U.S. Department of Transportation, Climate Change Center
Climate Strategies that Work

# TRIP PLANNING TOOLS AND MODAL INTEGRATION

*By integrating travel mode information in real-time, trip planning tools facilitate faster, more connected trips and promote multimodal transport options, providing users with greater convenience and cost savings and reducing vehicle congestion and emissions.*

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# OVERVIEW

**Best Suited for:**
Long Term
Urban, Suburban, Rural & Tribal

**Trip planning tools can provide a range of information for multimodal travelers,** such as maps, routes, schedules, fares, and real-time arrival and departure information through websites, mobile phones, and other handheld devices with GPS location capabilities. These tools can also guide users toward time-saving or efficient routes and provide additional services such as payment of transit and taxi fares, bikes rentals, and parking.


(Source: CalITP)

In cities designed with multimodal options of travel, including walking, biking, rolling, and transit, **trip planning tools can plan routes integrating multiple modes to reach destinations according to preferences, accessibility needs, timing, and cost-efficiency.** For example, a trip planning mobile app can guide a traveler to their destination, which could include walking to an e-bike station, riding the e-bike to a bus stop, waiting in a safe and covered shelter, and reaching the destination by bus in time. Trip planning tools can also facilitate awareness of and access to multimodal transportation options.

## *Did you know?*

The first transit agency to implement a multimodal trip planner with integrated walking, cycling, and transit journeys is in Portland, Oregon. The Trimet Trip Planner includes features such as an elevation chart for cycling preferences and locations of carshare options.

**Trip planning and modal integration tools increasingly rely on vehicle-to-infrastructure (V2I) technologies for real-time, multi-modal data.** V2I is a type of intelligent transportation system (ITS) that can wirelessly provide information to drivers related to safety, mobility, or environmental conditions. V2I technologies use vehicle-generated traffic data to produce information, enabling communication between road systems and vehicles. V2I-based tools allow for more precise and convenient multi-modal planning, reducing traveler reliance on single occupancy vehicles and other high GHG emitting transportation sources.

*See the U.S. Department of Transportation's ITS Joint Program Office website for more information about recent V2I deployments, including trip planning tools.*

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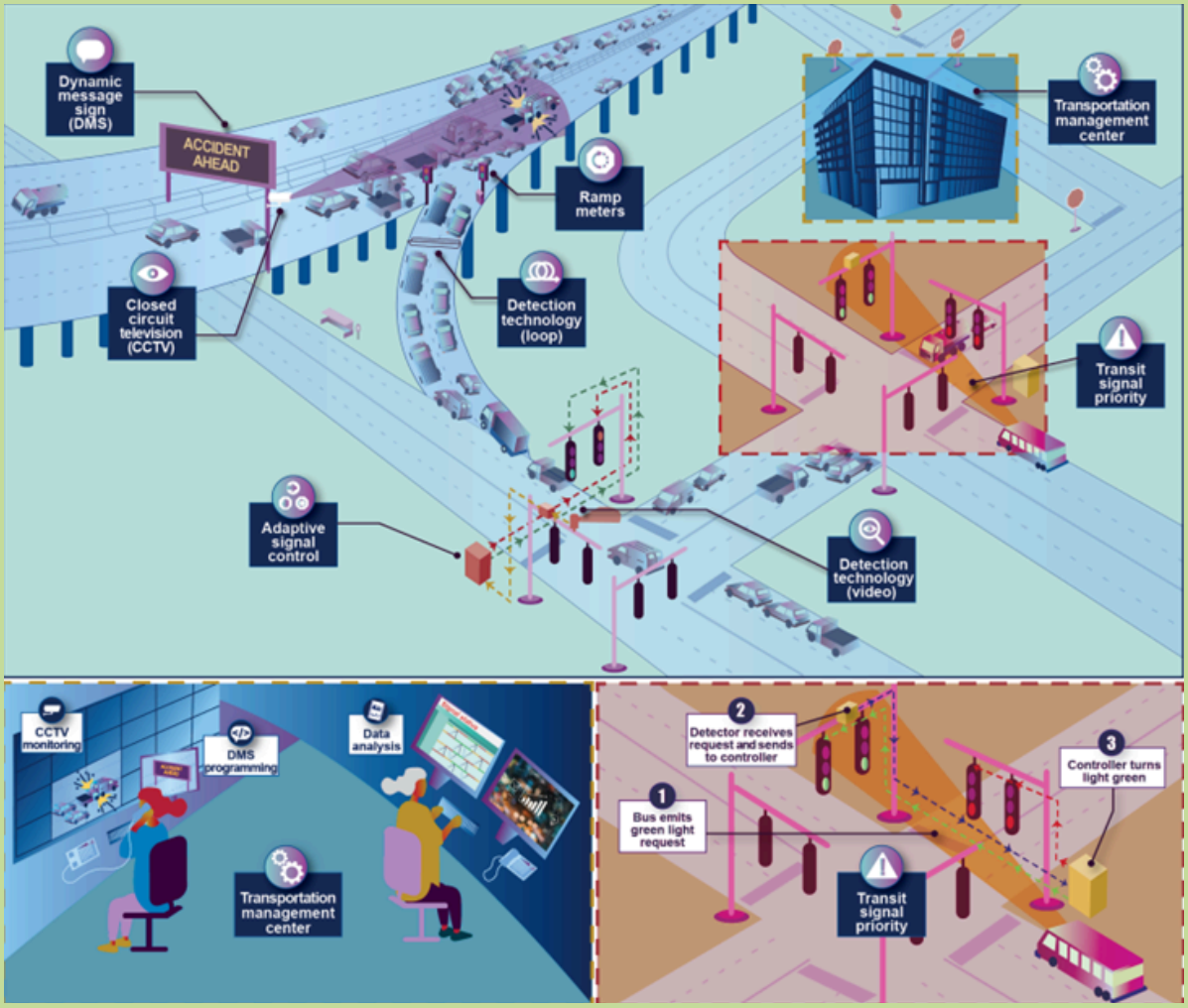
### *Connected Vehicles and V2I:*

