



# The Northeast Megaregion Travel Demand and Investment Model: Final Report and User's Manual

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16. <b>Abstract</b> The Northeast Megaregion Travel Demand and Investment (NEMR TD&I) Model is a standard 4-step travel demand model that brings together population and job forecasts for 2030 and 2040 with detailed highway and public transportation network data across the 13-state Northeast Megaregion to help transportation planners evaluate the demand for new transportation facilities and services. Implemented using <b>TransCAD</b> , a PCbased transportation planning package that combines a map-based interface with cutting-edge travel demand forecasting procedures, the NEMR TD&I Model functions at two spatial scales: (i) the megaregional scale, spanning counties along the I-95 corridor from Maine to Virginia; and (ii) the multi-metropolitan area scale, based on zip code districts for the combined Boston-Providence-Worcester region, the Greater New York City region, the Greater Philadelphia region, and the Baltimore-Washington-Richmond metro area clusters.			
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# CHAPTER 1: INTRODUCING THE NORTHEAST MEGAREGION TRAVEL DEMAND AND INVESTMENT (NEMR TD&I) MODEL

## 1.1 OVERVIEW OF THE NORTHEAST MEGAREGION TRAVEL DEMAND & INVESTMENT (NEMR TD&I) MODEL

The Northeast Megaregion Travel Demand and Investment (NEMR TD&I) Model is a standard 4-step travel demand model that brings together population and job forecasts for 2030 and 2040 with detailed highway and public transportation network data across the **13-state Northeast Megaregion** to help transportation planners evaluate the demand for new transportation facilities and services.

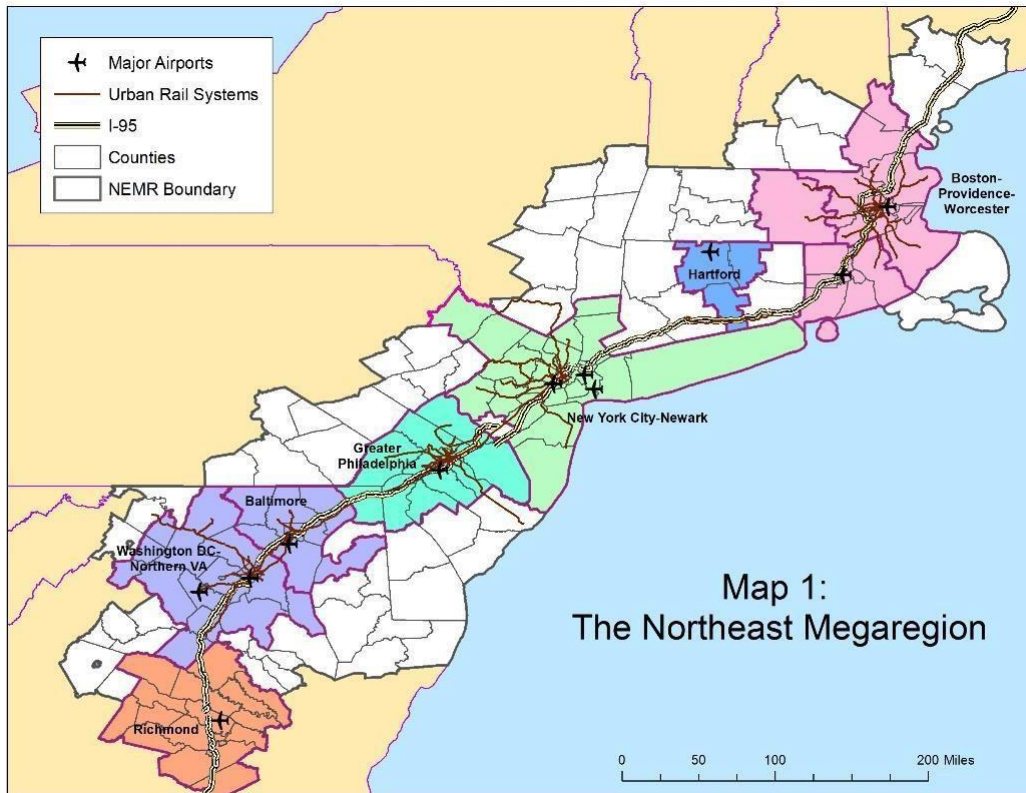
Implemented using **TransCAD**, a widely-used PC-based transportation planning package that combines a map-based interface with cutting-edge travel demand forecasting procedures, the NEMR TD&I Model functions at two spatial scales: (i) the megaregional scale, spanning counties along the I-95 corridor from Maine to Virginia; and (ii) the multi-metropolitan area scale, based on zip code districts for the combined Boston-Providence-Worcester region, the Greater New York City region, the Greater Philadelphia region, and the Baltimore-WashingtonRichmond metro area clusters.

The NEMR TD&I Model is written in GISDK, TransCAD's scripting language and runs on any PC with TransCAD is installed. In addition to travel demand modeling scripts and procedures, the NEMR TD&I Model brings together all the input data required to conduct a comprehensive 4-step travel demand analysis, including alternative 2030 and 2040 population and job forecasts by county and zip code district grouping; a detailed highway network that includes major and minor roads; rail, subway and bus networks for each metropolitan area constructed from open-source General Transit Feed Specification (GTFS) data; and baseline mode share percentages drawn from the 2017 National Household Transportation Survey (NHTS) and local MPO travel demand surveys. The NEMR TD&I also includes options to help users enter their own forecasts, network data, and mode share information. The NEMR TD&I Model is also the only urban forecasting model to give users the option of combining truck and private automobile trips on the same roadways.



## A Transportation Snapshot of the Northeast Megaregion

<b>NEMR Characteristics &amp; Transportation Facilities</b>	<b>NEMR</b>	<b>Share of</b>
	<b>Total</b>	<b>US Total</b>
NEMR States (all or part)	13	25%
NEMR Counties	152	5%
NEMR Metropolitan Planning Organizations	46	11%
2015 Population (millions)	54.4	17%
2015 Employment (millions)	22.5	15%
Miles of Interstate Highway	3,679	8%
Miles of 4-lane Highway	8,832	10%
Share of 25 Most Congested Highway Hotspots		28%
Urban Rapid Transit (URT) Systems	8	53%
URT Track Length (miles)	494	60%
URT Stations	753	71%
URT Ridership (2018, billions of passengers)	3.2	86%
Public Airports	146	3%
Commercial Airports	37	7%
Share of 30 Largest U.S. Airports		27%
2017 Airport Passengers (millions)	136	22%
Major Cargo Seaports	14	14%
Cargo Volume (millions of short tons)	290	12%



Map 1:  
The Northeast Megaregion

## 1.2 WHY WE DEVELOPED THE NEMR TD&I MODEL & WHO SHOULD USE IT

Multi-jurisdictional transportation planning efforts in the U.S. are currently undertaken at the state and metropolitan level. This arrangement works well enough in some regions but not in the Northeast, where 13 states and nearly 50 Metropolitan Planning Organizations (MPOs) share a complex multi-modal transportation system serving more than 50 million residents and 22 million jobs. We developed the NEMR TD&I Model to help transportation planners collaborating across states and metropolitan areas better evaluate how future changes in population and jobs will shape the future demand for transportation infrastructure and services.

Based on the widely-used 4-Step transportation planning model and bringing together detailed information on highways and public transportation networks, the NEMR TD&I Model is intended for use by a broad spectrum of transportation stakeholders including state, regional, metropolitan and city transportation planners; transportation decision-makers and funders looking to make sure proposed projects and investments respond to real transportation needs; highway engineers and transit system operators seeking to understand how new facilities and services will affect modal use patterns, congestion levels, and transit ridership; and advocacy



groups and entrepreneurs concerned with improving mobility levels for all metropolitan and city residents.

Potential users of the NEMR TD&I Model should have a general familiarity with the 4-step travel demand modeling process and a working knowledge and legally-installed copy of TransCAD.

### 1.3 WHAT IS THE NEMR TD&I MODEL GOOD FOR?

The NEMR TD&I Model is designed to help regional transportation planners evaluate the metropolitan-level transportation demand and service implications of different population and job projections; to help state and metropolitan planners coordinate their transportation analysis and modeling work across multiple metropolitan areas; to help public transit operators understand where their services are most competitive; and to help local stakeholder groups identify transportation service equity and performance issues. By including all the input data needed to run a 4-step travel demand model, the NEMR TD&I also serves as a convenient stepping-off point for transportation planners and others looking to incorporate new forecasts, new methods and new transportation service data into their work without having to create new transportation networks and demand forecasts from scratch. Lastly, the NEMR TD&I Model is intended as an education tool to help future generations of transportation planners, engineers and entrepreneurs understand why multi-modal urban transportation systems perform the way they do and how they can be made to work better.

### 1.4 HOW THE NEMR TD&I MODEL WORKS

The NEMR TD&I Model runs as series of GISDK scripting tabs that progress through the standard 4-step travel demand model procedures including: (i) *Trip Generation*, which converts future population and job projections into trip productions and attractions; (ii) *Shortest Path and Trip Distribution*, which coverts trip productions and attractions into a trip table of complete trips (by purpose) between every trip origin and destination zone; (iii) *Mode Share Analysis*, which identifies the share and number of trips using each competing mode; and *Traffic and Route Assignment*, which assigns each set of modal trips to the appropriate highway or transit routes.

4. Traffic & Route Assignment
----------------------------------

Population &  
Job Forecasts

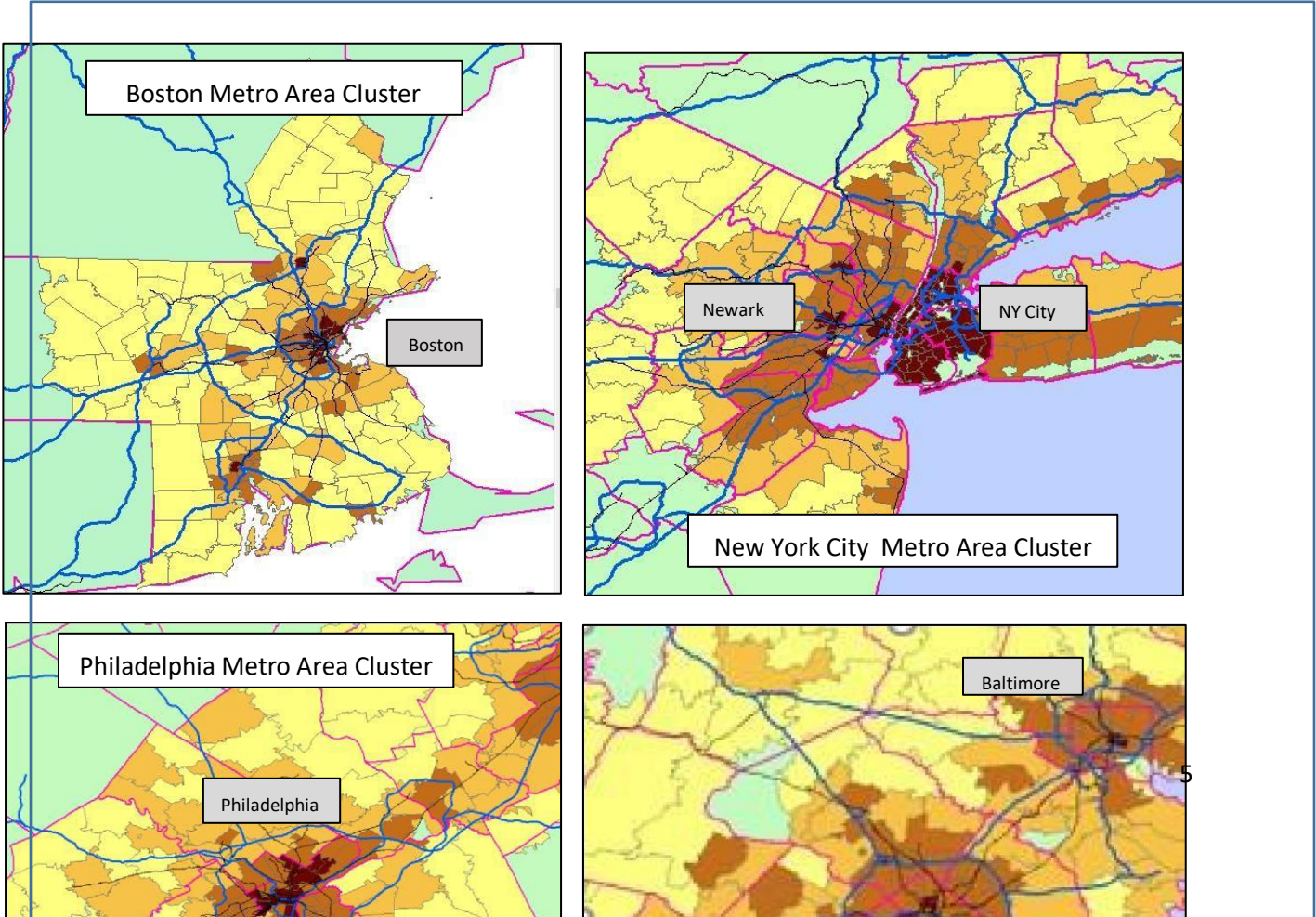
1. Trip Generation  
Analysis

2. Trip  
Distribution  
Analysis

3. Mode  
Share  
Analysis

Users begin a

NEMR TD&I Model run by choosing *either* the entire Northeast Megaregion or a metro area cluster (MAC) as the study area for their analysis, and choosing a population and job forecasting method and year. If they wish, users can also input their own forecasts. The results of every step in the NEMR TD&I Model are automatically used as the input into the subsequent step, however users are also given the option of saving and inputting their own intermediate files and data tables. The task of dividing the table of future trips into its modal components is accomplished using a mode share percentage table drawn from the results of local travel demand surveys conducted by the appropriate metropolitan planning organization. Users can adjust these mode share percentages up or down to simulate modal different scenarios, as well as use their own mode share percentages. The result of a NEMR TD&I model run is an assignment of modal trips to the appropriate highway or transit routes. . The modal assignment results can be further displayed and analyzed in TransCAD's map window. Once the traffic and route assignment step has been completed, users can go back to ay previous step to build a new scenario or trip table.



## **1.5 WHAT'S DIFFERENT ABOUT THE NEMR TD&I MODEL?**

Compared to most conventional 4-step travel demand models, the NEMR TD&I Model offers several unique features, including:

- It can be run at both the megaregional and multi-metropolitan area level.
- It includes population and job projections for 2030 and 2040 based on alternative growth assumptions.
- It incorporates both inter-city and metropolitan level rail and bus service.
- It uses mode share percentages drawn from local travel surveys.
- It can combine auto trips with truck trips based on national freight flow data.
- It makes use of open-source GTFS data describing local public transit services.
- It allows users to modify or insert their own data inputs at every step.

## **1.6 GETTING STARTED USING THE NEMR TD&I MODEL AND DATA**

To get started using the NEMR TD&I Model, download the model User's Manual and skim Chapters 1-4. Then go to the Download Center of the NEMR TD&I website and download the model and input data to your local hard drive. Follow the directions in Chapter 3 of the User's Manual about setting up the appropriate directory structures. Start TransCAD and make sure it recognizes the NEMR TD&I Model script, which is written in GISDK. Then click on the opening "Getting Started" menu tab.

## **CHAPTER 2:**

### **LOGIC & ORGANIZATION OF THE NEMR TD&I MODEL**

The Northeast Megaregion Travel Demand & Investment Model (NEMR TD&I Model) is a traditional 4-step (Trip Generation, Trip Distribution, Mode Share, Route Assignment) travel demand model that converts population and job projections into future trips between a series of origin and destination zones, divides those trips by mode (e.g., drive, commuter rail, subway, bus, walk), and then allocates the resulting modal trips to highway and transit routes. The NEMR TD&I Model runs on top of TransCAD, a widely-used desktop travel demand modeling

package, using a series of pre-organized datasets and custom-designed scripts written in GISDK, TransCAD's built-in scripting language.

