JPB Board of Directors
Meeting of January 9, 2025

Correspondence as of December 13, 2024

#	Subject
1.	Holiday train stops
2.	Re: Broadway Burlingame Station –*Response to Staff's Response*
3.	FW: Transit Rich paper published
4.	City of Millbrae: Notice of City Council Reorganization
5.	Re: SFMTA Holiday Train Event
6.	Re: SFMTA Holiday Train Event – *Staff response*

From: Edrica Orlova
To: Board (@caltrain.com)
Subject: Holiday train stops
Date: Sunday, December 8, 2024 11:48:15 AM

[You don't often get email from edrica.orlova@gmail.com. Learn why this is important at https://aka.ms/LearnAboutSenderIdentification]

Hello all,

Please include San Carlos which is the best community on the peninsula on your holiday train stop.

Thanks
Edrica Orlova

From:	Elizabeth Hawley
To:	Caltrain BOD Public Support
Cc:	Board (@caltrain.com)
Subject:	Re: Broadway Burlingame Station
Date:	Tuesday, December 10, 2024 11:03:29 AM

Thank you for your thorough explanation. I understand the traffic congestion caused by the train; however, it would be a great service if Broadway had just one trip per day for commuters especially since the Broadway/Burlingame Grade Separation is in limbo and maybe for several years.

Sincerely,
Elizabeth Hawley

From: Caltrain BOD Public Support <CaltrainBODPublicSupport@caltrain.com>
Sent: Thursday, December 5, 2024 9:21 AM
To: stormhawley23@hotmail.com <stormhawley23@hotmail.com>
Cc: Board (@caltrain.com) <Board@caltrain.com>
Subject: Re: Broadway Burlingame Station

Dear Elizabeth Hawley,

Your message to the Caltrain Board of Directors was referred to me for response. The Board members will receive a copy of our correspondence. Thank you for reaching out and sharing your feedback regarding the Broadway station. We understand the inconvenience of having to drive to the Burlingame Ave station for parking, especially when the Broadway station is not open during the work week.

The current limitations on weekday service at Broadway station are due to its configuration, which prevents two trains from being in the station at the same time. Passengers boarding or alighting from northbound trains must cross the southbound tracks, and implementing weekday service under these conditions would cause significant delays to the overall system and increase gate downtime for vehicles crossing Broadway Avenue.

Caltrain is committed to restoring weekday service at Broadway station once the Broadway/Burlingame Grade Separation Project is completed. This project, led by the City of Burlingame, will address the current track configuration, improve safety and efficiency at the station, and eliminate the vehicle/railroad crossing at Broadway Avenue.

Thank you again for your feedback, and we appreciate your patience as we work toward enhancing service in the future.

Sincerely,

Your Caltrain BOD Public Support Team

From: Board (@caltrain.com) <Board@caltrain.com>
Sent: Sunday, December 1, 2024 4:59 PM
To: Caltrain BOD Public Support <CaltrainBODPublicSupport@caltrain.com>
Subject: FW: Broadway Burlingame Station

From: Elizabeth Hawley <stormhawley23@hotmail.com>
Sent: Monday, December 2, 2024 12:58:53 AM (UTC+00:00) Monrovia, Reykjavik
To: Board (@caltrain.com)
Subject: Broadway Burlingame Station

[You don't often get email from stormhawley23@hotmail.com. Learn why this is important at https://aka.ms/LearnAboutSenderIdentification]

ATTENTION: This email came from an external source. Do not open attachments or click on links from unknown senders.

Dear CalTrains Board,
My husband & I take Caltrains everyday to our jobs in Redwood city. We live a few blocks from the Broadway station, but need to drive to the Burlingame Ave station to pay to park. This is not very convenient for us & we would appreciate if the Broadway station was open during the week. We don't quite understand why train stops are made on weekends but not during the work week at the Broadway station.

Thank you for your attention to this matter. We appreciate having convenient public transportation available to us.

Elizabeth & Norman Utigard

Sent from my iPhone

From:	Andrew Tang
To:	Tom Wenzel
Cc:	Joe Castiglione; Julia Friedlander; WongSh@samtrans.com; Board (@caltrain.com); Howard Der; Cecily Anna Spurlock; Cristian Poliziani; Zach Needell; Zach Needell
Subject:	FW: Transit Rich paper published
Date:	Wednesday, December 11, 2024 9:28:45 AM
Attachments:	Poliziani, et al, Transit rich simulation Bay Area, TRR 2024.pdf

Tom,
Thank you for sharing this paper, and congratulations on getting it accepted for publication in TRR. I look forward to hearing about continued research and development on BEAM CORE.
Andrew

From: Tom Wenzel <tpwenzel@lbl.gov>
Sent: Wednesday, December 4, 2024 9:46 AM
To: Joe Castiglione <joe.castiglione@sfcta.org>; Julia Friedlander <Julia.Friedlander@sfmta.com>; Andrew Tang <ATang@bart.gov>; WongSh@samtrans.com; BoardCaltrain@samtrans.com; Howard Der <HDer@actransit.org>
Cc: Cecily Anna Spurlock <caspurlock@lbl.gov>; Cristian Poliziani <cpoliziani@lbl.gov>; Zach Needell <zaneedell@lbl.gov>
Subject: Transit Rich paper published

Colleagues-

Attached is Cristian's paper published in TRR using BEAM CORE to simulate the effect of five recent/planned transit projects in the Bay Area on ridership and energy use (Central Subway, Caltrain electrification, Van Ness and Oakland BRT lines, and BART extensions in San Jose), under a pre-COVID baseline. Table 1 shows simulated results for each individual project (column SP) and all projects combined (TR column). Although the initial changes are rather small, Cristian is working on simulating impacts over the longer term, when households are able to change their home and/or work locations. Thanks for all your help providing GTFS schedules, and vehicle capacities and energy use, for the BEAM CORE model.

Thanks,
Tom

Research Article

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Simulating Impacts from Transit Service Enhancements in the San Francisco Bay Area

Cristian Poliziani[1], A. Zachary Needell[1], Haitam Laarabi[1], Rashid Waraich[1,2], Annika Todd-Blick[1], K. Sydny Fujita[1], Nazanin Rezaei[3], D. Juan Caicedo[4,5], Carlos Guirado[1,5], C. Anna Spurlock[1], and Tom Wenzel[1]

Abstract

Preemptively assessing the potential impacts of large transportation projects is an essential step in achieving better outcomes. However, for transformative public transit projects, it can be difficult to weigh the many complicated downstream impacts on individual travelers in a coherent, cost-effective, and comprehensive way. This research focuses on leveraging the Behavior, Energy, Autonomy & Mobility Comprehensive Regional Evaluator (BEAM CORE) to gauge regional responses to changes in existing and planned public transit services, capturing service performance, system impacts, and users' responses. We applied BEAM CORE to a case study in the San Francisco Bay Area to simulate the effects of recent and upcoming transit projects, showcasing its potential for transportation planning. By simulating individual traveler movements, it becomes possible to delve deeply into the equity and accessibility ramifications of transit system enhancements. The analysis of ridership, mobility, accessibility, and equity presented for this study highlights the benefits of this method in providing a clear understanding of the performances of public transit projects, facilitating more informed and efficient decision-making for transport stakeholders. The results obtained from BEAM CORE aligned closely with expectations and observed data, demonstrating its effectiveness and reliability. Finally, because of the BEAM CORE model's responsiveness to changes in the systems, the method can in the future be applied not only to test existing or planned interventions but to a large variety of hypothetical scenarios to identify the optimal solution, including other transport modes.

Keywords

transport system, planning and analysis, public transportation, transit data, GTFS, ridership

Projects aimed at improving the service of the public transit system, such as adding new lines/routes and stations/stops and increasing the frequency/speed, can represent substantial economic investments, and their benefits in increased ridership can take several years to materialize. Predicting the impacts of planned transit projects entails exhaustive and time-consuming analyses, often accompanied by significant costs. In this context, possessing a cost-effective tool that simulates the impacts of these projects in a detailed manner is of paramount importance: such tools provide the opportunity to understand the potential ramifications of different scenarios, which aids in making informed decisions and ensuring the most effective outcome for transit investments. Transport system planning is becoming increasingly supported by technology and advanced models: an emerging

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approach that has gained prominence is the calibration and utilization of agent-based transport system models that simulate the multimodal travel of millions of individual travelers (or agents). These models are particularly sensitive to alterations in the system, allowing for the prediction of outcomes across various hypothetical scenarios. This capability empowers planners to make more informed choices and anticipate the consequences of different interventions in the transport system, enabling cost-effective and informed decision-making: both time and resources can be saved by simulating, analyzing, and optimizing hypothetical scenarios within the transport system model environment before investing resources and testing or implementing services, projects, and other initiatives.

