refuges, parks, trails, and other places. On the "data and apps" page, it is mentioned that in addition to making all the data available to the public, the data have also been included in other trip planning platforms apps as Google Transit and Transit.[38]

[37] https://www.nworegontransit.org/interactive-map/
[38] https://www.nworegontransit.org/data-and-apps/

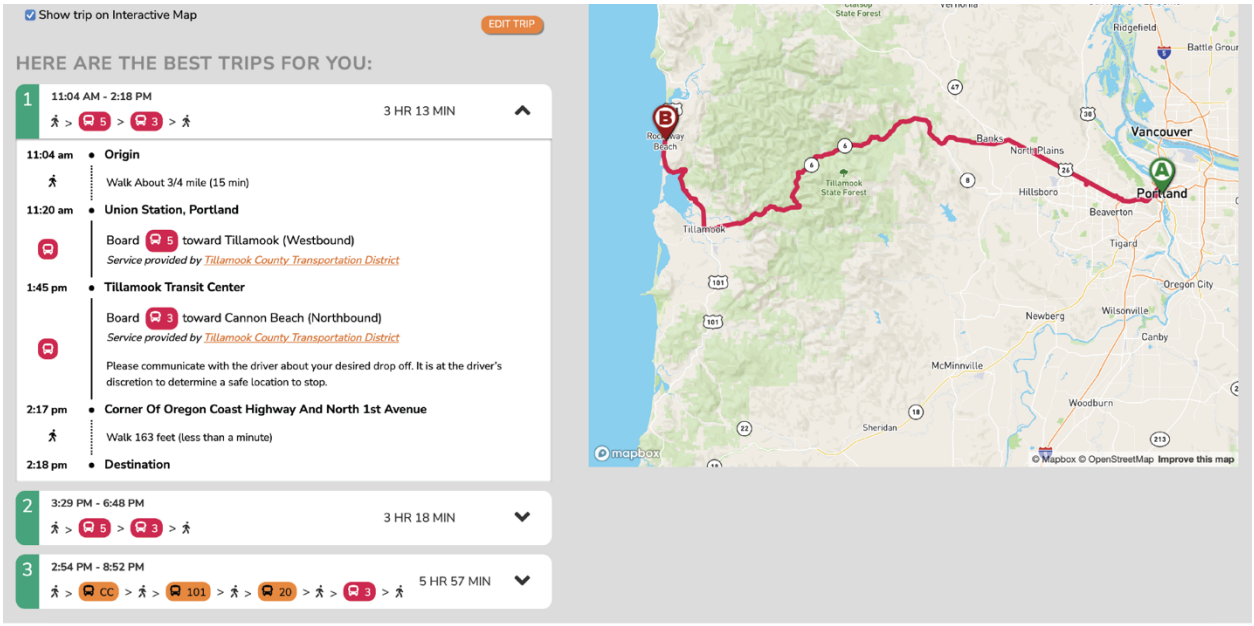


Image Source: NWConnector Trip Planner, https://www.nworegontransit.org/trip-planner/

Figure 17

Process and people

By forming an alliance, these five transit agencies have laid the groundwork for the kind of coordination needed to make their collective services most helpful to users. The group meets monthly to make decisions on route coordination, schedules, operations, and other regional needs. Visitor passes for three or seven days are available across all five agencies and have been designed especially for residents of the more urban areas such as Portland and Corvallis to travel to the coast.[39] The alliance also has a joint policy on bicycle storage.[40] As shown in Figure 18, the bus stops have been equipped with the NW Connector brand, so that the system has a unified appearance even though there are five agencies providing the service. Agreeing on policies for joint fare payment, bicycle storage, and unified branding shows this partnership has an advanced level of governance in place.

[39] https://www.nworegontransit.org/passes/
[40] https://www.nworegontransit.org/bicycle-policy/

Image Source: NWConnector Website, https://www.nworegontransit.org/how-to-ride/

Figure 18

How this project could improve the complete trip

- Based on the project documentation, it appears that as a result of the interactive trip planning project**, transit users are more aware of the complete list of their transit options** in Northwest Oregon. By including transit options that require the "include trips with eligibility requirements" and/or "include trips requiring reservations" items to be checked, the project team has designed a **more inclusive trip planner that reflects a wider diversity of transit options** than is typically shown in a trip planner. By widening the scope of the options shown, users can better compare their personal requirements with their travel options and **arrive at a more optimal solution** that works for them.
- The Complete Trip components that were involved include:
    - **Travel modes** such as fixed-route transit, on-demand transit, and Americans with Disabilities Act (ADA) paratransit/human-services transportation.
    - **Technology infrastructure** in the form of the interactive trip planner, a digital tool that ingests and displays GTFS and GTFS-flex data under the NW Connector brand. This tool communicates information about service areas, transit routes, and bus stop locations—elements of the physical and service infrastructure of the transit agencies—without fundamentally changing these elements on-the-ground.
    - **Physical infrastructure** in the form of bus stops that have been equipped with the NW Connector brand. This reinforces that physical and digital

experiences should have a similar feel. Once someone has used the trip planner with the NW Connector brand and then goes to a bus stop with the NW Connector brand, even though there may be multiple transit agencies providing the trip, the fact that the branding is consistent from the digital to the physical realm reinforces the feeling of a unified effort. It also reduces confusion for the transit user.
    - **Governance infrastructure and collaboration** in the form of data/trip planner maintenance, unified branding, joint fare policies, and joint bicycle storage policies. Trip planners, once created, take significant work to keep up and running. The data sets must be updated and the trip planning platform must also be maintained, both of which require some sort of joint oversight when five agencies are involved—as is the case with this project. The same is true of unified branding across multiple agencies; some governance is required to set the standards and agree upon the look and feel of the branding products. The joint fare policies and joint bicycle storage policies help reduce confusion for the user; regardless of the agency they use, their bike will be treated the same. They also know if they purchase a joint transit pass from one agency, it will be accepted by the other. Unified efforts such as these require a great deal of behind-the-scenes work to present a public face.
- The end-to-end **journey segment impacted** by the intermodal trip planner is the segment between the *evaluate options* and *select option* milestones.

2.4.2 Bus stop accessibility map in Northwest Indiana

Place and purpose

In May of 2021, the Northwestern Indiana Regional Planning Commission (NIRPC) launched an interactive online transit map, called the Northwest Indiana ADA Transit Map,[41] to assist transit customers in northwestern Indiana with making decisions regarding which bus stop to use. This map supplements the trip planning process a customer with a disability would perform. As a first step, the customer would search for a trip as shown in Figure 19 since the region's transit data are included in Google Maps in the GTFS format.

[41] https://nirpc.org/northwest-indiana-ada-transit-map/

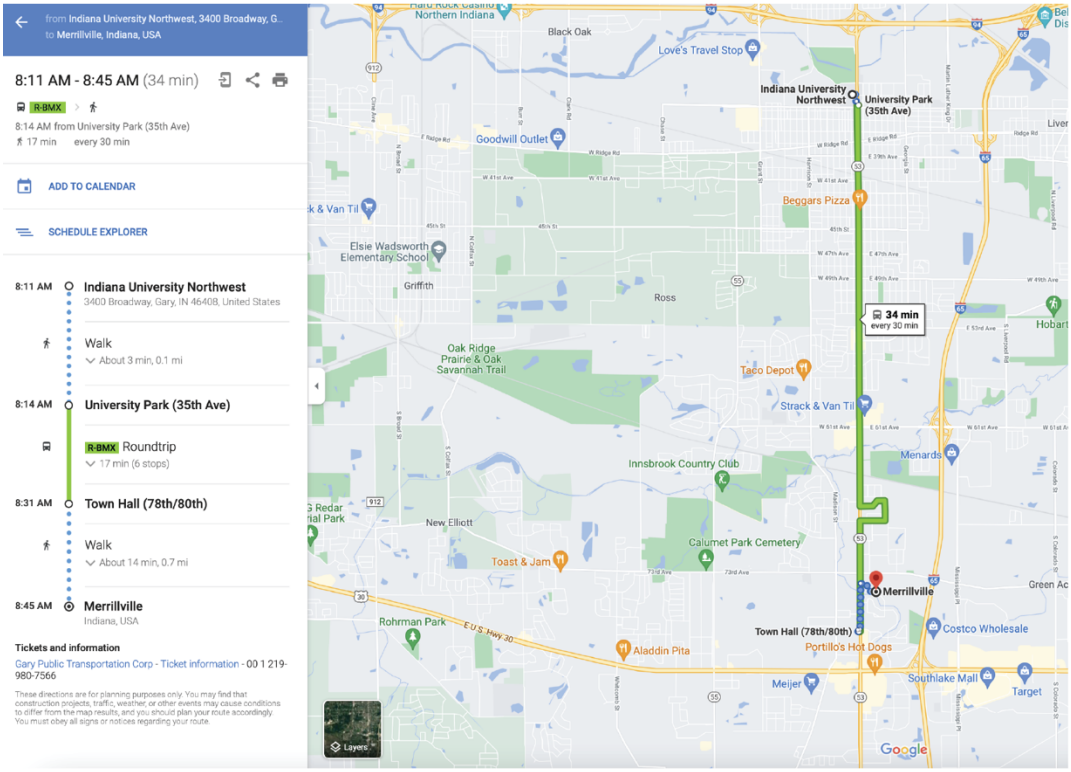


Image Source: Google Transit, https://www.google.com/maps

Figure 19

Once the bus stop that might be used is known, as a second step, the customer can review the details of that particular bus stop to assess if they would be able to navigate it safely and comfortably. Tools such as this help reduce the uncertainty that many people with disabilities encounter daily. By knowing what to expect, such customers can make decisions in advance during the trip planning process that better meet their needs. For this example, bus stop GPTC027B is being considered. As shown in Figures 20 and 21, the customer can view the details of the stop and two pictures taken on-site. When compared with the Google Maps streetview image that is available (Figure 22), the NIRPC image is a significant improvement.

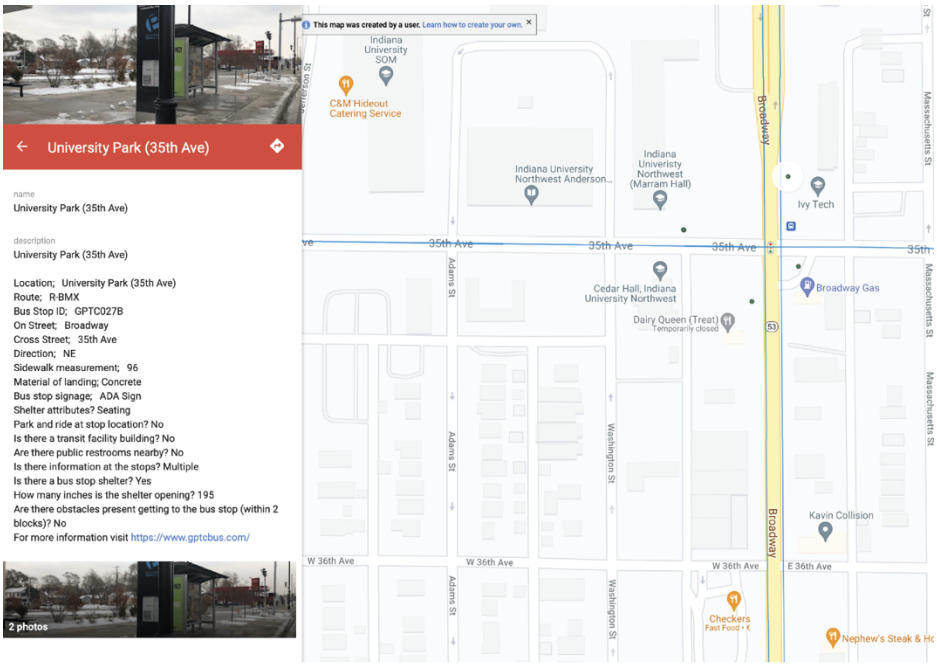


Image Source: NIRPC, https://nirpc.org/northwest-indiana-ada-transit-map/

Figure 20

Image Source: NIRPC, https://nirpc.org/northwest-indiana-ada-transit-map/

Figure 21

Image Source: Google Street View, https://www.google.com/maps

Figure 22

Trip planning can also work in the other direction with this bus stop accessibility map. As a first step, a customer can locate a stop on the interactive map and then, as a second step, plan a route that starts or ends with the stop in Google Maps. After locating the arrow on the red banner beneath the photo, the user can click on it. This opens another Google Maps tab which puts the bus stop in the place of the trip destination, which can also be switched to the trip origin.

Process and People

This project represents a major undertaking. As stated in the press release, "NIRPC data analysts Peter Kimball and Kevin Polette traveled to each bus stop in Lake, Porter, and La Porte counties—a total of 561 locations—during 2020 to assess many criteria for the inventory."[42] The map is shown in Figure 23. Each stop has the following description: location information, physical characteristics, and amenity information; some stops include pictures of the stop and its immediate surroundings. A link to the transit agency providing the service is shown for each bus stop. N-CATT featured this project in Episode Two of its Season Two podcast.[43]

[42] https://nirpc.org/2021/05/19/nwi-transit-map-ada-access-news/
[43] https://n-catt.org/resources/podcasts-season-2/

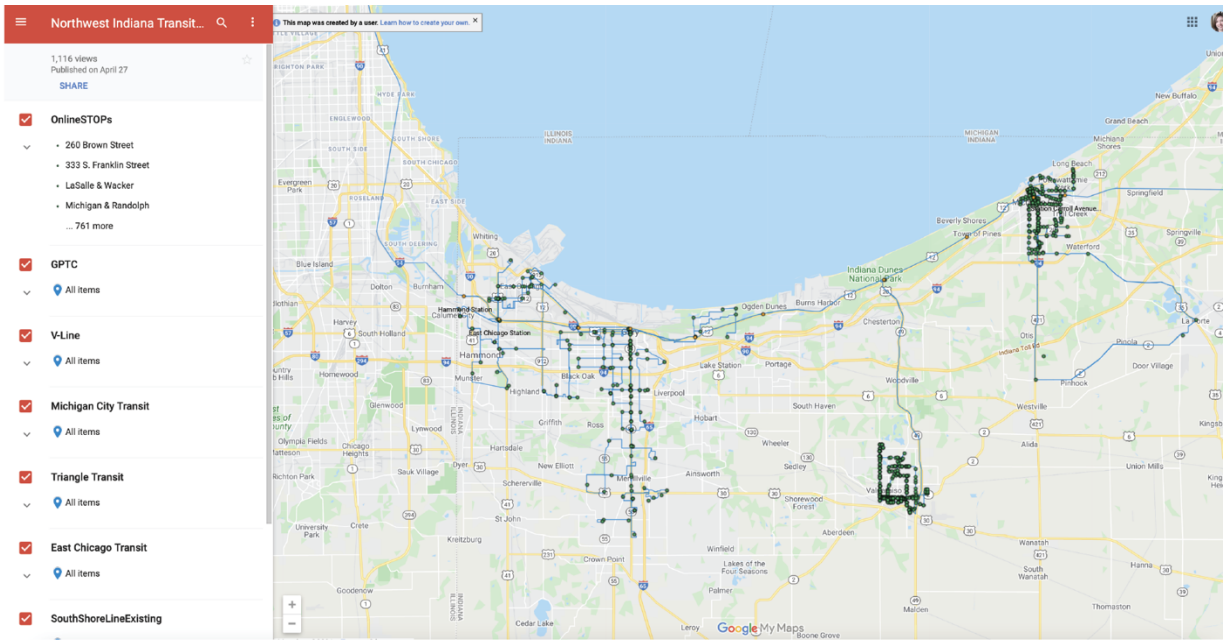


Image Source: NIRPC, https://nirpc.org/northwest-indiana-ada-transit-map/

Figure 23

The bus stops of eight transit operators in the region were included in the project: Gary Public Transportation Corp., East Chicago Public Transit, North Township Dial-a-Ride Opportunity Enterprises, Porter County Aging Community Services, City of Laporte Transit, Michigan City Transit, City of Valparaiso V-Line and Chicago Dash, and Lake County Community Services. Some of the agencies, such as Gary Public Transportation Corp. (GTPC) and East Chicago Public Transit leverage other apps to provide customers with even more trip planning options. On a GTPC webpage announcing Moovit and Token Transit apps, the following is stated regarding Moovit: "multimodal journey planning, coupled with mobile ticketing, will enable riders to easily plan, pay, and ride on Gary Public Transportation Corporation, The South Shore Line, East Chicago Transit, Chicago-area transit and beyond."[44]

How this project could improve the Complete Trip

- Based on the project documentation, it appears that as a result of the bus stop accessibility map project, **transit users with disabilities** will have significantly improved trip planning information in Northwest Indiana. By considering the types of bus stop information an individual with a disability might need to assess if a bus stop meets their **personal requirements**, NIRPC has enabled transit users with disabilities to make much **more informed decisions** regarding their transit trips—possibly shedding light on bus stops that offer **greater levels of safety and comfort** which could increase the feasibility of trips.
- The Complete Trip components that were involved include:
    - **Travel modes** such as walking and fixed-route transit.