V2I technologies support information exchange between vehicles and roadway infrastructure (GAO, 2023). They can provide routing and passenger information from vehicles to agencies and vice versa for all road users related to safety issues and traffic information (Lee et al., 2016). V2I can be incorporated in transit apps or other trip planning tools to enhance routing capabilities and ensure the most up-to-date information is available.




The image is an example of ITS in action in a metropolitan area to improve transportation management. The integrated system includes the technologies in place as well as a management center for monitoring, programming, and data analysis. Transit signal priority technology is featured, in which (1) a bus emits a green light (2) the light is detected and sent to a traffic signal controller and (3) the traffic signal controller sends a command to turn the light green (Source: GAO, 2023).

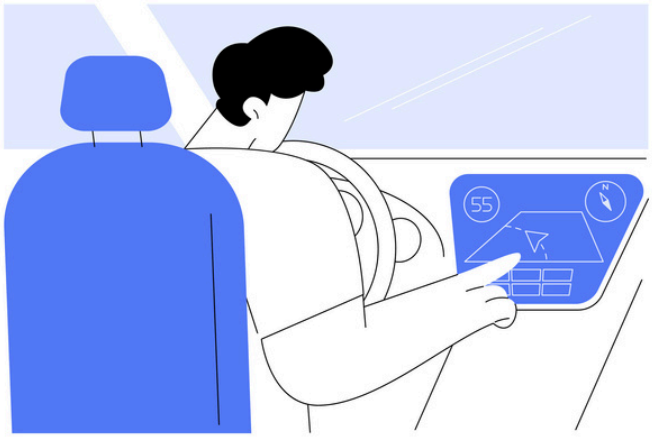
# GREENHOUSE GAS REDUCTION POTENTIAL

*This section provides an overview of greenhouse gas (GHG) emission reductions associated with the strategy. It highlights key findings and relevant metrics from GHG modeling resources, peer-reviewed studies, and real-world applications.*

## GHG EMISSIONS BENEFITS OF TRIP PLANNING TOOLS

Providing travelers with information about more accessible, convenient routes through multimodal navigation tools can lead to increased use of alternative modes and reduced vehicle travel (VTPI, 2016).