The NEMR TD&I offers a number of useful features compared to travel demand models used by metropolitan planning organizations (MPOs). These include:

- It covers the entire Northeast Megaregion (NEMR) from Portland (Maine), down through Boston, Providence, Hartford, New York City, Philadelphia, Baltimore, Washington D.C., and Richmond metropolitan areas.
- It operates at two spatial scales, the afore-mentioned Northeast Megaregional (NEMR) scale; and the Metropolitan Area Cluster (MAC) scale, which includes clusters of metropolitan areas around Boston, New York City, Philadelphia, and Washington, D.C.
- It makes use of a series of common population and job projections for 2030 and 2040 based on forecasts produced by state planning departments.
- It makes use of mode share percentages (e.g., the share of trips between a particular origin and destination pair using a particular mode) using survey data collected by local MPOs.
- It makes use of rail and bus networks generated using the industry-standard General Transit Feed Specification (GTFS) standard.
- It gives the users the option of incorporating truck trips as estimated using the Federal Highway Administration's Freight Analysis Framework (FAF) Model.
- It allows users to quickly update their input assumptions and to graphically compare the results of different scenarios
- It provides a series of convenient entry points for users to add their own population and job projections and mode share estimates.

## 2.1 A PRIMER ON 4-STEP TRAVEL DEMAND MODELS

Four-step travel demand models convert externally-generated population and employment projections to a trip table (a square-shaped table of trips between origin and destination zones) and then to modal trip tables which are then allocated to particular roads and routes. As presented below and shown in EXHIBIT 2A, each of the four steps in the model uses its own set of modeling procedures and algorithms to generate its results:

**2.1.1 Travel Analysis Zones:** Travel analysis zones (TAZs) are aggregations of census tracts, zip code districts, or other census geographies that serve as trip origin and destination “catchment” areas for tabulating trip-making activity.

► The NEMR TD&I Model uses two types of TAZs: Superzone TAZ (STAZs), which consist of single or multiple counties; and MAC TAZs (MTAZs), which consist of combinations of zip code districts.

**2.1.2 Networks:** Networks consist of collections of links and nodes that allow trip-makers and/or vehicles to travel from an origin location or zone to a destination location or zone. Common transportation networks include highway networks, commuter rail networks, subway and light-rail networks, and bus networks. Each network link includes information on its physical length and permissible travel speed, or, in the case of transit networks, vehicle schedules. Each node includes information on which links it connects, and which link-to-link transfers are allowed. Centroids are a special class of nodes located at the center of TAZs. Once a network has been

“built,” travelers can use it to travel from connected origin zones to connected destination zones regardless of the distance or time between them. Highway networks can be connected to transit networks, making it possible to transfer between modes.

► The NEMR TD&I Model makes use of FHWA’s national road network as the basis for its highway network, and metro area-level commuter rail, subway, light-rail, and bus networks which are provided in open-source form using the General Transit Feed Specification (GTFS) format.

**2.1.3 Step 1: Trip Generation:** Trip generation is the first step in the standard 4-step travel demand model. Trip generation procedures use statistical models or census-based trip generation rates to convert population and employment projections to



trip productions and attractions by purpose and zone. Trip productions are the beginning points of trips such as homes. Trip attractions are the ending points of trips such as work, shopping, school, or visiting friends. Common trip purposes include home-based work (where trips are produced from homes and attracted to work locations); home-based shopping (where trips are produced from homes and attracted to shopping or retail activities); home-based other (where people travel from home to personal business or recreational activities), and non-home-based (where people begin a trip from a location that is not their home). All home-based trips have an outbound leg and a return leg. Trip generation models use either regression models or standardized rates to convert population and household counts (disaggregated by income group or household type or household auto ownership levels) to home-based productions; and employment counts (disaggregated by business type) to work and shopping attractions.

► The NEMR TD&I Model makes use of three trip purposes (home-based work, home-based other, and non-home-based) and purpose-specific trip generation rates as published in the National Cooperative Highway Research Project's (NCHRP) Report 365: Travel Estimation Techniques for Urban Planning

**2.1.4 Step 2: Trip Distribution:** The second step in the standard 4-Step model, Trip Distribution converts zonal-based lists of trip productions and attractions (by purpose) as produced in the trip generation step into a single trip table, a square matrix of trips from each TAZ origin zone to each TAZ destination zone. Trip distribution is usually undertaken as a two-step process. The first step is the production of “minimum path skim trees.” These are particular combinations of highway or transit network links and nodes which deliver a traveler going from a specific origin zone to a specific destination zone in the minimum time or distance. Each origin-destination zone combination (O-D couple) has a single minimum-time or minimum-distance highway and/or transit path, although not every O-D couple is connected via transit. The second Trip Distribution step uses the minimum paths generated in the first step and some form of spatial interaction algorithm to convert productions and attractions into trips. The most widely-used

► The NEMR TD&I Model makes use of TransCAD’s default minimum time path and gravity model algorithms.

spatial interaction algorithm is known as the “gravity model.” Like its physical namesake, travel gravity models distribute trips to origin-destination couples based on the level of activity (productions and attractions) at each origin and destination zone; and at the difficulty of traveling between those zones based on the estimated minimum paths.

**2.1.5 Step 3: Mode Share Analysis:** The third step in the standard 4-Step model, Mode Share Analysis divides the single trip table produced in the Trip Distribution step into multiple trip tables by mode based on observed survey data or the results of statistical models.

► For the full Northeast Megaregion study area, the NEMR TD&I Model uses mode share percentages (e.g., percentage of travelers who drive, or take commuter rail, subway, or bus, or who walk or ride a bike) tabulated from the 2017 National Household Travel Survey (NHTS). For the four Metro Area Cluster (MAC) models, the NEMR TD&I Model uses mode share percentages tabulated from travel surveys conducted by individual MPOs. Depending on the particular survey, these tabulations list mode share by trip purpose, trip length, and type and location of trip origin.

**2.1.6 Step 4: Route Assignment:** The final step in the standard 4-Step model, Route Assignment assigns modal trip volumes (as generated in the Mode Share Analysis step, above) to particular highway or transit routes based on minimum travel time and available vehicle capacity or transit vehicle schedules.

► The NEMR TD&I Model makes use of TransCAD’s default route assignment procedures which incrementally assign trips or vehicles to routes based on minimum travel time subject to the amount of remaining vehicle capacity. These route volumes can be displayed graphically or in list form.



Exhibit 2A: Structure & Logic of the NEMR TD&I Model

Study Area ►	Full Megaregional (FMR) Model spanning 13-state Study Area	Boston-Providence-Worcester MAC Model	Greater New York City MAC Model	Greater Philadelphia MAC Model	Baltimore-Washington-Richmond MAC Model	
	▼	▼	▼	▼	▼	
	<b>A. Model Setup Activities: Identify Traffic Analysis Zones (TAZs) and Build Highway and Transit Networks.</b>					
	<b>Identify Traffic Analysis Zones (TAZs) based on:</b>	County-based Superzone TAZs (STAZs)	MAC traffic analysis zones (MTAZs) based on combinations of zip code districts			
	<b>Build Modal Networks</b>	Build highway and intercity rail networks	Build highway network. Use GTFS data to build commuter rail, subway & trolley & local bus networks as appropriate			
<b>B. Four-Step Travel Demand Modeling</b>						
<b>Step 1: Trip Generation</b>	Generate trip productions and attractions (Ps & As) by trip purpose and county	Generate trip productions and attractions (Ps & As) by trip purpose and county				
<b>Step 2: Trip Distribution</b>	Generate trip tables (by purpose) using minimum path times and gravity model	Generate trip tables (by purpose) using minimum path times and gravity model				
<b>Step 3: Mode Share Analysis</b>	Use distance-based mode share percentages from 2017 National Household Travel Survey	Use zonal-type and distance-based mode share percentages from local MPO travel demand surveys				

<b>Step 4: Traffic Assignment</b>	All-or-nothing highway and intercity rail route assignments	All-or-nothing highway, commuter rail, subway, and local bus route assignments
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## 2.2 TWO MODELING GEOGRAPHIES

The NEMR TD&I Model operates at two geographic scales. The first is the megaregional scale which spans the full Northeast Megaregion from Portland (Maine) to Richmond ( Virginia). The Full Megaregional Model (FMR Model) uses counties as its traffic analysis zones (TAZs); is limited to analyzing roadway and inter-city rail service; and uses mode share percentages calculated from the 2017 National Household Transportation Survey (NHTS).

The FMR Model is meant to be used by transportation planners and decisionmakers who want to understand how big transportation investments or service changes undertaken in one part of the NEMR will likely affect travel behavior and travel patterns in other parts of the NEMR. Situations where planners would want to use the FMR Model could include upgrading existing Northeast Corridor regional rail service to a high-speed rail service or building a new rail tunnel under the Hudson River between Manhattan and New Jersey or adding additional freeway capacity between Baltimore and Richmond. The effects of each of these investments on travel patterns and traffic would be felt far beyond the specific counties or even metropolitan areas where they occur. Fully understanding the magnitude and spatial extent of those effects requires having a modeling and forecasting system whose coverage goes well beyond existing MPO and state boundaries. Exhibit 2B identifies the spatial extent of the Full Megaregional Model.

The second scale at which the NEMR TD&I Model operates is the multi-metro area scale. This scale joins adjacent metropolitan areas into four clusters (MACs) served by common roadway or rail corridors. The four MAC Models uses combinations of zip code districts as their traffic analysis zones (TAZs) and make use of MPO travel survey data as the basis of their mode share calculations. In addition to highway and commuter rail travel, the MAC models incorporate travel by subway and light-rail, and local bus service. The four MAC Models include:

- The Boston-Providence-Worcester Cluster (BPW MAC) which extends from the Boston suburbs in the north to Providence County (Rhode Island) in the south to Worcester County (Massachusetts) in the west; The BPW MAC includes 14 counties and 144 zip code-based TAZs.
- The Greater New York City Cluster (NYC MAC) which includes the five boroughs of New York City plus Fairfield County in Connecticut, Westchester, Putnam, Rockland, and

Nassau and Suffolk Counties in New York State, and Bergen, Passaic, Hudson, Essex, Union, and Somerset Counties in New Jersey. The NYC MAC includes 21 counties and 271 zip code-based TAZs.

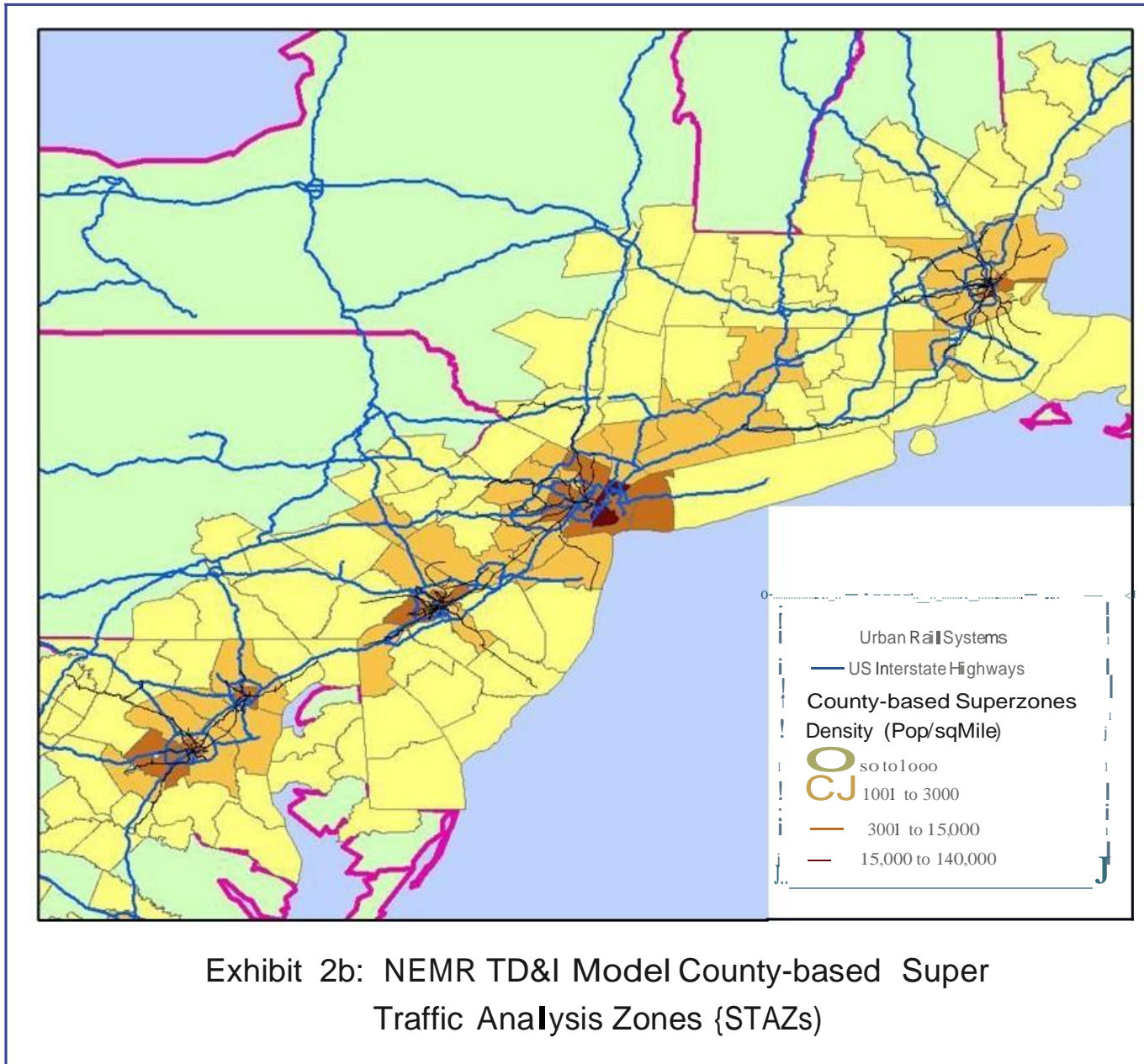
13

- The Greater Philadelphia Cluster (PHILLY MAC) which centers on Philadelphia and extends from Mercer County (New Jersey) in the north to Camden and Burlington County (New Jersey) in the east to New Castle County (Delaware) in the south, to Chester County (Pennsylvania) in the west. The PHILLY MAC includes 13 counties and 140 zip codebased TAZs.
- The Baltimore-Washington DC-Richmond Corridor Cluster (BDCR MAC) which follows Interstate 95 south from Baltimore County through Washington D.C.'s Maryland and Virginia suburbs to Richmond and Henrico County (Virginia) in the south. The BDCR MAC spans 39 counties and 207 zip code-based TAZs.

Exhibit 2C identifies the four MAC study areas.

Exhibit 2D summarizes the key operational differences between the Full Megaregion Model and the four MAC Models.