[44] https://www.gptcbus.com/token-transit-and-moovit/

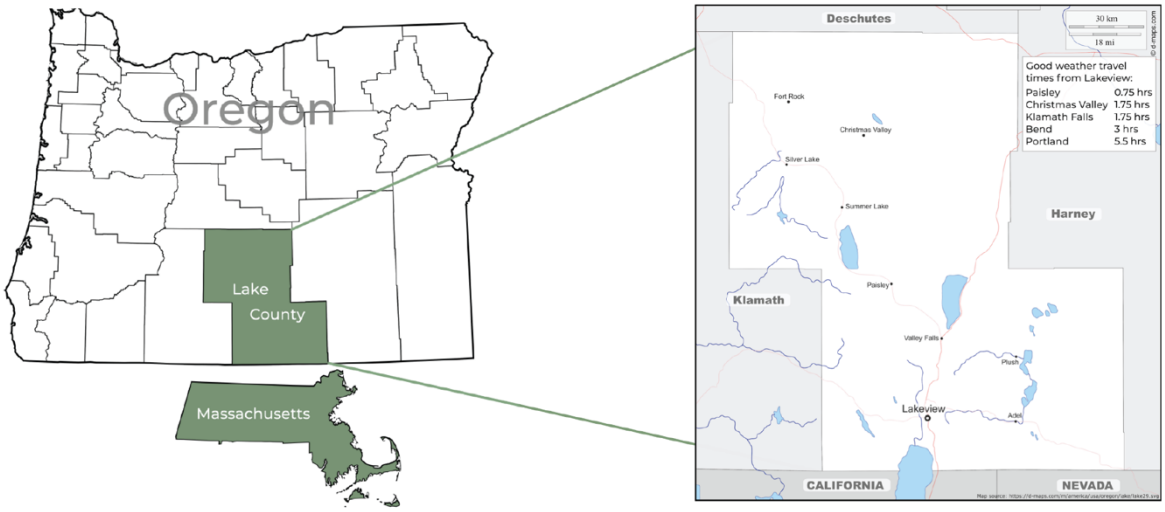
    - **Collaboration** in the form of digital tool maintenance. Since the bus stops of eight transit operators in the region were included, NIRPC would likely need to work collaboratively with the transit agencies to maintain this tool—updating it as conditions on-the-ground at the bus stops change. The joint work to keep such a tool updated would generally involve some level of oversight.
    - **Technology infrastructure** in the form of the bus stop accessibility map, a digital tool that displays details about bus stops for transit users with disabilities during the trip planning process. This tool communicates about bus stops—an element of the physical infrastructure of the transit agencies—without changing the actual physical infrastructure.
- The end-to-end **journey segment primarily impacted** is the segment between the *evaluate options* and *select option* milestones. If the tool were applied further once the user departed from their origin during transit trips, then it could also impact the segments between the *depart from origin* and *enter vehicle* milestones as well as *exit vehicle* and *arrive at destination* milestones.

2.4.3 Rural transit coordination in Lake County, Oregon

Place and Purpose

Lake County, located in the southcentral area of Oregon is classified as a "frontier" area, which is the most rural in the classification system for the United States; the rural categories include "rural," "highly rural," and "frontier."[45] With a population of approximately 7,895 and a land area slightly larger than the state of Massachusetts as shown in Figure 24, the population density is extremely low.

[45] https://www.ruralhealthinfo.org/topics/frontier#definition



Lake County, Oregon is slightly larger in land area than the state of Massachusetts.

Map of Lake County, Oregon, along with typical travel times between selected towns.

Image Source: AARP Report on RideSheet, https://www.aarp.org/ppi/info-2021/ridesheet-rural-transportation-benefits-new-coordination-technology.html

Figure 24

In Lake County, there are very few mobility options outside of driving one's own vehicle. There are no taxi companies or TNCs in operation, and in terms of public transit, there are two providers—both of them non-profit organizations providing demand-response transit (DRT). These two organizations, Inner Court Family Center (ICFC) and Lake County Senior Center Association (LCSCA), embarked on the "RideSheet" rural transit coordination project to enable one organization to quickly check with the other one when there was difficulty providing a ride—essentially coordinating their services for the benefit of customers. Since they are the only two transit providers in the county and their service areas overlap, they have many of the same customers in common.

This project does not involve an explicit trip planning component. Since local residents have such limited options in Lake County; transit customers likely move straight into trip booking with the organization that has a service area most closely aligned with their trip needs. This project helps significantly with the trip booking process for these customers. Instead of the customer being denied a trip with one provider and then contacting the other provider to find out if they can handle the ride instead, the providers coordinate this activity among themselves—providing a much more customer-friendly service. As explained by the National Aging and Disability Transportation Center,[46] "…while the mechanics of the software happen behind the scenes, riders benefit directly. Riders gain more opportunities to travel as regional providers come to rely on one another when their own vehicle and driver capacity is constrained. Tapping this capacity won't require any additional phone calls or website logins on the part of the rider. They simply

[46] https://www.nadtc.org/news/blog/ridesheet-a-transportation-technology-solution-for-rural-america/

make their request for a ride through their preferred provider and the system is set up to serve them. Ultimately, the rider could end up paying less for a ride if the system finds enough riders to share a given trip."

The primary purpose of the project for the transit service providers, ICFC and LCSCA, was to achieve greater operational efficiency. Prior to the RideSheet project, the agencies coordinated trips through emails and phone calls, and scheduled the routes by hand. After the RideSheet project, the agencies coordinate trips and schedule the routes through the new software—which should save significant time after staff members become accustomed to the new way of working. The primary purpose of the project for transit customers is to simplify the trip booking process; they can contact one provider to access the resources of both transit providers.

Process and People

ICFC and LCSCA had been coordinating with each other prior to the RideSheet project, but their coordination processes were mainly paper and phone based. The RideSheet project enabled the organizations to try out a more automated way of coordinating trips—for both scheduling the trips across the two providers and generating demand-response routes—by using applicable software. Figure 25 illustrates how the joint scheduling process works across the two providers.

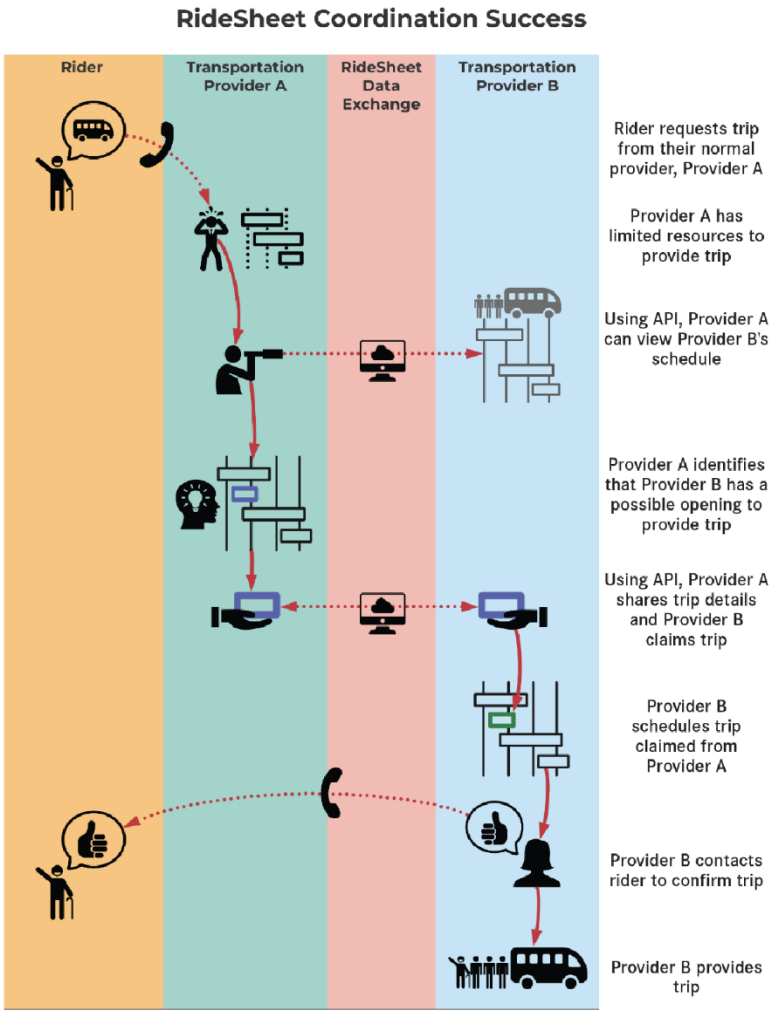


Image Source: AARP Report on RideSheet, https://www.aarp.org/ppi/info-2021/ridesheet-rural-transportation-benefits-new-coordination-technology.html

Figure 25

Other project innovations include leveraging the "transactional data specification," assistance with trip data tracking, and generating the routes for vehicles to take. As explained in the AARP RideSheet project brief,[47] "RideSheet was programmed to use the transactional data specification (TDS) as defined by Transit Cooperative Research Program's (TCRP) Report 210, *Development of Transactional Data Specifications for Demand-Responsive Transportation*.[48] By making sure that RideSheet follows the structure established in the TDS, the project follows a best practice for data management." RideSheet also automates the process of tracking the various details of trips taken; these data are required for reporting processes and are shared with funding

[47] https://www.aarp.org/ppi/info-2021/ridesheet-rural-transportation-benefits-new-coordination-technology.html
[48] https://www.trb.org/Main/Blurbs/180593.aspx

organizations. In addition to enabling the sharing of route details between the transit providers, so they can see if there is capacity to add additional passengers, the software also generates the routes for vehicles to take, referred to in the project brief as a "run."

AARP funded this effort in 2020 and enlisted consulting support to create the custom software. The software consulting team, Full Path LLC, worked with ICFC and LCSCA, as well as Lake County, during 2020 to understand their processes and the results they required. Full Path LLC sought to provide a "lightweight" software solution that did not require staff to spend too much time learning a complex product.

The open-source software was made available in early 2021 and is free to use for other transportation providers with similar needs. Although the software is custom, it was designed with the needs of similar agencies in mind. AARP is interested in both the TDS and RideSheet being more widely used.

How this project could improve the complete trip

- By working **directly with the transit service providers**, Inner Court Family Center (ICFC) and Lake County Senior Center Association (LCSCA), the project team was able to gain valuable information about how the software could improve the joint operations of these organizations while also simplifying the trip booking process for the customers.
- Based on the project documentation, it appears that **operational efficiency and the customer trip booking process** should have improved as a result of the project.
- The Complete Trip components that were involved include:
    - **Travel modes** such as demand-response transit (DRT).
    - **Collaboration** between AARP, Full Path LLC, ICFC, LCSCA, and Lake County—foundational for the research and implementation of this project. Even if there is no formal written document about how they should work together, by taking part in this project and using the software day-to-day, ICFC and LCSCA have committed to significant coordination between their two operations.
    - **Technology infrastructure** in the form of the RideSheet software, a digital tool that helps providers of rural transit coordinate their services. This tool communicates about the service infrastructure—the planned routes and trips requested—without fundamentally changing them.
- The end-to-end **journey segments impacted** are those between *select option* and *exit vehicle* + *arrive at destination milestones* for DRT.

2.3.4 On-demand transit in Tompkins County, New York

Place and purpose

Tompkins County in New York state is served by Tompkins Consolidated Area Transit (TCAT). In the center of Tompkins County is Ithaca, which includes Cornell University

and Ithaca College. Outside of Ithaca, which has a population of around 30,000,[49] Tompkins County is less densely populated and is characterized by areas that are more rural.

As explained in Section 2.2.3, advances in technology have made on-demand transit service a modal option for transit agencies. TCAT realized that fixed-route transit service may not be financially viable for parts of the county with sparser population patterns. Beginning in 2020, TCAT began providing an on-demand transit service for Lansing and Etna and then in 2021, expanded the on-demand service area to Freeville and Dryden. These areas, Lansing, Etna, Freeville, and Dryden, were previously underserved with public transit options. TCAT considered on-demand transit a cost-effective way to expand the reach of the services the agency provides the county. In addition to helping the residents of Lansing, Etna, Freeville, and Dryden travel around the area, it also helps these residents reach the densest part of Tompkins County—Ithaca and its immediate surroundings.

Leveraging on-demand transit to provide entirely new transit service to previously underserved areas is one potential purpose for on-demand transit. For the sake of comparison, there are agencies who leverage on-demand transit to bring existing demand-response service into a new era of technology—moving from a typical requirement of day-prior booking to accepting more immediate trip requests such as 30 minutes prior to taking the trip. By moving forward with the newer technology, it is possible to serve the same service area in a manner that is more convenient for customers—which may enable more trips to be taken by expanding the possibilities into more spontaneous travel. One example of an agency who pursued on-demand transit for this reason is Traverse City, Michigan.[50] They moved from an existing "dial-a-ride" demand-response service to on-demand service in 2020. In less common cases, transit agencies have shifted their fixed-route transit service to on-demand service. This is the case in Hall Area Transit Services in Hall County, Georgia with its WeGo service.[51]

Trip planning, trip booking, and sometimes trip payment for on-demand transit is typically handled entirely through an app dedicated to the on-demand service, as explained in Section 2.2.3. Considering the state of the practice for multi-modal trip planners, it is uncommon to find on-demand transit as an option in such apps. Take, for example, Tompkins County. A TCAT webpage lists a few trip planning apps including Moovit, Transit, and Google Maps.[52] One trip planner featured on TCAT's website, embedded within a dedicated trip planning page, is Moovit.[53] When a trip is planned within the Freeville and Dryden service area, which TCAT serves with on-demand transit, only fixed-route bus options come up as shown in Figure 26. This seems to imply that on-demand options are not included within the trip planner. Generally, such

[49] https://www.census.gov/quickfacts/fact/table/ithacacitynewyork/PST040219
[50] https://learn.sharedusemobilitycenter.org/casestudy/modernizing-mobility-on-demand-at-bata-traverse-city-mi/
[51] https://n-catt.org/resources/microtransit-when-and-where-it-makes-sense/, https://www.gainesville.org/Faq.aspx?QID=62
[52] https://tcatbus.com/ride/apps/
[53] https://tcatbus.com/ride/moovit-trip-planner/

options are not intentionally excluded; more commonly the software does not enable the data for such options (such as GTFS-flex) to be added, and therefore, they are not displayed. Section 2.4.1 of the Guidebook, which covers the "intermodal trip planner" project in Northwest Oregon, showcases a trip planner that *does* enable on-demand and demand-response options to be included alongside fixed-route transit options. The Oregon trip planner is based on the Open Trip Planner (OTP) open source software, which includes demand-response as well as many other trip options, explained further in Section 2.2.2.