This study utilizes the Behavior, Energy, Autonomy, and Mobility (BEAM) Comprehensive Regional Evaluator (CORE) integrated modeling system (*1*), implemented in the Platform for Integrated Land Use and Transportation Experiments and Simulations (PILATES) (*2*). PILATES allows users to orchestrate the runs of various simulation modules of different aspects of a regional transportation system across the same scenarios. The core modules are represented by the BEAM mesoscopic agent-based transport network simulation (*3*), developed at the Lawrence Berkeley National Laboratory (LBNL), and the ActivitySim activity-based travel demand model (*4*). We use BEAM CORE to gain insights into how changes in a regional transportation system influence the behavior and preferences of travelers using all available travel modes, evaluating impacts on mode shifts, ridership, performance, and the affected demographics. In this paper, we focus on a case study on the expected impact of several recent or planned transit improvement projects in the nine-county San Francisco Bay Area, California ("SF Bay Area"). First, we present background information framing the study, including a discussion of related literature and the local context. Then we summarize the modeling platform and methodology used and how we specified scenarios of the public transit projects simulated in the SF Bay Area. We then present and discuss in detail our results, and we compare them with observed ridership data to demonstrate their validity. Finally, the paper concludes with key findings and implications drawn from the analysis.

Discussion of Related Work

Several studies attempt to understand the demand response to public transit projects and their associated benefits across various scales and methodologies. In a comparative analysis conducted by Hansson et al. (*5*), the focus was on examining the quality attributes of regional public transport and their impact on modal choice, demand, and customer satisfaction. Through an extensive literature review, they observed a lack of specific knowledge about regional public transport, as most of the existing research in the field has primarily concentrated on local travel (*5*). Haas (*6*) conducted a comprehensive review of scholarly literature focused on the topic of modal shifts and high-speed rail (HSR). The study revealed that research pertaining to direct competition between HSR and other modes of transportation, such as automobiles and express buses, was relatively underdeveloped. However, the analysis also pointed out that HSR services have demonstrated a remarkable ability to gain a competitive edge in the market, effectively attracting more passengers to this mode (*6*).

Furthermore, Litman (*7*) summarizes research on the effects of rail transit on the performance of transportation systems in major U.S. cities, finding that cities in the U.S. with larger, well-established rail systems have significantly higher per capita transit ridership, lower average per capita vehicle ownership and mileage, and less traffic congestion than otherwise comparable cities (*7*). Levinson et al. (*8*) provide an overview of bus rapid transit (BRT) projects and state that decisions to make BRT investments should be the result of a planning process that stresses problem solving, addresses needs, and provides an objective examination of the full range of potential solutions, of which BRT is only one (*8*).

Several researchers have explored transport system models to simulate the performance of regional transportation systems based on different modes of travel in a region (*9–11*). In particular, Schweizer et al. (*9*) created an agent-based microscopic-level model for the entire city of Bologna, Italy, which included the following transport modes: bikes, walking, public transit, and personal vehicles (*9*). They modeled the public transit supply through General Transit Feed Specification (GTFS) data and the public transport demand through origin to destination census data reporting the number of people using this mode between each traffic assignment zone (TAZ) in Bologna. Poliziani et al. (*12*) simulated the introduction of shared, automated, and electric vehicles (SAEVs) as a first and last mile connection to public transit in a large-scale transport system model of the SF Bay Area using an older version of the mesoscopic agent-based BEAM model (*12*).

Our study aims to address existing research gaps by using BEAM CORE for evaluating the impacts of single or multiple public transit projects. Key considerations include shifts from other transport modes or transit options, equity and accessibility-related measures like the Individual Experienced Utility-Based Synthesis (*13*) (INEXUS – a person-trip-based accessibility metric), the overall effects on the transport system, and the calculation of person-level benefits for new service users, facilitating comparisons between various scenarios. All these

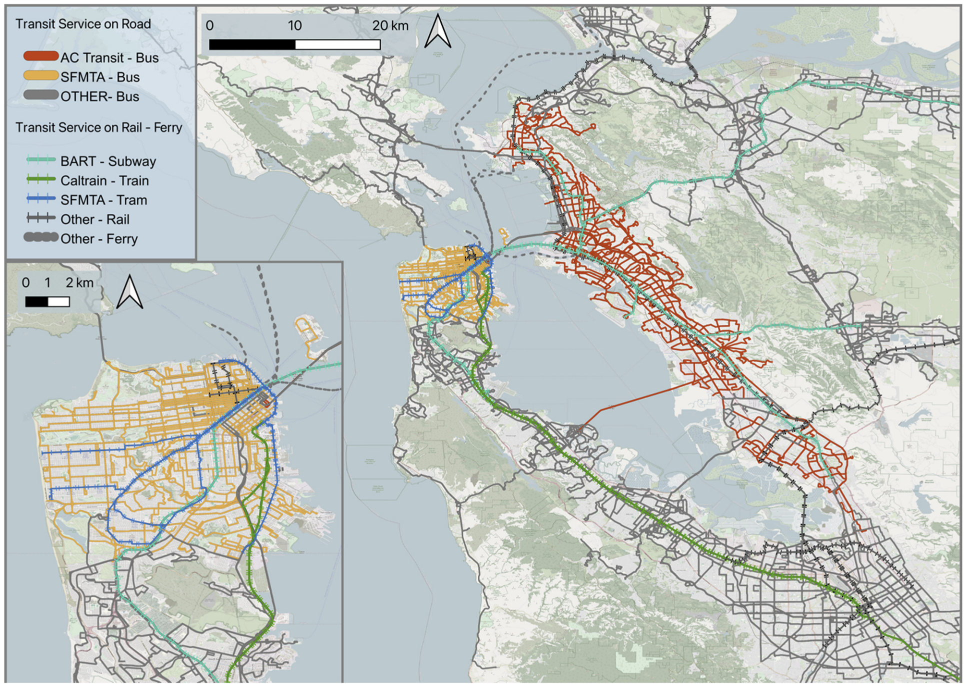

Figure 1. Public transit agency routes in the San Francisco Bay Area extracted from GTFS data, highlighting the studied agencies.
Note: AC = Alameda-Contra Costa Transit District; SFMTA = San Francisco Municipal Transportation Agency; BART = Bay Area Rapid Transit; GTFS = General Transit Feed Specification.

analyses are conducted at a regional level, leveraging a transport system model of a large-scale transport system. This method has significant relevance in estimating the effectiveness of transit interventions. However, it is important to note that it may not be fully generalizable to other regions because of data availability.

Background for Our Case Study: Major Recent SF Bay Area Public Transit Projects

The BEAM CORE integrated modeling system potentialities have been evaluated through a case study of the SF Bay Area. The SF Bay Area includes more than 30 different transit agencies, including those in border proximity, whose schedule coordination is limited, discouraging long trips with public transit. Figure 1 shows the public transport network coverage, with the studied agencies indicated in color.