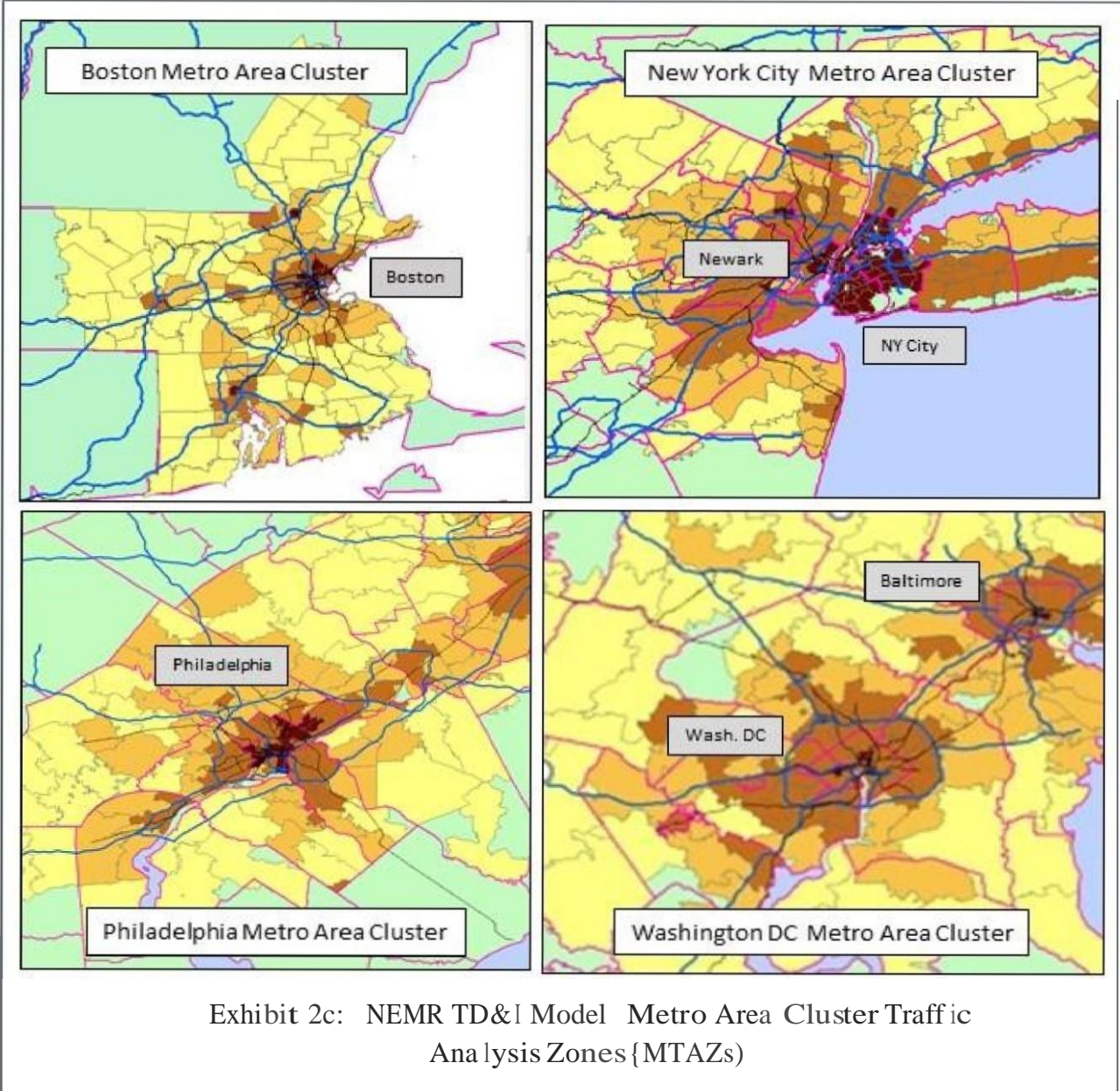


Exhibit 2D: Comparing the Full Megaregion (FMR) and Metro Area Cluster (MAC) Models

Model Type & Scale ►		Full Megaregional (FMR) Model	Metro Area Cluster (MAC) Models
Geographical Coverage ►		13-state Northeast Megaregion	4 separate metro area clusters (Boston, New York City, Philadelphia, Washington DC)
Model Setup Activities	Traffic Analysis Zones (TAZs) based on:	Counties (Super-TAZs, or STAZs)	Combinations of zip code districts (MAC TAZs or MTAZs)
	Modal Networks	Highways and Inter-city rail only	Highways, regional and commuter rail, subways, metropolitan and urban bus
	Forecasting Geographies	County-based population and job projections	County-level projection and job projections are disaggregated to the zip-code-based MTAZ level
Four-Step Travel Demand Modeling	Step 1: Trip Generation	Uses NCRP 365 trip generation rates to generate trip productions and attractions by purpose & STAZ	Uses NCRP 365 trip generation rates to generate trip productions and attractions by purpose & MTAZ
	Calculate Minimum Path Times	Calculates highwaybased minimum travel times between each origin-destination STAZ pair	Calculates highway-based minimum travel times between each origindestination MTAZ pair
	Step 2: Trip Distribution	Generate trip tables (by purpose) using STAZ-based minimum path times and gravity model	Generate trip tables (by purpose) using MTAZ-based minimum path times and gravity model
	Step 3: Mode Share Analysis	Use distance-based mode share percentages from 2017 National Household Travel Survey	Use zonal-type and distance-based mode share percentages from local MPO travel demand surveys
	Step 4: Traffic Assignment	All-or-nothing highway and intercity rail route assignments	All-or-nothing highway, commuter rail, subway, and local bus route assignments
	Truck Traffic Assignment II (Optional)	Add in truck trips generated from modified FAF4.1 freight flows	
	Scenario Building Approaches	Similar approaches for both scales: (i) Alternative population and job forecasts; (ii) User-specified alternative mode share percentages; (iii)user-specified changes to highway or rail network to incorporate changes in service	

## 2.3 ALTERNATIVE POPULATION AND EMPLOYMENT PROJECTIONS

To help ensure that the megaregional forecasting process is consistent across the 13 states and 20 metro areas in the NEMR study area, the NEMR TD&I Model comes pre-packaged with three sets of 2030 and 2040 population and employment projections. The three sets include:

1. State-generated Forecasts and Projections: This set of projections starts with 2030 and 2040 state- and county-level population projections as generated by each state's planning department, data center, or other applicable agency; and with 2015 state and county job counts as identified in the Census Bureau's *County Business Patterns* database. To convert the 2030 and 2040 population projections to 2030 and 2040 job projections, the former are divided by the applicable state or county population-to-job ratio as of 2015. To account for expected increases in labor force participation rates, the 2030 state-level population-to-jobs ratio is reduced by 0.1 over the 2015 ratio, and the 2040 ratio is reduced by another 0.1 over the 2030 ratio. These upward-adjusted state employment projections are then used as control totals to adjust the 2030 and 2040 county-level job projections.
2. County Growth Trend Projections: This method assumes that recent county-level population and employment trends will continue indefinitely into the future. In terms of population projections, it first calculates annualized rates of county population change between 2000 and 2018 and compounds them forward by 12 and 22 years respectively to generate 2030 and 2040 county population estimates.

These county-level estimates are then adjusted upward or downward so that they sum to the state projections. Similarly, in terms of employment projections, we first calculate annualized rates of county employment change between 2012 and 2018, and then use those job growth rates to generate 2030 and 2040 job projections. Because the 2012-2018 period was one of atypically sustained job growth, we impose categorical limits of +1% and -1% on each county's annualized job growth rate. The resulting state-level job projections are cross-checked for reasonableness with the 2015 population-to-job ratios used in the prior method, and then used as control totals to adjust the county-level job projections accordingly.

3. State Share Trend Projections: This method assumes that recent county population and job share trends will continue into the future. For example, if a county's share of its state's population fell from 12% in 2000 to 10% in 2018 and the trend continues, its 2030 population share will be 8.67% (10% - [12 years \* -.11% annual share change]) while its 2040 population share will be 7.56% (10% - [22 years \* -.11% annual share change]).

These annual share trend rates are used to generate 2030 and 2040 county population and

job estimates, which are then adjusted upward or downward so that they sum to the statelevel population and job projections generated in the state forecasting method described earlier.

4. User Projections: This option allows for user flexibility in incorporating alternative population and job shared trends/assumptions. By utilizing the Projections Editor script, the user will have the ability to export and

recombine the provided projection databases, allowing for alternative analysis. Exhibit 2E below summarizes the key differences between the three projections series.

Table 2E: Population and Job Projection Method Comparisons

<b>State-generated Projections</b>	<b>County Growth Trend Projections</b>	<b>State Share Trend Projections</b>
------------------------------------	--	--------------------------------------

<b>Assumptions</b>	High-quality state forecasts; no big shifts in population-to-job ratios or TAZ-to-county ratios	Current county-based population growth trends continue through 2040; no big shifts in current population-to-job ratios or TAZ-to-county ratios	Current county population share trends continue through 2040; no big shifts in current population-to-job ratios or TAZ-to-county ratios
<b>Geography</b>	Counties	Counties	Counties
<b>Years</b>	2030 & 2040	2030 & 2040	2030 & 2040
<b>Source Data</b>	State planning and finance agencies	2000 and 2018 Census and ACS estimates	2002 and 2018 Census and ACS estimates
<b>Job Sources</b>	2018 County Business Patterns	2018 County Business Patterns	2018 County Business Patterns
<b>Population Projection</b>	Relies on county population projections generated by state agencies	Extends each county's 2000-2018 (annualized) growth rate, subject to 1% annual limit	Extends each county's 2000-2018 share of state population growth
<b>Population Total</b>	Yes	Yes	Yes
<b>Projection</b>	Extends 2018 countybased jobs-to-population ratios, with gradual convergence to state ratio.	Extends 2018 countybased jobs-to-population ratios, with gradual convergence to state ratio.	Extends 2018 countybased jobs-to-population ratios, with gradual convergence to state ratio.
<b>Ratio to Model TAZs</b>	2018 Population and Job MTAZ-to-County Ratio	2018 Population and Job MTAZ-to-County Ratio	2018 Population and Job MTAZ-to-County Ratio

## 2.4 MPO-BASED MODE SHARE PERCENTAGES

The usual approach to mode share or mode choice analysis is to use travel survey information to build a statistical model that relates traveler characteristics and modal level of service measures to the share of zonal trips using each competing mode, or to the choice of mode for a particular trip destination and

purpose. This approach is very data intensive and works well when all the travelers in a particular study region have the same choices among modes. It is less useful, as in the current case, when the choice of modes varies between metro areas or even within metro areas. For this reason, instead of building a statistical model, we applied existing mode share percentage as derived from the results of locally-appropriate travel demand surveys. In the case of the Full Megaregion Model (FM), we calculated mode share percentages from the 2017 National Household Travel Survey as tabulated by origin metro area, trip length, and trip purpose.

For the four Metro Area Cluster (MAC) models, instead of using NHTS tabulations, we used tabulations and mode share percentages derived from local MPO travel demand surveys. These included the 2011 Massachusetts Travel Demand Survey, which was administered for the Boston region by the Boston Region Metropolitan Planning Organization; the 2010-2011 New York Regional Household Travel Survey (covering parts of New York, New Jersey and Connecticut) conducted by the New York Metropolitan Transportation Council; the 2012-2013 Delaware Valley Regional Travel Survey (covering parts of Pennsylvania, New Jersey and Delaware) conducted by the Delaware Valley Regional Planning Commission; and the 2007/2008 TPB Household Travel Survey (covering Washington DC, Baltimore, and parts of Maryland and Northern Virginia) by the National Capital Region Transportation Planning Board. Each of these agencies uses its own surveying frames and formats, making it difficult to directly compare the results of one survey to another. This limitation notwithstanding, planners can use the individual surveys to see how the use of various travel modes varies within each MAC region by trip purpose, origin area or type, and trip distance.

NEMR TD&I Model users can use the various survey-based mode share percentages as is, or they can vary them in a manner consistent with proposed transportation facility investments or level of service changes. Suppose, for example, that Boston were to build a connector link between North Station and South Station enabling commuter rail travelers coming from Boston's southern suburbs via South Station to continue on directly—something they cannot currently do—to North Station, which serves Boston's northern suburbs. This improvement in commuter rail service could be simulated by increasing commuter rail's current mode share for medium-

distance Boston area work trip from its current level of 3-7% (depending on the purpose) up to 4-8% to reflect commuter rail's improved modal attractiveness.

Exhibit 2F summarizes the major differences between the 2017 National Household Travel Survey (NHTS) and the four MPO-based travel surveys.





Table 2F: Sources of Mode Share Percentages Used in the NEMR TD&I Model

Study Area & Model	Northeast Megaregion FMR Model	BostonProvidence-Worcester MAC Model	Greater New York MAC Model	Greater Philadelphia MAC Model	Washington DC-Baltimore-Richmond MAC Model
<b>Surveying Organization</b>	Federal Highway Administration National Household Travel Survey (NHTS)	Boston Area trips selected from the NHTS	New York Metropolitan Transportation Council	Delaware Valley Regional Planning Commission	National Capital Region Transportation Planning Board
<b>Survey Years</b>	2017	2017	2010-2011	2012-2013	2007-2008
<b>Data Classification System</b>	Metro area, trip purpose, travel distance band, top 4 modes	Trip purpose & distance band, top 4 modes	County of origin, trip purpose, trip distance band, top 4 modes	Origin zone type (e.g., CBD, outer CBD, etc.), trip purpose, trip distance band, top 4 modes	County of origin, trip purpose, trip distance band, top 4 modes
<b>Trip Distance Bands</b>	< 25 miles; 25-50 miles; 50-75 miles; 75-100 miles; 100-150 miles; 150-200 miles; 200-300 miles; 300-500 miles; 500-1000 miles; > 1000 miles	< 1 mile; 1-3 miles, 3-5 miles; 5-10 miles; 10-15 miles; 15-20 miles; 20-25 miles; 25-30 miles; 30-40 miles; 40-50 miles; 50-99 miles; 100+ miles	< 1 mile; 1-3 miles; 3-5 miles; 5-10 miles; 10-15 miles; 15-20 miles; 20-25 miles; 25-30 miles; 30-40 miles; 40-50 miles; 50-75 miles; 75+ miles	< 1 mile; 1-3 miles; 3-5 miles; 5-10 miles; 10-15 miles; 15-20 miles; 20-25 miles; 25-30 miles; 30-40 miles; 40-50 miles; 50+ miles	< 1 mile; 1-3 miles; 3-5 miles; 5-10 miles; 10-15 miles; 15-20 miles; 20-25 miles; 25-30 miles; 30-40 miles; 40-50 miles; 50-75 miles; 75+ miles
<b>Major modes</b>	Auto driver or passenger, commuter/regional rail, subway, bus, taxi, walk & bike, ferry, air, other	Auto driver or passenger, commuter/regional rail, subway, bus, taxi, walk & bike, ferry, air, other	Auto driver or passenger, commuter/regional rail, subway, inter-city bus, urban bus, school bus, taxi, walk & bike	Auto driver or passenger, commuter/regional rail, subway, inter-city bus, urban bus, school bus, taxi, walk & bike	Auto driver, auto passenger, commuter rail, subway, inter-city bus, urban bus, school bus, taxi, walk & bike, ferry

## 2.5 ADDING TRUCK TRIPS

One of the NEMR TD&I Model's most useful features is its ability to assign truck trips to highway links along with passenger vehicles. In terms of estimating the number of truck trips to be assigned, the NEMR TD&I Model makes use of 2012 freight flow estimates and 2030 and

2040 freight flow projections as produced by the Federal Highway Administration's Freight Analysis Framework, now in its fourth iteration and known as FAF4.1. FAF4.1 identifies U.S. goods movement flows by weight and value across 150 national freight-analysis zones (FAZs) comprised of major metropolitan areas and non-metropolitan state remainders. FAF 4.1 divides these flows across seven freight modes (truck, rail, water, air, pipelines multiple modes, and other) and into 47 commodity types ranging from coal and petroleum products to precision instruments. Because FAF 4.1 operates with a different geography than the NEMR TD&I Model, identifying and incorporating FAF 4.1-based truck flows into the NEMR TD&I Model requires a number of geographic and categorical modifications. These include:

1. Aggregating FAF4.1's freight flows based on a zonal geography that is consistent with the Full Megaregional Model's county-based zones. All told, this involved collapsing FAF4.1's 150 national freight zones into 29 county-based NEMR TD&I super zones.
2. Collapsing FAF4.1's 47 distinct commodity types into 27 commodity groups.
3. Developing updated freight flow projections for 2030 and 2040 based on more recent economic and populations growth rates—FAF4.1's projections were last updated in 2012—and using the updated zonal geographies and commodity categories.
4. Separating out truck-based freight flows from other modes and parsing them into discrete truck trips based on commodity types and weights.
5. Converting annual truck trips by commodity type into single-day and hourly trip volumes between NEMR TD&I Model zones. These single-day and time-of-day truck trips can then be assigned to the same highway links used by the FM and MAC Models.