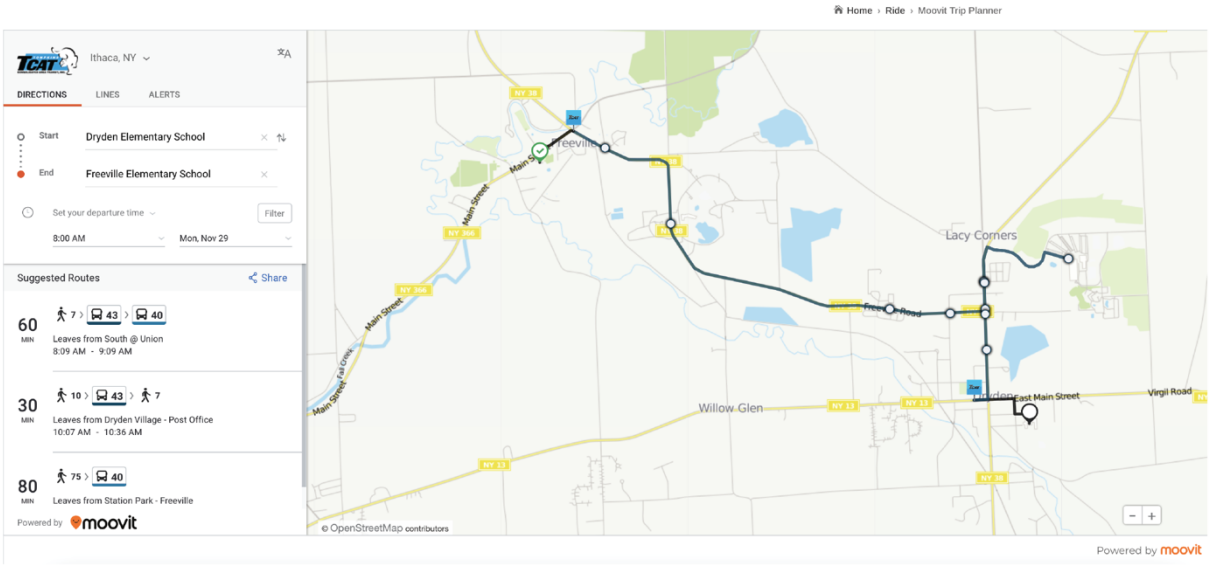


Image Source: TCAT Trip Planner, https://tcatbus.com/ride/moovit-trip-planner/

Figure 26

Process and People

TCAT's on-demand service, called Tconnect, includes two separate service areas that do not connect with each other directly; one includes Lansing and Etna and operates on the weekends,[54] while the other includes Freeville and Dryden and operates on weekdays.[55] Transfers from Tconnect to TCAT's fixed-route service are free. The Lansing-Etna service connects to TCAT's Route 30, and the Freeville-Dryden service connects to TCAT's Route 43—both routes providing service to/from downtown Ithaca and Cornell. In establishing this service, TCAT explains their intent is to "target geographic areas with so-called 'transit deserts,' or low-density residential pockets that don't have enough demand to cover the high cost of fixed-route transit, but yet enough population to merit a less-costly on-demand service. These types of services can be life changing, especially for low-income households that struggle to find transportation to work and to obtain basic services."[56] TCAT explains that an important aspect of Tconnect is the "use of smaller buses, which are far less costly to operate than the typical 40-foot, large-capacity bus typically needed for fixed-route service. The Tconnect

[54] https://tcatbus.com/wp-content/uploads/77.pdf
[55] https://tcatbus.com/wp-content/uploads/Tconnect-Dryden-FREEVILLE_map-image-scaled.jpg
[56] https://tcatbus.com/tconnect-app-based-on-demand-service-extends-to-dryden-8-9-21/

service in the Lansing-Etna area is being operated by TCAT drivers using TCAT's small cutaway 30-foot, 29-passenger buses. The Dryden service will use Gadabout drivers and Gadabout's 18-foot, 10-passenger buses. In addition to being less expensive to operate, smaller buses are easier for drivers to maneuver on rural roads."[57]

Customers use the HyperCommute app, provided by Urban Mobility Inc., to plan and book Tconnect trips.[58] As an alternative, customers can also book trips over the phone. TCAT explains this option, "We recognize that some would-be riders do not have access to a mobile device, or choose not to have a data plan and we are more than happy to accommodate anyone in those situations."[59] In addition, TCAT provides guidance to customers who would like to use the app, but do not know how. "For those who would like app training and/or additional information, Tconnect team members will be conducting outreach and welcome would-be riders to contact them for app training or to answer any questions about the service. To request assistance or a meeting, email team members..." [60] This is a best practice in providing on-demand services; there is often a gap that can be bridged by teaching customers who are less accustomed to apps of this type on how to use the app in a group-based or one-on-one setting. TCAT has also provided an online video on how to use the app,[61] also a best practice.

Tconnect is a joint effort with multiple funding sources. As explained in the SUMC article, "Tconnect Microtransit Service Expands to Dryden, NY 2021," TCAT "developed Tconnect in partnership with Way2Go, a program under the Cornell Cooperative Extension of Tompkins County, and is financially supported by grants from the New York State Energy Research and Development Authority (NYSERDA) and the Federal Transit Administration's Integrated Mobility Innovation program."[62] With two years of funding that should run through 2023, the project team has set up an ideal situation that allows for a few years of operating the service with the potential to scale up operations.

How this project could improve the Complete Trip

- Based on the project documentation, it appears that **transit options for customers previously living in so-called "transit deserts" have been expanded** as a result of the project. By considering the personal requirements of customers living in low-density areas, TCAT seeks to address the gaps in transit service that these customers experience.
- The Complete Trip components that were involved include:
    - **Travel modes** such as on-demand transit.
    - **Collaboration** between TCAT and the Cornell Cooperative Extension of Tompkins County, which contributed to the project.
    - **Service infrastructure** in the form of a new on-demand service called Tconnect.

[57] https://tcatbus.com/tconnect-app-based-on-demand-service-extends-to-dryden-8-9-21/
[58] https://play.google.com/store/apps/details?id=com.rider.hypercommute
[59] https://tcatbus.com/tconnect/
[60] https://tcatbus.com/tconnect/
[61] https://www.youtube.com/watch?v=CjK3fUxsDqM
[62] https://learn.sharedusemobilitycenter.org/overview/tconnect-microtransit-service-expands-to-new-area-dryden-ny-2021/

    - **Technology infrastructure** in the form of the HyperCommute app and accompanying software that assists TCAT in generating dynamic on-demand routes. The HyperCommute app and TCAT's website communicate about the service infrastructure including the on-demand service areas and service details.
- The end-to-end **journey segments impacted** are those between *select option and exit vehicle* + *arrive at destination* milestones for on-demand transit.

2.5 Transit Agency Initiatives

A few transit agency initiatives are explained to illustrate additional ways to support complete trip efforts.

2.5.1 Practices for using multiple tools together

As the project table in Section 2.3 of the Guidebook illustrates, some modes such as fixed-route transit benefit from leveraging multiple digital tools together to support various needs across the end-to-end journey. As explained in N-CATT's *Guidebook on New Software Adoption for Small Transit Agencies,*[63] "Whether an agency is acquiring multiple types of software to meet its needs or is adding a new type of software to its current software ecosystem, it is essential that it determine how much connectivity between the software applications will be needed. If the different software applications need to exchange data with one another, then the software must be 'interoperable.' When interoperability is necessary, the agency must ensure that its software acquisition process makes this a high priority in terms of the scope of the acceptable software solutions." Chapter 1 and Chapter 3 of the *Guidebook on New Software Adoption* go into detail about why interoperability is needed and ways to go about considering interoperability during decision-making for digital tools.

Using multiple tools together does not necessarily require a significant amount of interoperability. As an example, the transit agency for the greater Oklahoma City area, EMBARK, has an app center with a wide range of digital tools that have been made available to its customers.[64] The apps, all commercial off-the-shelf platforms, likely do not interoperate among each other. Instead, standardized data has been made available to populate each app, essentially allowing each app to stand alone. The EMBARK customer would typically select a few apps they find useful and then use them together throughout their end-to-end journey to support various functions with EMBARK. Each app pertains to journey segments in the project table in Section 2.3 of the Guidebook:

- Google Maps – Trip Planning, Trip Navigation (wayfinding from origin to stop and from stop to destination)
- Moovit – Trip Planning, Trip Navigation (real time vehicle updates), Trip Navigation (wayfinding from origin to stop and from stop to destination), Trip Payment (in some cases)

[63] https://n-catt.org/resources/new-software-adoption-for-small-transit-agencies/
[64] https://embarkok.com/apps

- Transit App – Trip Planning, Trip Navigation (real time vehicle updates), Trip Navigation (wayfinding from origin to stop and from stop to destination), Trip Payment (in some cases)
- Token Transit – Trip Payment

2.5.2 Innovative procurement processes

The process of procuring digital tools for the Complete Trip can be challenging. In the case of Bangor, Maine, as a part of N-CATT's 2021 Innovative Technology Strike Team effort,[65] the project team agreed upon certain customer needs that should be addressed through digital tools. Once the key outcomes were clear, they went about designing a dynamic procurement process that could deliver on the project requirements through a range of methods—a single platform or multiple interoperable platforms. Due to cost considerations, the project team preferred a commercial off-the-shelf (COTS) platform, as opposed to a custom software, but they encouraged respondents to consider making alterations to their COTS platforms—to meet the basic project requirements as well as the interoperability requirements. Respondents were also encouraged to form teams that comprised multiple COTS products in the proposal. For more information on procurement processes, see N-CATT's "Procurement Playbook."[66]

2.5.3 Embarking on GTFS data creation and maintenance

As explained in Section 2.2.1, there are various types of GTFS data and extensions such as GTFS, GTFS-RT, GTFS-flex, and others. Depending on the specific needs of a particular digital tool project, one or more types of GTFS data may be needed. In general, there are two options to consider to generate GTFS data and update it on a regular basis:

1. Leverage in-house skills
2. Leverage consulting support

Leveraging in-house skills for GTFS data would involve a staff member creating and maintaining GTFS feeds; this staff member would typically be part of the project team. In some areas of the US, organizations that support multiple transit agencies, such as a state Department of Transportation or a regional organization, lead GTFS creation and maintenance efforts.

Regarding the information presented below, references were found through online research and are provided for informational purposes only; they are not endorsed by N-CATT or the author of the Guidebook.

To leverage in-house skills, using Mobility Data's "getting started"[67] and Google's "how do I start?"[68] with GTFS "static" (i.e., the basic GTFS feed without extensions such as RT and flex) as a knowledge base, the following steps are suggested:

- **Step 1: Basic information**

[65] https://n-catt.org/technology-strike-teams/
[66] https://n-catt.org/resources/technology-procurement-playbook/
[67] https://gtfs.org/getting-started/
[68] https://developers.google.com/transit/gtfs

    - Gain a general understanding of GTFS feeds by reviewing examples of feeds other agencies have created.
    - Mobility Data provides access to examples and an overview of GTFS concepts.[69]
    - An overview provided by Google includes a model feed that can be used to understand all the parts of the feed and how they fit together.[70]
    - Open Mobility Data displays worldwide GTFS feeds.[71]
    - Review Mobility Data's best practice document for general familiarity.[72]
- **Step 2: Feed creation**
    - Create a set of feeds in line with the GTFS static reference document that "defines the format and structure of the files that comprise a GTFS dataset."[73]
- **Step 3: Feed validation**
    - A list of validators to consider using is provided by Mobility Data[74] and Google.[75]
    - The page provided by Mobility Data explains, "Before publishing, GTFS feeds should be validated to catch errors. A number of different validation tools exist. Some tools check individual feeds while others are made to be integrated into software."
- **Step 4: Feed publishing**
    - Mobility Data shares guidance on how to go about publishing the dataset,[76] as does Google.[77]

"Step 2: Feed creation" is the most challenging of all the steps. To move from Step 1 and get ready for Step 2, pursuing some basic training is suggested. Recommended by Mobility Data, the World Bank Open Learning Campus (OLC) offers a self-paced, online course called "Introduction to the General Transit Feed Specification (GTFS) and Informal Transit System Mapping."[78] It includes the following sections:

- What is GTFS? History & File Structure
- What is GTFS? Visualization & Community
- Setting up a GTFS Feed
- Introduction to GitHub & Open Source Tools
- Stories from the Field
- How to Map Transit Data
- How to Collect Data for a City's First Feed
- App Survey

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[69] https://gtfs.org/examples/
[70] https://developers.google.com/transit/gtfs/examples/overview
[71] https://transitfeeds.com
[72] https://gtfs.org/best-practices/
[73] https://gtfs.org/reference/static
[74] https://gtfs.org/testing/
[75] https://developers.google.com/transit/gtfs/guides/tools
[76] https://gtfs.org/best-practices/#dataset-publishing--general-practices
[77] https://support.google.com/transitpartners/answer/1111577
[78] https://olc.worldbank.org/content/introduction-general-transit-feed-specification-gtfs-and-informal-transit-system-mapping

- GTFS-Realtime

As a part of getting ready to create feeds, the staff member leading the effort may want to consider leveraging tools to help with the feed creation—these are commonly referred to as "GTFS editors." This is a challenging part of the process, because there are many options available as the screenshot from StackExchange shows (Figure 27).[79] To mention a few options, the National Rural Transit Assistance Program (RTAP) provides GTFS Builder[80] free of charge, and Trillium provides GTFS Manager[81] for a fee. ESRI supports a Transit Feed (GTFS) toolset,[82] which may be of interest to professionals with an ESRI license or subscription.

[79] https://gis.stackexchange.com/questions/91220/choosing-gtfs-editor-for-creating-and-exporting-routes
[80] https://www.nationalrtap.org/Technology-Tools/GTFS-Builder
[81] https://trilliumtransit.com/gtfs/gtfs-manager/
[82] https://pro.arcgis.com/en/pro-app/latest/tool-reference/conversion/an-overview-of-the-transit-feed-gtfs-toolset.htm

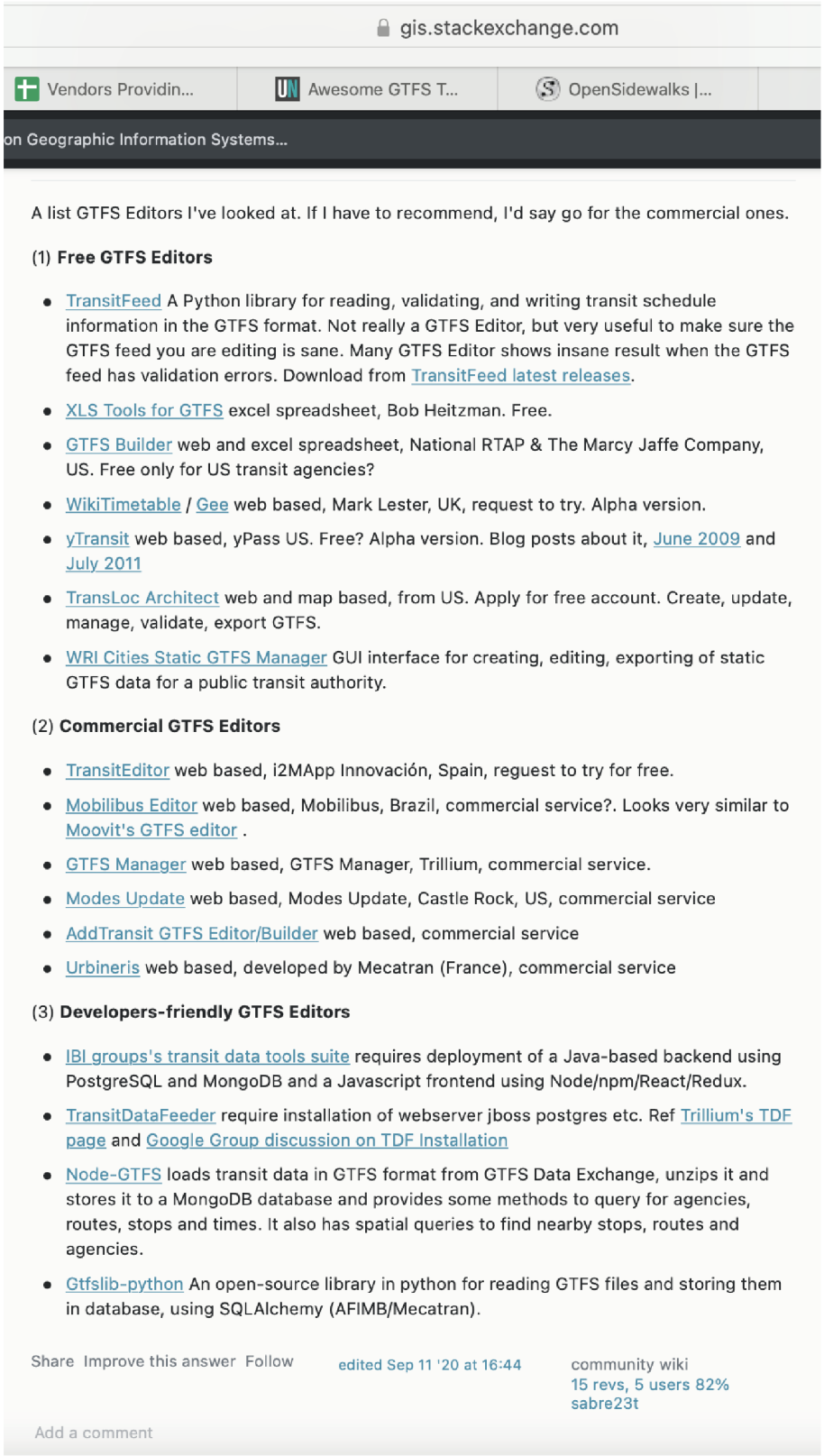


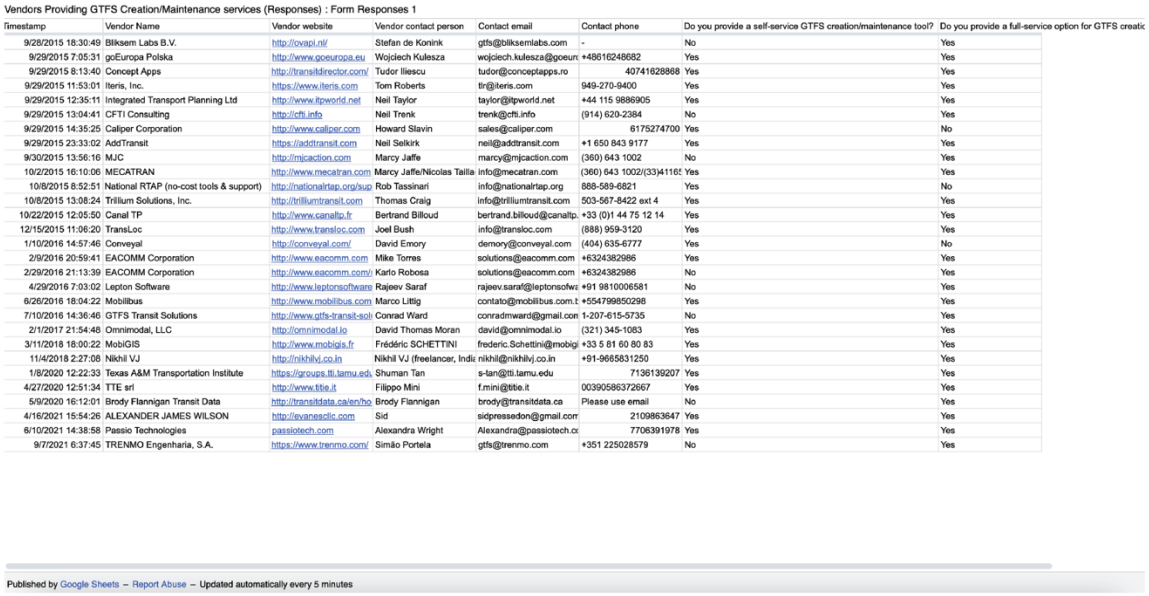
Image Source: GIS StackExchange, https://gis.stackexchange.com/questions/91220/choosing-gtfs-editor-for-creating-and-exporting-routes