- A study of employee commutes found that providing high quality navigation tools reduced vehicle use by 17% with shifts to walking, cycling, and transit modes. The study noted that the effectiveness of the planning tool depended on the quality of alternative modes available, conditions, and the availability of adequate information (RTA, 2003; VTPI, 2016).
- Researchers for a pilot program in a metropolitan area of Japan developed a travel planning system to help commuters choose routes with fewer carbon emissions. The program encouraged users to switch use of cars with public transportation, walking, or cycling. Using the tool, participants produced 20% fewer greenhouse gas emissions; decreased car use by 20%; increased walking and bicycling by 82%; and increased use of public transportation by 103% (Usui et al., 2008).

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## SPOTLIGHT ON V2I TECHNOLOGIES

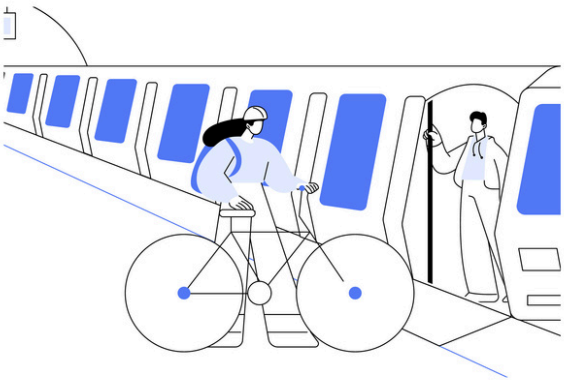
V2I can reduce trip time, congestion, and idling by providing real-time travel advisories and up to date roadway information for drivers to find alternate routes. The reduction of trip time, congestion, and idling can improve air quality and reduce greenhouse gas emissions (USDOT, 2022).

A study comparing the traffic safety and carbon dioxide emissions reduction of vehicle-to-vehicle (V2V) and V2I technology suggests these technologies can support GHG emissions reduction by approximately 5% for a density of 3000 vehicles/hour. Vehicles in the analysis included standard vehicles, slow vehicles, and trucks. The study noted the technology alert systems create vehicle speed harmonization, which reduces starts and stops as well as fuel emissions (Outay et al., 2019).

## TRIP PLANNERS CAN ENCOURAGE MODAL SHIFT

Trip planning tools with modal integration encourage the use of alternative modes of travel, which can help reduce vehicle congestion.

An evaluation and survey of a multimodal trip planning tool, Multimodal Trip Planning System (MMPTS), based in Chicago, found that the tool helped new residents learn about and navigate the local transportation system (Biernbaum et al., 2011). The survey results showed a significant percentage of overall respondents (close to 40%) noted that the tool helped them use at least one new transit service. Around 50% of suburban respondents reported the same (Biernbaum et al., 2011).



# CO-BENEFITS

*This section outlines the multiple co-benefits associated with the strategy, including safety benefits, local air quality improvements, and improved accessibility. Each co-benefit presents examples that demonstrate how the strategy enhances regional or community well-being while addressing emissions.*

## SAFETY

Trip planning and modal integration can encourage the use of active transportation and public transit. Communities designed with pedestrians, transit riders, bicyclists, and other micromobility users in mind can reduce the incidence of collisions, injuries, and fatalities on shared roadways (Litman, 2024a).

Investment in active transportation can promote the perception and reality of safety. Safe and comfortable walking and biking infrastructure can also reduce the likelihood of vehicle-pedestrian and vehicle-bicycle fatalities and serious injuries (Boutros et al., 2023).

## AIR QUALITY AND HEALTH

Reducing the number of emissions-emitting vehicles on the road (especially in densely populated areas) will decrease air pollutants that are harmful to human health. Trip planning tools can facilitate the use of alternative travel modes to support reduction of high emissions-emitting vehicles (Litman, 2024b).

## RURAL COMMUNITIES

Trip planning tools are extending toward rural communities. Vermont and Minnesota have developed initiatives to bring trip planning tools to connect travelers to public transportation in rural areas, where previous investment has been lacking. In Vermont, the rural trip planning tool has seen a significant amount of usage with close to 20% of users planning transit trips involving walking, biking, and carpool and vanpool-matching between 2022-2023. The initiatives in Minnesota and Vermont are federally funded through the Accelerating Innovative Mobility Project and Mobility on Demand Sandbox grant, respectively (Pan, 2024).