Exhibit 2G summarizes these steps in greater detail. A separate NEMR TD&I Freight Module allows users to interactively specify which commodity groups they wish to include in the mapped truck trip volumes as well as how many tons of each commodity an individual truck can carry.

Exhibit 2G: Converting FAF4.1 Freight Flows to NEMR TD&I Model  
Truck Trips

Step 1	Collapse 150+ FAF4.1 Freight Analysis Zones into 29 Countybased Superzone TAZs (STAZ)
Step 2	Aggregate 47 FAF4.1 Commodity Types into 27 Commodity Groups
Step 3	Summarize FAF4.1 Freight Flows by NEMR TD&I Origin and Destination STAZ, Commodity Group and Freight Mode
Step 4	Extract Truck Trip Freight Flows
Step 5	Divide Truck Freight Flows (by commodity group) by Average Truck Capacity (in tons) to calculate Truck Trips
Step 6	Convert Yearly Truck Trips (by commodity group) into Daily and Hourly Flows
Step 7	Assign Truck Trips (by commodity group or in total) to NEMR TD&I Highway Links

## CHAPTER 3: DOWNLOADING AND CONFIGURING THE NEMR TD&I MODEL & DATA

### 3.1 HOW THE NEMR TD&I MODEL WORKS WITH TRANSCAD

The NEMR TD&I Model is written in GISDK, a proprietary scripting language that works with TransCAD. Both GISDK and TransCAD are products of the Caliper Corporation. To use the NEMR TD&I Model, you must have purchased a legal copy of TransCAD.

The NEMR TD&I Model runs by accessing designated TransCAD procedures which generate new data files to be used sequentially in the standard 4-step travel demand forecasting model as follows:

<u>Input Files</u>	<u>TransCAD Procedure</u>	<u>Output File</u>
Population & Job Projections >	Trip Generation >	Trip Productions & Attractions
Highway Network File	Minimum Path Calculation >	Minimum Path File
Productions & Attractions & Minimum Paths >	Trip Distribution	Total Trip Table
Total Trip Table & Mode Share Percentages >	Mode Share Analysis	Trip Table by Mode
Highway or Transit Network File & Modal Trip Table >	Traffic & Route Assignment	Traffic Flows by Link

Note that once created and saved, these data files can later be accessed by TransCAD outside of a NEMR TD&I session.

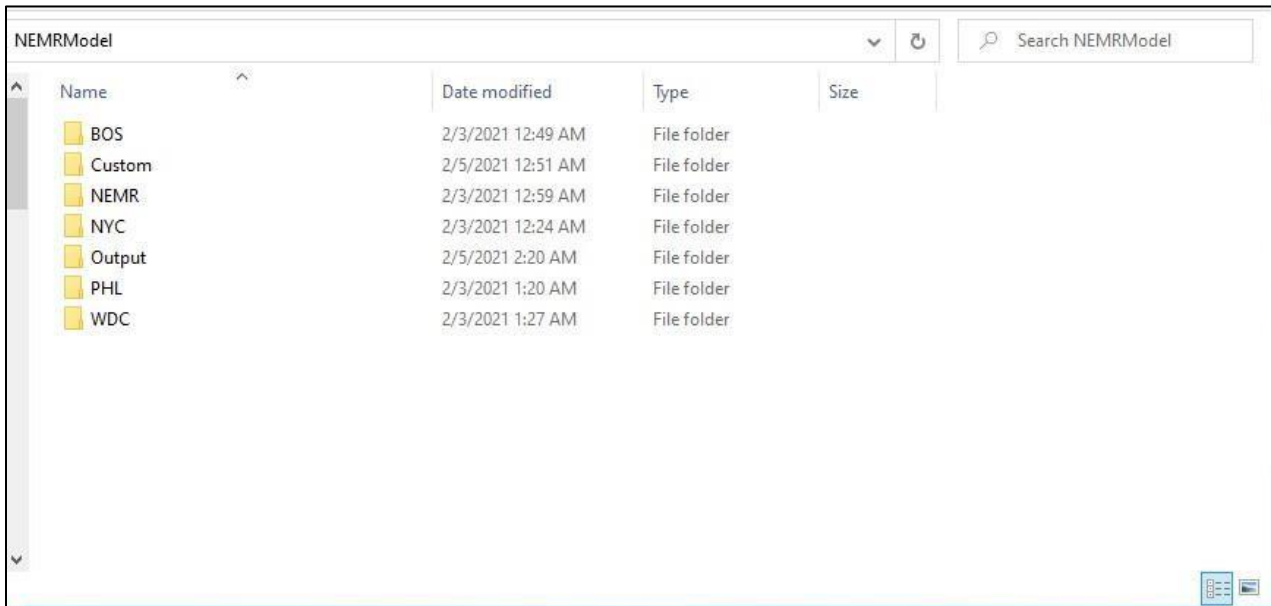
To run the NEMR TD&I Model, it must first be compiled and linked to TransCAD.

### 3.2 DOWNLOADING AND CONFIGURING THE NEMR TD&I MODEL & DATA

The NEMR TD&I Model and associated input data can be downloaded from the Download section of the Northeast Megaregion Travel Demand and Investment Model website ( ). The model scripts must be downloaded separately from the data. The model scripts are all contained in one .zip file (NEMRModelScripts.zip) while the data (NEMRModelData.zip) is contained in another. The following steps explain how to download the model scripts and data, create a robust file structure, and link the model scripts to TransCAD.

1. Go to the NEMR TD&I website). Once there, go to the **Download Center**.
2. Click on the **Download Model Scripts** link. Your browser will ask you for a destination location for the .zip file that contains the various model scripts. Create a “**temp**” folder on your desktop or local disk drive and download it there.

3. Create a new folder on your Desktop or local disk drive named “**NEMRModel**” and unzip the model scripts into it.
4. Repeat Steps 2 and 3 for the **Download Data** link.
5. Properly unzipping the model scripts and data to the “**NEMRModel**” folder should create a folder and directory structure that looks as follows:



The BOS (Boston MAC), NYC (New York MAC), PHL (Philadelphia MAC), and WDC (Washington DC MAC) **Region** folders each contain all the relevant input files and data for their corresponding metro area clusters. The **NEMR** (Northeast Megaregion) folder contains similar files and data for the entire Northeast Megaregion. The **Output** folder is where files generated by the NEMR TD&I Model will automatically be stored. The **Custom** folder is where files used by the Projection Editor and Mode Share Editor modules will be copied to and modified

Each **Region** folder contains the following files and folders:

NEMRModel > BOS

Search BOS

Name	Date modified	Type	Size
HBO	1/20/2021 11:55 PM	File folder	
HBW	1/20/2021 11:56 PM	File folder	
MapFiles	2/3/2021 12:58 AM	File folder	
NHB	1/20/2021 11:56 PM	File folder	
BOSBus.net	2/5/2021 1:58 AM	NET File	2,828 KB
BOSDrive.net	12/21/2020 11:44 AM	NET File	107,268 KB
BOSRail.net	2/4/2021 12:45 AM	NET File	150 KB
BOSSub.net	1/26/2021 4:54 PM	NET File	72 KB
BostonMACZones.bdr	1/19/2021 2:38 AM	BDR File	9 KB
BostonMACZones.BIN	1/19/2021 2:38 AM	BIN File	51 KB
BostonMACZones.BX	1/19/2021 2:38 AM	BX File	5 KB
BostonMACZones.cdd	1/19/2021 2:38 AM	CDD File	1 KB
BostonMACZones.cdk	1/19/2021 2:38 AM	CDK File	2 KB
BostonMACZones	1/19/2021 2:38 AM	Caliper Standard ...	5 KB
BostonMACZones.DCB	1/19/2021 2:38 AM	DCB File	3 KB
BostonMACZones.dsc	1/19/2021 2:38 AM	DSC File	2 KB
BostonMACZones.dsk	1/19/2021 2:38 AM	DSK File	2 KB
BostonMACZones	1/19/2021 2:38 AM	Microsoft Progra...	2 KB
BostonMACZones.lok	1/19/2021 2:38 AM	LOK File	11 KB
BostonMACZones.pnk	1/19/2021 2:38 AM	PNK File	9 KB
BostonMACZones.pts	1/19/2021 2:38 AM	PTS File	143 KB
BostonMACZones.r0	1/19/2021 2:38 AM	R0 File	12 KB
BostonMACZones.r1	1/19/2021 2:38 AM	R1 File	20 KB
BostonMACZones.sty	1/19/2021 2:38 AM	STY File	1 KB
Distance_ShortestPaths	10/29/2020 2:37 AM	TransCAD Matrix	117 KB
Time_ShortestPaths	10/29/2020 2:37 AM	TransCAD Matrix	118 KB

The **HBO**, **HBW**, and **NHB** folders contain mode share information for all appropriate region modes (car, rail, bus, subway).

NEMRModel > BOS > HBO

Search HBO

Name	Date modified	Type	Size
busS	1/14/2021 1:19 AM	TransCAD Matrix	10 KB
driveS	12/4/2020 10:58 PM	TransCAD Matrix	41 KB
railS	1/14/2021 1:17 AM	TransCAD Matrix	7 KB
subS	1/14/2021 1:18 AM	TransCAD Matrix	50 KB

**MapFiles** contains road and rail geography files that users can import to TransCAD in order to generate Flow Maps using finished Traffic Assignment tables from the Model.

NEMRModel > BOS > MapFiles

Search MapFiles

Name	Date modified	Type	Size
BOSBus.BIN	2/3/2021 12:56 AM	BIN File	10,503 KB
BOSBus.BX	2/3/2021 12:56 AM	BX File	528 KB
BOSBus	2/3/2021 12:56 AM	Caliper Standard ...	2 KB
BOSBus.DCB	2/3/2021 12:56 AM	DCB File	1 KB
BOSBus.dln	2/3/2021 12:56 AM	DLN File	6,458 KB
BOSBus.kln	2/3/2021 12:56 AM	KLN File	5,010 KB
BOSBus.pts	2/3/2021 12:56 AM	PTS File	4,899 KB
BOSBus.sty	2/3/2021 12:56 AM	STY File	1 KB
BOSBus_.sty	2/3/2021 12:56 AM	STY File	2 KB
BOSDrive.BIN	2/3/2021 12:53 AM	BIN File	81,338 KB
BOSDrive.BX	2/3/2021 12:53 AM	BX File	9,522 KB
BOSDrive.ctp	2/3/2021 12:53 AM	CTP File	1,962 KB
BOSDrive	2/3/2021 12:52 AM	Caliper Standard ...	2 KB
BOSDrive.DCB	2/3/2021 12:52 AM	DCB File	5 KB
BOSDrive.dln	2/3/2021 12:53 AM	DLN File	83,858 KB
BOSDrive.kln	2/3/2021 12:53 AM	KLN File	70,832 KB
BOSDrive.pts	2/3/2021 12:53 AM	PTS File	26,293 KB
BOSDrive.st1	2/3/2021 12:53 AM	ST1 File	6 KB
BOSDrive.sty	2/3/2021 12:53 AM	STY File	32 KB
BOSDrive_.sty	2/3/2021 12:53 AM	STY File	2 KB
BOSRail.BIN	2/3/2021 12:57 AM	BIN File	23 KB
BOSRail.BX	2/3/2021 12:57 AM	BX File	12 KB
BOSRail	2/3/2021 12:57 AM	Caliper Standard ...	2 KB

**Network** files (.net) for each region and mode are in this folder. The relevant MACZone geography file contains data that will be used by the Model to generate Trip Productions and Attractions. Finally, the Distance and Time Shortest Path files are default matrices used to create total trip matrices for each relevant purpose.

6. Before the NEMR TD&I Model script can be run, it must be compiled within TransCAD.  
[More here]

7. To run the NEMR TD&I Model..... Upon opening, the “Getting Started” tab in the NEMR TD&I Model will ask you to identify a particular file path from which it will draw needed data inputs. Set this path to either “NEMR,” “BOS”, “NYC”, “PHL”, or “WDC.”After compiling the NEMR TD&I Model, the user will be asked to identify the specific path location of this folder on the first tab.

Upon downloading the Model script and compiling it in TransCAD, you should be able to follow the relevant instructions to correctly set your Input and Output file paths according to the location of your NEMRModel download. The Model should be able to run smoothly from there.

### 3.3 DATA FILE ORGANIZATION AND STRUCTURE

#### 3.3.1 Directories

As noted above, the input and output data files used by the NEMR TD&I Model are organized according to the following directory structure:

- Home Directory ○ Boston
  - Input Files ○ NEMR Input
  - Files ○ New
- York Input Files ○
  - Philadelphia Input Files ○
  - Washington Input Files ○
  - All Output Files

#### 3.3.2 Input File Types and Characteristics

The NEMR TD&I Model includes four sets of input files per study area. These include:



1. Population and employment projections for 2030 and 2040, which are used in the **Trip Generation** step to generate future trip productions and attractions by TAZ and trip purpose. Separate input files are included for each of three projection methods (current state-based forecasts, current growth trends, and current share trends) and for each projection year (2030 and 2040). These files are each stored in TransCAD's table format.
2. Highway and transit network files, which are used to construct minimum highway travel minimum paths between every TAZ origin and destination pair as input into the **Trip Distribution** step; as well as to provide the base layers for assigning and displaying highway and transit vehicle and passenger flows. These files are stored in TransCAD's network file format.
3. Default highway minimum path files, which list the highway links that comprise the minimum time path between each TAZ origin destination pair. These files serve as inputs into the **Trip Distribution** step. These files are meant to be used as the default option for users NOT wishing to generate new minimum path files. These files are stored in TransCAD's network file format
4. Mode share tables, which list the different highway, commuter rail, subway, and bus mode shares between every TAZ origin and destination pair. These estimates are derived from the 2017 national Household Transportation Survey (NHTS) or from local MPO surveys and are used to divide the total trip table created in the **Trip Distribution** step into its modal component trips. Separate mode share files are included for each trip purpose (HBW, HBO and NHB) and mode (highway, intercity rail, commuter rail, subway/light rail, and bus). These files are each stored in TransCAD's table format.

In addition, users can access 2030 and 2040 truck trip tables for the Full Megaregion (FMR) Model created using freight flow data from the U.S. Department of Transportation's Freight Analysis Framework (FAF version 4.1) Model. These files are also stored in TransCAD's table format.

Each set of input files is located in the Study Area home directory (e.g., the population and employment projections for the Boston-Providence-Worcester Metro Area Cluster (MAC) are located in the "/Boston Study Area" directory, while the highway, commuter rail, subway, and bus network files for the Greater Philadelphia Metro Area Cluster are located in the "/Philadelphia Study Area" directory.

### **3.3.3 Default Output File Locations**

Each step in the NEMR TD&I Model produces one or more output files (e.g., the Trip Generation step produces a file of 2030 or 2040 trip productions and attractions; while the Trip Distribution step produces a total trip table detailing the number of trips between each TAZ origin-destination pair.) These files are located always located in the “/Output” directory regardless of study area, and can be identified according to the name of the process used to create them:

- TripGen\_Output
- MinPath\_Output
- TripDist\_Output.
- ModeShare\_Output

Each successive step in the NEMR TD&I Model is automatically set up to use the output from the previous step as its input. This means that prior output files are automatically overwritten every time the user undertakes a new NEMR TD&I Model run. For this reason, each step in the NEMR TD&I Model gives the user to copy its output to an external location. This allows users to accumulate intermediate output files for later analysis and use. Note that there is no default location for the results of the Traffic and Route Assignment step, and that users must save the results of that step to an external location.