Figure 27

Note that for the tools listed, it is possible that they only support GTFS "static"—not the other extensions such as GTFS-RT, GTFS-flex, and others. National RTAP's GTFS Builder references GTFS-flex specifically in its GTFS Builder Guidebook, published in May 2021, "An add-on to GTFS, known as GTFS-Flex is currently in development, and when complete, will accommodate on-demand, dial-a-ride and flex route services. Until GTFS-Flex is fully available, GTFS Builder offers a 'work-around' consistent with current GTFS data guidelines to publish trip information related to on-demand and flex routes. Instructions for the workaround are found in *Section 15*."[83]

Leveraging consulting support involves connecting with companies who provide GTFS creation and maintenance services. The "awesome-transit" list[84] references a "community-maintained list" of "Vendors Providing GTFS Creation/Maintenance Services"[85] (with an option to add new vendors) as shown in Figure 28; the "awesome-transit" list also provides other GTFS items of interest. For smaller agencies, it may be worth checking in with organizations that support multiple transit agencies, such as a state Department of Transportation or a regional organization, to find out if they could hire a GTFS consultant for the entire area. This is the case for VTrans, the Department of Transportation for Vermont; it oversees the GTFS consulting support for the state as well as a state-wide project that utilizes the data—the Go! Vermont trip planner.[86] For organizations starting down the path of GTFS for the first time, it may be worth considering taking a similar approach.

[83] https://irp.cdn-website.com/270961f6/files/uploaded/GTFS_Builder_Guidebook.pdf
[84] https://project-awesome.org/CUTR-at-USF/awesome-transit#
[85] https://docs.google.com/spreadsheets/u/1/d/1Gc9mu4BIYC8ORpv2IbbVnT3q8VQ3xkeY7Hz068vT_GQ/pubhtml
[86] https://govermont.agilemile.com



Vendors Providing GTFS Creation/Maintenance services (Responses) : Form Responses 1

Timestamp	Vendor Name	Vendor website	Vendor contact person	Contact email	Contact phone	Do you provide a self-service GTFS creation/maintenance tool?	Do you provide a full-service option for GTFS creatic
9/28/2015 18:30:49	Bliksem Labs B.V.	http://ovapi.nl/	Stefan de Konink	gtfs@bliksemlabs.com	-	No	Yes
9/29/2015 7:05:31	goEuropa Polska	http://www.goeuropa.eu	Wojciech Kulesza	wojciech.kulesza@goeur	+48616248682	Yes	Yes
9/29/2015 8:13:40	Concept Apps	http://transitdirector.com/	Tudor Iliescu	tudor@conceptapps.ro	40741628868	Yes	Yes
9/29/2015 11:53:01	Iteris, Inc.	https://www.iteris.com	Tom Roberts	tlr@iteris.com	949-270-9400	Yes	Yes
9/29/2015 12:35:11	Integrated Transport Planning Ltd	http://www.itpworld.net	Neil Taylor	taylor@itpworld.net	+44 115 9886905	Yes	Yes
9/29/2015 13:04:41	CFTI Consulting	http://cfti.info	Neil Trenk	trenk@cfti.info	(914) 620-2384	No	Yes
9/29/2015 14:35:25	Caliper Corporation	http://www.caliper.com	Howard Slavin	sales@caliper.com	6175274700	Yes	No
9/29/2015 23:33:02	AddTransit	https://addtransit.com	Neil Selkirk	neil@addtransit.com	+1 650 843 9177	Yes	Yes
9/30/2015 13:56:16	MJC	http://mjcaction.com	Marcy Jaffe	marcy@mjcaction.com	(360) 643 1002	No	Yes
10/2/2015 16:10:06	MECATRAN	http://www.mecatran.com	Marcy Jaffe/Nicolas Taill	info@mecatran.com	(360) 643 1002/(33)41165	Yes	Yes
10/8/2015 8:52:51	National RTAP (no-cost tools & support)	http://nationalrtap.org/sup	Rob Tassinari	info@nationalrtap.org	888-589-6821	Yes	No
10/8/2015 13:08:24	Trillium Solutions, Inc.	http://trilliumtransit.com	Thomas Craig	info@trilliumtransit.com	503-567-8422 ext 4	Yes	Yes
10/22/2015 12:05:50	Canal TP	http://www.canaltp.fr	Bertrand Billoud	bertrand.billoud@canaltp.	+33 (0)1 44 75 12 14	Yes	Yes
12/15/2015 11:06:20	TransLoc	http://www.transloc.com	Joel Bush	info@transloc.com	(888) 959-3120	Yes	Yes
1/10/2016 14:57:46	Conveyal	http://conveyal.com/	David Emory	demory@conveyal.com	(404) 635-6777	Yes	No
2/9/2016 20:59:41	EACOMM Corporation	http://www.eacomm.com	Mike Torres	solutions@eacomm.com	+6324382986	Yes	Yes
2/29/2016 21:13:39	EACOMM Corporation	http://www.eacomm.com/	Karlo Robosa	solutions@eacomm.com	+6324382986	No	Yes
4/29/2016 7:03:02	Lepton Software	http://www.leptonsoftware	Rajeev Saraf	rajeev.saraf@leptonsofwa	+91 9810006581	No	Yes
6/26/2016 18:04:22	Mobilibus	http://www.mobilibus.com	Marco Littig	contato@mobilibus.com.b	+554799850298	Yes	Yes
7/10/2016 14:36:46	GTFS Transit Solutions	http://www.gtfs-transit-sol	Conrad Ward	conradmward@gmail.com	1-207-615-5735	No	Yes
2/1/2017 21:54:48	Omnimodal, LLC	http://omnimodal.io	David Thomas Moran	david@omnimodal.io	(321) 345-1083	Yes	Yes
3/11/2018 18:00:22	MobiGIS	http://www.mobigis.fr	Frédéric SCHETTINI	frederic.Schettini@mobigi	+33 5 81 60 80 83	Yes	Yes
11/4/2018 2:27:08	Nikhil VJ	http://nikhilvj.co.in	Nikhil VJ (freelancer, Indi	nikhil@nikhilvj.co.in	+91-9665831250	Yes	Yes
1/8/2020 12:22:33	Texas A&M Transportation Institute	https://groups.tti.tamu.edu	Shuman Tan	s-tan@tti.tamu.edu	7136139207	Yes	Yes
4/27/2020 12:51:34	TTE srl	http://www.ttie.it	Filippo Mini	f.mini@ttie.it	00390586372667	Yes	Yes
5/9/2020 16:12:01	Brody Flannigan Transit Data	http://transitdata.ca/en/ho	Brody Flannigan	brody@transitdata.ca	Please use email	No	Yes
4/16/2021 15:54:26	ALEXANDER JAMES WILSON	http://evanescllc.com	Sid	sidpressedon@gmail.com	2109863647	Yes	Yes
6/10/2021 14:38:58	Passio Technologies	passiotech.com	Alexandra Wright	Alexandra@passiotech.co	7706391978	Yes	Yes
9/7/2021 6:37:45	TRENMO Engenharia, S.A.	https://www.trenmo.com/	Simão Portela	gtfs@trenmo.com	+351 225028579	No	Yes

Published by Google Sheets – Report Abuse – Updated automatically every 5 minutes

Image Source: Awesome Transit, https://project-awesome.org/CUTR-at-USF/awesome-transit#

Figure 28

Once GTFS data are available and kept current, it is of value to the wider transit community that the data are published and easily accessible online for public use. This can, for instance, enable developers to plug the data into other useful digital tools or allow university researchers to bring transit data into analyses. For example, VTrans publishes its GTFS data online for the public.[87]

[87] https://vermont-gtfs.org

Chapter 3: Best Practices

In order to bring digital tools to bear on Complete Trip planning, transit and mobility professionals should keep the following best practices in mind—illustrated through the seven highlighted projects in Chapter 1 and Chapter 2. By taking these topics into account early on in a project, transit and mobility professionals can set up a solid foundation for a new project:

1. Prioritizing customer input
2. Defining collaboration roles for various actors
3. Considering governance topics early
4. Leveraging feedback loops between infrastructure types

3.1 Prioritizing Customer Input

Since the Complete Trip concept centers on the customer experience, it follows that projects involving digital tools for Complete Trip planning should also center on the customer experience. Bringing digital tools to bear on the complete trip necessitates that transit agencies understand potential customer journeys within their service area as well as wider metro area and rural connections. This lays a foundation for agencies to pinpoint common challenges that mobility system users encounter, which users are best positioned to explain, and seek their feedback on potential solutions.

For example, throughout the “roadway upgrades for rural pedestrians” project in Northeast Minnesota, the project team relied on tribal authorities, as representatives of the wider community, to pinpoint areas with pedestrian challenges, so that cameras could be set up to track the activity. Without this input, the project team would likely have had a difficult time deciding where to begin, and perhaps may have chosen less optimal locations. The project team for the “complete street upgrades” project in Westfield, Massachusetts is reaching out to the public directly to find out what challenges they have encountered along the Route 20/Main Street corridor. By gaining the input of people affected, these projects have been grounded in the experience of local mobility system users. It is important to note that the ways the input was gained differed In Minnesota, representatives were consulted as opposed to individuals directly; while in Massachusetts the project team sought out the direct input of individuals. Both approaches are valid, so long as the representative organization is deeply involved in the community and has concrete ways to go about gaining the feedback needed.

Whenever possible, during discussions with individuals it is important to consider that their knowledge about trips can be either “experienced” or “anticipated.” “Experienced” knowledge pertains to trips that actually happened in the past, meaning the individual travelled along the journey which resulted in takeaways to share, while “anticipated” knowledge deals with trips they’d like to take but have not taken due to barriers. The latter addresses situations in which an individual mentally considers a trip but does not physically take it, often because some aspect of the trip is in question such as safety concerns. To elicit discussions about anticipated knowledge, engagement processes should explicitly include questions about trips the individual would like to take, but have not taken, exploring in detail why they do not take such trips. In these high-tech times,

when data are all around us, it is possible to overlook the most important data source—the voices of the mobility system users.

3.2 Defining Collaboration Roles for Various Actors

Each actor in a network behind a project will have a role depending on the type of activities they expect to be involved in throughout the project development effort. In the early phases of the project, actors will participate in the research, planning, and design activities, while in later phases the work will be focused on implementation. Trip planning, which aids users in figuring out which itinerary makes the most sense for a certain journey, enables cross-jurisdictional trips in many cases. The trip planning area may encompass multiple transit and mobility providers as it crosses jurisdictions including municipal and county boundaries. For this reason, digital tools for trip planning, which often encompass entire metro areas or networks of towns, sometimes have significant involvement—even project leadership—from regional and state-level organizations.

The project led by the Northwestern Indiana Regional Planning Commission (NIRPC), the "bus stop accessibility map" project in Northwest Indiana, serves as an example of regional level oversight and leadership. To produce the interactive online transit map, NIRPC staff gained the details for 561 bus stops across the region in Lake, Porter, and La Porte counties. The bus stops are attributed to eight transit providers, Gary Public Transportation Corp., East Chicago Public Transit, North Township Dial-a-Ride Opportunity Enterprises, Porter County Aging Community Services, City of Laporte Transit, Michigan City Transit, City of Valparaiso V-Line and Chicago Dash, and Lake County Community Services. NIRPC is positioned well to lead a regional project of this type and help guide collaboration among the eight transit providers.

It is important to define all the actors and roles early on in the project, since knowing this will help with project planning and involve the appropriate resource at the appropriate times in the right activities. During the "roadway upgrades for rural pedestrians" project in Northeast Minnesota, the tribal leaders were involved throughout the project in an advisory role, first helping to identify local sites with major challenges for pedestrians, then reviewing the results of the data collected from the cameras and taking part in brainstorming solutions, and finally participating in the evaluation of the effectiveness of the implemented solutions. In addition, due to this project having such a strong research component, the University of Minnesota provided the research base from the beginning of the project until later steps that involved evaluating the effectiveness of the implemented solutions. The county engineers, on the other hand, could have begun their involvement early on in the project, but the majority of their active involvement would likely have been focused on handling the later implementation on-the-ground, since pedestrian infrastructure is within the realm of their direct responsibilities.

For the "bus stop and sidewalk upgrades" project in the Portland, Oregon metropolitan area, although it was led by TriMet, it required strong coordination with state and local authorities tasked with maintaining sidewalks and adjacent areas surrounding bus stops. The "intermodal trip planner" project in Northwest Oregon is led by a regional

transit system called the NW Connector that includes five transit agencies in Northwest Oregon: Columbia County Rider, Sunset Empire Transportation District, Tillamook County Transportation District, Benton County Transit, and Lincoln County Transit. The roles for this regional collaboration have been formally defined through an established transit agency partnership. Handling tasks and projects far beyond the trip planner, such as unified bus stop signage in the region and regional transit passes, the partnership's activities together have a wide range. Their informational webpage points out that they also work together on funding strategies and hold monthly meetings to help guide their collaborative activities.[88]

Any activity oriented toward making significant progress on the Complete Trip, and the digital tools to support it, will more than likely involve a group effort. Such efforts can be more or less formal. Defining roles and activities for all involved parties will pay off throughout the project development process by helping to chart a clearer path for everyone involved.

3.3 Considering Governance Topics Early

Some of the most difficult collaborative tasks to tackle relate to governance. As mentioned in Section 1.1, governance can be thought of at three levels. The first level involves a *single transit agency*, governing the relationship between the customer and the transit agency, which encompasses agency policies such as payment structures and passenger codes of conduct. The second level is the *multi-transit agency* , governing the relationship between the customer and multiple transit agencies together, involving policies such as transfer agreements and reciprocity of paratransit eligibility. The third level is the *mobility system* , governing the relationship between the customer and the mobility system, which deals with policies such as monthly mobility subscription models for payment that offer a bulk discount of sorts in exchange for committing to several modes at one time and for a certain duration.

While the first level can be handled internally within a single organization such as a transit agency, the second and third levels require at least two organizations to agree on joint policies that they will implement within their own organizations. Typically, policies at the second and third levels involve some sort of financial implications. For example, transfer agreements between transit agencies often involve both sides agreeing that one receives payment on the outgoing trip, while the other receives payment on the incoming trip, assuming a round trip by the customer. In order for this to work out for both organizations financially, the best situation would be for the two agencies to have a fairly equal amount of travel with just as many people originating their round trip in one service area as the other. However that might not be the case, and if so, this could lead to a more complex financial understanding behind a transfer agreement.