## COST SAVINGS

Trip planning and modal integration can increase awareness and utilization of public transit, which can lead to improved farebox recovery ratios. (*Farebox recovery is the percentage of operating costs recovered by transit passenger fares.)* Increased ridership is one way transit agencies can recover

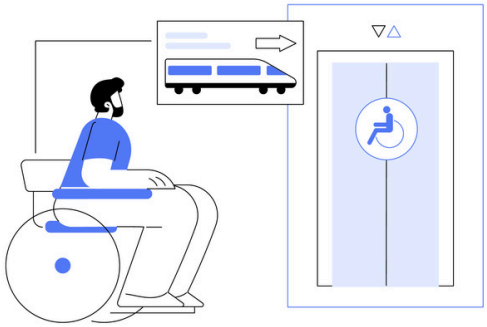
a higher percentage of operating costs (FTA, 2013).

Trip planning can result in traveler time and cost savings.

A study in Washington, DC simulated roadway travel trips with and without a pre-trip notification service that assisted in on-time arrivals. Using a framework to calculate the cost value of the time savings with on-time arrivals, travelers using the service received a net benefit of approximately $60 or more per year (Shah et al., 2003).

## ECONOMIC GROWTH

Trip planning tools can facilitate awareness of and access to multimodal transportation options which also means more access to job and education centers, leading to economic opportunities. Increased use of public transit and associated foot traffic is also beneficial for small businesses near transit stations (USDOT, 2015).



A study in Phoenix, AZ examined the impact of the opening of a public transit light rail system on the start of new independent businesses in the vicinity. Over a 24 year period, the area had an 88% increase in new business starts in the knowledge sector, a 40% increase in the service sector, and a 28% increase in the retail sector. The study also noted these businesses were located mainly within a quarter mile of transit stations, with a significant decrease in new business starts 1 mile away from the transit stations (Credit, 2018).

## ACCESSIBILITY AND EQUITY

Trip planning tools allow users to better access transportation modes around them. Access to mobility options increases access to job opportunities, education, and everyday destinations for those who cannot or do not drive, especially the elderly, disabled, youth, and people living in lower-income communities.

A study in Phoenix, AZ of the piloted Pass2Go smartphone app showed that out of 332 participants, 74% of users in the study reported the app improved access to public transportation. Out of the 24 study participants using the app's accessibility features, 75% rated the app 7/10 or higher, with 11 of those users with disabilities rating the app

8/10 or higher. The pilot is part of the FTA Mobility on Demand Sandbox program (Martin et al., 2020).

Active and public transportation are linked to decreased loneliness, increased access to family and friends, and greater levels of socialization (Williams et al., 2021; Litman, 2024b).

Accessibility is an important consideration to include in trip planning tools, as people with disabilities using the tools may need to consider various accessibility options, such as text-to-speech and American with Disabilities Act (ADA) infrastructural features. To support accessible commutes, trip planning tools can highlight features such as kneeling buses, curb ramps, elevators to station platforms, and communication signals for information and safety (Breitenbach, 2022).

A 2021 study developed a pedestrian wayfinding mobile application to assist people with disabilities to safely use and access sidewalks and pedestrian pathways. The study used feedback from users to develop and design the app, finding that "accessible entrances" was the top feature selected by wheelchair users (Singara, 2020).

Access or means to use the trip planning tools is an important equity consideration. Disadvantaged populations may lack access to smartphone technology or have limited internet connections to support trip planning apps. Low income populations may not have access to credit cards to pay electronically through multimodal planning apps (Breitenbach, 2022). To address this, agencies can consider access to trip planning tools by offering offline options and alternative payment methods.

Providing more travel options to users through trip planning tools can benefit those without vehicles or people with disabilities, leading to safer, more convenient, and accessible travel (VTPI, 2016).

Findings from a 2022 Mobility Assistance for People with Cognitive Disabilities (MAPCD) study show that a wayfinding smartphone application with advanced accessibility features helped participants with cognitive disabilities navigate fixed-route buses independently. Around 87% of participants reported increased ability to use fixed-route buses more independently using the app, with its assistance in addressing barriers such as missing on-board announcements and navigating public transit systems (City of Columbus, 2021).

# COST CONSIDERATIONS

The cost to implement trip planning tools varies widely depending on scale, scope, and location of the project.

Depending on the customization, software, and consolidation of data feeds, the initial development of multimodal trip planning tools can cost between $138,000 to $4 million on average (Biernbaum et al., 2011).

