LINK21

CONNECT NORTHERN CALIFORNIA

MODEL DOCUMENTATION: REFINED TRAVEL DEMAND MODEL SUMMARY

DRAFT

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Acronyms and Abbreviations

ACRONYM/ABBREVIATION	DEFINITION
ABM	Activity-based Travel Demand Model
BART	San Francisco Bay Area Rapid Transit
CCJPA	Capitol Corridor Joint Powers Authority
MTC	Metropolitan Transportation Commission
OD	Origin-Destination
RTDM	Refined Travel Demand Model
TAZ	Traffic Analysis Zone
TM	Travel Model

Link21 Program Team Names

TEAM NAME	TEAM MEMBERS
Program Management Consultants (PMC)	The HNTB Team
Program Management Team (PMT)	BART/CCJPA + PMC
Consultants	Consultants supporting program identification/project selection
Link21 Team	PMT + Consultants
TDLU Team	Travel Demand and Land Use Consultant Team

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1. Executive Summary

The *Model Documentation: Refined Travel Demand Model* report describes the approach to develop and validate the Link21 Refined Travel Demand Model (RTDM). This is a summary document and more details can be found in the main body which is available upon request.

The Link21 RTDM estimates the travel behaviors of the people who live in the Bay Area. This refined tool was developed based on observed travel patterns and estimates how travelers will respond in future-year conditions. Because many of those future conditions are uncertain, the RTDM is sensitive to a host of potential changes, compared to today. Planners and decision-makers can use this tool to address "what-ifs," such as change in forecasted population, increased rates of telecommuting, higher costs of driving, or improvements to transit service.

The RTDM was designed and developed to:

- Support the refinement and evaluation of project alternatives.
- Provide information to support the program's Business Case.
- Provide quantitative analysis to support decisions needed for project identification milestones.
- Provide information as needed for environmental analysis, stakeholder/public engagement, and funding opportunities.

The program will provide benefits and impacts to the Northern California Megaregion, many of which must be quantified to support the strategic, economic, and financial aspects of the Business Case. The model will be utilized to inform the preliminary project to advance to the next stages of the Link21 program.

The Metropolitan Transportation Commission (MTC) Travel Model (TM) 1.5 is the nine-county Bay Area activity-based travel demand model (ABM) utilized for Plan Bay Area 2050. More information on TM 1.5 can be found in the Plan Bay Area 2050 Forecasting and Modeling Report.[1] The RTDM utilizes TM 1.5 as the base, or donor model, but includes modifications that focused on meeting the unique needs of the Link21 program. Link21's investments will increase rail capacity and, in so doing, may alleviate crowding on transit lines. A travel demand modeling system that will be used to evaluate these investments needs to understand and quantify the role that crowding plays on travelers' route and mode choice decisions. Therefore, the RTDM enhances TM 1.5 to include sensitivity to transit crowding.

[1] Plan Bay Area 2050 Forecasting and Modeling Report, October 2021. Metropolitan Transportation Commission. https://www.planbayarea.org/sites/default/files/documents/Plan_Bay_Area_2050_Forecasting_Modeling_Report_October_2021.pdf.

In addition, the Link21 model is specifically designed to ensure appropriate sensitivity to network and service improvements to new and existing rail services of varying operators and ensure competitiveness between other modes is accurately captured. Therefore, additional modifications were made to TM 1.5 including refining the traffic analysis zone (TAZ) system to include greater granularity around transit stations, and modifying how varying transit operators and modes are distinguished within the model.

1.1. Model Overview

The RTDM covers the nine Bay Area counties: San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma, and Marin. The region is split into 3,332 TAZs, which represent the origins and destinations for trips. The Link21 TAZ system is based on the TM 1.5 TAZ system, which has 1,454 TAZs, but with finer resolution within approximately one mile of existing, future, and potential rail stations. The model estimates the travel patterns between these zones throughout a typical weekday, spread out over five time-of-day periods: early morning, AM commute, midday, PM commute, and evening.

There are two primary inputs into the model: a simulated population and a network. The size and distribution of this population differs by year, depending on assumed growth rates or trends in a given scenario. This population has home locations, as well as household and person attributes, such as income, employment status, and age. The model simulates travel for each person, and each trip has attributes such as mode, purpose, and time of day. The network, representing both highway and transit systems, contains attributes such as toll costs, roadway type and capacity, high-occupancy vehicle lane distinctions, transit fares, service frequency, and train or bus capacity. These attributes vary depending on the time-of-day period. The highway and transit networks can be altered to represent planned or proposed infrastructure projects.