Digital tools for trip planning tend to require some level of governance to make sure that data sets (e.g., GTFS and GTFS-flex) are intact and maintained to ensure that one organization takes on a leadership role. This leadership role, for some projects, involves overseeing arrangements across multiple participating organizations and may also

[88] https://www.nworegontransit.org/nw-connector/

involve providing project management, holding stakeholder participation forums, and supporting other critical project tasks.

The NW Connector regional transit system that includes five transit agencies, with its "intermodal trip planner" project in Northwest Oregon, is an excellent example of how impressive projects often have notable governance behind them. As mentioned in Section 2.4.1, trip planners, once created, take significant work to keep up and running. The data sets must be updated and the trip planner platform needs to be maintained, both of which require some sort of joint oversight when multiple agencies are involved, as is the case with this project.

Some of the more challenging governance aspects for the NW Connector may involve the fare policy behind the multi-day regional transit passes, "3-day and 7-day visitor passes may be purchased from drivers on any route served by NW Connector partner agencies. Visitor passes allow one trip to the coast from Portland or the Albany/Corvallis area, one return trip, and unlimited travel in Clatsop, Tillamook and Lincoln Counties (from Astoria to Yachats)."[89] There is likely some agreement behind-the-scenes among the five agencies to handle the financial reconciliation of this joint fare policy.

In some cases, for more complex digital trip planning projects, an agency may want to consider what type of governance and collaboration will be needed in the short, medium, and long term to build the project and maintain it adequately over time. In addition, the NW Connector partnership shows that for the strongest partnerships, a group can take on many projects and initiatives together. If a transit agency can foresee that it would be beneficial to establish some sort of alliance, consortium, or partnership, a Complete Trip planning project may be an opportunity to begin this.

3.4. Leveraging Feedback Loops Between Infrastructure Types

Although this Guidebook is focused on digital tools for Complete Trip planning, it is important to stress the interconnectivity between digital tools/technology infrastructure and physical/services infrastructure. As digital tools become increasingly ubiquitous in the transit and mobility field, it is possible to lose sight of what good transit has always depended upon—reliable service that meets the need along with physical infrastructure to support optimal and accessible service. While digital tools for trip planning, booking, payment, and navigation have the potential to improve the customer experience, they are not a replacement for physical infrastructure or services.

On the other hand, digital tools can help with communication about projects that have involved upgraded physical infrastructure or services. For instance, if a "complete trip before and after" comparison was completed on all three projects mentioned in Chapter 1, the "after" would demonstrate significant improvements. However, if a customer had a negative experience in the "before" times and had not been informed about the upgrades or had no reason to notice them for other reasons, then they would not know to try the same journey again—this time with the benefit of the improved infrastructure.

[89] https://www.nworegontransit.org/passes/

In these situations, it is ideal to consider a feedback loop between the physical/services infrastructure and the digital tools so that this information is communicated to the customer. For example, now that improvements have been completed through the “bus stop and sidewalk upgrades” project in the Portland, Oregon metropolitan area, these upgrades should be communicated to customers during the trip planning process so they have this information at their fingertips. As illustrated through NIRPC’s project, the “bus stop accessibility map” project in Northwest Indiana, some organizations go to great lengths to provide details to customers about bus stop conditions—far beyond what is required for ADA compliance—especially so passengers with disabilities can be informed before selecting their itinerary. While such tools may exist within a trip planning platform directly as is the case in Northwest Indiana and Washington D.C. (see the project in the project table in Section 2.3, “trip planner with bus stop accessibility details”), any digital tool providing comparable information—even outside of a trip planner—would be a valuable resource for customers as they perform trip planning.

At the same time, digital tools can be leveraged to communicate to customers about upgrades that have not happened yet (and may not happen), and therefore, are communicated as potential barriers. As aforementioned, although digital tools can help communicate this information, there is no substitute for removing the barrier by upgrading the physical infrastructure. When a customer learns of barriers that are relevant to them during the trip planning process, they can select alternative itineraries that work around such barriers. For example, the “wheelchair-accessible trip planning” project in Boston, MA, mentioned in the project table in Section 2.3, leverages recent developments in GTFS data to accommodate real-time elevator outage information. While the static elements of GTFS communicate with the customer about the fact that an elevator *is* or *is not* present, this dynamic element of GTFS communicates its current operational status. When a wheelchair user begins their trip planning process, knowing about elevator outages is extremely valuable. Of course, the agency should get the elevator up and running as quickly as possible, but in the meantime, hopefully there is an alternative route the customer could take—arriving at a station with an elevator outage can lead to many hours of lost time and extreme frustration. In situations such as this, having the ability of digital tools to communicate these barriers is critical.

By going through the process of analyzing the needs for a digital tool to support Complete Trip planning, professionals may also end up identifying key gaps in physical, services, and governance infrastructure—potentially even other technology infrastructure gaps—since these components are almost always connected. If key gaps are discovered that fall outside of the immediate project scope for digital tools, organizations should strive to address them through other means.

Chapter 4: Providing a Digital Tool for Complete Trip Planning

4.1 Aims and Shortcomings

4.1.1 Overall aim of the Complete Trip concept

When individuals can navigate a transit and mobility system largely without worry, a more "seamless" Complete Trip is in place. They can move around in their physical surroundings and leverage digital tools effortlessly; they know they have been considered as improvements were made.

To get to this place, all the components of the Complete Trip—the travel modes and collaboration as well as physical, service, governance, and technology infrastructure—must work together in such a way as to reduce uncertainty for people. This means people don't ask themselves as often – *Are these two modes going to connect well? Will my wheelchair fit there? Is this bike lane going to continue?* – because they know the answers. They have personal experience finding this out for themselves, or the answers are available online from a trusted source. When physical and psychological strain is kept to a minimum during the customer experience, trust and confidence in the transit and mobility system can flourish.

4.1.2 Shortcomings of digital trip planners

The general purpose of a digital trip planner is to enable users to compare mobility options and select the itinerary that best meets their personal requirements. Although trip planners have been around for more than a decade, they still have major shortcomings that must be taken into account. As explained in Section 2.1.1 of the Guidebook, trip planning is a process that may or may not involve digital tools. The process of trip planning involves evaluating different options, anticipating the experience of taking these options, and selecting an option.

First, multimodal trip planners (i.e., those that enable searching for options across two or more modes) and intermodal trip planners (i.e., those that enable individual trips with two or more modes to be shown) **still do not include all the transit modes that are commonly used**. Widely used, commercially available trip planners such as Google Maps, Moovit, and Transit do not include a default option to display demand-response transit (DRT) and on-demand transit modes. In many places, such as low density and rural areas, DRT is the only local transit option. Americans with Disabilities Act (ADA) paratransit and human-services transportation (HST) are types of DRT that add on the additional requirement of eligibility. Typically, these DRT services are available to people in certain age groups, with certain types of disabilities, with certain medical conditions, and/or going to specific destinations often connected with their age/disability/medical condition. On-demand transit, as explained in Section 2.2.3, is becoming increasingly popular in all kinds of geographic contexts. In some cases, on-demand transit is replacing an existing DRT service, essentially using more modern technology to operate a long-standing service.

The "intermodal trip planner" project in Northwest Oregon is an exception to the rule. The Oregon trip planner is based on the Open Trip Planner (OTP) open source

software, which includes demand-response as well as many other trip options, explained further in Section 2.2.2.

Second, digital trip planners and related tools **rarely include all of the critical decision-making criteria needed** to make thoroughly informed mobility decisions—such as safety and comfort. This could include key details about individual bus stops, sidewalk conditions, and other safety-related information and could be provided for individuals with disabilities in mind or from a more general perspective. Projects such as the "bus stop accessibility map" in Northwest Indiana are rare, and projects that detail sidewalk information as shown in Section 2.3 in the project table, notably the "AccessMap" project in Seattle, WA and the "Accessibility Mapping Project" for the University of Pennsylvania, are uncommon as well.

Third, trip planning is connected with other customer experience processes such as trip booking, payment, and navigation, but **apps do not always connect these functions seamlessly**. Major inroads have been made to better integrate these functions into common interfaces but, currently, it is still typical for the customer to bounce around multiple apps for different steps in the process—even to different apps for different transit providers in the same geographic area.

In short, for all the progress that has been made with trip planners over the past decade, glaring omissions remain. Before digital tools were available, people performed trip planning calculations mentally. Now that digital tools have entered the picture, some aspects of the mental calculations are aided significantly with trip planning tools—but not all. Simply because digital tools exist does not mean the technology aspects of trip planning are all addressed adequately.

4.2 Guidelines for Improving the Complete Trip Through Digital Tools

For professionals to assess if their digital tool and trip planning effort supports the aims of the Complete Trip, a set of guidelines are provided that break down specific Complete Trip aims and pinpoint the corresponding role that the digital tool should have.

#1: Complete information

Complete Trip Aim: The Complete Trip requires complete information for all people in order to reduce uncertainty.
Digital Tool Role: Provide digital tools that display the most complete information possible, even if that means providing multiple tools—including the full range of modes and all the information on personal requirements that users may need.

#2: Accessibility

Complete Trip Aim: The Complete Trip requires accessibility for all.
Digital Tool Role: Provide digital tools that all users can access. Refer to standards such as the Web Content Accessibility Guidelines (WCAG)[90] and consider having a specialist review the tool; this could come in the form of assistance from a local university, a consultant, or a professional contact.

[90] https://www.w3.org/WAI/standards-guidelines/wcag/

#3: Intermodal options
Complete Trip Aim: The Complete Trip requires all options to be included—both single-mode *and* intermodal options—making them as seamless as possible.
Digital Tool Role: Provide digital tools that give special attention to intermodal options; introducing a transfer between modes requires additional attention. Make sure that the complete intermodal trip is as seamless as possible for the end-to-end journey.

#4: Connected plan, book, pay, and navigation steps
Complete Trip Aim: The Complete Trip requires seamlessness throughout the end-to-end journey.
Digital Tool Role: Provide digital tools that assist with the typical steps that individuals take physically and digitally. They plan for the trip, may need to book it depending on the mode, pay for the trip, and navigate various trip segments. While trip planning tools may be the initial focus, it is also important to consider how book, pay, and other steps individuals will take will be addressed—perhaps in future projects and connected in some way to the trip planner.

#5: Ability to update status of services and physical infrastructure
Complete Trip Aim: The Complete Trip requires that physical infrastructure and service infrastructure are considered as key components.
Digital Tool Role: Provide digital tools that ensure that the status of physical and service infrastructure is reflected within the tool, while allowing for that status to change temporarily (such as with an elevator outage) or permanently (such as with a sidewalk upgrading project).

#6: Foundation for collaboration and governance
Complete Trip Aim: The Complete Trip requires that collaboration and governance infrastructure are considered as key components.
Digital Tool Role: Provide digital tools along with a longer-term strategy that considers the collaboration and governance setup needs to ensure success over time.

#7: Holistic approach to digital and mental calculations
Complete Trip Aim: The Complete Trip requires technology infrastructure and digital tools to be considered holistically along with other needs users have—including those needs currently underserved by data and digital tools.
Digital Tool Role: Provide digital tools that make the most of current digital capabilities while considering the necessary mental calculations that will occur in tandem through design of the complete user experience. Allow for the fact that current trip planners do not yet enable the trip planning calculation to be done 100% digitally.

#8: Customer experience focus
Complete Trip Aim: The Complete Trip is customer-centric, keeping the customer experience at the center of the effort.

Digital Tool Role: Provide digital tools that have had thorough input from customers, early on to help determine the best path forward and later to assess the usability and functionality of the tool.

4.3 How to Approach Providing a Digital Tool for the Complete Trip

This section of the Guidebook offers guidance on how professionals can take their next steps toward providing a digital tool for complete trip planning. One highly applicable resource is N-CATT's white paper, "A Framework for Making Successful Technology Decisions," published in October 2020.[91]

> The focus of this white paper: electronic- and information-based systems that are being adopted now, are quickly developing, or are not really on the market yet, while keeping in mind that technology should allow an agency to do more at a larger scale in a way that supports the agency mission. By making good technology decisions, we want to end up with a set of systems that support and make transit either more efficient, more usable, or, ideally, both. Making decisions about when to add, remove, or update any technology can be daunting, but there are ways to make it more successful in the long run.

The white paper covers core concepts including capacity building and systems thinking as well as steps to take:

- Phase 1: Define and Rank Problems
- Phase 2: Develop Potential Solutions
- Phase 3: Procuring
- Phase 4: Implementation and Maintenance

Another resource that explains related topics in depth is N-CATT's *Guidebook on New Software Adoption for Small Transit Agencies*, published in March 2021.[92]

> During the past decade, there has been a veritable explosion of software options that are available to small city/rural/tribal transit agencies to assist them in improving their operations and passenger interactions… There has never been a better time for a small transit agency to take advantage of software to help achieve its objectives and improve service to its customers… New software adoption has the potential to range from a relatively simple undertaking to an extremely complex one. This Guidebook provides a four-step process to move from the initial stages of software consideration to later steps involving set-up, operations, and maintenance.

The four-step process includes:

- Step 1: Set the Software Scope
- Step 2: Collaborate with the Software Stakeholders
- Step 3: Move Forward with a Software Product

[91] https://n-catt.org/resources/a-framework-for-making-successful-technology-decisions/
[92] https://n-catt.org/resources/new-software-adoption-for-small-transit-agencies/

- Step 4: Support the Software

While these two resources aid professionals in making technology decisions and help them go about adopting new software in general, the *Guidebook on Digital Tools to Facilitate Complete Trip Planning* deals specifically with technology and software that serves a particular purpose—trip planning for the complete trip. These resources will be referenced, when applicable, to guide professionals toward more detailed guidance on particular topics, allowing additional information below to be tailored to complete trip planning. A series of steps is proposed for the process of providing a digital tool for complete trip planning including:

- Step 1: Clarify challenges related to digital tools for the Complete Trip
    - 1a. Set up stakeholder and project management roles
    - 1b. Research and list digital challenges
    - 1c. Evaluate and rank the challenges according to impact
- Step 2: Consider potential tactics to address digital challenges
    - 2a. Research and list potential tactics
    - 2b. Consider factors that impact tactic feasibility
    - 2c. Evaluate and rank feasibility of the tactics
- Step 3: Plan for providing digital tools
    - 3a. Consider what should happen in the next 10 years
    - 3b. Identify supportive infrastructure needed for the next 10 years
    - 3c. Confirm what will be done in the first 3 years and how it will be implemented
- Next steps

Note that the involvement of transit and mobility system users, including specific user groups such as individuals with disabilities, is a constant theme throughout the steps as shown in the table.

Step 1	Transit and mobility system users should provide input on draft journey diagrams as well as on digital challenges they experience, or avoid, during specific journey segments.
Step 2	Transit and mobility system users should provide input on potential tactics to address digital challenges.
Next steps	Transit and mobility system users should provide input on the selection of digital tools (reviewing mock-ups and wireframes of specific tools that are being considered) and provide user feedback during the beta testing process.

4.3.1 Step 1: Clarify challenges related to digital tools for the Complete Trip

Substep 1a. Set up stakeholder and project management roles

The *Guidebook on New Software Adoption for Small Transit Agencies* goes into significant detail in Chapter 2 / Step 2: "Collaborate with the Software Stakeholders" on how to identify all the relevant stakeholders (including end users) for a project, ways to actively involve them, and how to incorporate their feedback into decision-making processes. Chapter 1 of the Guidebook also mentions the need for a "software adoption lead" to help spearhead the effort; this person could also be referred to as a project manager. "The lead does not need to come from a software development or information technology background. The most important skill sets and knowledge the lead should have include transit operations knowledge, software benefits awareness, and organizational skills."[93] Early on to provide digital tools for complete trip planning, the full range of stakeholders, including the transit and mobility system users, should be identified; the person supporting the project management of the entire effort should also be clarified. Once this is complete, the effort will have its project team in place.

Substep 1b. Research and list digital challenges

First, draft customized "journey diagrams" for the local area.

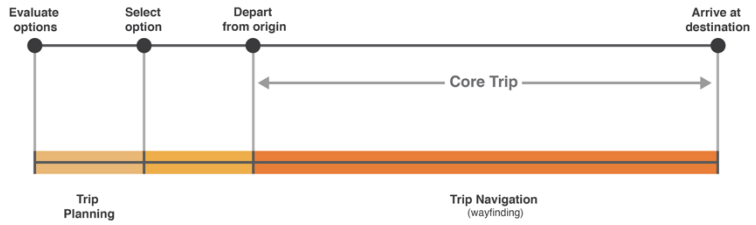
To understand the types of challenges and gaps that people face when using digital tools for the Complete Trip, the project team should prepare to draft all the known and potential end-to-end journeys in the area as illustrated in Section 1.2. The mapping out of the journeys should have the input of the entire stakeholder group, including the transit and mobility system users, to ensure the set of end-to-end journeys is complete.