For the case study, we model some of the recently completed and planned projects in the area (see Figure 2 for an overview map):

- The Van Ness Avenue BRT project, operational as of April 2022, was part of a larger Van Ness Improvement Project totaling $346 million that was aimed at combining the improvement of the public transit service on Van Ness Avenue in San Francisco with several infrastructure upgrade projects. The project encompassed a range of enhancements, including dedicated bus lanes, an expedited bus service, prioritized traffic signals for buses, and a comprehensive set of safety improvements (*14*).
- Alameda-Contra Costa Transit District's (AC Transit's) 1Tempo BRT line, which became operational in August 2020, represents an enhancement of the previous 1 line from San Leandro to Uptown Oakland in Alameda County. The project has brought significant improvements to Oakland and San Leandro, including upgraded transit stations, new bike lanes, improved pavement, enhanced safety measures, increased accessibility, and added greenery along the corridor (*15*).
- The Central Subway project (highlighted in Figure 3), which began construction in 2013 and became operational in January 2023, extends the San Francisco Municipal Transportation Agency (SFMTA) Municipal Railway (SF Muni) T Third Street light rail line (in red) another 1.7 miles north beyond 4th and King station into Chinatown, adding three additional underground stations and one aboveground station, offering an enhanced service

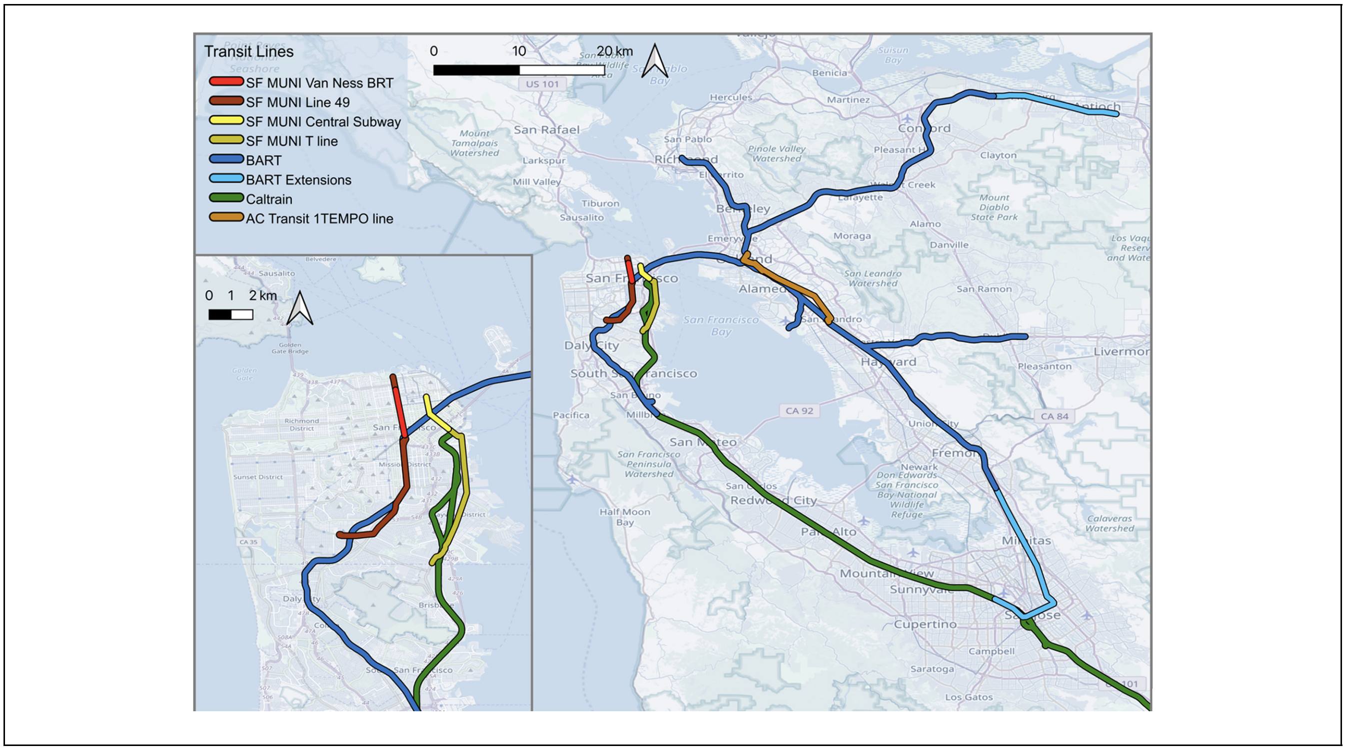

Figure 2. Overview map of the transit projects simulated in this study.
Note: SF MUNI = San Francisco Municipal Transportation Agency; BRT = Bus Rapid Transit; BART = Bay Area Rapid Transit; AC = Alameda-Contra Costa Transit District.

Figure 3. Muni light rail lines after the implementation of the central subway, which extends the red T line from 4th & King to Chinatown, as highlighted with a dotted purple circle in the top right of the figure.
Source: The figure has been exported from the San Francisco Muni website and partially edited: https://www.sfmta.com/maps/muni-metro-map.

in one of the most-congested areas in the city. The T Third line no longer travels along the route of the N Judah line (in dark blue) to Embarcadero station; it now connects with the N line at 4th & King station and the Muni J, K, M, and N lines as well as the Bay Area Rapid Transit (BART) at Powell station (*16*).

- The Caltrain electrification project aims to electrify the existing corridor between the San Francisco stations and Tamien station in San Jose, with a new service planned to start in 2024. This includes converting diesel-hauled trains to electric trains and increasing the operational speed and peak-hour service in each direction (*17*). The service from Tamien station south to Gilroy will remain unchanged.
- The Transbay Corridor Core Capacity Program (CORE) consists of hardware and software investments that will allow the BART subway service to operate up to 30 ten-car trains per hour in each direction through the existing transbay tube by 2032 (28 by 2028), maximizing the capacity in the most heavily used part of its system. The program includes four elements: 306 additional railcars, a new communications-based train control system that will allow closer headways, a new railcar

Figure 4. Bay Area Rapid Transit (BART) system map by route. The BART Silicon Valley Extension Program (BSV) is highlighted in the bottom right of the figure with a dotted purple line, while the BART Yellow line extension to Antioch is highlighted in the top right of the figure with a dotted purple circle.

Source: The figure has been exported from the BART website and partially edited: https://www.bart.gov/system-map.

storage yard at the Hayward Maintenance Complex, and additional traction power substations to provide the additional power needed for the more frequent service (*18*).

- The BART Silicon Valley Extension Program (BSV), funded by the Santa Clara Valley Transportation Authority (VTA), aims to extend the BART service into Santa Clara County, benefiting over 1.7 million residents (see Figure 4). The project is divided into three main phases. The first phase added the Warm Springs station in Fremont at the southern end of the Green and Orange lines, which became operational in 2017. The second phase extended the Green and Orange lines by adding new stations at Milpitas and Berryessa/North San José; it began operations in June 2020. The third phase will extend service from the Berryessa station to four new stations, including 28th Street/ Little Portugal, Downtown San José, Diridon Station, and ultimately reaching Santa Clara. The Diridon and Santa Clara stations will provide connections to Caltrain, Amtrak, and Altamont Corridor Express rail lines. It is anticipated that the BSV will include the development of transit-oriented communities, improved multimodal transportation connections, and upgrades to roadways, utilities, and environmental aspects around the new stations (*19*). Along with the new stations under the BSV extension, BART recently extended the northern end of the Yellow line with additional BART stations (Pittsburg Center and Antioch), which became operational in 2018.

Methods

The study employs the BEAM CORE integrated modeling system on the PILATES platform to represent baseline conditions of an existing transportation system, allowing us to capture the multimodal travel patterns of all travelers in the SF Bay Area. Modifications are then made to the public transport system by editing the GTFS data to simulate future scenarios. We simulate several transit improvement projects separately (SP) or combined in a single scenario (which we call transit rich, or TR). We validated the reliability and accuracy of the GTFS data with the open-source GTFS validator by Cal-ITP