## **3.4 USER INPUT FILES AND TABLES**

## **3.5 SAVING USER OUTPUT FILES AND TABLES**

## CHAPTER 4: NEMR TD&I MODEL DATA INPUTS

The NEMR TD&I Model uses four sets of inputs: (i) a set of population and job projections for 2030 and/or 2040 as input into its trip generation procedures; (ii) a series of highway, rail, and bus networks as input into its trip distribution and traffic assignment procedures; (iii) mode share tables as input into its modal trip calculation procedures; and (iv) a table of truck trips as an option input into its traffic assignment procedures. Each of these inputs is explained in greater detail below.

### 4.1 POPULATION AND JOB PROJECTION DATA INPUTS

The NEMR TD&I model uses a series of 2030 and 2040 population and job projections as inputs into the **Trip Generation** step, which calculates trip productions and attractions from and to each transportation analysis zone. These projections were developed at the county level for the Full Megaregion (FMR) Model and at the zip code district level for the four MAC Models. The data are stored in TransCAD's native database format, but can be edited using the **Projections Editor** script, which exports the data as an Excel (.xlsx) spreadsheet, and then re-imports any user changes.

Key data fields in the Projections data files include:

- Superzone TAZ number (STAZ)
- MAC TAZ number (MTAZ)
- State number
- State abbreviation
- County or place name
- Population projection for 2030 or 2040 by STAZ or MTAZ • Job projection for 2030 or 2040 by STAZ or MTAZ
- Household projection for 2030 or 2040 by STAZ or MTAZ
- Automobiles Available for 2030 or 2040 by STAZ or MTAZ
- # of Households with 0 cars in 2030 or 2040 by STAZ or MTAZ
- # of Households with 1 car in 2030 or 2040 by STAZ or MTAZ • # of Households with 2 car in 2030 or 2040 by STAZ or MTAZ • # of Households with 3 car in 2030 or 2040 by STAZ or MTAZ • # of Households with 4 car in 2030 or 2040 by STAZ or MTAZ
- # of Households with 5 car in 2030 or 2040 by STAZ or MTAZ
- # of Retail Jobs in 2030 or 2040 by STAZ or MTAZ
- # of Service Jobs in 2030 or 2040 by STAZ or MTAZ

- # of Other Jobs in 2030 or 2040 by STAZ or MTAZ

To help users analyze the travel impacts of alternative growth futures, three different sets of forecasts were created:

#### **4.1.1 Projection Set 1: County and Superzone-level 2030 and 2040 Population and Job**

**Projections based on State-generated Population Forecasts:** This set of projections makes use of the current “as-is” set of 2030 and 2040 county population forecasts developed by each NEMR state. Most states use some combination of trend and cohort survival methods to develop their population projections, and no attempt was made to standardize methods or models among states.

Since states do not routinely develop long-term job projections, we started with the assumption that the 2015 job-to-population ratio in each county will remain unchanged through 2030 and 2040. This assumption, which presumes that the connection between the number of residents and the number of jobs in each county is fairly stable, enabled us to convert county-level population projections into county-level job projections.

To account for expected increases in labor force participation rates, 2030 state-level population-to-jobs ratios are reduced by 0.1 compared to their 2015 values and reduced by another 0.1 for 2040. These upward-adjusted state employment projections are then used as control totals to adjust county-level 2030 and 2040 job projections.

TransCAD’s trip generation routines also require information on the number of future households and retail jobs. These were generated from county-level population and job projections using 2015 household-to-population and retail job-to-total job ratios.

As input into the MAC Models, county-level population and job projections are then converted to MTAZ-level population and job projections using 2015 MTAZ-to-county population and job ratios.

#### **4.1.2 Projection Set 2: County-level Growth Trend Projections:**

Most state population forecasts assume that county-level population growth trends will correspond to state-level trends. This second set of population and job projections relaxes this assumption by *allowing recent county-level population and job growth trends to continue forward on their own through 2030 and 2040* so long as they do not collectively exceed state forecasts.

In terms of developing population projections, we begin by calculating annualized rates of population growth or decline between 2000 and 2018 for each county. These 2000-2018 annualized change rates are then applied forward for 12 and 22 years to yield 2030 and 2040 county population estimates. These county-level estimates are then adjusted upward

or downward so that in total do not exceed or fall short of their respective state population projection.

A similar procedure is used to generate 2030 and 2040 job projections. Using data from the U.S. Department of Commerce's *County Business Patterns* series, we first calculate 2012to-2018 annualized rates of employment change for each county. To prevent any past shortterm job bursts—either positive or negative—from cascading uncontrollably forward, we impose categorical limits of +1% and -1% on each county's annualized job growth rate.

These modified job growth rates are then applied forward for 12 and 22 years to generate 2030 and 2040 job projections. The resulting county-level job projections are then aggregated to the state level where they are cross-checked to the state job totals produced in the previous method (which account for rising labor force participation rates) and modified upward or downward as need be. This prevents the sum or the parts (counties) from exceeding the whole (states).

With these corrected 2030 and 2040 population and job projections in hand, we then apply the same 2015 county-level population-to-household and retail-job-to-total job ratios used in the previous forecasting method to project 2030 and 2040 county-level households and retail jobs.

As input into the MAC Models, these county-level population, household and job projections are then converted to Superzone-level projections using 2015 Superzone-to-county population and job ratios.

**4.1.3 Projection Set 3: County-level Share Trend Projections:** This third set of population and job projections assumes that recent share trends relating each county's population and job totals to its respective state will continue through 2030 and 2040. For example, if a county's share of its state's population fell from 12% in 2000 to 10% in 2018 and this trend continues, then its 2030 population share will be 8.67% ( $10\% - [12 \text{ years} * -.11\% \text{ annual share change}]$ ), and its 2040 population share will be 7.56% ( $10\% - [22 \text{ years} * -.11\% \text{ annual share change}]$ ). After being adjusted upward or downward to ensure that the statewide share total doesn't exceed 100%, these county share projections are then multiplied by their respective state's 2030 and 2040 statewide population projections to yield county-level population and job projections.

As with the previous two projection sets, these population and job projections are then converted into households and retail jobs using 2015 county-level population-to-household

and retail-to-total jobs ratios. As input into the MAC Models, these county-level population, household and job projections are then converted to Superzone-level projections using 2015 Superzone-to-county population and job ratios.

► Users wishing to input their own projections as the basis for a NEMR TD&I Model run should use the **Projections Editor** script to do so. The Projections Editor script exports one or more projections from its native TransCAD file format to an Excel file, where existing values can be edited or new values inserted. Once any changes are made, the Projections Editor will convert the file to a TransCad-compatible file format and correctly join it to appropriate source file.

For illustrative purposes, Exhibit 4A presents a side-by-side comparison of the three population and job projection results for Connecticut's six counties.

Exhibit 4A: Comparison of Connecticut County 2030 and 2040 Population and Job Forecasts

County ►	<u>Fairfield</u>	<u>Hartford</u>	<u>Litchfield</u>	<u>Middlesex</u>	<u>New Haven</u>	<u>New London</u>	<u>Tolland</u>	<u>Windham</u>
Superzone TAZ	101	102	103	104	105	106	107	108
Number								
Population 2015	994,943	896,290	186,304	165,165	860,186	273,185	151,948	117,470
Jobs 2015	421,295	440,169	51,957	60,899	335,845	102,909	32,903	30,354
State-generated Population Forecasts								
Pop 2030F	897,553	930,629	180,866	166,533	891,371	280,847	155,697	130,497
Pop 2040F	905,219	948,876	170,300	163,400	900,635	276,200	154,600	134,900
Jobs 2030F	409,726	492,712	54,378	66,197	375,189	114,054	36,347	36,353
Jobs 2040F	429,849	522,582	53,261	67,564	394,339	116,679	37,543	39,091
County-level Growth	Trend P	rejections						
Pop 2030F	510,734	2,202,824	92,647	86,570	455,377	139,311	83,261	63,270
Pop 2040F	202,413	3,092,212	35,168	33,881	177,782	53,868	33,575	25,103
Jobs 2030F	447,093	497,494	51,087	66,013	358,034	106,211	27,078	31,946
Jobs 2040F	470,003	529,418	50,513	69,370	375,485	106,505	26,616	32,998
County-level Share T								
Pop 2030F	975,309	905,019	176,634	165,356	866,043	266,014	158,804	120,815
Pop 2040F	991,839	906,882	171,622	166,115	866,595	263,913	164,041	122,992
Jobs 2030F	448,874	499,307	51,121	66,277	359,471	106,445	21,390	32,071

Jobs 2040F	473,622	532,987	50,403	69,905	378,408	106,768	15,572	33,245
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## 4.2 HIGHWAY AND TRANSIT NETWORKS

Like all 4-step travel demand models, the NEMR TD&I Model makes extensive use of highway and transit networks to derive minimum time and distance routes between every trip origin and destination zone and for traffic assignment purposes. Minimum paths are used as inputs into **Trip Distribution** procedures as well as to generate trip level-of-service characteristics as inputs when building mode share models.

Networks consist of links, nodes and centroids. Links are road or transit route segments and begin and end at nodes. Nodes are connection points for one or more links. Centroids are specialized nodes located at the centers of TAZs. Travelers embark and disembark from trips at centroids, travel along links, and transfer at nodes. In addition to locational and connection characteristics, links, nodes and centroids all have attributes. Link attributes include length, travel speed, travel time, and typically vehicle capacity. Node attributes include turning movements and turning capacity.

The NEMR TD&I Model makes use of three types of networks:

**4.2.1 The National Highway Network** as implemented in TransCad which includes interstate highways, limited access roads, and major and minor arterials. It does not include collector roads and non-through streets. TransCAD's version of the National Highway Network comes "pre-built," meaning that its links and nodes are already connected and that vehicles can flow through it.

**4.2.2** Urban rail and bus networks as implemented using the open-source **General Transit Feed Specification** (GTFS) format. GTFS data is available online for most U.S. commuter rail, subway, light-rail, and urban bus systems. GTFS data consists of multiple data files that are linked "relationally" through a common field. Exhibit 4B summarizes the standard GTFS data files and structure. Once downloaded, GTFS-based transit networks must be "built," meaning their links and nodes must all be properly connected.

**4.2.3** Amtrak and inter-city rail links as assembled from multiple GTFS files and the **National Rail** network.

All told, the NEMR TD&I model includes two megaregion-scale networks and 14 sub-regional networks, four for each MAC area:

1. A single highway network that covers the full Northeast Megaregion.

2. A single inter-city rail network that covers the full Northeast Megaregion composed of Amtrak lines.
3. A highway network that covers the Boston-Providence-Worcester MAC area.
4. A GTFS-based regional and commuter rail network that covers the Boston-ProvidenceWorcester MAC area.
5. A GTFS-based subway and light-rail network that covers the Boston-ProvidenceWorcester MAC area.
6. A GTFS-based urban bus network that covers the Boston-Providence-Worcester MAC area.
7. A highway network that covers the Greater New York City MAC area.
8. A GTFS-based regional and commuter rail network that covers the Greater New York City MAC area.
9. A GTFS-based subway and light-rail network that covers the Greater New York City MAC area.
10. A GTFS-based urban bus network that covers the Greater New York City MAC area.
11. A highway network that covers the Greater Philadelphia MAC area.
12. A GTFS-based regional and commuter rail network that covers the Greater Philadelphia MAC area.
13. A GTFS-based subway and light-rail network that covers the Greater Philadelphia MAC area.
14. A GTFS-based urban bus network that covers the Greater Philadelphia MAC area.
15. A highway network that covers the Baltimore-Washington, DC-Richmond MAC area.
16. A GTFS-based regional commuter rail network that covers the Baltimore-Washington, DCRichmond MAC area.
17. A GTFS-based subway and light-rail network that covers the Baltimore-Washington, DCRichmond MAC area.
18. A GTFS-based urban bus network that covers the Baltimore-Washington, DC-Richmond MAC area.

Exhibit 4B: General Transit Feed Specification [GTFS] File Structure

GTFS File	Fields
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[Transit] Agency	Name URL Timezone
Route	Route ID Route Name (short) Route Name (long) Route Type
[Vehicle] Trip	Trip ID Route ID {links to Routes file} Service ID Schedule Block (optional)
Stop Times	Stop ID {links to Stops File} Trip ID {links to Trips file} Arrival time Departure time Stop sequence
Stop	Stop ID {Links to Stop Times file} Stop Name Stop Longitude Stop Latitude
Calender File	Service ID {links to Trips file} Service day Start date End date
Optional .txt Files	Calendar dates Fare attributes Fare rules Shapes Frequencies Transfers Feed Information

Note: Color-coding indicates key fields in multiple GTFS

The NEMR TD&I model *does not include* a bus network or commuter rail network that covers the full megaregion. The various highway networks connect to every Superzone TAZ and MAC TAZ at their respective centroids. The transit networks connect only to those Superzone and MAC TAZs that they provide a particular transit service to. As a practical matter, this means that while it is possible to travel by car to and from every TAZ, the range of TAZs served by bus and particularly rail modes is much more limited.

Travelers can access the rail or bus networks either by walking or driving. They cannot access the highway network via a transit mode. Transit passengers are allowed an unlimited number of transfers within transit modes (e.g., from one bus route to another) *but only one transfer between transit modes* (e.g., bus-to-commuter rail).

None of the highway networks include link or node vehicle capacity measures. This means that the NEMR TD&I Model cannot perform traffic assignments that make use of volume-to-capacity measures to reallocate vehicle traffic away from congested links. The various transit network do include headway and schedule data, but they are not used in the NEMR TD&I's transit route allocation runs.

Since all the NEMR TD&I Model networks come “pre-built,” they cannot be easily edited by users while in a NEMR TD&I Model session. Users interested in adapting any of the NEMR TD&I networks (e.g., to add new links or nodes or change link and node attributes) for their own use are free to do so and should consult TransCAD's “Help” feature for tips about editing and modifying networks.

### 4.3 MODE SHARE PERCENTAGE TABLES

The NEMR TD&I Model uses a series of mode share percentages to divide the “combinedmodes” trip table produced in the **Trip Distribution** step into multiple trip tables that list trips between every origin-destination pair by mode (e.g., highway, rail, subway, and bus trips). These are the trip volumes that are then allocated to roads and transit lines in the **Route Assignment** step.

For the Full Megaregion (FMR) Model, the mode share percentages are derived from the 2017 National Household Travel Survey (NHTS). For the MAC Models, the mode share percentages are based on the results of travel demand and behavior surveys conducted by individual metropolitan planning organizations (MPOs). Because each survey is organized differently, the different mode share tables each follow slightly different formats. This section reviews those formats.

**4.3.1 Full Megaregion Model Mode Share Table:** The Full Megaregion Model (FMR) makes use of metro area-specific trip activity data published in the 2017 National Housing Travel Survey (NHTS) for the Baltimore, Boston, Hartford, New York City, Philadelphia, Providence, Richmond, and Washington, D.C. metropolitan areas. The 2017 NHTS data has very good coverage in terms of mode, trip distance and trip time, but is less detailed with regard to trip purpose and destination. Outside of the New York City metropolitan area, the 2017 NHTS's sample sizes for some modes can be on the small side. With these limitations in mind, the modal share table for the FMR is organized by metro area, trip purpose, and trip distance category as shown in Exhibit 4B; with the top four mode shares listed for each combination of trip purpose and trip distance. Trips originating in counties that fall outside a listed metropolitan area are assigned mode share percentages based on the average of all trips originating within the NEMR. These percentages are used to build individual mode share tables for every Superzonal pair based on trip purpose, county of origin and trip distance category.

**4.3.2 Boston Regional MAC Mode Share Table:** Unlike the New York, Philadelphia, and Washington DC MAC Models, the Boston MAC Model draws on Boston area trip activity data published in the 2017 National Housing Travel Survey rather than the results of a local MPO survey. The resulting mode share tabulations list the mode share percentages for the top four modes (e.g. car, commuter rail, bus, taxi, subway, bike/walk, or air) for each combination of trip purpose (home-based work, home-based other, nonhome-based), and trip distance category (less than one mile, 1-3 miles, 3-5 miles, 5-10 miles, 10-15 miles, 15-20 miles, 20-30 miles, 30-40 miles, 40-50 miles, 50-75 miles, 75-100 miles, and 100+ miles).