This input could be gained through both general public events and by holding smaller gatherings with representatives of specific user groups. Many transit agencies have advisory boards or committees, for example, some involving individuals with disabilities and older adults who provide feedback to the transit agency on an ongoing basis. The input of such groups could be sought to help create the journey diagrams. If a long list of journeys ends up being generated and is considered too unwieldy for discussion, 5-10 common journey types could be selected.

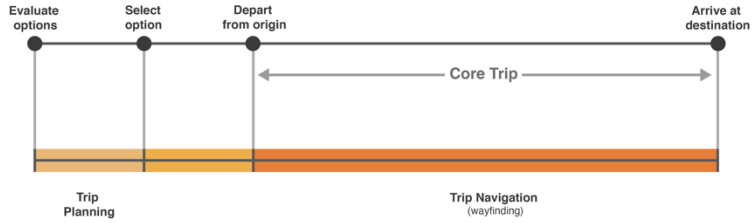
Then, identify digital challenges encountered during specific journeys.

Once the set of end-to-end journeys has been drafted and is considered complete by those involved, the project team and the user groups, the challenges can be identified through discussions and work sessions. It may also be worth considering online feedback options as shown through the "complete street upgrades" project in Westfield, Massachusetts. Each identified challenge should be located on a specific end-to-end journey and with the journey segments to which it applies. To better connect the Complete Trip segments with digital tools that are commonly used during each segment, Figures 29 and 30 should be leveraged as a visual reference.

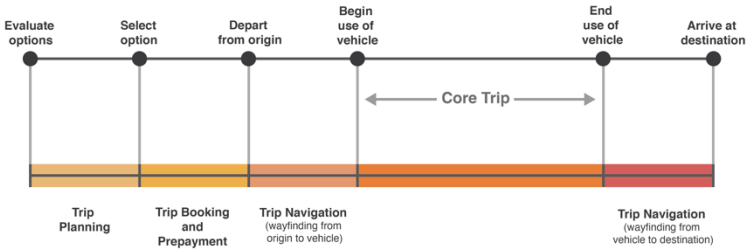
[93] https://n-catt.org/resources/new-software-adoption-for-small-transit-agencies/



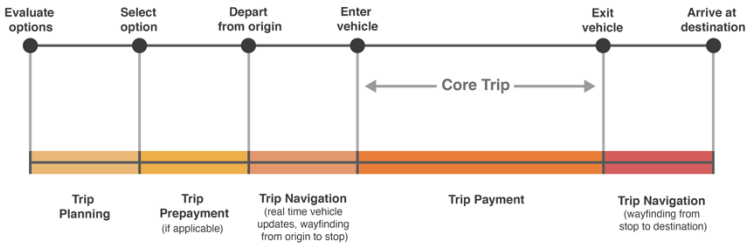
Walking



Cycling

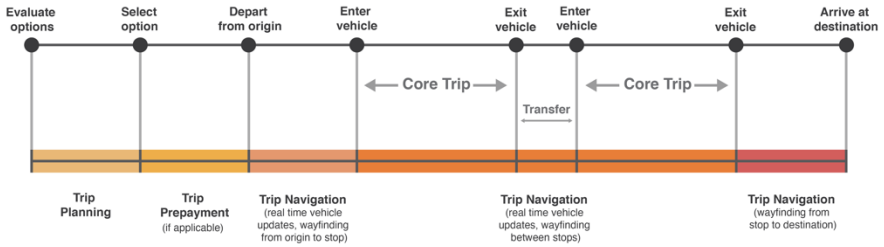


Micromobility

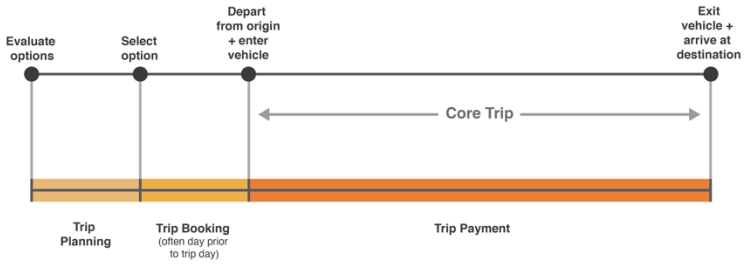


Fixed-route transit (no transfer)

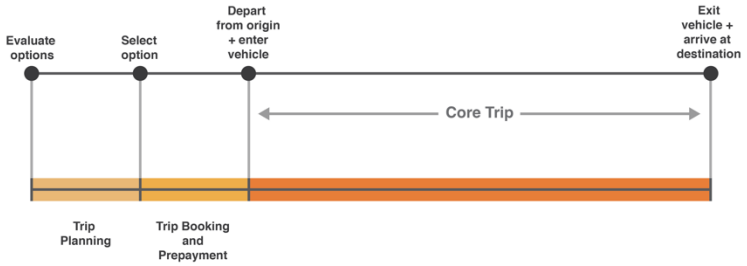
Figure 29



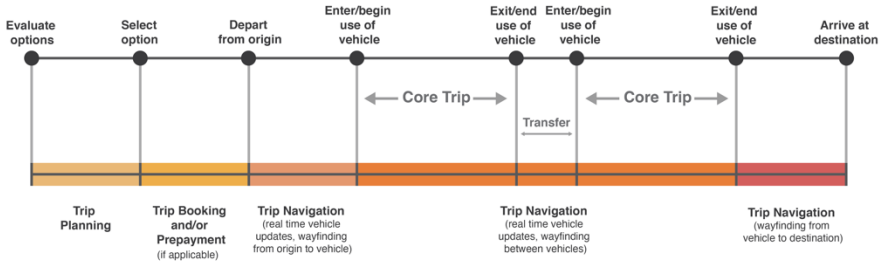
Fixed-route transit (with transfer)



Demand-Response / Paratransit / HST



On-demand transit



Intermodal

Figure 30

Again, the input would ideally be gained through both public events and by holding smaller gatherings with representatives of specific user groups. Some of the highlighted projects in this Guidebook provide examples of types of digital challenges to look out for such as:

- For multi/intermodal trips during trip planning: Trip planners missing entire modes such as demand-response transit, which leads to a fundamental lack of information on transit and mobility options.
- For demand-response transit trips during trip planning/booking: Customer difficulty in booking trips across multiple demand-response transit providers (without contacting each one separately), causing confusion about which one to contact first and what to do when a trip request is denied.
- For transit, cycling, and pedestrian trips during trip planning: Digital gaps in information about physical barriers impacting the feasibility of trips. These physical barriers could include inadequate bus stop conditions, missing bike lanes, or dangerous sidewalk conditions, for example.

Substep 1c. Evaluate and rank the challenges according to impact

Once a complete list of challenges has been generated, the challenges should be compared against each other as ”High”, ”Medium”, or ”Low” impact. While some challenges will have major impacts—presenting significant digital barriers—others will have relatively minor impacts. Making these assessments will be a subjective process involving the project team and user groups. For instance, in Substep 1b, “trip planners missing entire modes” will likely be seen as a High impact challenge. Another challenge example, “customer difficulty in booking trips across multiple demand-response transit providers” may be characterized as Medium or Low impact. It is frustrating for users, but overall may present less impact when compared to the other challenges in question. For this step, there are no right or wrong answers; the project team and user groups can discuss and debate these topics—using analytical tools for a more precise assessment as they see fit—eventually coming to agreement on how to characterize the challenges.

4.3.2 Step 2: Consider potential tactics to address digital challenges

Substep 2a. Research and list potential tactics

Once the challenges are confirmed, considerations can move toward identifying various tactics with the project team and the users providing input. Tactics are activities that could be undertaken to help address challenges, often focused on providing a specific tool or taking on a new initiative. For one challenge mentioned under Substep 1b, “trip planners missing entire modes,” different types of tactics could be proposed, for example. One tactic could be “make adaptations to the existing trip planner to enable all modes to be included.” Another tactic could be “provide a new trip planner that includes all modes.” For the challenge “digital gaps in information about physical barriers impacting the feasibility of trips,” tactics could be proposed such as “include barrier-related information within a new trip planner,” “adapt the existing trip planner to include barrier-related information,” or “setup a tool dedicated to providing barrier-related

information, to be used along with a trip planner" as was done through the "bus stop accessibility map" project in Northwest Indiana. Tactics are highly context-dependent. Identifying them depends not only on the challenge they could help address, but also on the existing situation surrounding the potential tactic—the projects and initiatives that are, or are not, already in place that could help or hinder it.

Substep 2b. Consider factors that impact the level of effort for a tactic

There are various factors that can impact the level of effort of a tactic, making it much easier or more difficult to accomplish. For instance, for the potential tactics that should address the challenge "trip planners missing entire modes" which are "make adaptations to the existing trip planner to enable all modes to be included" and "provide a new trip planner that includes all modes," more than likely both tactics would involve using GTFS-flex feeds in a trip planner, so that demand-response transit options (one of the missing modes) could be shown in the trip planner. If GTFS-flex feeds had already been created, then both/either of the tactics may involve less effort. If the GTFS-flex feeds had not been created, but one of the organizations on the project team offers one of their staff members to create the GTFS-flex feed, that would likely be easier than, for instance, going through the process of locating funding and procuring a tool/consulting services to create the data. Each situation regarding the status of getting GTFS-flex feeds ready presents information that makes the related tactic more or less effortless.

For this example, the GTFS-flex feeds are not the only input into the tactic. Another input to consider involves the status of the existing trip planner (if one exists); can it be adapted to add demand-response options, or would the difficulty of doing so contribute to considering another trip planner altogether? Is there even an existing product on the market than can include demand-response options, or would pursuing this tactic require the project team to create a custom software solution?

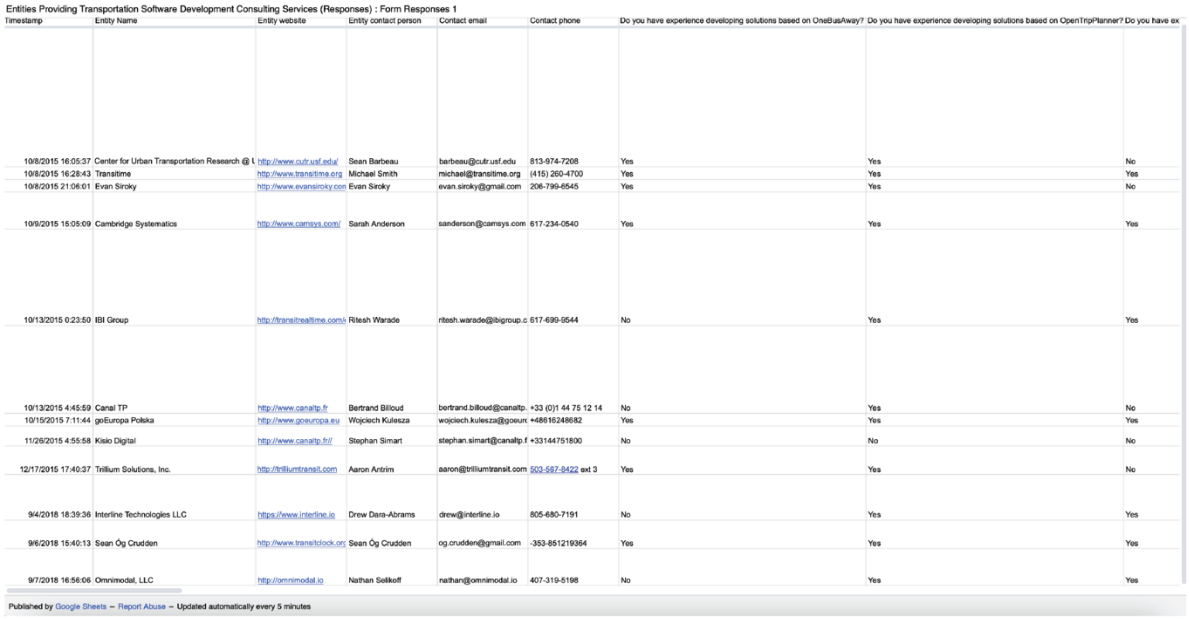
While the Guidebook Section 2.2 provides information on core topics pertinent to assessing the level of effort, a few more core topics are provided below:

- Considering existing software vs. creating new software
- Leveraging available resources
- Using the project table in Guidebook Section 2.3 as a state of the practice summary

When considering existing software vs. creating new software, there are several factors to consider. In the *Guidebook on New Software Adoption for Small Transit Agencies,* Chapter 3 goes into detail on this topic, "Small transit agencies today have a choice among multiple types of software products that address the same functional needs of the agency. These include commercial off the shelf (COTS) products, open source/public domain software, and custom software solutions. The advantages and disadvantages of each is discussed in this chapter."[94] In general, COTS products will be easier to set up, but they may potentially not have all the desired features and functions—and often, this cannot be changed. Custom software solutions typically

[94] https://n-catt.org/resources/new-software-adoption-for-small-transit-agencies/

require a very high level of effort to ensure that software consultants deliver a product that meets what the project team and end users have in mind. The “awesome-transit” list[95] references a “community-maintained list” of “Entities Providing Transportation Software Development Consulting Services”[96] (with an option to add new vendors) as shown in Figure 31.



Entities Providing Transportation Software Development Consulting Services (Responses) : Form Responses 1

Timestamp	Entity Name	Entity website	Entity contact person	Contact email	Contact phone	Do you have experience developing solutions based on OneBusAway?	Do you have experience developing solutions based on OpenTripPlanner?	Do you have ex
10/8/2015 16:05:37	Center for Urban Transportation Research @ U	http://www.cutr.usf.edu/	Sean Barbeau	barbeau@cutr.usf.edu	813-974-7208	Yes	Yes	No
10/8/2015 16:28:43	Transitime	http://www.transitime.org	Michael Smith	michael@transitime.org	(415) 260-4700	Yes	Yes	Yes
10/8/2015 21:06:01	Evan Siroky	http://www.evansiroky.com	Evan Siroky	evan.siroky@gmail.com	206-799-6545	Yes	Yes	No
10/9/2015 15:05:09	Cambridge Systematics	http://www.camsys.com/	Sarah Anderson	sanderson@camsys.com	617-234-0540	Yes	Yes	Yes
10/13/2015 0:23:50	IBI Group	http://transitrealtime.com/	Ritesh Warade	ritesh.warade@ibigroup.c	617-699-9544	No	Yes	Yes
10/13/2015 4:45:59	Canal TP	http://www.canaltp.fr	Bertrand Billoud	bertrand.billoud@canaltp.	+33 (0)1 44 75 12 14	No	Yes	No
10/15/2015 7:11:44	goEuropa Polska	http://www.goeuropa.eu	Wojciech Kulesza	wojciech.kulesza@goeuro	+4861624682	Yes	Yes	Yes
11/26/2015 4:55:58	Kisio Digital	http://www.canaltp.fr//	Stephan Simart	stephan.simart@canaltp.f	+33144751800	No	No	No
12/17/2015 17:40:37	Trillium Solutions, Inc.	http://trilliumtransit.com	Aaron Antrim	aaron@trilliumtransit.com	503-567-8422 ext 3	Yes	Yes	No
9/4/2018 18:39:36	Interline Technologies LLC	https://www.interline.io	Drew Dara-Abrams	drew@interline.io	805-680-7191	No	Yes	Yes
9/6/2018 15:40:13	Sean Óg Crudden	http://www.transitclock.org	Sean Óg Crudden	og.crudden@gmail.com	-353-851219364	Yes	Yes	Yes
9/7/2018 16:56:06	Omnimodal, LLC	http://omnimodal.io	Nathan Selikoff	nathan@omnimodal.io	407-319-5198	No	Yes	Yes

Published by Google Sheets – Report Abuse – Updated automatically every 5 minutes

Image Source: Awesome Transit, https://project-awesome.org/CUTR-at-USF/awesome-transit#

Figure 31

Custom software solutions often need be hosted through a solution provided by the organization that is managing it, but COTS products are increasingly provided as Software as a Service (SaaS) projects. In short, there are several factors to consider related to how software options can influence the level of effort of a tactic. Explained in the *Guidebook on New Software Adoption for Small Transit Agencies:*

> During the past decade, there has been a strong trend in business software in the direction of Software as a Service (SaaS) approaches. Among multiple advantages of a SaaS purchase, a major advantage for a small transit agency is that it does not have to concern itself with the computing infrastructure on which the software is hosted. This chapter discusses the relative merits of SaaS approaches compared to licensed software products that are hosted by the agency itself or for which the agency is directly responsible. For small transit agencies, software solutions that avoid the agency needing to be responsible for their own computing infrastructure are typically advantageous, assuming that broadband data access is available.[97]

[95] https://project-awesome.org/CUTR-at-USF/awesome-transit
[96] https://docs.google.com/spreadsheets/u/1/d/1n44CNMCK1vt1nyrsdYz-KD_hYxUMNIm6Me69M6ROBIg/pubhtml
[97] https://n-catt.org/resources/new-software-adoption-for-small-transit-agencies/

In some cases, available resources from among the project team can be leveraged to support efforts to provide digital tools for Complete Trip planning. The *Guidebook on New Software Adoption for Small Transit Agencies* provides information on this topic in Chapter 1, Step 1c. Anticipate Resources to Apply to Software Adoption,[98] "Resources relevant to the software adoption process include (at a minimum) financial resources, staff resources, existing software and computing infrastructure assets, and collaborator resources—financial, staff resources, or assets from partner organizations. An agency should create an inventory of its likely available resources early to be prepared for later steps in the process." Resources that could be particularly useful for complete trip-related efforts include existing data sets, software already in use that can be expanded, existing methods for centralizing data for multiple organizations, as well as in-kind financial and staff resources to help build and manage the work. If resources can be provided through a partner organization, instead of seeking out funding and going through a procurement process, then a tactic could become more feasible.