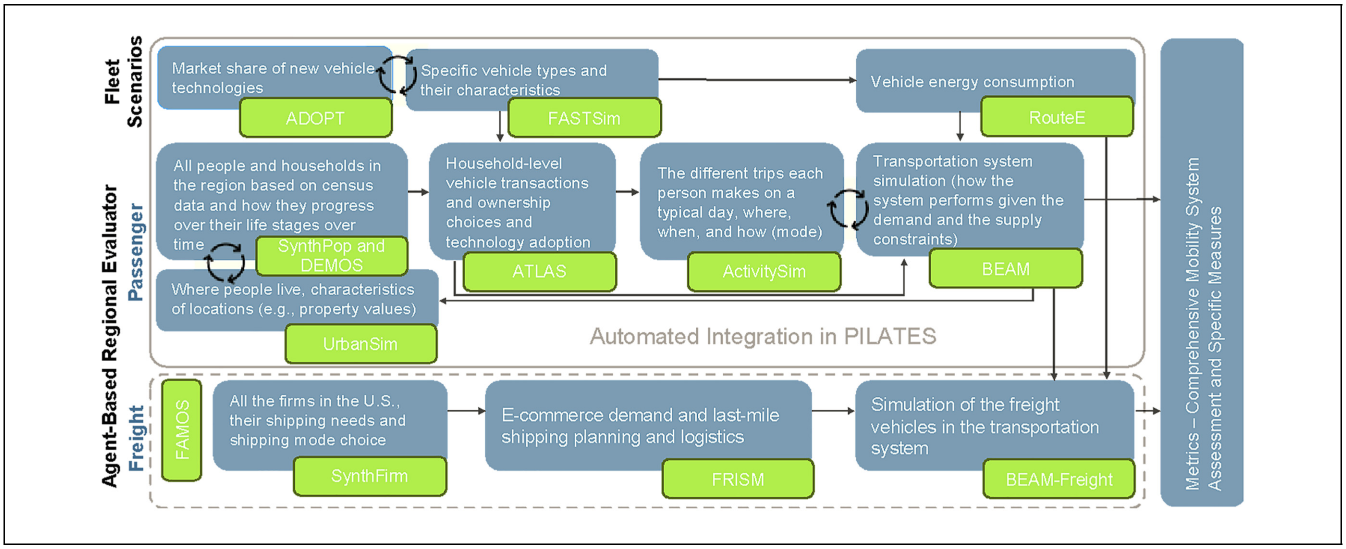

Figure 5. Behavior, energy, autonomy & mobility comprehensive regional evaluator (BEAM CORE) submodules.

and Jarvus (*20*). Subsequent post-processing of the results from the two scenarios provides a deep dive into the potential impacts and benefits of the proposed projects.

Transport System Regional Model: BEAM CORE

BEAM CORE is composed of models that run automatically in sequence to either simulate the passengers or freights trips (see Figure 5). For the passengers, the process can be summarized as follows: SynthPop and Demographic Microsimulation (DEMOS) create a synthetic population of individuals belonging to households and determine how they progress over the life stages to enable long-term scenario evaluations (*21*). UrbanSim, on the other hand, is responsible for land-use modeling and determining facility characteristics and is particularly used for households and the activity distribution (*22*). Automotive Deployment Options Projection Tool (ADOPT), Future Automotive Systems Technology Simulator (FASTSim), and Automobile and Technology Lifecycle-Based Assignment (ATLAS) determine the total number of vehicles, by type and powertrain, registered in the region and assign vehicles to individual households based on household characteristics (age, income, and number of children). These models start by analyzing the market share of new vehicles, determining the vehicle types and their characteristics, and estimating their acquisition by the household. Based on the population and land-use characteristics, ActivitySim determines daily home-to-home tours, including both primary (mandatory work or school) and secondary (discretionary, such as dining out and shopping) activities, activity locations and start/end times, and the mode choice for every activity-to-activity trip (*23*).

BEAM simulates all the agents' plans using an event-based and mesoscopic simulation of all travel modes in the transportation network, including personal vehicles and carpools, public transit, shared-vehicle services (such as ride-hailing, carsharing, and bike/scooter sharing), and active modes (such as walking and personal bikes) (*3*). Unlike other simulation models, BEAM can easily be used to perform agent-based simulations in large-scale case studies. RouteE estimates the energy consumption of all vehicles used in the simulation, including transit vehicles. The results from all submodules are then post-processed based on the type of information needed. It is worth noting that each of the BEAM CORE submodules can be independently calibrated with their data of interest and by tweaking their own parameters. This is particularly useful when calibrating scenarios related to different periods or study areas, as it removes the need to create a new model from scratch—it is only necessary to recalibrate the parameters that allow the changes in the transport demand and on the supply side that are specific to that period and case study to be reproduced.

The public transit system is replicated using GTFS, which describes the stops, travel paths, schedule, and fares for different service days (e.g., weekdays, weekends, and special days) for each transit agency operating in the region. To simulate each transit project, the GTFS for a particular bus line/train route is revised to reflect the updated service provided by that project. Changes made to the baseline scenario can affect only the mode and route choice in the short term but also the trip generation and distribution phases in a long-term multi-year analysis. After the agents' travel plans are created, the route choice in BEAM depends on the road flows and traffic congestion, with the model attempting to converge to a users' equilibrium by iterating in alternation with the ActivitySim mode choice until all travelers are able to accomplish their daily travel while minimizing their generalized cost. During each iteration, BEAM passes TAZ-level skim information to ActivitySim to update the mode choice (a skim is an origin-to-destination table that contains information on a specific attribute, e.g., ride-hailing waiting time or car travel time, between each pair of TAZs).

ActivitySim's mode choice is based on a multitude of attributes that add up to create mode-related utilities that are used in a large multinomial nested logit model. In a long-term analysis, the population, vehicle ownership, technology adoption in new vehicles, and activity location are updated after each set of ActivitySim and BEAM iterations up to convergence based on current trends and simulation results. BEAM CORE requires high computational power, and a standard laptop can only run local studies with some tens of thousands of agents. For the case study, when using an external instance with 50 cores and 512 GB of memory, the simulation took around 12 h. However, steps are being taken to make the computational workflow more efficient and to further shorten simulation times

For this reason, a BEAM CORE run can be focused on only a portion of the population, and the road network, ride-hail fleet size, parking, and public-transit vehicle capacities are scaled accordingly during the BEAM simulation to correctly consider the effect of traffic and traveler congestion on the roadway and transit network. The simulation results can then be scaled up to reflect the impact on energy use and emissions for all travelers across the region.

Post-processing of BEAM CORE Results

After the simulation, the results are post-processed to get insights into the simulated service performance and the transport demand response. The first process isolates the desired transit lines and evaluates changes in the transport supply based on the number of vehicle trips from one terminal to another, ridership, vehicle miles traveled (VMT), vehicle hours traveled (VHT), revenue passenger kilometers (RPK), person hours traveled (PHT), available seat kilometers (ASK), load factor, and average speed. Equation 1 shows how RPK, ASK, and LF are evaluated:

$$\begin{cases} \text{RPK} = \sum_{l \in L} R_l \cdot d_l \\ \text{ASK} = \sum_{l \in L} C_l \cdot d_l \\ \text{LF} = \dfrac{\text{RPK}}{\text{ASK}} \end{cases} \tag{1}$$

Here, R_l, d_l, and C_l are the paying ridership, distance, and vehicle capacity, respectively, of each transit vehicle leg l, and L is the set of transit vehicle legs between each pair of stops. A second process filters from the future scenario trips made by people using the simulated projects, which are compared with the corresponding trips made by the same people at the baseline. This comparison provides insight into the reasons behind decisions to switch between transport modes or among different public transit options and how people of different backgrounds and demographics have been affected, addressing issues of equity and accessibility.

A successive step creates a from/to matrix containing all possible travel options on each row and the simulated projects on each column, with each cell $x_{i,j}$ representing the number of trips that shifted from travel option i in the baseline scenario to option j in the future scenario. This means that these people used travel option i in the baseline scenario but not in the future scenario, while they used travel option j in the future scenario but not in the baseline scenario. In the case with $i = j$, $x_{i,j}$ represents the number of people that were using travel option i or j in both the baseline and future scenarios, as described by Equation 2:

$$\begin{cases} x_{i,j} = \sum_{t \in T} \beta_{i,t} \cdot \underline{\delta}_{i,t} \cdot \underline{\beta}_{i,t} \cdot \delta_{j,t} & \text{if } i \neq j \\ x_{i,j} = \sum_{t \in T} \beta_{i,t} \cdot \delta_{j,t} & \text{if } i = j \end{cases} \tag{2}$$

Here, i and j represents a travel option, T is the set of all door-to-door trips, $\beta_{i,t}$ is 1 if trip t used travel option i in the baseline scenario and 0 otherwise, $\underline{\delta}_{i,t}$ is 1 if trip t did not use travel option i in the future scenario and 0 otherwise, $\underline{\beta}_{j,t}$ is 1 if trip t did not use travel option j in the baseline scenario and 0 otherwise, and $\delta_{j,t}$ is 1 if trip t used travel option j in the future scenario and 0 otherwise. Instead of reporting the number of trips that transitioned between travel options i and j, we can also report the benefit in doing that ($y_{i,j}$), as described by Equation 3:

$$\begin{cases} y_{i,j} = \sum_{t \in T} \left(\alpha_{j,t} - \alpha_{i,t}\right) \cdot \beta_{i,t} \cdot \underline{\delta}_{i,t} \cdot \underline{\beta}_{j,t} \cdot \delta_{j,t} & \text{if } i \neq j \\ y_{i,j} = \sum_{t \in T} \left(\alpha_{j,t} - \alpha_{i,t}\right) \cdot \beta_{i,t} \cdot \delta_{j,t} & \text{if } i = j \end{cases} \tag{3}$$

Here, $\alpha_{j,t}$ and $\alpha_{i,t}$ represent the attributes we want to compare for the future and baseline scenarios, respectively, such as travel length, INEXUS (*13*), travel duration, average speed, and number of transfers between transit vehicles. INEXUS is a quantification of the benefit (or loss) to each person of having the transit options in one scenario relative to another (e.g., the benefit of the new transit options from the projects relative to the baseline), which is built from the BEAM CORE outputs. This comparison is made possible because, when doing a short-term analysis, we suppose fixed daily diaries for people, which means that they will perform the trips between the same activities and at the same time of the day in both scenarios.