Trip planning tools can be developed and implemented in a variety of ways, depending on the needs of an organization, budget, and preferences. Options for cost effective open source resources further provide ease of implementation. The following are examples of open source software and services available for use by agencies and organizations to support trip planning and modal integration tools.

**OpenTripPlanner** is a multimodal open source trip planning software providing passenger information and transportation network analysis services. The software has an active community of developers supporting the system and keeping it up to date.

The Oregon TriMet system uses an open-source software, OpenTripPlanner, as part of its trip planner website. Integrating the open-source software cost $69,000 for the initial developer time investment and another $69,000 for the routing engine and interface (Biernbaum et al., 2011).

**GraphHopper** offers open source services to calculate routing such as distance, time, turn-by-turn instructions, and other route characteristics. It also offers a toolkit for solving vehicle routing problems through the tool jsprit.

Costs can be reduced if an organization has access to consolidated standardized databases and access to data feeds. Further reduction in costs results from the use of open-source software and data feeds.

Trip planning tools involve development and maintenance costs. Transit authorities typically must maintain static and regional data feeds, requiring investment in a general transit feed specification (GTFS). Annual maintenance costs are around 35% of the creation costs (Biernbaum et al., 2011).

- Costs for GFTS can vary depending on fare collection systems, difficult location stops, and other challenges.
- The labor required for the GTFS ranges from about 12 hours to 2 months, depending on existing database quality and compatibility of the operations scheduling software. Regional feeds have higher costs, particularly if they include multiple data feeds (Biernbaum et al., 2011).

Integrating V2I communication into roadside infrastructure has variable costs to implement and maintain. Infrastructure needed include wireless roadside units (RSU), backhaul telecommunications infrastructure, a Security Credential Management System for privacy-protected exchange of information, back office maintenance, and system monitoring and maintenance. Costs for each of these components vary by location, complexity, and scale. For example, RSU hardware can range from $900 to $8,226 per RSU, with design, integration, and testing costs in the range of $1,000 per RSU for installation and $101,000 for verification of 47 RSUs (NASEM, 2020).

# FUNDING OPPORTUNITIES

**Federal Highway Administration (FHWA) Flexible Funds:** In addition to FTA grant programs, certain funding programs administered by FHWA, including the Surface Transportation Block Grant (STBG) Program and the Congestion Mitigation and Air Quality Improvement (CMAQ) Program, may be used for public transportation purposes. These "flexible" funds are transferred from FHWA and administered as FTA funding, taking on the requirements and eligibility of the FTA program to which they are transferred. See 49 USC 5334(i) and FRA's Join Development Circular for more detail.

FHWA's **Congestion Mitigation and Air Quality Improvement (CMAQ) Program** supports surface transportation projects and other related efforts that contribute air quality improvements and provide congestion relief. CMAQ provides funding for V2I/ITS technologies, including travel advisories.

FHWA's **Advanced Transportation and Innovative Mobility Development (ATTIMD)/Advanced Transportation Technology and Innovation (ATTAIN)** ATTAIN and ATTIMD support programs support the deployment, installation, and operation of advanced transportation technologies. Eligible activities under this program that advance transportation system efficiency include implementing technology to integration of transportation service payment systems and implanting advanced mobility access and on-demand transportation service technologies.

USDOT's **Strengthening Mobility and Revolutionizing Transportation (SMART) Grants Program** provides grants to eligible public sector agencies to conduct demonstration projects focused on advanced smart community technologies and systems in order to improve transportation efficiency and safety. Eligible projects include connected vehicles, aviation innovation, smart grid, and traffic signal innovation.

FHWA's **Saving Lives with Connectivity: Accelerating V2X Deployment** grant program will fund projects that advance connected and interoperable vehicle technologies. Connected and interoperable vehicle technologies have the potential to greatly reduce motor vehicle crashes and resultant fatalities, injuries and property damage.

DOE's **New Mobility Systems** funding supports cooperative driving automation (CDA) in vehicles enabled by low-cost infrastructure upgrades or novel applications.

DOE's **ARPA-E NEXTCAR Program** supports research to enable technologies that use connectivity and automation to co-optimize vehicle dynamic controls and powertrain operation, thereby reducing energy consumption of the vehicle. These technologies have the potential to reduce congestion and increase the safety and efficiency of travel on roadways.