The *Guidebook on New Software Adoption for Small Transit Agencies* is a key reference for learning more about software options and the level of effort required for their success as well as how to pinpoint available resources from among the project team.

The project table in Guidebook Section 2.3 is also a key reference to better understand the potential effort level of tactics. Though not intended to be an exhaustive resource, the project table reflects the current state of the practice of digital tools for Complete Trip planning as of November 2021. When professionals are considering a certain tactic and are wondering if what they'd like to do has been done before, the project table could illuminate that question.

Substep 2c. Evaluate and rank the tactics according to level of effort

Once a complete list of tactics has been created, the tactics should be compared against each other as "High", "Medium", or "Low" effort. While some tactics will be "High" effort—representing a lot of work and effort—others will require relatively "Low" effort. Making these assessments will be a subjective process involving the project team and user groups. For example, in Substep 2a, the tactic "include barrier-related information within a new trip planner" would likely be "High" effort, but that would depend largely on if the trip planner already enables barrier-related information to be included (most do not), if data on barrier-related information already exists (it is difficult to collect), and what it would take to keep such datasets continually updated and accurate since barriers (e.g., deteriorating sidewalks and missing bike lanes) are constantly in flux. For this step, there are also no right or wrong answers; the project team and user groups can discuss and debate these topics—using analytical tools for a more precise assessment as they see fit—eventually coming to agreement on how to characterize the tactics.

4.3.3 Step 3: Plan for providing digital tools

[98] https://n-catt.org/resources/new-software-adoption-for-small-transit-agencies/

Substep 3a. Consider what should happen in the next 10 years

First, plot the tactics according to the level of effort and impact.

To gain a basic understanding of how the tactics compare, professionals should plot them as shown in the example of Figure 32. On the x-axis, the placement of the dot represents the challenge it seeks to address. The further to the right, the more impactful the challenge. The most impactful challenge, for example, would present an extremely significant barrier. On the y-axis, the placement of the dot represents the effort the tactic requires. The further toward the top, the more effortful the tactic. If a tactic has the potential to address multiple challenges, and its impact varies, estimate the combined impact of the challenges to plot the tactic on the table. In some cases, it can be difficult to consider tactics on a stand-alone basis because the tactics have the potential to reinforce each other—doing one could lay the groundwork for the other, or by combining them they can achieve much more impact than the sum of both. In these cases, a line can be drawn between the dots to show their potential for reinforcement. Further, if together their impact would change, a “ghosted” single tactic could be shown to represent their combined impact (keeping the effort level on par with the highest of the two unless the combination leads to a higher effort level) as shown in Figure 32 (points 3, 4, and 3+4). Once the comparison table has been plotted, it can be used as a planning aid.

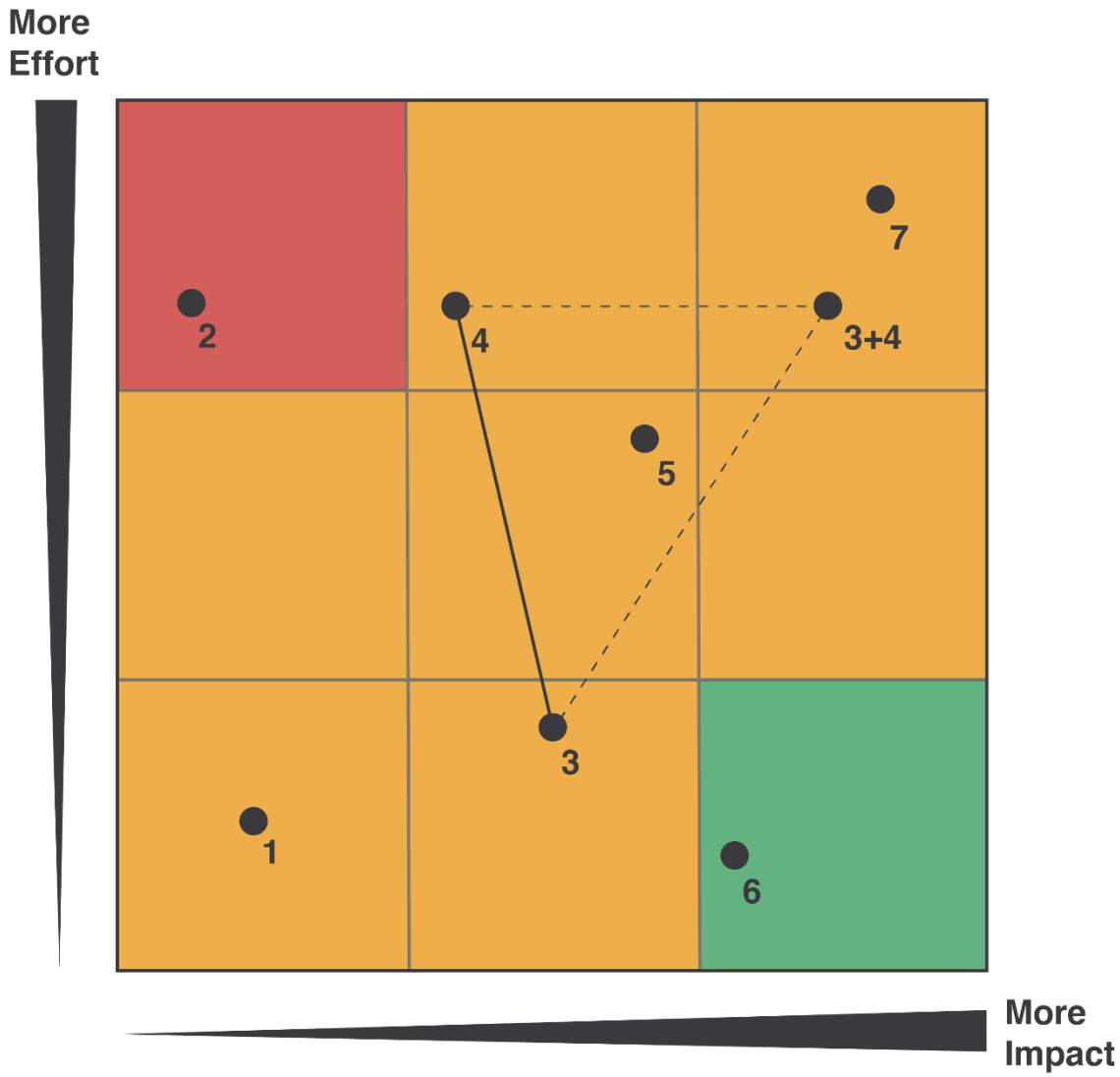


Figure 32

Then, add the tactics to the Complete Trip timeline.
Using the comparison table, a tentative 10-year timeline can be drafted. As shown in Figure 32, of the nine sections, only one is green and one is red. The others are orange. The green section would encompass all the tactics that are High impact and Low effort; in general, these tactics would make sense to implement. The red section would encompass all the tactics that are Low impact and High effort; in general, it would not make sense to implement these tactics. The interpretation of the remaining seven sections, in orange, is at the discretion of each project team. For example, some teams might find tactics that are in the middle of the table, those that are Medium impact and Medium effort, reasonable to pursue; other project teams may see this very differently.

Tactics that are High impact and High effort may make sense to pursue, at least in the longer term, since they can address major barriers. Tactics that are Low impact, regardless of if their effort level is Low or Medium should be assessed individually to decide if they are worth pursuing—even low effort tactics can reduce the overall bandwidth to take on more impactful and important efforts.

Each tactic should be added to the timeline as shown in the example in Figure 33. Those in the green section would typically be placed in the early years of the timeline, while those in the red section would be removed. The tactics in the orange section can be placed on the timeline, relative to an estimate of when they could be completed; they can also be removed at the discretion of the project team. The timeline is a simple approximation of what should happen when—representing basic draft ideas. Notes can be included and lines can be drawn between the tactics to help add on additional layers of information the project team finds helpful.

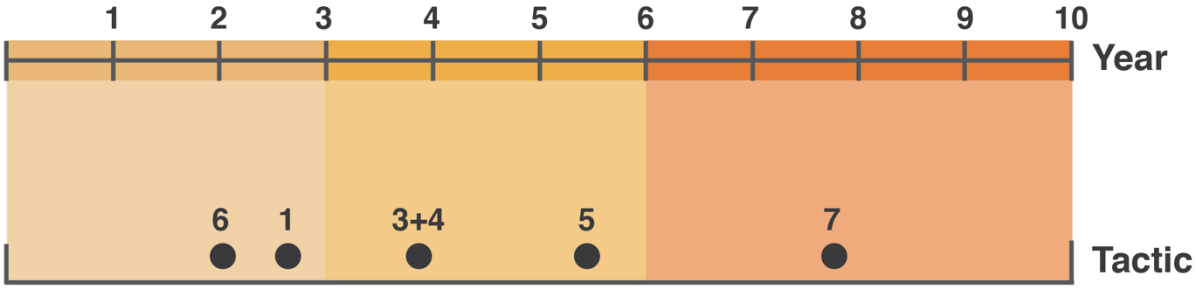


Figure 33

Substep 3b. Identify supportive infrastructure needed for the next 10 years

After Substep 3a is complete, it is time for the project team to look at the big picture and consider the supportive infrastructure—the physical, service, and governance infrastructure—that will be needed not only for separate tactics but for the effort as a whole. Each infrastructure element should be added generally where it is likely needed within the overall time frame as shown in Figure 34; for example, perhaps some elements should be up and running prior to a certain tactic being implemented. It is typical that an infrastructure element could support multiple tactics at once. If helpful, the tactic numbers can be noted beside the infrastructure elements to keep them connected.

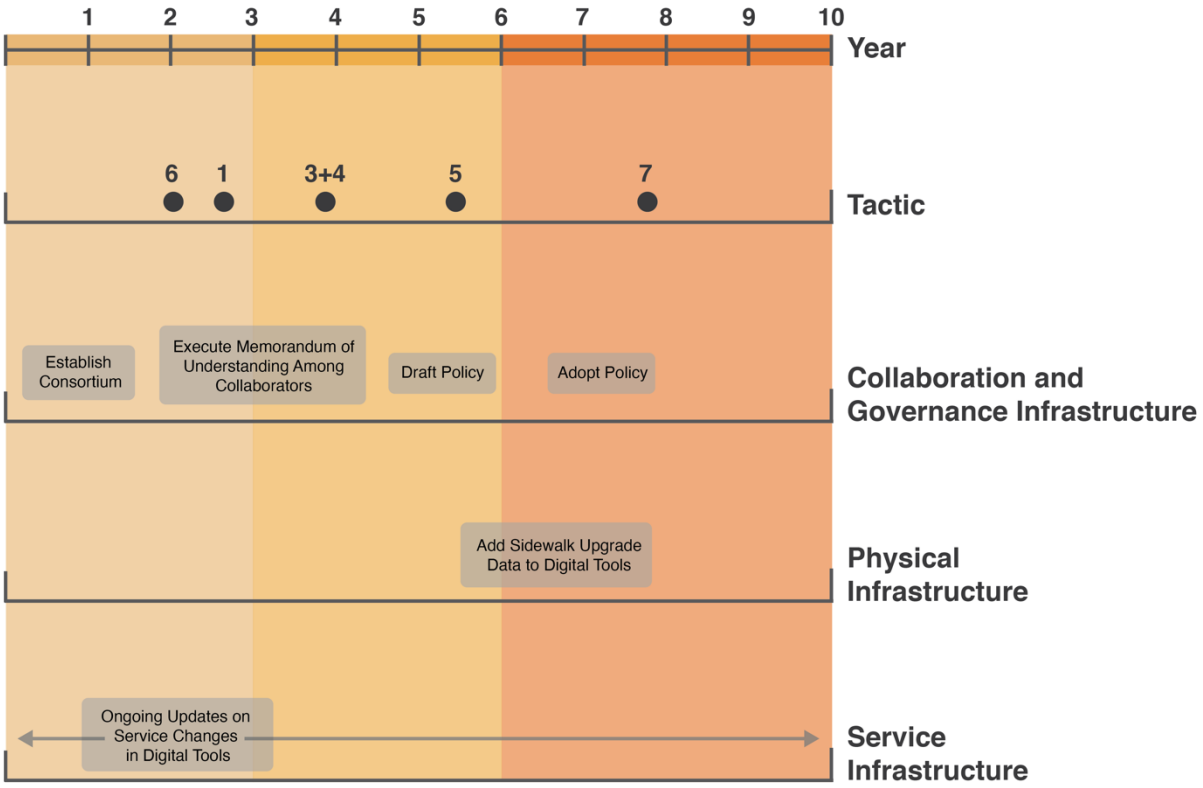


Figure 34

Substep 3c. Confirm what will be done in the first 3 years and how it will be implemented

First, establish the general direction of the first three years through exploratory questions.

Substeps 3a and 3b helped generate a rough idea of what the effort might include over the ten-year horizon. At this point in the planning process, a closer look is called for into the first three years. The draft generated during Substeps 3a and 3b should be used as a start, but the project team can look at this more closely for the near-term effort. To decide if the tactics and supportive infrastructure listed are what should be pursued, the project team should consider the following questions:

- What is the reinforcement potential for the tactics listed for the first 3 years? The reinforcement potential refers to the way the tactics build upon each other to have a more significant impact as a set rather than separately. If the reinforcement potential is Low, but that is true for most/all of the tactics, that means the tactics are largely stand-alone tactics. If the reinforcement potential is Low, but moving a few years out on the timeline starts to gain some traction, it may be worth detailing the tactics on a five-year basis instead of three years—that would still be in the near term while allowing for some benefits of combining the efforts. By the end of discussing and debating this question, the project team should have agreed to keep the tactics as shown or revise them, including

revising the time horizon as needed for the near term (around three to five years).

- Once the tactics have been agreed upon, are all the supportive infrastructure elements that are needed included in the draft for the agreed upon time horizon? If not, but the elements are included in the timeline at a later point in time, then they can slide over to an earlier time in the near term. If not, but the elements are not included in the draft at all, they should be added. At the end of this discussion, the project team should determine the supportive infrastructure elements that will be needed for the near term.

Then, establish the specifics for the first three years through a project management plan.

After the previous discussions have confirmed "what" will be done, the question becomes "how" will it be done? This will generally involve sorting through the issues of who to involve, the roles each organization/individual will have, what tasks and subtasks need to be completed, and when certain milestones should be met. The person supporting the project management role would help guide the project team in creating a project management plan, which could be created in excel or a software specifically designed for task and project management. If a procurement process is required, a set of procurement tasks would be included within the plan. More details on this can be found in N-CATT's "Procurement Playbook."[99] Creating a realistic and well-detailed project management plan is a major task, and the project team may need to gather additional information to be able to compete it.