**4.3.3 New York Regional MAC Model Mode Share Table:** The New York City Area MAC Model draws on mode share percentages calculated from the New York Metropolitan Transportation Council's 2010/2011 Regional Household Travel Survey. The resulting mode share tabulations list the mode share percentages for the top four modes (e.g. car, commuter rail, bus, taxi, subway, bike/walk, ferry, or air) for every combination of origin county (e.g., Bergen, Bronx, Brooklyn, Dutchess, etc.), trip purpose (home-based work, home-based other, non-home-based), and trip distance category (less than one mile, 1-3 miles, 3-5 miles, 5-10 miles, 10-15 miles, 15-20 miles, 20-30 miles, 30-40 miles, 40-50 miles, 50-75 miles, 75-100 miles, and 100+ miles). These percentages are used to build individual mode share tables for every New York City area zonal pair based on purpose, county of origin and trip distance category.

**4.3.4 Philadelphia Regional MAC Model Mode Share Table:** The Philadelphia Area MAC Model draws on mode share percentages calculated from tabulations of the Delaware Valley Regional Planning Commission’s 2012 Household Travel Survey. These mode share tabulations list the mode share percentages for the top four modes (e.g. car, commuter rail, bus, taxi, subway, bike/walk or air) for every combination of origin county (e.g., Bucks, Camden, Chester, etc.), trip purpose (home-based work, home-based other, non-home-based), and trip distance category (less than one mile, 1-3 miles, 3-5 miles, 5-10 miles, 10-15 miles, 15-20 miles, 20-30 miles, 30-40 miles, 40-50 miles, 50-75 miles, 75-100 miles, and 100+ miles). These percentages are then used-build individual mode share tables for every Philadelphia area zonal pair based on purpose, county of origin and trip distance category.

**4.3.5 Baltimore - Washington DC Regional MAC Model Mode Share Table:** The Baltimore-Washington DC-Richmond MAC Model draws on mode share percentages calculated from the Baltimore Metropolitan Council’s 2001 Household Travel Survey and the National Capital Region Transportation Planning Board’s 2007-2008 TPB Household Travel Survey. The resulting mode share tabulations list the mode share percentages for the top four modes (e.g. car, commuter rail, bus, taxi, subway, bike/walk or air) for every combination of origin county (e.g., Anne Arundel, Baltimore City, Baltimore County, etc.), trip purpose (home-based work, home-based other, non-homebased), and trip distance category (less than one mile, 1-3 miles, 3-5 miles, 5-10 miles, 10-15 miles, 15-20 miles, 20-30 miles, 30-40 miles, 40-50 miles, 50-75 miles, 75-100

miles, and 100+ miles). These percentages are then used-build individual mode share tables for every The Baltimore-Washington DC-Richmond zonal pair based on purpose, county of origin and trip distance category.

► The NEMR TD&I Model’s **Mode Share** procedures allow users to categorically increase or decrease particular mode share percentages (e.g., increase the share of home-based work trips in the Boston area using commuter rail by 10%) for the NEMR or MAC modeling regions. It does not permit users to adjust mode share percentages for particular origin-destination pairs or trip distance categories.

## CHAPTER 5: FULL MEGAREGION (FMR) MODEL TUTORIAL

This chapter works through the steps involved in running the NEMR TD&I Model for the entire Northeast Megaregion (NEMR) Study Area. As a reminder, the Full Megaregion (FMR) model makes use of county-based 2030 and 2040 population projections and is limited to simulating highway and inter-metropolitan rail trips.

The NEMR TD&I Model works by stepping through a sequence of six menu tabs that correspond to the steps in the standard 4-Step travel demand model. These menu tabs were created using GISDK, TransCAD's scripting language, and work by making calls to standard TransCAD procedures. Running the NEMR TD&I Model therefore requires having a legal copy of TransCAD installed and open on the user's own desktop or laptop computer. To make the most of the NEMR TD&I Model, prospective users should endeavor to develop a working knowledge of TransCAD procedures, data formats, and display tools.

The six FMR and MAC Model menu tabs include:

- A GETTING STARTED menu tab which ask the user to set a **Study Area** and **Forecast Year**.
- A TRIP GENERATION menu tab which lets users specify which population and employment projections they wish to convert to **Trip Productions and Attractions**.
- A CREATE MINIMUM PATHS menu tab which uses the appropriate highway network to generate a series of minimum travel time paths between every origin and destination TAZ in the selected study area.
- A TRIP DISTRIBUTION menu tab which uses the minimum time paths created in the previous step as input into a gravity model which converts the production and attractions created in the Trip Generation step into a **Total Trip Table** of trip-making activity for every origin-destination zonal pair in the selected study area.
- A MODE SHARE ANALYSIS menu tab which uses survey data results or user-specified mode shares to divide the total trip table generated in the Trip Distribution step above into



one or more **Modal Trip Tables** (e.g., the number of trips between each origin and destination zone by highway, commuter rail, subway, bus, etc.).

- A ROUTE ASSIGNMENT menu tab which assigns the modal trip flows generated in the Mode Share step to particular highway, rail, or bus routes using different route assignment criteria (e.g. all-or-nothing, capacity constrained, etc.). When used at the Full Megaregion scale, the NEMR TD&I Model can also be used to assign truck trips to highway links.

The results of the Route Assignment procedure include route volume flow files which can be summarized, displayed and compared using TransCAD's map-based user interface or else imported into route tables and compared with other route assignment results.

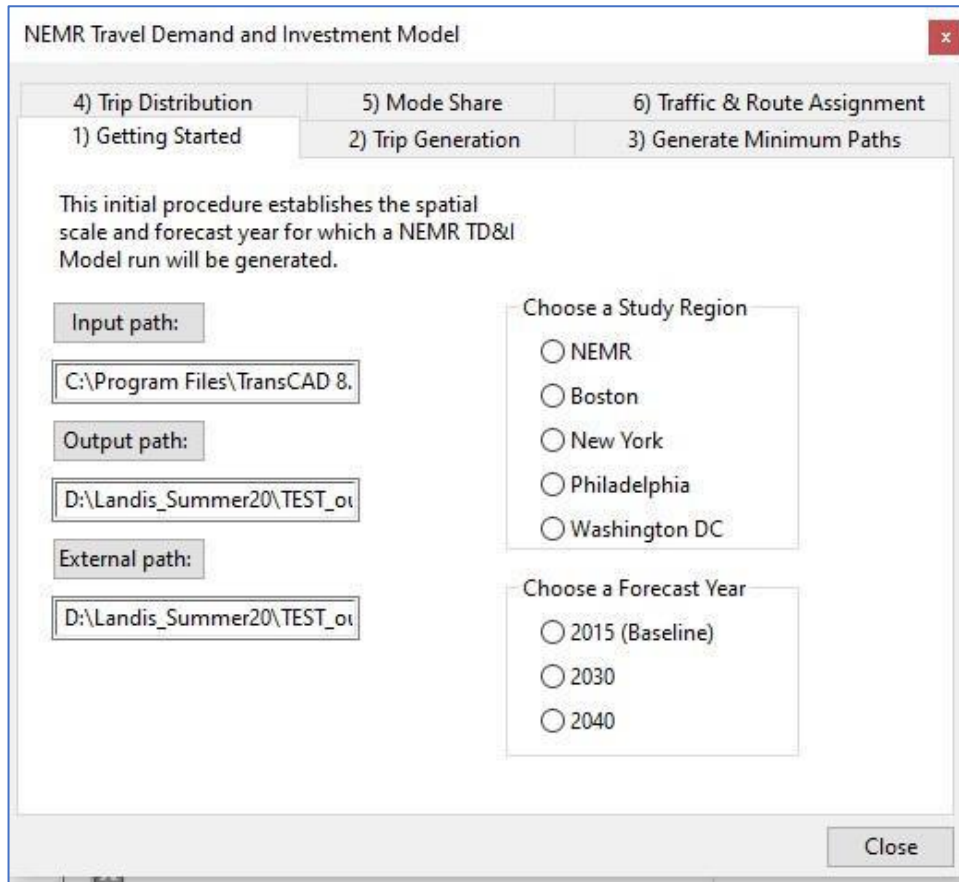
Except for the GETTING STARTED menu tab, each menu tab produces a new TransCAD data file which then serves as input into the next menu tab procedure. As an option, these intermediate data files can also be save to user-specified locations where they can be used by TransCAD independently of the NEMR TD&I Model.

The following step-by-step tutorial will: (1) Build a set of 2040 trip productions and attractions by county for the Full Megaregion (FMR); (2) Build a set of highway shortest time paths between every county-based trip origin and destination zone (O-D zonal pair) in the FMR; (3) Use the minimum paths as input into a gravity model which will convert the county-based productions and attractions into a complete trip table of home-based work trips; (4) Identify the share of trips between each O -D zonal pair that will travel by highway; (5) Allocate those highway trips to the appropriate shortest route on an all-or-nothing basis, and (6) Graph those trips on the appropriate highway network routes.

1. Make sure TransCAD is properly installed on your computer and then open it.
2. Access the **NEMR TD&I Model** script by opening TransCad and clicking on **Tools > GIS Developer's Kit**. After the "GISDK Toolbar" appears on your menu TransCad menu bar, click on the "**Compile to UI**" icon. Then, navigate to the **NEMR TD&I Model** script (wherever you have downloaded and saved it) and follow the directions to compile the script.
3. After the **NEMR TD&I Model** script has been compiled, click on **Tools > GIS Developer's Kit > Add-Ins**. Select the "**NEMR TD&I Model**" script to open the NEMR TD&I Model's tab-based interface.

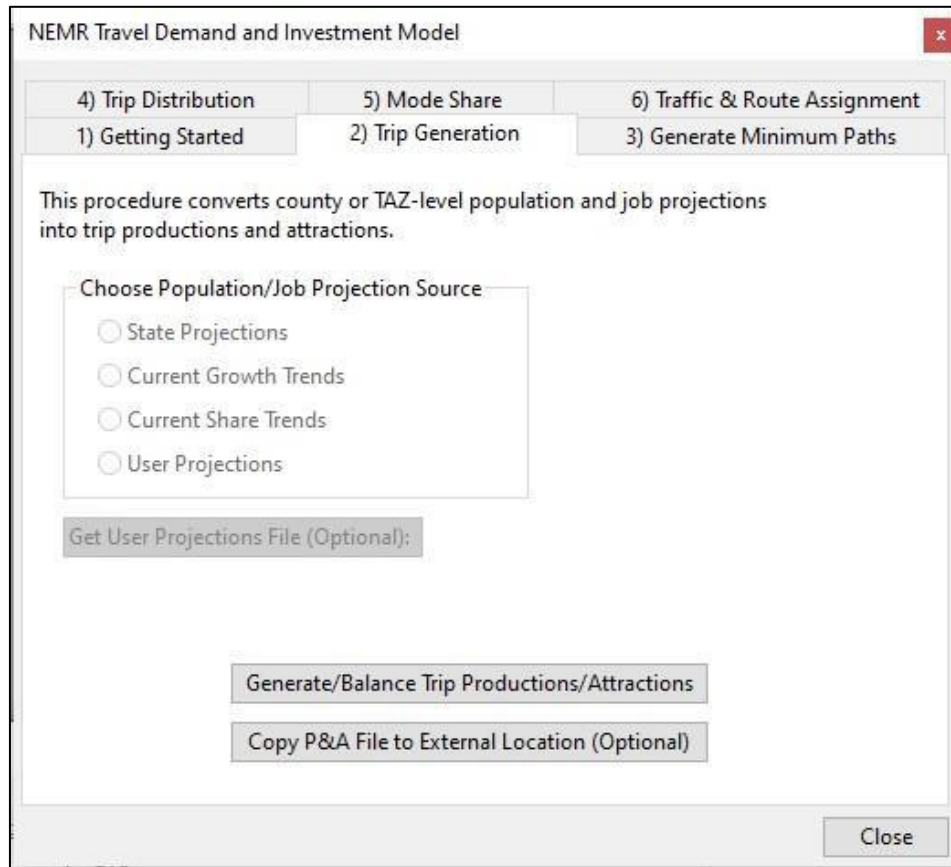
4. If you have not previously done so previously, use **File Explorer** to navigate to the locations where you have downloaded the various model datafiles to make sure they are all there.

### 1. Getting Started



5. Click on the GETTING STARTED menu tab to choose a study area and forecast year for this model run.
- ▶ Confirm that your Input Path setting is pointing to the appropriate NEMR destination directory where you downloaded the NEMR TD&I Model. ◀
  - ▶ Confirm that your Output Path setting is pointing to the “**Output**” Directory. ◀
  - ▶ Confirm that your External Path setting is pointing to a directory where you can write output files. ◀
  - ▶ In the Choose a Study Region box, choose “NEMR” to indicate you will be using the Full Northeast Megaregion (FMR) model option. ◀
  - ▶ In the Choose a Forecast Year box, choose “2030” to indicate you will be developing trip projections for the Year 2030. ◀

## 2. Trip Generation



- Next, click on the TRIP GENERATION menu tab to choose which population and employment projections you will be using and which trip purpose type you will be generating trips for.

► For the purposes of this example, choose the “**State Projections**” option, which indicates you will be using population projections created by the individual states in the NEMR ◀ Chapter 4 in this manual explains the differences between the three forecast options.

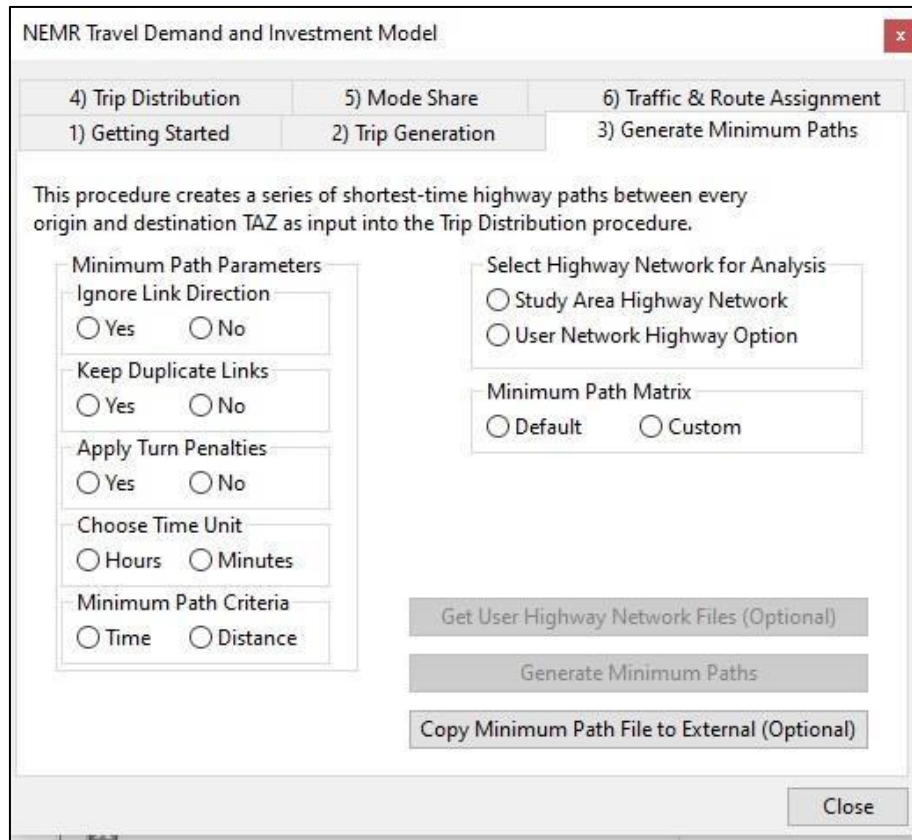
☀ If instead of the one of the three default projection methods, you wish to use your own, choose the “**User Projections**” option. Then, click on the **Get User Projection File** command bar to retrieve your own set or population and job projections.