Case Study: Transit-Rich Scenarios in the SF Bay Area

For this study, we first created and validated a baseline simulation of the travel patterns of all travelers in the nine counties of the SF Bay Area on a typical weekday in 2019 using the BEAM CORE integrated modeling system and a large variety of available data and using a 30% random sample of the population. It is worth noting that the transit service is reproduced from the open GTFS folders from the OpenMobilityData website by MobilityData IO (*24*).

Then, we included three recent and three planned—or partially implemented—public transit projects in the SF Bay Area (as discussed in the"Background for Our Case Study: Major Recent SF Bay Area Public Transit Projects" section) to simulate the future scenarios and compare their outcomes with the baseline to assess the overall impact of the transit projects in the region, as discussed in the "Methods" section. The future scenarios consist of a single TR scenario where all the projects have been implemented plus an additional SP scenario where each of the projects is simulated independently.

The three recent projects are (1) the SF Municipal Railway (Muni) Central Subway, (2) the Van Ness BRT projects implemented by SFMTA, and (3) the Tempo BRT line in Oakland implemented by the Alameda-Contra Costa Transit District (AC Transit).

The three planned projects, which are under development and will be implemented in the next few years, are (1) the BART CORE program; (2) the Silicon Valley Extension Program (BSV), which comprises new BART stations in the San Jose area; and (3) the Caltrain electrification project. The simulated public-transit projects were implemented by revising the original GTFS data used as input to BEAM CORE in the PILATES platform as described below.

- As the bus service on **Van Ness Avenue** was previously dominated by the Muni 49 line, to implement the project in the PILATES software, the 49 line GTFS was updated using a more recent (September 2022) version downloaded from the SFMTA GTFS website.
- To implement the **1Tempo BRT** project in BEAM, line 1 was replaced with the line 1Tempo from the most recent AC transit GTFS data (June 2023). It is worth noting that the updated GTFS schedule reduced the frequency of the previous 1 line by 8% since it does not yet reflect the proposed frequency of 12 vehicles per hour. This was probably to avoid load factors that were too low, as ridership might not have fully recovered from the shutdown as a result of the coronavirus (COVID-19) pandemic.
- To implement the **Central Subway project** in BEAM, the lines K, T and K/T were replaced with the new K and T lines in the SFMTA GTFS data. Figure 3 shows the paths of the K line and the T line extending through the Central Subway. The schedule of the new K and T lines was recreated manually for an average weekday from the SFMTA website (*25*), with a frequency of 6 vehicles per hour during most of the day.
- To implement the **Caltrain electrification project** in BEAM, the Caltrain GTFS data were manually edited to reproduce the estimated higher speeds and frequencies of the new trains based on Caltrain's current plans for 6 trains per hour during peak service, with trains designed to travel all stops in 57 min plus an estimated 13 min of boarding time and to operate at a speed of 130 km/h for the initial service.
- **BART** currently has the capacity to operate a maximum of 24 ten-car trains per hour in each direction through the Transbay Tube between San Francisco and Oakland; under the CORE plans, an increased capacity of 30 ten-car trains will be achieved during commute hours. To implement the project in BEAM, the BART GTFS data were updated with a version provided by BART containing the planned changes in the service.
- For the **BSV project**, we adjusted another set of GTFS files provided by BART to reproduce the development phases: the BSVI scenario combines the two recently opened stations (Milpitas and Berryessa), while our BSVII scenario includes the third phase of BART's BSV plan (four additional stations in San Jose/Santa Clara). The Warm Spring station is already included in the baseline since it started operating in 2017. Similarly, since the BART extension to Antioch was already present in 2019, this extension is already implemented in the baseline, so we do not determine its impact in this specific study.

Results and Discussion

The simulation of the SF Bay Area baseline results in approximately 24.7 million trips made by 6.4 million people, requiring approximately 53 TJ of propulsion energy.

This section compares the outcomes from the TR and SP scenarios (as described in the "Case Study: Transit-Rich Scenarios in the SF Bay Area" section) based on the travel demand response as well as the additional outcomes of accessibility, mode choice, and equity.

Demand Response Analysis

The baseline travel mode split is distributed as follows: 51.9% use personal vehicles, 31.3% carpool, 8.9% walk, 5.3% use public transit, 1.4% bike, 1.2% solo ride-hail, and 0.1% use pooled ride-hailing. The VMT and person miles traveled (PMT) are, respectively, 230 million km and 241 million km, indicating that there are only slightly more PMT than VMT. The VHT and PHT are, respectively, 7.93 million h and 8.3 million h, translating into an average vehicle and person speed of about 29 km/h. Looking at transit, people took 1.3 million trips, with an average of 1.8 different transit vehicles used per trip. The transit VMT and PMT are, respectively, 1.0 million km and 13.7 million km, while the transit VHT and PHT are, respectively, 0.033 million h and 0.5 million h, resulting in about the same average speeds as for personal vehicles. Table 1 shows the results for both the TR scenario, where all the projects were simulated in a single scenario, as well as the results from simulating each separate project (or SP) independently.

Table 1 also combines the three BART SP scenarios (BSV1, BSV2, and CORE) into a single BART scenario. Table 1 provides an overview of the changes in public transit ridership between the baseline and the TR and SP scenarios for each agency and line of interest described in the "Case Study: Transit-Rich Scenarios in the SF Bay Area" section.

On the other hand, Table 2 provides an overview of the transport supply changes and transport demand response of the SP scenarios compared with the baseline, as described in the "Methods" section. It is worth noting that results are in general larger when simulating a single project alone; under the combined TR scenario there is greater competition for ridership from enhancements made to other transit systems and lines/routes. From these tables we see that the Caltrain electrification project increased the average riders' speed by 17.9%, offered 19.6% more train trips, and captured 14.4% more ridership, resulting in a 0.6% decrease in the overall load factor.

The implementation of the 1Tempo line by AC transit brought a 12.5% increase in average rider speed, while ridership increased 18.9% and vehicle frequency decreased 73.2%, resulting in a 32.6% decrease in load factor. In the combined scenarios, BART projects had the largest absolute increase in ridership, over 30,000, which represents a 6.2% increase across the BART system. However, the even larger increases in the number of train trips (24.0%) and VMT (51.0%) resulted in a net 27.9% reduction in load factor.

The BART Green and Orange lines are simulated to have the most significant increase in ridership, with increases of 53.3% and 36.6%, respectively; these lines connect the new San Jose stations to Richmond and San Francisco, respectively. Despite the Green line's substantial ridership increase, its load factor declined by 37.6% because of the 88.5% increase in transit frequency and 125.6% increase in VMT. Similarly, the *Orange* line increased its frequency by 29.3% and VMT by 79.5%, resulting in a 17.8% decrease in load factor, indicating an inelastic commuter demand response, probably caused by overlapping transit options. Ridership on the Yellow, Red, and Blue lines decreased by 3.9%, 10.7%, and 2.4%, respectively, in the combined TR scenario, which was likely a result of passengers switching to either the Green or Orange lines. Surprisingly, despite all four transbay BART lines benefiting from a supply enhancement in the CORE project (all but the Orange line), ridership decreased on the lines not involved with the BSV project (i.e., the Yellow and Red lines as well as the Orange line) in both the CORE and combined TR scenarios. This can be explained by the notable supply enhancement experienced by the Green line in both the CORE and BSV projects: a 88.5% increase in train trips from the CORE project combined with a 38.9% increase in train VMT from the BSV projects. This improved service on the Green line likely captured ridership from overlapping lines.