The major components of the RTDM are shown in Figure 1-1. The RTDM is composed of two types of model components—demand and supply. The four demand components, grouped within the teal-colored dashed rectangle, represent distinct market segments for generating total travel demand for the region.

The **activity-based simulation of household travel,** shown in blue, simulates the daily activity-travel patterns of residents, including both long-term mobility choices, short-term household coordination, and travel location, mode, and timing decisions.

The ABM simulation begins with the creation of a **synthetic population** of households and persons (blue box, upper left), based on TAZ-level control totals for the population supplied by land use forecasts, which may be observed data for the base year or forecasts, such as those adopted by a metropolitan planning organization. The simulated population is intended to represent the population of the Bay Area, based on Census attributes.

Whereas the ABM covers typical resident daily travel within the Bay Area, three additional demand modeling components (green boxes) are needed to cover other market segments and provide a full accounting of the demand load on the regional transportation system. Each of the three auxiliary demand components described below were derived from existing MTC or Link21 models, as specified in TM 1.5.

- An **Airport model** covers the land-based auto travel of residents flying in and out of the region's major commercial airports (SFO, OAK) as well as airport access and egress by visitors to the region and was borrowed from TM 1.5 and disaggregated to the Link21 zone system.
- **Externally based trips** include surface-transportation and interregional rail trips with at least one trip end outside of the Bay Area's nine counties, but which either begin, end, or pass through the model region. Accordingly, these are labeled: Internal-External, External-Internal, and External-External trips.
  - Auto and truck vehicle trips were borrowed from TM 1.5 and disaggregated to the Link21 zone system.
  - Interregional rail trips are developed in the Link21 Initial Tool[2]. Output from the Initial Tool, input into the RTDM, is a trip table that assigns one trip end to the transit station nearest the external gateway where the transit service would provide access to the trip origin-destination (OD) outside of the region and the other trip end to the Link21 zone with the OD inside of the region.
- A **Commercial Vehicle model** covers light, medium, and heavy truck movements within the Bay Area and was borrowed from TM 1.5 and disaggregated to the Link21 zone system.

Each of the four demand modeling components use job and household totals in each TAZ as a basis for trip productions and/or attractions. The output of all four demand components are trips by OD pair, mode, and time period of the day. These trips are combined in OD table formats, segmented by mode and time of day, and collectively represent the demand loaded into the regional highway network (auto and truck) or the regional transit network (transit only).

As shown in Figure 1-1, the two red boxes enclosed within the red-colored dashed rectangle represent the supply components of the travel demand modeling system. The **Transit Network Assignment** step loads place-to-place transit trips onto a transit network model to predict passenger flows through the network, expressed as numbers of boardings, alightings, and transfers, specific to stations and service lines. Passenger responses to service attributes of the transit network model, such as line-haul times,

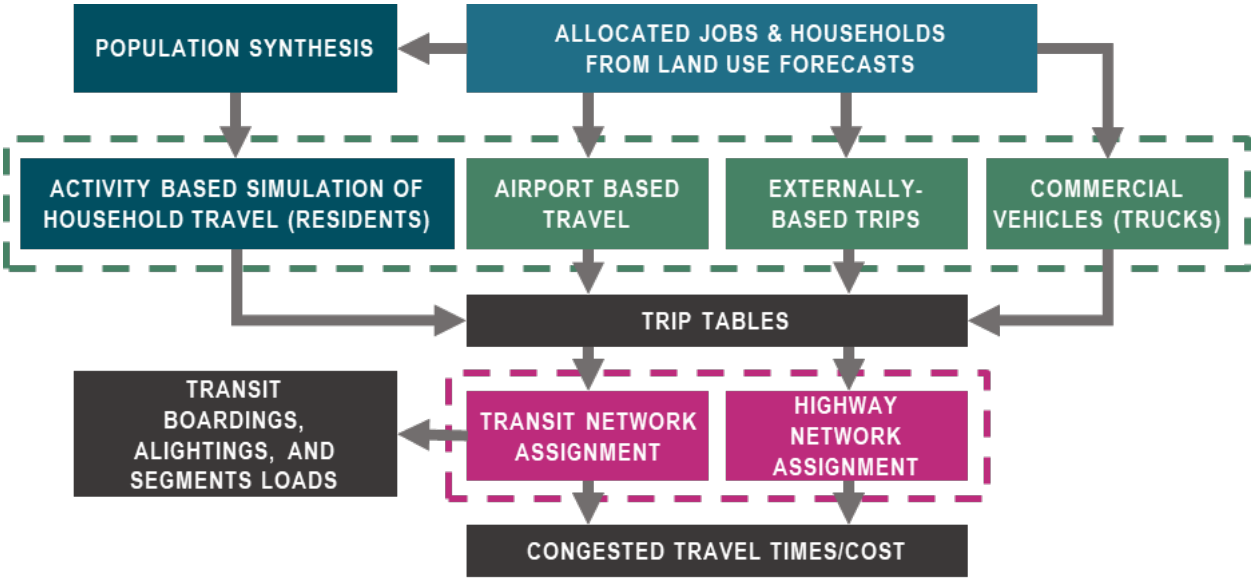
[2] More information on the initial tool can be found in the *Initial TDLU Tool Documentation Report: Draft Executive Summary*.