- Click on the **Generate and Balance Trip Productions and Attractions** command bar. This will tell TransCAD to use the NCHRP 365 Trip Generation method to convert your countylevel

population and employment forecasts into home-based work trip productions and attractions. It will also ensure that the number of productions exactly equals the number of attractions.

8. (Optional): The NEMR TD&I Model will automatically save the results of the Trip Generation step to the Trip Generation Productions and Attractions Output file. If you also want to copy the results to a location where they can be independently accessed, click on the **Copy P&A File to External Location** command bar, and then follow the appropriate prompts to name and save your file.

### 3. Trip Distribution Steps



9. Click on the GENERATE MINIMUM PATH menu tab. This set of procedures will create a set of minimum path “skim trees” consisting of the minimum time or distance path between every origin and destination zone in your study area. As currently implemented, all NEMR TD&I Model minimum paths are based on highway travel times and/or distances. For this example, we will allow two-way travel on all highway links, not impose any turn penalties, and keep track of the minimum time path in minutes. In the Minimum Path Parameters box:

- ▶ Choose “Yes” to the Ignore Link Direction option ◀
- ▶ Choose “Yes” to the Keep Duplicate Links option ◀
- ▶ Choose “Yes” to Turn Penalties ◀
- ▶ Choose “Minutes” as your Time Unit ◀

► Choose “**Shortest Time**” as your Minimum Path Metric ◀

10. In the Select Highway Network for Analysis box, choose “**Study Area Highway Network**” to indicate that you will be using the Full Megaregion study area highway network to build the minimum path skim trees.

☀ Alternately, if you would prefer to use an alternative highway network to construct your minimum paths, choose the “**User Highway Network Option**”, and then click on the **Get User Highway Network Files** to indicate the appropriate file path where your network can be found. Note that any user-specified networks must reference the same traffic analysis zone (TAZ) numbers as the default Boston study area highway network..

11. (Optional): If you want to copy the soon-to-be-generated set of minimum paths to an external file location, click on the **Copy Minimum Path File to External Location** command bar, and then follow the appropriate prompts to name and save your file. *Make a note of the location of your exported file.*

12. Review your selections to make sure they are correct, and then click on the **Generate Minimum Paths** command bar to generate a full set of highway minimum paths. Note that this process may take some time to complete.

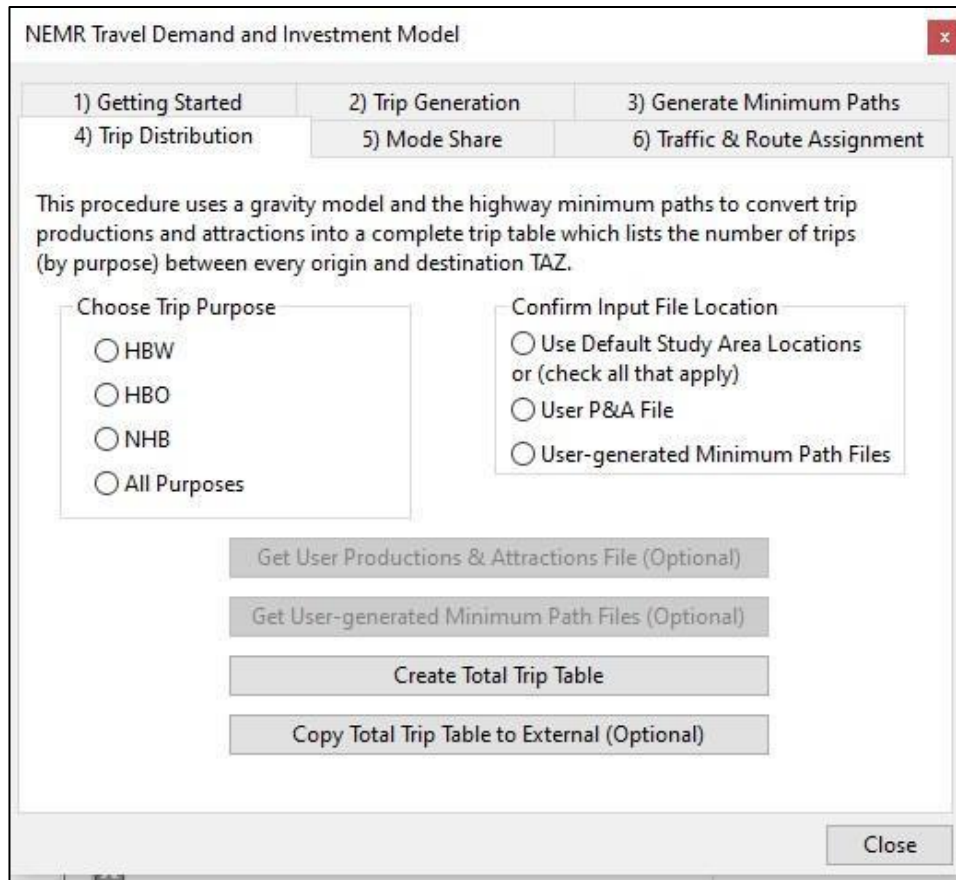
13. You should now be ready to run the Trip Distribution procedure. This procedure uses a gravity model to connect trip productions and trip attractions to form a set of complete trips for every origin and destination pair in your study area.

14. Click on the TRIP DISTRIBUTION menu tab.

15. In the Choose Trip Purpose box, choose which trip purpose you will use the gravity model to create a trip table for. ► In the current case, choose “**HBW**” to indicate you will be creating a trip table of Home-based Work trips. ◀

16. The Confirm Input File Locations box allows you to choose which trip productions and attractions and which minimum path skim trees you will use as input into the gravity model.

► Choose “**Use Default Study Area File Locations**” to indicate you will be using the Full Megaregion study area productions and attractions file and minimum path files developed in the previous steps ◀.



☀ If instead of the default Full Megaregion productions and attractions and minimum path files generated in the previous steps, you wish to use your own, choose “**User P&A File**” and/or the “**User-generated Minimum Path Files.**” Then, depending on which options you chose, click on the **Get User Production & Attractions File** command bar and/or the **Get User-generated Minimum Path** command bar. Note that the Trip Distribution process will only work properly if your user-generated files have the same zone and variable structure as the default Boston area files.

17. Review all your selections to make sure they are correct, and then click on the **Create Total Trip Table** command bar to run TransCAD’s Trip Distribution procedure. Note that this process may take some time to complete.
18. (Optional): If you want to copy your trip table to an external location, click on the **Copy Total Trip Table to External Location** command bar, and then follow the appropriate prompts to name your file. *Make a note of the location of your exported file.*

#### 4. Mode Share Calculations

NEMR Travel Demand and Investment Model

1) Getting Started    2) Trip Generation    3) Generate Minimum Paths  
4) Trip Distribution    5) Mode Share    6) Traffic & Route Assignment

This procedure uses local mode share survey results to divide the total trip table created in the previous step into one or more modal trip tables.

Choose Mode to Generate Modal Trip Table

Highway or Car (NEMR/MAC Study Areas)  
 Intercity Rail (NEMR only)  
 Commuter Rail (MAC only)  
 Subway/Light Rail (MAC only)  
 Metro Area Bus (MAC only)

Modify Default Mode Share Table (Optional)

Increase mode shares  
 Decrease mode shares

by How Much (choose only one)

5    10    15    20    25  
 30    50    100    200

Import User Mode Share Table (Optional)  
Calculate Modal Trips  
Copy Modal Table to External Location (Optional)  
Close

19. Click on the **MODE SHARE** menu tab. This set of procedures will all allow you to apply a series of mode share percentages to the total trip table created in the previous Trip Distribution step to generate a series of mode-specific trip tables. Depending on the study area, these mode share percentages are derived either from the 2017 National Household Travel Demand Survey or from travel surveys administered by local metropolitan planning organizations (MPOs).
20. In the Choose Mode to Generate Trip Table box, click on the mode you wish to develop the trip table for. ► In the current case, choose **“Highway or Car”** ◀ *Note that you can only develop one mode-specific trip table at a time.*
  - ☀ The NEMR TD&I Model also gives users the option to import their own mode share tables or to modify an existing mode share table by increasing all the mode share percentages by a fixed amount. To import your own mode share table, click on the **Import User Mode Share Table** command bar and locate the table you wish to import. Then go to Step 22.
21. In this example, we will be uniformly decreasing the share of commuter rail trips by 10% below their default values. Note that you can also choose to increase your trip shares.

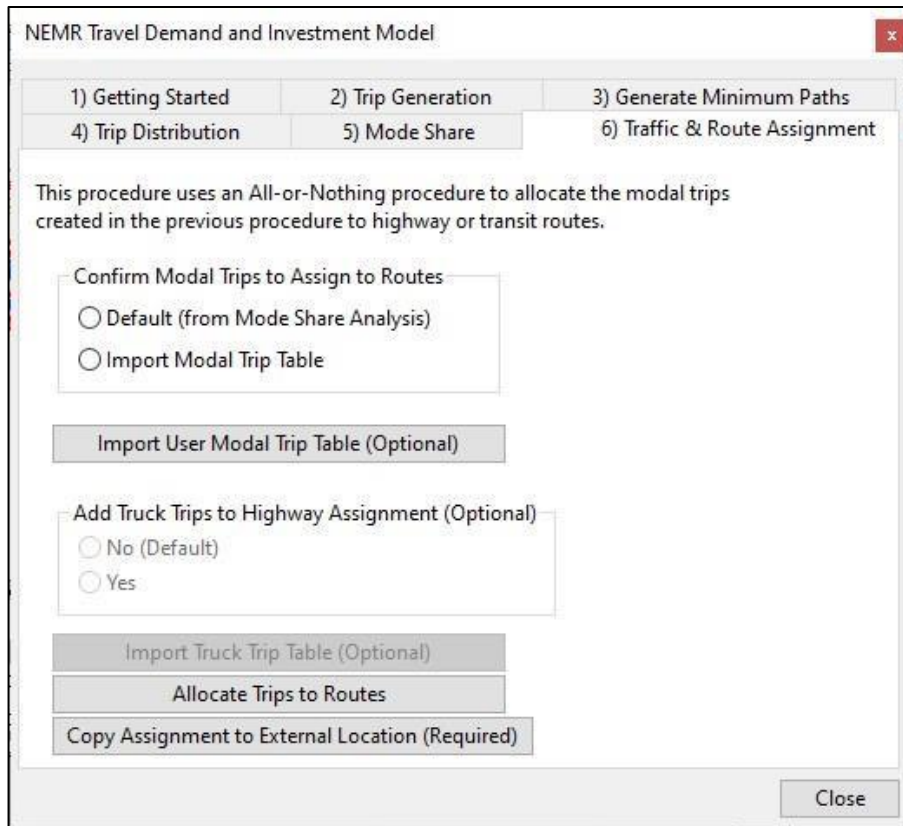


- ▶ In the [Modify Default Mode Share Table](#) box, choose “**Decrease Mode Shares**” ◀
- ▶ Then, choose the percentage you wish to increase the current mode share percentage by. In the current example, choose “**10%**” ◀.

This will have the effect of decreasing the current highway rail mode share by 10% for all origin destination pairs. So, for example, if the current commuter highway mode share between an origin-destination pair is 80%, decreasing it by 10% will reduce the highway mode share to 72% ( $80\% - (80\% * 10\%)$ ). Note that this will not affect the mode share of any other mode.

22. Review all your selections to make sure they are correct, and then click on the **Calculate Modal Trips** command bar to calculate a trip table for your mode of choice. This is the trip table you will allocate to a route in the next step.
23. (Optional): If you want to copy your just-created modal trip table to an external location (for later use, or so that you can generate a mode trip table for a different mode or purpose), click on the **Copy Modal Trip Table to External Location** command bar, and then follow the appropriate prompts to name your file. *Make a note of the location of your exported file.*

## 5. Trip and Route Assignment



24. Click on the TRAFFIC & ROUTE ASSIGNMENT menu tab. This set of procedures will allow you to allocate the highway, rail, and bus trips generated by the MODE SHARE CALCULATOR to particular highway, rail, and bus links routes. The current version of the NEMR TD&I Model is limited to an “all-or-nothing assignment,” meaning that all trips are assigned to the shortest route regardless of congestion levels or available capacity.

Users wanting to use a different route assignment method should do so in TransCAD. Unless otherwise indicated, all trip assignments cover a 24-hour period. Note that the Full Megaregion (FMR) model is limited to allocating highway and inter-city rail trips, and cannot be used to allocate commuter rail, subway, or bus trips.

25. In the Confirm Modal Trips to Assign to Routes box, you can choose either the **Default Option** to indicate you will be using the modal trip table calculated in the previous Mode Share step, or the **Import User Modal Trip Table** to indicate you will be using a different modal trip table. ► In the current case, choose “**Default**” to indicate you will be using modal trip table created in Step 23. ◀

☀ If instead of the **Default Option** you had chosen to import a modal trip table of your own, you would now click on the **Import User Modal Trip Table** command bar.

26. When used at the Full Megaregion (FMR) scale, the NEMR TD&I model gives users the option of also assigning truck trips to highway routes, thereby providing a link-by-link estimate of traffic volumes that includes both car and truck trips. Truck trip volumes are generated using an updated version of the Federal Highway Administration’s Freight Management Framework (FMF4.1) freight flow model. ► **In the current case, choose “Yes” to indicate you will be adding truck trips to the highway assignment** ◀ Then, click on the **Import Truck Trip Table** to locate and access the appropriate truck trip table.
27. Click on the **Allocate Trips to Routes** command bar. TransCAD will then begin the route allocation process, which, depending on the size of your study area and highway or networks, may take several minutes. Currently, the only available assignment method is “all or nothing,” meaning that all trips are allocated to the shortest highway path or transit route(s) regardless of congestion levels or available capacity.
28. The NEMR TD&I Model gives users the option of preparing and saving multiple route allocations and saving the results in a location of the user’s choice. Accordingly click on the **Copy Route Assignment Results to External Location** command bar and choose the file location where you wish to save your route assignment results. *Make a note of this location.*
29. You have now completed a run of the **NEMR TD&I Full Megaregion Model**.  
CONGRATULATIONS!

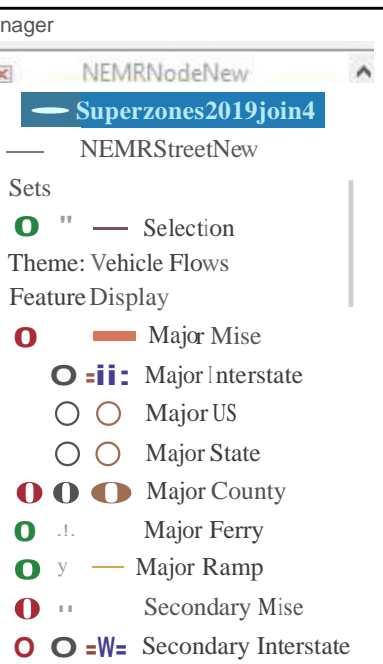
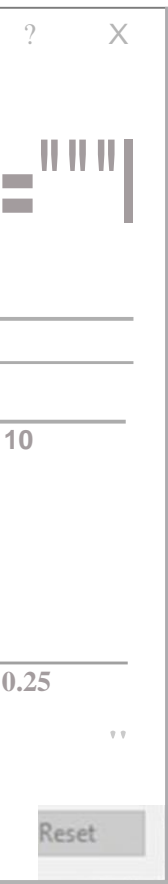
#### 6. Displaying Your Route Assignment Results in TransCAD

30. Minimize the GISDK window in which you are running the NEMR TD&I Model. **If you have not done so previously, start TransCAD and wait for it to load.** If TransCAD is already open, use the Windows Task Bar to access it:
31. Click on the TransCAD **File Menu**:
  - **Open the Streets Map file in TransCAD and locate the NEMR study region.** ◀
  - **Open the Traffic Assignment table you saved in Step 28 above.** ◀
32. Click on the TransCAD **View Menu** and make the **Streets Map** file your primary TransCAD window.