While the CORE project increases overall travel speed by 12.8% (compared with only 1.4% with the BSV2 projects), the BSV projects increase ridership by 4.9% (compared with only 0.6% with the CORE project). The 49 Van Ness and Central Subway projects combined increased the total number of SF Muni vehicle trips by 1.15%. In particular, ridership on line 49 increased by 66.6% thanks to a 40.3% higher frequency, and average rider speed increased by 7.7%, showing hyper-elastic behavior with respect to supply changes. The Central Subway project, on the other hand, decreased VMT by 9.7% for the combined K/T lines, but it brought 45.5% more vehicle trips because of the disconnection of the K/T path; this resulted in a 4.1% increase in ridership. It is worth noting that the ridership and load factor both increase for the N line as it is still connected to the T line at the 4th/King and Union Square/Market stations.

Additional Analysis: Accessibility, Mode Choice, and Equity

Figure 6 presents the distribution of the modes the new riders previously took for each of the SP scenarios, as detailed by Equation 2 in the "Methods" section. The

Table 1. Change in Ridership Under Future Scenarios by Transit Agency/Project

Route/line	Baseline	TR	TR Δ	TR Δ%	SP	SP Δ	SP Δ%
Caltrain							
Electrification							
All	19,090	21,280	2,190	11.47	21,833	2,743	14.37
AC Transit							
1Tempo BRT							
All	392,466	390,640	−1,826	−0.47	392,226	−240	−0.06
1 BRT	14,546	17,116	2,570	17.67	17,296	2,750	18.91
BART							
BSV and CORE							
All	515,816	550,366	34,550	6.70	547,963	32,147	6.23
Blue	98,736	97,646	−1,090	−1.10	96,383	−2,353	−2.38
Green	57,310	88,163	30,853	53.84	87,856	30,546	53.30
Orange	67,150	91,920	24,770	36.89	91,760	24,610	36.65
Red	135,113	121,626	−13,487	−9.98	120,686	−14,427	−10.68
Yellow	157,450	151,010	−6,440	−4.09	151,276	−6,174	−3.92
BSVI							
All	na	na	na	na	521,463	5,647	1.09
Blue	na	na	na	na	98,346	−390	−0.39
Green	na	na	na	na	60,193	2,883	5.03
Orange	na	na	na	na	70,763	3,613	5.38
Red	na	na	na	na	134,456	−657	−0.49
Yellow	na	na	na	na	157,633	183	0.12
BSVII							
All	na	na	na	na	540,896	25,080	4.86
Blue	na	na	na	na	98,636	−100	−0.10
Green	na	na	na	na	65,943	8,633	15.06
Orange	na	na	na	na	84,833	17,683	26.33
Red	na	na	na	na	134,426	−687	−0.51
Yellow	na	na	na	na	156,980	−470	−0.30
CORE							
All	na	na	na	na	519,090	3,274	0.63
Blue	na	na	na	na	96,910	−1,826	−1.85
Green	na	na	na	na	79,253	21,943	38.29
Orange	na	na	na	na	70,350	3,200	4.77
Red	na	na	na	na	121,366	−13,747	−10.17
Yellow	na	na	na	na	151,210	−6,240	−3.96
Van Ness BRT							
All	608,573	615,550	6,977	1.15	608,976	403	0.07
49 BRT	15,446	24,596	9,150	59.24	25,740	10,294	66.65
Central Subway							
All	na	na	na	na	606,236	−2,337	−0.38
K/T	28,836	29,386	550	1.91	30,006	1,170	4.06
J	10,003	9,170	−833	−8.33	9,723	−280	−2.80
L	20,326	20,116	−210	−1.03	20,460	134	0.66
M	17,463	16,043	−1,420	−8.13	16,483	−980	−5.61
N	30,833	34,216	3,383	10.97	34,270	3,437	11.15

Note: TR = transit-rich scenario; SP = separate-project scenario; AC = Alameda-Contra Costa Transit District; BRT = Bus Rapid Transit; BART = Bay Area Rapid Transit; BSV = BART Silicon Valley Extension Program; CORE = Transbay Corridor Core Capacity Program; na = not applicable.

"Other" segment in the figure includes all the cases where it is not possible to determine the travel option that travelers switched from; for example, it might be that a rider used the BART Blue line at the baseline and the BART Blue line plus the 1Tempo line in the future scenario. The figure shows that nearly all of the users of the new projects previously used the regional transit system under the baseline conditions (ranging from 88.6% of Caltrain riders to 95.2% of Central Subway riders). Moreover, most of those riders used the same transit agency at the baseline (ranging from 46.1% of all Caltrain riders to 83.2% of all Central Subway riders). The largest mode shift to public transit came from Caltrain riders: 3.3% of the riders on the Caltrain electrification project had

Table 2. Percent Difference from Baseline to SP Scenario by Factor and Transit Agency/Project

Route/line	Person trips (%)	Veh trips (%)	Veh hours (%)	RPK (%)	Person hours (%)	ASK (%)	Load factor (%)	Avg speed (%)
Caltrain								
Electrification								
All	14.4	19.6	0.9	18.1	0.7	18.9	−0.6	17.9
AC Transit								
1Tempo BRT								
All	−0.1	2.6	2.5	0.4	0.1	2.4	−2.0	−0.1
1 BRT	18.9	73.2	56.4	18.6	8.2	76.0	−32.6	12.5
BART								
BSV and CORE								
All	6.2	24.0	31.8	8.9	−8.1	51.0	−27.9	14.6
Blue	−2.4	27.7	14.9	−2.3	−16.6	28.8	−24.1	12.1
Green	53.3	88.5	98.6	40.8	23.3	125.6	−37.6	13.6
Orange	36.6	29.3	50.8	47.5	18.2	79.5	−17.8	19.0
Red	−10.7	21.7	19.1	−5.5	−20.0	25.6	−24.7	5.4
Yellow	−3.9	21.3	8.2	−0.5	−14.0	23.6	−19.5	14.3
BSVI								
All	1.1	0.0	6.3	2.8	1.9	8.4	−5.2	2.0
Blue	−0.4	0.0	0.0	−0.5	−0.4	0.0	−0.5	0.0
Green	5.0	0.0	18.9	10.5	8.7	23.5	−10.5	3.9
Orange	5.4	0.0	19.1	13.5	9.2	24.8	−9.1	4.8
Red	−0.5	0.0	0.0	−0.5	−0.5	0.0	−0.5	0.0
Yellow	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0
BSVII								
All	4.9	0.0	12.3	6.9	5.4	13.9	−6.1	1.4
Blue	−0.1	0.0	0.0	0.2	0.0	0.0	0.2	0.0
Green	15.1	0.0	37.0	20.5	18.0	38.9	−13.3	1.3
Orange	26.3	0.0	37.3	34.2	27.6	41.2	−4.9	2.9
Red	−0.5	0.0	0.0	−1.1	−1.0	0.0	−1.1	0.0
Yellow	−0.3	0.0	0.0	0.8	0.6	0.0	0.8	0.0
CORE								
All	0.6	24.0	17.2	1.3	−13.4	32.2	−23.4	12.8
Blue	−1.8	27.7	14.9	−2.8	−17.0	28.8	−24.5	12.1
Green	38.3	88.5	54.0	21.8	8.9	69.6	−28.2	10.2
Orange	4.8	29.3	7.6	7.5	−11.2	26.8	−15.3	17.9
Red	−10.2	21.7	19.1	−4.0	−18.8	25.6	−23.6	5.4
Yellow	−4.0	21.3	8.2	−1.4	−14.8	23.6	−20.2	14.3
SF Muni								
Van Ness BRT								
All	0.1	0.8	0.8	−0.1	−0.2	0.7	−0.8	−0.1
49 BRT	66.6	40.3	28.0	74.7	66.9	37.8	26.8	7.7
Central Subway								
All	−0.4	−0.9	−2.9	−0.4	−1.6	−2.3	1.9	0.7
K/T	4.1	45.5	−3.0	−10.1	−20.4	−9.7	−0.4	−6.9
J	−2.8	0.0	0.0	−2.1	−0.5	0.0	−2.1	0.0
L	0.7	0.0	0.0	−0.8	−0.1	0.0	−0.8	0.0
M	−5.6	0.0	0.0	−8.3	−5.8	0.0	−8.3	0.0
N	11.1	0.0	0.0	5.7	6.5	0.0	5.7	0.0

Note: AC = Alameda-Contra Costa Transit District; BRT = Bus Rapid Transit; BART = Bay Area Rapid Transit; BSV = BART Silicon Valley Extension Program; CORE = Transbay Corridor Core Capacity Program.

previously used their personal vehicles, and 6.4% had previously used ride-hail services.