dwell times, frequencies, fares, vehicle capacities, and parking lot capacities will be some of the most important variables tested for Link21.

The **Highway Network Assignment** module loads the place-to-place auto and truck trips onto a highway network model. The highway network model represents link and interchange capacities and levels of service, including saturation flow rates, numbers of lanes, free-flow speeds, tolls, and functions that predict traffic volumes and congested travel times as a function of the demand load.

Both transit and highway assignments produce tables of **congested travel times and costs** (fares or tolls), specific to OD pairs, times of day, and modes.

Figure 1-1. Link21 RTDM Major Model Components, Inputs, and Outputs



1.2. Model Calibration/Validation

To ensure the model best represents resident's behaviors and choices, the RTDM was calibrated based on observed data sources for Bay Area travel in the year 2015. Household travel surveys, census data, ridership reports, and traffic counts provided reference points to determine the reasonableness of the model. Extensive stress and sensitivity testing was conducted to evaluate its performance under different conditions. An external panel of experts was convened to review the model's assumptions and performance and provide guidance during its development, as described in Link21 Travel Demand Forecasting External Technical Peer Review Panel Executive Summary.

Since the RTDM is based on MTC TM 1.5, TM 1.5 was used as a reference point during validation. While all model components were evaluated for reasonableness, calibration, validation, and testing of the RTDM focused on the components most important for evaluating project alternatives. Adjustments to model parameters were prioritized for model components that most directly impact transit ridership and other markets of

importance to Link21. For these key components the validation to observed data matched or exceeded MTC 1.5.

The RTDM underwent extensive sensitivity and scenario testing that was designed not to tell whether the travel model is "correct," but rather, to provide information about the overall behavior of the model. The sensitivity and scenario testing included examining sensitivity of the model in regard to key model inputs (i.e. auto operating cost, transit fares, frequency of rail service, new stations), future policy assumptions (i.e., fare assumptions, telecommuting, auto and transit travel times, parking costs, employment levels), and new component functionality (i.e. crowding effects, park-n-ride lot capacity, and timed transfers). The sensitivity tests accomplished the following objectives:

1. Quantified sensitivity to various changes in the model, comparing to MTC TM 1.5, where applicable;
2. Ensured updated inputs and parameters show reasonable sensitivities;
3. Assessed magnitude of individual impacts of future year assumptions;
4. Stress tested the model;
5. Verified new features of the RTDM were operating as expected; and
6. Served as dry runs for production mode.

1.3. Model Outputs

After the model is run, it can be used to produce metrics from which decision-makers can draw insights. OD tables provide information on how many people are traveling between zones, what the purpose of their travel is, and which mode of transportation they take. The highway network is populated with statistics on vehicle volume and flow speed for each road segment and time period, which reveals where and when congestion occurs. The transit network provides information on boardings, alightings, and segment loads for all transit services in the network.

A detailed list of performance metrics was identified by the Business Case Team to use in the evaluation of Link21 alternatives. Several of the key performance metrics produced by the RTDM are presented below:

- Zone-level trips by time of day, mode, purpose, and priority population status (these should also be easily aggregated to and reported at various subcounty levels).
- Segment, route, and station-to-station rail ridership by time of day, mode, purpose, and priority population status.
- Rail station-level boardings and alightings.
- Vehicle miles traveled by passenger auto mode, time of day, and population segment (including priority populations).
- Vehicle-miles traveled by rail vehicles by time period.

- Travel time savings for trips served by new/improved services.
- Crowding metrics for the transit network and key links/corridors.
- Metrics reflecting the level of accessibility of priority populations to new/improved services.
- Metrics reflecting the level of accessibility to jobs/businesses (by category) and other non-work activity centers.
- Measurements of consumer and wider economic benefits.