For background reading on "how to move forward with a software product" see chapter 3 of the *Guidebook on New Software Adoption for Small Transit Agencies* which includes a "series of 7 steps that need to be navigated from the time when the agency decides it wishes to acquire new software until the point when the software becomes operational for the agency, enabling them to move forward with a software product."[100] These steps include:

- Step 3a. Determine What Type of Software Your Agency Needs
- Step 3b. Understand Your Available Software Choices
- Step 3c. Determine Whether to Obtain a SaaS System or a Licensed Software Product
- Step 3d. Determine Your Core Requirements for the Software
- Step 3e. Develop the Request for Proposals
- Step 3f. Evaluate the Proposals and Select the Most Appropriate Software Product
- Step 3g. Begin the Software Implementation Process

For additional reading on how to "support the software," see Chapter 4 of the same resource. The steps include:

[99] https://n-catt.org/resources/technology-procurement-playbook/
[100] https://n-catt.org/resources/new-software-adoption-for-small-transit-agencies/

- Step 4a. Plan for One-Time Software Setup and Training
- Step 4b. Prepare for Ongoing Support Needs
- Step 4c. Consider Additional Support as the Software Scope Expands

Once the roles, tasks, and milestones are clear for the time horizon (typically 3-5 years), implementation can begin.

4.3.4 Next Steps

After Step 3 has been completed, implementation can begin by following the project management plan for the time horizon specified. Throughout the implementation process, the project team should consider any major changes that affect the effort and adjust plans as necessary. It is important to make sure the project management plan includes user involvement activities that will take place during the implementation process as well. This would largely be focused on two efforts; the first would be gaining input on the selection of digital tools, reviewing mock-ups and wireframes of specific tools that are being considered, for example, to narrow in on products that would address the challenges adequately. Second, they would provide user feedback during the beta testing process; such an activity would result in identifying the details of the digital tool that need refinement to make the public release of the tool ready for prime time.

Since the overall effort is designed with a ten-year horizon in mind, at some point the project team may be ready for the next phase of the effort, for example moving from years 1-3 to years 4-6 as shown in Figure 35. The planning for “phase 2” can even begin during the implementation of Phase 1. When the project planning work begins for Phase 2, the draft materials from Substeps 3a and 3b can be used as a starting point. Many of the inputs and details would likely have changed, so significant revisions are probably required. Nonetheless, Substeps 3a and 3b provide a starting point, and if the project team is still comprised of most of the same members, the institutional knowledge—based on the group having completed this exercise before—will be very helpful.

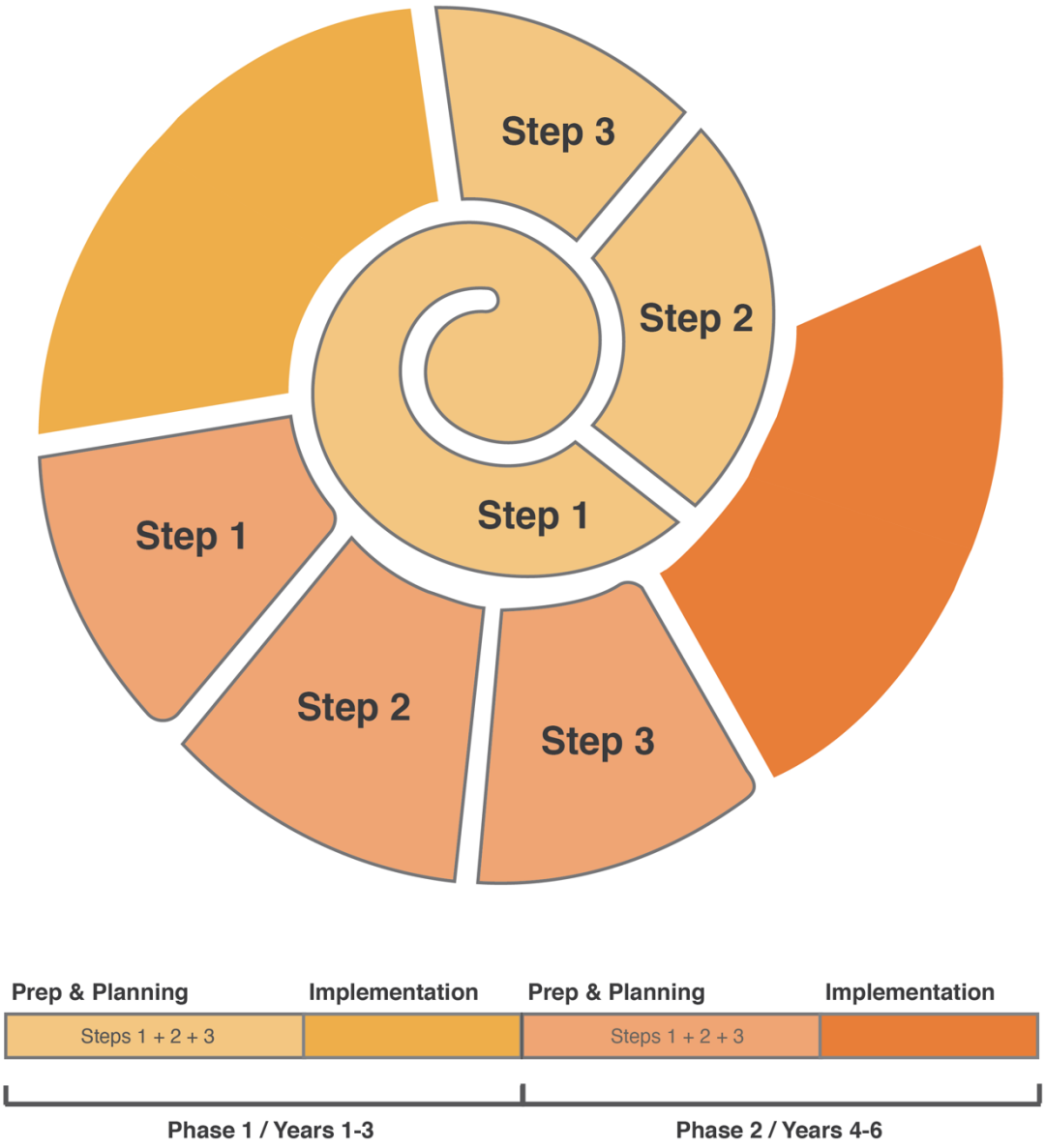

Step 3
Step 2
Step 1
Step 1
Step 2
Step 3
Prep & Planning
Implementation
Prep & Planning
Implementation
Steps 1 + 2 + 3
Steps 1 + 2 + 3
Phase 1 / Years 1-3
Phase 2 / Years 4-6

Figure 35

Appendix: Worksheets

The worksheets help leverage what was learned through Chapters 1, 2, and 3 and apply the knowledge to the action steps provided in Chapter 4. These worksheets can be completed as a group, the project team for example, or by individual professionals. The purpose of the worksheets is to help apply the information in the Guidebook to the unique situations of professionals—resulting in basic guidance for how to go about providing digital tools for Complete Trip planning.

Part I: Preparing for Steps 1-3

Answer the questions below to the best of your ability. If an answer is unknown on the first pass, pause and collect information and/or discuss the question with colleagues, then attempt to answer the question again.

Step 1: Clarify challenges related to digital tools for the Complete Trip

- Who are the likely stakeholders (including end users) for the project?
- Who will the project manager likely be?
- What are some commonly known end-to-end journeys in your project team's area? Draft a set of journey diagrams as shown in Section 1.2. Note the digital tool components such as trip planning, booking, payment, and navigation that are likely within the journey segments as shown in Section 4.3.1.
- What might some digital challenges along those end-to-end journeys be?
- Who is likely to experience these challenges? Which individuals or groups?
- How impactful are these challenges?

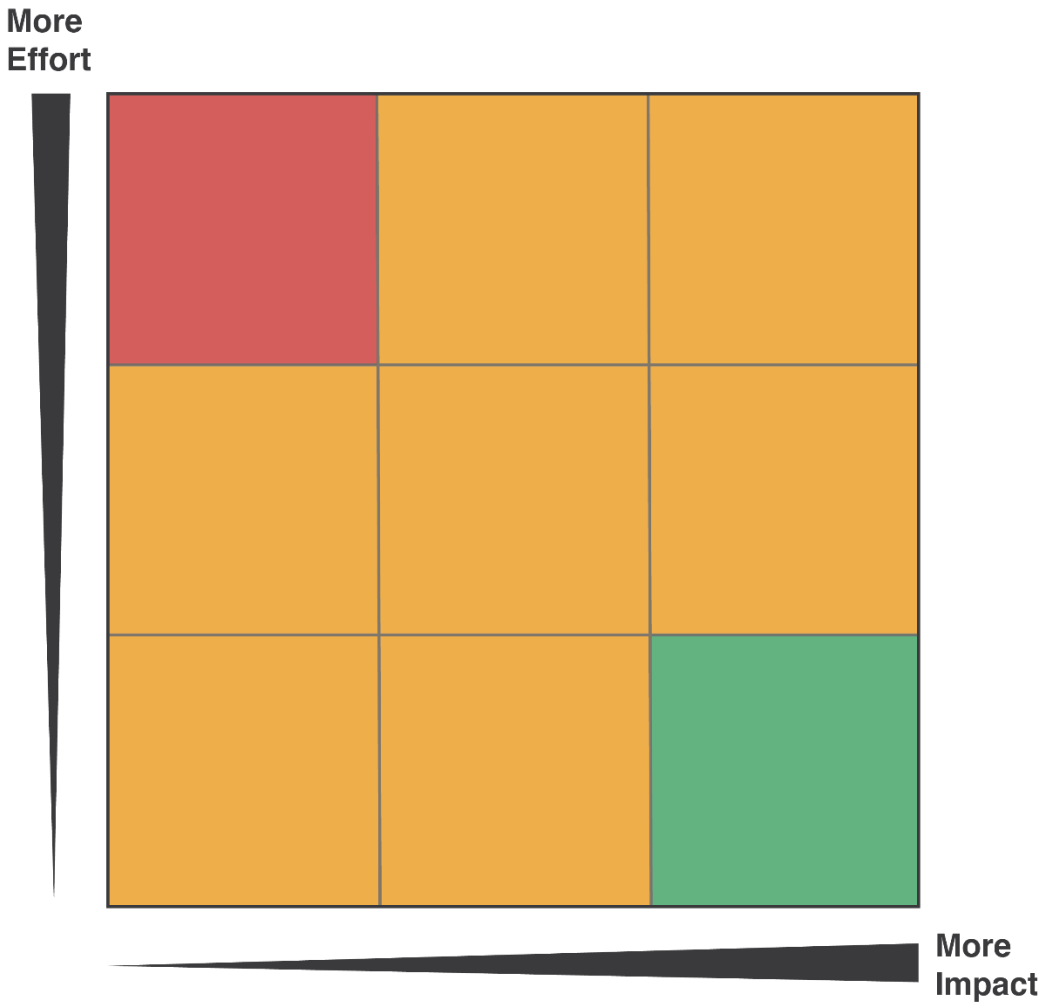
Step 2: Consider potential tactics to address digital challenges

- What are some potential tactics that could help address the identified challenges?
- What factors might impact the level of effort for these tactics?
- Which software option is more likely: commercial off-the-shelf (COTS), open source/public domain, or custom software?
- What types of available resources might be brought to bear on the project, provided by your organization? And from partner organizations?
- What projects covered in the Guidebook as "highlighted projects" or in the project table in Section 2.3 can be used as relevant examples?
- Which tactics are High effort? Medium effort? Low effort?

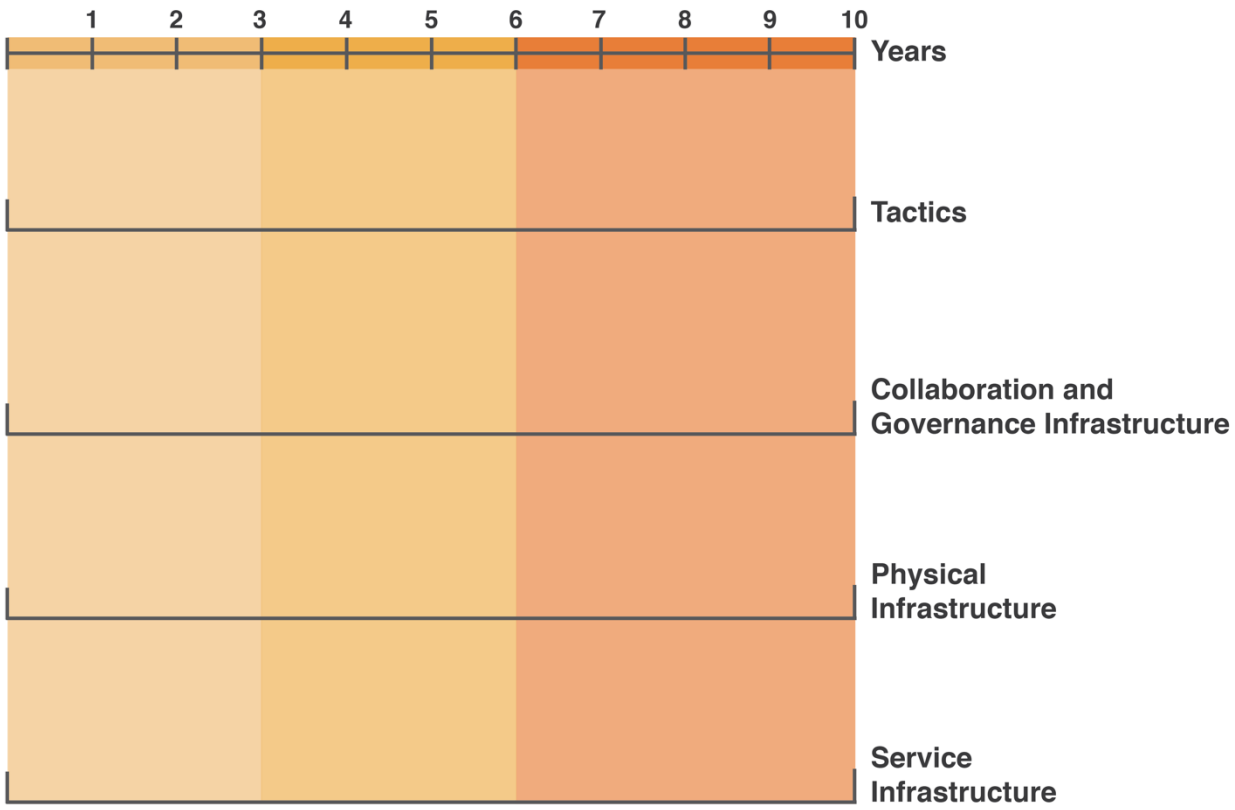
Step 3: Plan for providing digital tools

- Plot your tactics in the "tactic comparison table" below according to level of effort and impact.
- Add your tactics to the "planning timeline" below according to the estimated date of completion.
- Add your ideas for supportive infrastructure below to the "planning timeline."
- Which tactics have significant "reinforcement potential" during the next 3 to 5 years?

- Revise the timeline and supportive infrastructure as needed based on the reinforcement potential of the tactics.
- Consider and discuss plans to begin work on a project management plan for the first phase of the project, typically for a three- or five-year horizon.



Tactic Comparison Table



Planning Timeline

Part II: Planning Effort Checklist

Once the 10-year general timeline is ready, the project team should check if the "guidelines for improving the Complete Trip through digital tools" from Chapter 4 are being followed. If not, adjustments should be made to the general timeline. Some of the items below relate more to the project management plan that will be created later, rather than the 10-year general timeline. In such cases, make notes about what to ensure is included in the project management plan.

- **Complete information:** Will the planned digital tools display the most complete information possible, even if that means providing multiple tools—including the full range of modes and all the information on personal requirements that users may need?
    - If so, how will this be integrated?
    - If not, what is missing, and how might it be better addressed in the short or long term?
- **Accessibility:** Will all users be able to access the planned digital tools?
    - If so, how can this be determined?

    - If not, how can this be rectified?
- **Intermodal options**: Will the planned digital tools give special attention to intermodal options and the transfers that are required?
    - If so, how have transfers been addressed?
    - If not, revisit the tools through the lens of intermodal options.
- **Connected plan, book, pay, and navigation steps:** Have these typical steps been considered for the planned digital tools?
    - If so, how are they addressed?
    - If not, how can they be considered?
- **Ability to update status of services and physical infrastructure:** Will the status of physical and service infrastructure be reflected within the planned digital tools?
    - If so, how will this be reflected?
    - If not, how can it be reflected?
- **Foundation for collaboration and governance:** Has the longer-term strategy for the planned digital tools included the collaboration and governance setup requirements to ensure success over time?
    - If so, how has this been reflected?
    - If not, how can it be reflected?
- **Holistic approach to digital and mental calculations:** Has the complete user experience been considered, aligning the planned digital tools with the necessary mental calculations that will occur in tandem?
    - If so, how has this been designed?
    - If not, how can the design be improved?
- **Customer experience focus:** Has thorough input from transit and mobility system users been included in the planning effort, early on to help determine the best path forward and later to assess the usability and functionality of the planned digital tools?
    - If so, how has this been included?
    - If not, what should be included?