A substantial number of riders switched from the BART lines to other transit projects, notably the two BRT lines and the Central Subway. The majority of the Caltrain riders who switched from another transit agency previously rode San Mateo County Transit District (SamTrans) buses (5.9% of all Caltrain riders), with SamTrans bus lines running along the peninsula adjacent to Caltrain. Around 10% of 1Tempo BRT, Van Ness BRT, and Central Subway riders came from other lines in the same transit system. Notably, many Van Ness BRT riders switched from the Golden Gate Transit Agency, which runs a bus service from Marin County on Van Ness Avenue, and from the walking mode. Figure 6 indicates that most of the new BART riders who did not

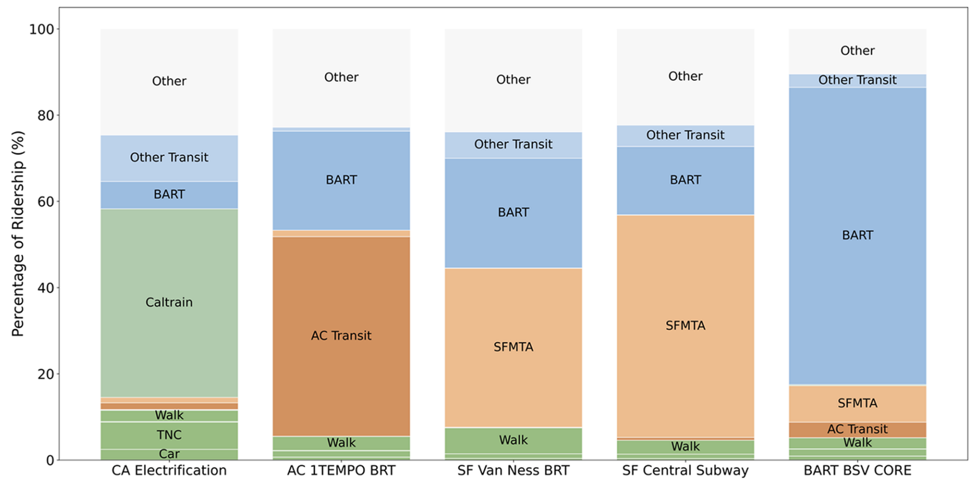

Figure 6. Number of person trips switching from a previous travel option at the baseline by project and scenario for the separate-project (SP) scenario.

Table 3. Mobility and Accessibility Outcomes and Average Household Income for Riders on Each of the New Transit Projects, Based on Their Previous Travel Option as the Baseline

				Average household income ($1,000s)		
Project	Distance (%)	Duration (%)	INEXUS (%)	Switch from another mode	Switch from another transit agency	Switch from same transit agency
Separate-project (SP) scenario						
Caltrain—CA	2.19	−3.22	1.04	143	130	132
1Tempo—1T	−2.46	−0.67	0.68	83	69	66
SF:49—VN	−3.80	−6.98	2.88	136	117	121
SF:T—CS	−6.94	−2.37	2.29	110	108	105
BART—BSV CORE	1.58	−3.78	0.81	122	108	108
BART - BSVI	2.24	2.12	1.35	115	101	97
BART—BSVII	3.14	−0.48	1.09	112	103	97
BART—CORE	1.16	−3.02	0.79	123	109	108
Combined transit-rich (TR) scenario						
CA—TR	3.05	−5.50	0.69	149	133	135
1Tempo—TR	−3.46	−3.56	1.03	75	68	67
SF:49—TR	−3.96	−9.69	4.54	138	113	121
SF:T—TR	−7.32	−5.83	1.06	140	108	105
BART—TR	1.59	−3.96	0.87	124	109	108

Note: INEXUS = Individual Experienced Utility-Based Synthesis; SF = San Francisco; BART = Bay Area Rapid Transit; BSV = BART Silicon Valley Extension Program; CORE = Transbay Corridor Core Capacity Program; CA = Caltrain; TR = transit-rich scenario.

come from other BART lines switched from either AC Transit or SFMTA routes. These findings align with expectations, given that the public transit lines and agencies involved with the simulated projects share part of their route with the public transit lines/agencies in the baseline scenario from which some people are switching (see Figure 2).

Table 3 shows the percent changes from the baseline in travel distance, duration (including access and wait times), and INEXUS for the users of each project and scenario. Riders on Caltrain and BART projects had the largest increases in average travel distance (up to 3.1%), while riders on the SF Muni Central Subway project reduced their average travel distance by 7.3%. Almost all riders on the new projects reduced their average trip duration, with Van Ness BRT, Central Subway, and Caltrain riders reducing their trip durations by 9.7%, 5.8%, and 5.5%, respectively. Riders on each project experienced an increase in INEXUS travel utility, with the largest increases seen for riders on the Van Ness BRT

(4.5%). It is worth noting that this increase in INEXUS is composed of better transit services for existing riders as well as people using other transport modes.

Additionally, Table 3 compares the average household income of all riders on each new project with that of all travelers in the region ($106k). Riders on the 1Tempo BRT have, on average, almost half the average income of all households in the region. Except for this project, the average income of people using each of the new transit projects is mostly higher than the average of all travelers in the region, especially for those riding Caltrain along Silicon Valley. The table indicates that riders switching from other transport modes usually have a higher income than people already using the service at the baseline. This metric, together with INEXUS and other person attributes from the synthetic population, like age, gender, race, and home location, can provide valuable insights for addressing equity and accessibility concerns.

Validation

A conventional validation of the results from our simulations with observed data is challenging given the unique circumstances of the COVID-19 pandemic, which coincided with the start of several of the recent transit projects we simulated.

This section compares our simulated ridership with the observed ridership provided by several transit agencies for selected months, with the understanding that changes in travel behavior as a result of the COVID pandemic greatly contributed to the observed changes in ridership. We specifically analyze ridership data from the San Francisco Van Ness Bus Rapid Transit (BRT), AC Transit's line 1T, SFMTA line 30, and BART, provided by the agencies. The observed daily ridership for the Van Ness line 49 bus route was 25,000 before the pandemic in January 2020, dipped to 12,000 in February 2021, and then increased to 17,000 by September 2021. The Van Ness BRT began operations in April 2022, with daily ridership surging to 30,000 by January 2023, representing a 18% increase over pre-pandemic levels and a 79% increase over ridership in the fall of 2021. Because of the dramatic reduction in ridership during the pandemic, the actual increase in ridership from implementation of the BRT service would likely have been between 18% and 79%; we simulated a 59% increase without accounting for ridership changes induced by the pandemic. The observed average daily ridership on AC Transit's Line 1T decreased from 5,600 in February 2020 to 3,100 (or by 45%) by April 2020, but it then increased to 7,100 (26% above pre-pandemic levels) by May 2021 (and to 8,600 by May 2023). We simulated a 18% increase from the implementation of BRT on the 1T line in August 2020, which is comparable with the observed 26% increase from pre-pandemic levels. The validation of our simulated ridership on the 1T BRT line is further complicated as we assumed the increased bus frequency originally planned for the project, whereas the frequency was actually severely curtailed because of low ridership during the pandemic.

The Central Subway, which became fully operational in January 2023, was designed in part to relieve traffic congestion on the 30 line bus route operating on Stockton Street directly above the subway. Observed average daily ridership on the 30 Stockton bus line increased 1.1% between September 2021 and January 2023 but then increased another 7.6% between January and February 2023, suggesting that ridership was recovering from the pandemic at a fast rate, and that increase was dampened by the opening of the Central Subway. We simulated a 7.4% decrease in line 30 ridership under the Central Subway scenario. The new BART stations in the BSV1 project opened right after the beginning of the COVID-19 pandemic, when overall BART ridership was down substantially from pre-pandemic levels. Between April 2020 and June 2020, BART ridership increased 69%; we simulated a 1.1% increase in ridership from the expansion to the Milpitas and Berryessa stations under the BSV1 scenario and project an additional 3.8% increase from the eventual expansion to the four stations in San Jose under the BSV2 scenario. These different values are very probably related to the fast recovery after the first pandemic phase in June 2020. This comparison underscores the complexities inherent in modeling public transport demand during a period of global disruption of travel behavior and emphasizes the necessity for transit agencies to employ flexible and responsive planning strategies to adapt to such challenges.