FHWA's **Exploratory Advanced Research (EAR) Program** is exploring the development of artificial intelligence (AI) and machine learning technology within the surface transportation sector. The EAR program has also funded several computer vision research projects to enhance the safety and efficiency of surface transportation.

USDOT offers grant funding to enhance intermodal efficiency through several programs, including the **Reduction of Truck Emissions at Port Facilities Grant Program**, the **National Highway Freight Program (NHFP)**, and the **Accelerated Innovation Deployment Demonstration Program**.

# COMPLEMENTARY STRATEGIES


Supporting low carbon trip planning and modal integration requires the availability of multimodal options for travelers to be able to use and plan connected trips that are not reliant on single occupancy vehicles. Coordinated transportation planning can support the vision of a network of connected transport and transit options for efficient and convenient travel by ensuring different modes are coordinated and planned effectively with lower carbon options.


TOD and trip planning and modal integration are closely linked. TOD facilitates trip planning by providing easy access to transit options. Trip planning and modal integration can be attractive to TOD residents and visitors, allowing them to easily plan trips using digital, real-time trip planning tools and apps, while knowing that stations are conveniently located and well-connected to their destinations.


By integrating transit and providing travelers with the trip planning and modal integration tools they need to plan their journeys effectively, communities can encourage more people to use public transportation.

**View All Strategies**

# CASE STUDIES

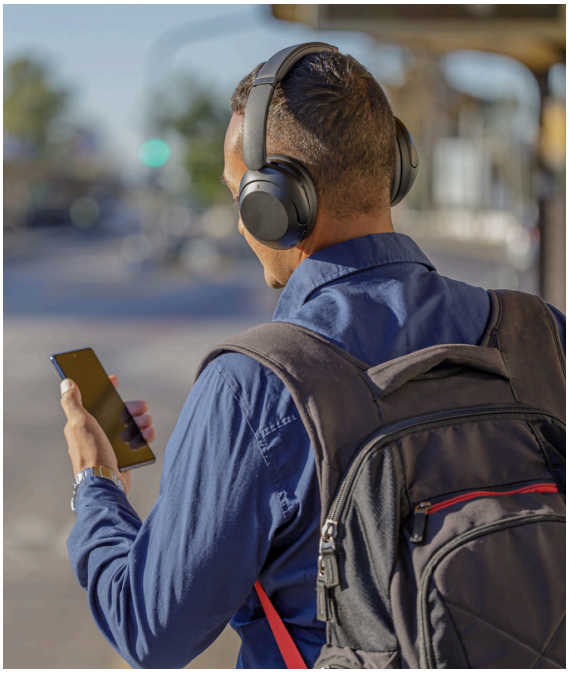
## MONTGOMERY COUNTY, MD DOT RIDE ON TRIP PLANNING APP

Montgomery County launched the Ride On Trip Planner App allowing travelers to plan routes in advance and track buses in real time. The app was released alongside efforts to increase accessibility and adjust services based on ridership, among other initiatives, to make the transit network faster. Increased bus ridership is part of the county's 2023 climate goal.


(Source: Montgomery County DOT)

## COLUMBUS, OH MULTIMODAL TRIP PLANNING APP

Columbus, OH developed a multimodal trip planning app for residents to access a range of travel options. The Pivot app allows residents to find the best way to a destination and book payments for the services across transport modes of walking, public transit, ridehailing, bike and ride sharing, vehicles, and biking. The app aims to reduce vehicle traffic, increase access to multimodal transportation, and reduce reliance on vehicle travel, in turn reducing congestion and emissions.



## CALIFORNIA INTEGRATED TRAVEL PROJECT (CALITP)

The California Integrated Travel Project (CalITP) is a travel integration tool bringing the payment systems of hundreds of public transit providers across the State of California into one app. By simplifying the payment structure, CalITP makes it easier for travelers to use more carbon efficient modes of transportation, reduces transit agency operating costs, and provides a user-friendly system to make travel by transit quicker and more efficient.

# SFMTA MULTIMODAL TRIP PLANNING TOOL AND ASSISTANCE

The San Francisco Municipal Transportation Agency (SFMTA) has a multimodal trip planning tool incorporating public transit, walking, biking, drive and park, and taxi travel modes, with a range of accessibility features. To assist travelers, especially older adults and people with disabilities, in using the tool and planning trips, SFMTA provides free, pre-scheduled individual and group travel training sessions. The training sessions can include sharing recommendations for navigating multimodal trips, providing lessons on accessing accessibility features, offering practice riding public transit with a travel assistant, and improving skills and confidence to use multiple modes of transportation (SFMTA, 2013).

# IMPLEMENTING TRIP PLANNING TOOLS AND MODAL INTEGRATION: **WHAT TO READ NEXT**

The U.S. DOT Intelligent Transportation Systems Professional Capacity Building Program provides a range of resources, such as trainings, webinars, peer exchanges, and academic resources on ITS, including resources on connected vehicle deployment and third party transit information and trip planning.

The U.S. DOT Intelligent Transportation Systems Joint Office Program offers several publications and information on V2I deployment, analysis, safety, and licensing.

FHWA's Integrating Shared Mobility into Multimodal Transportation Planning: Improving Regional Performance to Meet Public Goals is a framework transportation agencies, local governments, and MPOs can plan to integrate multimodal transportation practices, and can lay the groundwork for trip planning tools to then be developed and implemented.

Guide to Licensing Dedicated Short Range Communications for Road Side Units is a resource with best practices and information on licensing requirements for organizations seeking services to support V2I applications.

# RESOURCES

## GENERAL RESOURCES

FTA National Transit Database (NTD): FTA requires transit agencies to upload financial, operational, and asset conditions data to the NTD on an annual basis. The publicly available NTD provides data to inform decision making at all government levels, in addition to providing information to the private sector and for research.

- In 2023, FTA began requiring transit agencies to submit a link to their updated General Transit Feed Specification (GTFS) as part of the NTD reporting. This requirement encourages transit agencies to publish their data on GTFS, which feeds into other trip planning tools. Annual updates to GTFS will help trip planning tools to stay current and accurate.

EPA Smart Location Database analyzes a wide array of indicators relevant to the built environment and location efficiency, to better understand the impacts of land use on transportation outcomes. The Database allows users to measure the location efficiency and convenience at the census block level, with indicators such as housing density, urban design, transit access, and more.

America Planning Association Open Sources: This list of open source tools for multimodal planning offers resources for modal integration tools to be developed by planners and practitioners.

FHWA CARMA Program: This program is leading research on cooperative driving automation (CDA) which would enable communication and cooperation between properly equipped vehicles and infrastructure.

## TOOLKITS AND MODELLING APPROACHES

The National Renewable Energy Laboratory has developed several simulation and modeling tools. These tools allow users to estimate and evaluate impacts of transportation and land use decisions on emissions and energy use, among others, to support data-driven decision making to maximize the potential for emissions reductions.

- Open Platform for Agile Trip Heuristics (OpenPATH): This is an open-source application that allows users to track their mode of transportation and measure the associated emissions and energy use.
- Route Energy Prediction Model (RoutE):The tool allows users to create data-informed energy consumption models for any vehicle type (existing and futuristic).

- Transportation Energy & Mobility Pathway Options Model (TEMPO): This is a comprehensive travel demand model that can develop long-term scenarios to evaluate energy use, emissions, and impact on energy supply/systems.
- Mobility Energy Productivity Tool (MEP): The tool evaluates the ability of a transportation system to connect individuals to goods, services, employment opportunities, and others while accounting for time, cost, and energy. This tool also includes a separate metric to evaluate freight connectivity, called Freight MEP.

Argonne Laboratory POLARIS Transportation System Simulation Tool: This is an open-source simulation tool that allows users to simultaneously model all aspects of travel decisions through a network-demand model. This tool can be used to understand impacts of transportation decisions across several key metrics, which includes congestion, accessibility, cost, emissions, energy, and environmental justice, that can be integrated into land use planning.

DOE Behavior, Energy, Autonomy, and Mobility Comprehensive Regional Evaluator (BEAM CORE): This is an open-source, integrative modeling tool that can capture and analyze a wide set of transportation system components. The tool produces various metrics such as aggregate vehicle and person miles traveled, congestion, energy consumption, and accessibility metrics, for insight on the interconnected impacts between transportation and land use decisions.

## WORKING WITH COMMUNITIES

Open Street Map: This is a platform allowing users to digitally map and record street infrastructure. The data from Open Street Map can be useful for trip planning tools, as information as detailed as sidewalk size is recorded and can help pedestrians understand walking environments within neighborhoods.

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