Conclusion

This paper provides detailed results on potential short-term impacts of the implementation of several transit projects which have been recently implemented or are planned for the San Francisco Bay Area, California. Notably, several transit agencies in the region are making substantial investments to improve their services, such as extending existing lines or enhancing vehicle capacity, frequency, and average rider speed. This paper has demonstrated the capabilities of the BEAM CORE integrated modeling system in assessing the impacts of specific public transit projects, and combinations of individual projects, in respect to increasing ridership and travel speed and improving accessibility for public transit riders. The results obtained from BEAM CORE aligned closely with expectations, demonstrating its effectiveness and reliability; where possible, we have validated our simulations with observed data. BEAM CORE provides transit planners with a powerful tool to estimate outcomes from individual or combinations of public transit improvement projects from different perspectives and eliminates the need to collect data to build a completely new scenario for each case study.

The tool can help planners not only assess the anticipated benefits of such projects but also better understand where new ridership may come from and how the projects can address historical inequities in respect to accessibility to mobility services. Indeed, one of the strengths of this tool lies in its ability to assess the impact of a specific project or collection of projects not only on the entire population but also on subgroups of the population that have historically been underserved by the transportation system. It takes into account how individual travelers' trips are influenced by changes in the public transit system, factoring in the current mode of transport, home location, daily activities, and personal attributes such as income, age, time value, and vehicle ownership. By analyzing the changes in travel made by individual travelers and evaluating any changes in their travel utility estimated using INEXUS, the tool offers valuable insights into the impacts of new transit projects on transportation equity and accessibility.

It is worth noting that, because of the BEAM CORE model's responsiveness to changes in transit systems, the model can be used to simulate not only proposed expansions of the transit network but also a large variety of scenarios that examine the impact of changes in multimodal travel services and prices on the regional transportation system.

One limitation of our analysis is that it only focuses on the impacts new transit projects have in the short term. We anticipate that these impacts will increase over time as travelers become more familiar with the changes to the transit system and adjust their home, work, and activity locations, as well as their vehicle ownership, in response to these changes. These adjustments will likely increase ridership on the new transit projects and may induce people to shift their travel mode from a personal vehicle to transit. Future research will take a longer-term perspective, and, by making the process sensitive to changes in home, work, and secondary-activity locations as well as the vehicle ownership choices of individual travelers, will estimate how changes to the public transit system influence travel patterns over multiple years, including exogenous changes in people's travel behavior.

Another limitation is that we used a baseline scenario based on the conditions before the COVID-19 pandemic, which does not account for the slow recovery of ridership, especially on regional rail systems such as BART, as the nation recovers from the pandemic. While our simulations do not necessarily reflect the current state of transit travel in the region, this type of modeling can be used to help transit planners identify cost-effective measures to increase ridership on their systems and make them more equitable.

In conclusion, the BEAM CORE tool offers promising capabilities in the planning of improvements to the public transit system, as well as the overall transportation system, in a region. The tool blends technology and data to provide useful insights for public agencies, researchers, and stakeholders working to make regional transportation systems more sustainable and equitable.

Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: CP, ZAN, CAS, TW; data collection: CP, ZAN, TW; analysis and interpretation of results: CP, ZAN, HL, RW, NR, JDC, CAS, TW; draft manuscript preparation: CP, ZAN, RW, ATB, SKF, NR, CG, CAS, TW; modeling input and data generation and recording: CP, ZAN, HL, RW, JDC; data collection, wrangling, analysis, interpretation, and visualization of results: CP, TW, ZAN, NR; manuscript preparation: CP, TW, ZAN, ATB, SKF, NR, CAS, CG. All authors reviewed and approved the final version of the manuscript.

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From: Eduardo Gonzalez
To: Board (@caltrain.com)
Cc: Tran, Elaine [etran@ci.millbrae.ca.us]; Nicole Huang
Subject: City of Millbrae: Notice of City Council Reorganization
Date: Wednesday, December 11, 2024 5:05:00 PM
Attachments: image003.png
image004.png
image005.png
image006.png
2024 City of Millbrae Notice of Reorganization.pdf

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ATTENTION: This email came from an external source. Do not open attachments or click on links from unknown senders.

Hello Caltrain board,

The City of Millbrae held its City Council Reorganization on Tuesday, December 10, 2024, please find the attached Notice of Reorganization.

Happy Holidays,

Eduardo Gonzalez
Project Manager
Administration
City of Millbrae
621 Magnolia Ave. | Millbrae, CA 94030
Tel. (650) 259-2409 | Egonzalez@ci.millbrae.ca.us

Stay up to date and connect with us:

At the December 10, 2024 City Council meeting, the Millbrae City Council reorganized as follows:

Name	**Term**
Mayor Anders Fung (District 5)	Mayor through December 9, 2025 Council term ends December 2028
Vice Mayor Reuben Holober (District 3)	Vice Mayor through December 9, 2025 Council term ends December 2028
Councilmember Stephen Rainaldi (District 1)	Council term ends December 2028
Councilmember Sissy Riley (District 2)	Council term ends December 2026
Councilmember Bob Nguyen (District 4)	Council term ends December 2026

* Mayor and Vice Mayor serve a one-year term.

Eduardo Gonzalez,
Deputy City Clerk

cc: San Mateo County Cities
San Mateo County Board of Supervisors
Legislators
Regional Agencies
League of California Cities
Millbrae School District

From:	Ramos, Joel <Joel.Ramos@sfmta.com>
Sent:	Thursday, December 12, 2024 3:02 PM
To:	Board (@caltrain.com)
Subject:	Re: SFMTA Holiday Train Event

Meant for you!

~Joél

From: Alden, Amiee <Amiee.Alden@ucsf.edu>
Sent: Thursday, December 12, 2024 12:40 PM
To: Ramos, Joel <Joel.Ramos@sfmta.com>
Subject: Fwd: SFMTA Holiday Train Event

Joel, UCSF's Senior Vice Chancellor Erin Gore took her young son to SFMTA's holiday train event and really enjoyed it. Please share our congratulations with the team! - Amiee

Subject: SFMTA Holiday Train Event

Aimee-

I took my son Wiley to the SFMTA holiday train event last Saturday Dec 7.

We had a blast what a great free event for the San Francisco Community.

A few pictures of the smiles and fun attached.

Please pass along my thanks to our SFMTA partners for this great event.

Erin

Erin S. Gore
Senior Vice Chancellor Finance and Administration

UCSF
Cell 415-962-6864


CALTRAIN
WATCH YOUR STEP


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This message is from outside of the SFMTA email system. Please review the email carefully before responding, clicking links, or opening attachments.

From: Caltrain BOD Public Support
Sent: Thursday, December 12, 2024 3:09 PM
To: Board (@caltrain.com)
Subject: Re: SFMTA Holiday Train Event

Hi Erin,

Thank you so much for sharing the delightful photos! It's wonderful to hear that you and Wiley had such a great time at the Holiday Train event. We're glad you enjoyed the event, and we'll be sure to pass along your thanks to our staff for making it such a memorable experience for the community.

Wishing you and Wiley a joyful holiday season!

Your Caltrain BOD Public Support Team

From: Ramos, Joel <Joel.Ramos@sfmta.com>
Sent: Thursday, December 12, 2024 11:02:03 PM (UTC+00:00) Monrovia, Reykjavik
To: Board (@caltrain.com) <Board@caltrain.com>
Subject: Re: SFMTA Holiday Train Event

You don't often get email from joel.ramos@sfmta.com. Learn why this is important

ATTENTION: This email came from an external source. Do not open attachments or click on links from unknown senders.

Meant for you!

~Joél

From: Alden, Amiee <Amiee.Alden@ucsf.edu>
Sent: Thursday, December 12, 2024 12:40 PM
To: Ramos, Joel <Joel.Ramos@sfmta.com>
Subject: Fwd: SFMTA Holiday Train Event

EXT

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Erin

Erin S. Gore
Senior Vice Chancellor Finance and Administration
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