33. Click on the TransCAD **Planning Menu** and choose **Assignment Utilities > Create Flow Map**:

- ▶ For the Line Layer, select the **Street Map** file opened in Step 31, above ◀
- ▶ For the Flow Table, select the **Traffic Assignment** table opened in Step 31, above ◀
- ▶ For the Flow Field, select the appropriate the **Total Flow field** (from Traffic Assignment table), most likely Tot\_Flow ◀
- ▶ For the V/C Field, select **None** (optional if V/C Field has been calculated by user) ◀

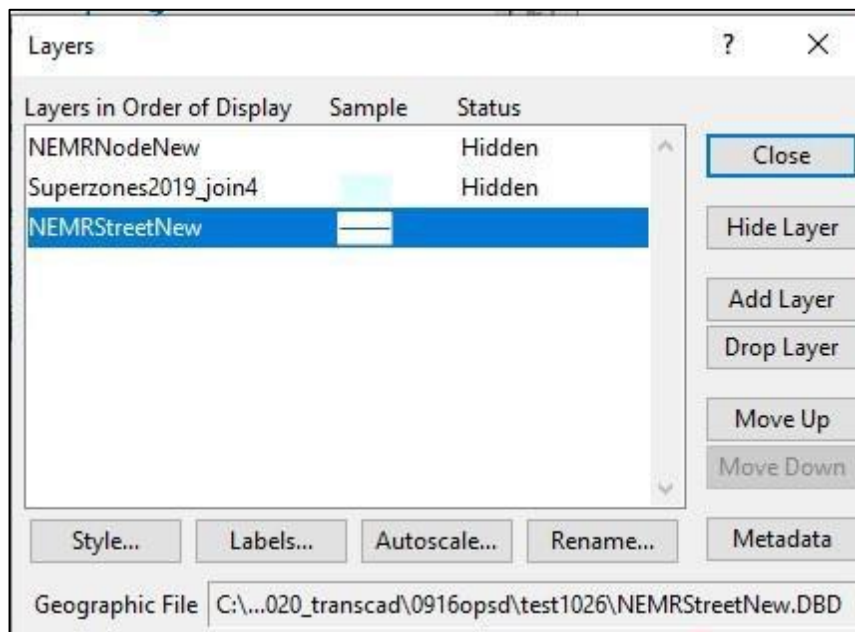
34. Click on **OK** to display your **Route Assignment Flow Map**. It will look something like the map below. The line colors and labels can be edited using the **Display Manager** and **Map** toolbars provided within the TransCAD user interface. Additional line layers can also be added to this flow map using the TransCAD interface. Upon clicking within the Flow Map window in TransCAD, the Display Manager will be visible on the right-hand side of the screen. This window shows all different line layers that are currently included in your Flow Map and allows you to manage what labels/icons will be displayed. For example, the Major Road icons can be toggled on or off by clicking on the green icons next to relevant road Features.

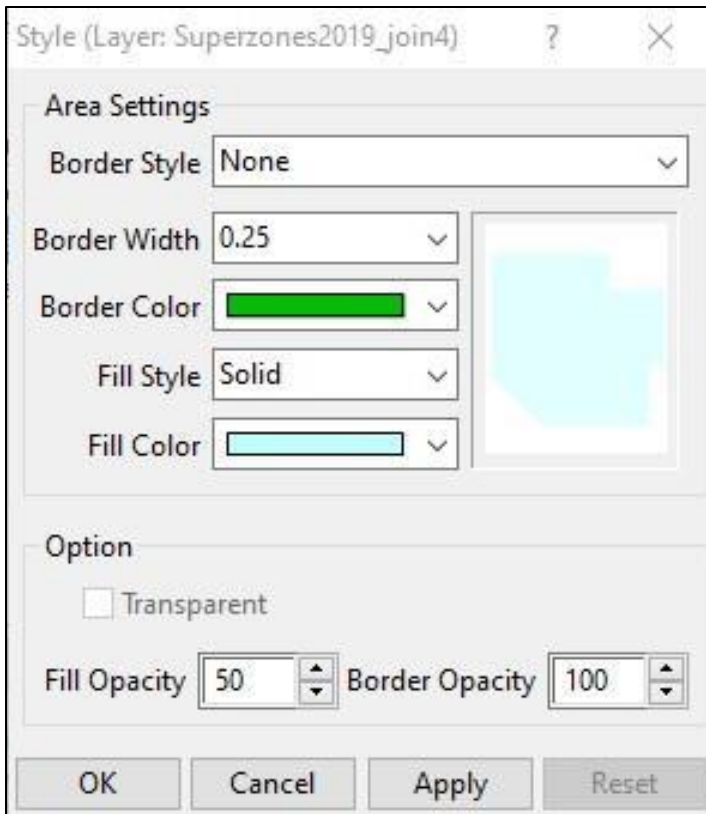


35. TransCAD also enables users to add additional network layers to give their Flow Maps more context. This can be done by going to the program toolbar and selecting **Map > Layers**. In the

**Layers** menu, you can choose to **Add, Drop, or Hide** different linework layers in your map. You can also use the **Move Up/Down** commands to arrange the linework layer display priorities within the Flow Map.

- 36. The Layers dialogue box also offers additional user control over line color, line weight, and fill color/transparency. The options available are dependent on the shapes contained within each Layer being used in the map. The Display options can be accessed by double clicking on the relevant layer being edited within the **L**ayer menu. Once the changes are made, click **A**pply to add them to the Flow Map.
- 37. By taking some time to work with the Map Editing features, you can arrive at a Flow Map that displays your model results for presentation.





## CHAPTER 6:

# BOSTON MAC MODEL TUTORIAL

This chapter works through the steps involved in running the NEMR TD&I Model for the **Boston-Providence-Worcester Metro Area Cluster** or MAC. As a reminder, the MAC models make use of transportation analysis zones (TAZs) that are assembled from zip code districts rather than counties, as is the case for the Full Megaregion (FMR) Model. Other significant differences between the FMR and MAC models is that the former are limited to highway and inter-city rail trips while the latter can also accommodate commuter rail, subway and light rail, and bus trips. The FMR Model is also capable of adding in truck trips while the MAC models are not.

Note that the New York City, Philadelphia, and Washington DC-Baltimore-Richmond MAC Models all function in the same way as the Boston MAC Model.

Like the FNEM Model, the MAC models work by stepping through a sequence of six menu tabs that correspond to the steps in the standard 4-Step travel demand model. These menu tabs were created using GISDK, TransCAD's scripting language, and work by making calls to standard TransCAD procedures. Running any of the MAC Models therefore requires having a legal copy of TransCAD installed and open on the user's own desktop or laptop computer. To make the most of the NEMR TD&I Model, prospective users should endeavor to develop a working knowledge of TransCAD procedures, data formats, and display tools.

The six FMR and MAC Model menu tabs include:

- A GETTING STARTED menu tab which ask the user to set a **Study Area** and **Forecast Year**.
- A TRIP GENERATION menu tab which lets users specify which population and employment projections they wish to convert to **Trip Productions and Attractions**.
- A CREATE MINIMUM PATHS menu tab which uses the appropriate highway network to generate a series of minimum travel time paths between every origin and destination TAZ in the selected study area.
- A TRIP DISTRIBUTION menu tab which uses the minimum time paths created in the previous step as input into a gravity model which converts the production and attractions created in the



Trip Generation step into a **Total Trip Table** of trip-making activity for every origin-destination zonal pair in the selected study area.

- A MODE SHARE ANALYSIS menu tab which uses survey data results or user-specified mode shares to divide the total trip table generated in the Trip Distribution step above into one or more **Modal Trip Tables** (e.g., the number of trips between each origin and destination zone by highway, commuter rail, subway, bus, etc.).
- A ROUTE ASSIGNMENT menu tab which assigns the modal trip flows generated in the Mode Share step to particular highway, rail, or bus routes using different route assignment criteria (e.g. all-or-nothing, capacity constrained, etc.)

The results of the Route Assignment procedure include route volume flow files which can be summarized, displayed and compared using TransCAD's map-based user interface or else imported into route tables and compared with other route assignment results.

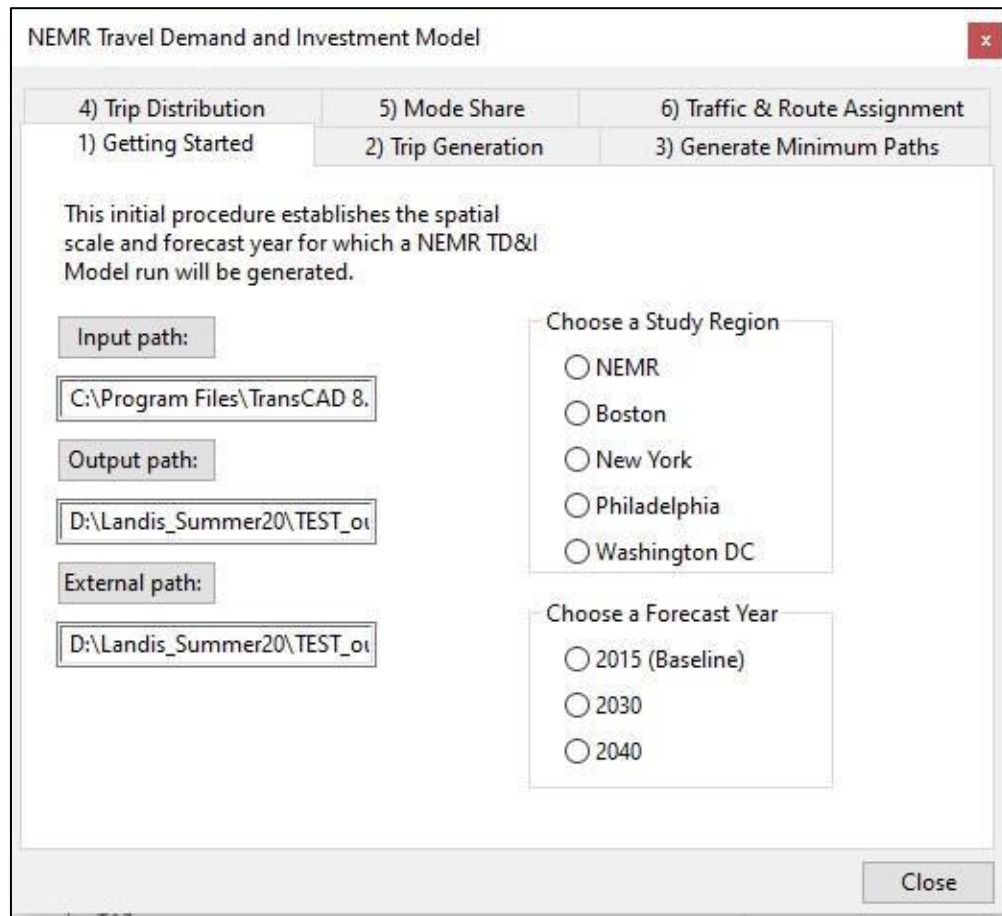
Except for the GETTING STARTED menu tab, each menu tab produces a new TransCAD data file which serves as the input into the next menu tab procedure. Each of these newly-generated files is saved to a preset file location based on the chosen study area and forecast year (e.g. "/Boston2030/"). In addition, users can choose to export their results to directories of their own choosing (e.g., "/My Model Run/") by clicking on the **Copy Results to External Location**, where they can be accessed by TransCAD independently of a particular NEMR TD&I Model run.

The following step-by-step tutorial will: (1) Build a set of **Year 2040 trip productions and attractions** by county for the entire **Boston-Providence-Worcester MAC Study Area**; (2) Build a set of highway minimum time paths between every origin and destination traffic analysis zone (O-D zonal pair) in the Boston-Providence-Worcester MAC Study Area; (3) Use the generated minimum paths as input into a gravity model which will convert the county-based productions and attractions into a **complete trip table of home-based work trips**; (4) Identify the share of home-based work trips between each O -D zonal pair that will travel by **commuter rail**; (5) Allocate those commuter rail trips to the appropriate **commuter rail routes**;, and (6) Graph those trips on the appropriate commuter rail routes.

1. Make sure TransCAD is properly installed on your computer and then open it.
2. Access the **NEMR TD&I Model** script by opening TransCad and clicking on **Tools > GIS Developer's Kit**. After the "GISDK Toolbar" appears on your menu TransCad menu bar, click on the "**Compile to UI**" icon. Then, navigate to the **NEMR TD&I Model** script (wherever you have downloaded and saved it) and follow the directions to compile the script.

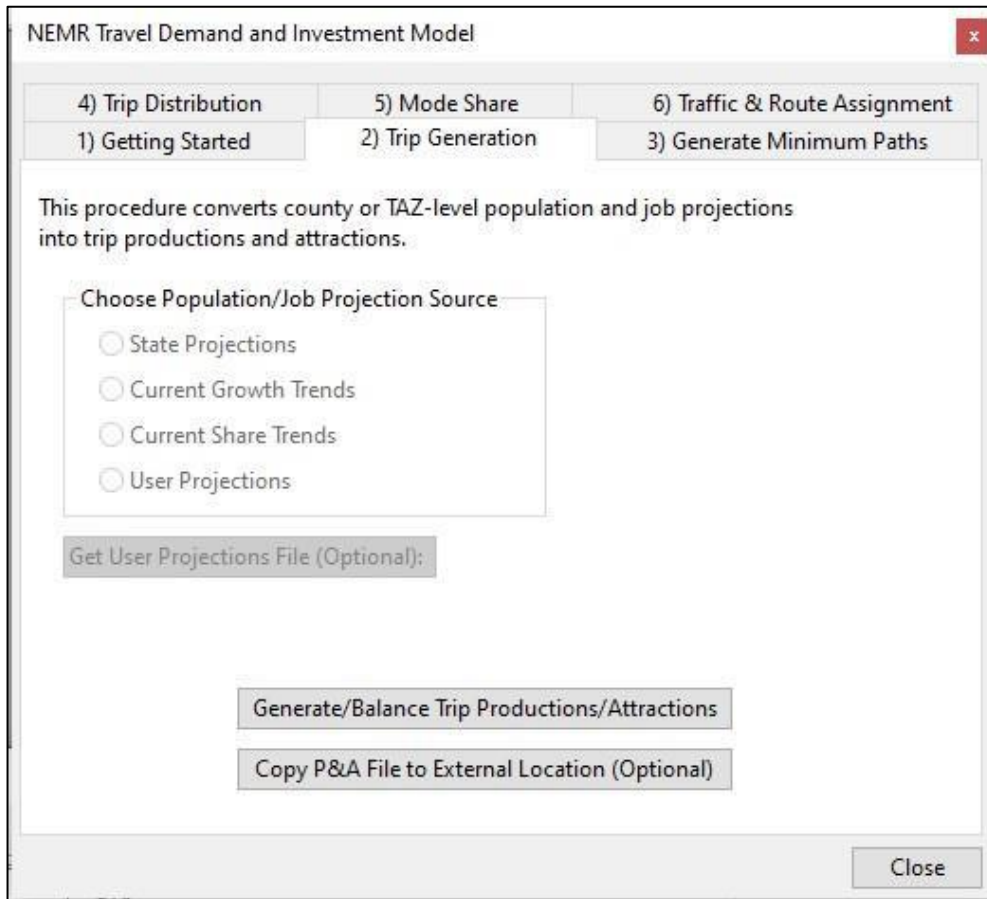
3. After the **NEMR TD&I Model** script has been compiled, click on **Tools > GIS Developer's Kit > Add-Ins**. Select the “**NEMR TD&I Model**” script to open the NEMR TD&I Model's tab-based interface.
4. If you have not previously done so previously, use **File Explorer** to navigate to the locations where you have downloaded the various model datafiles to make sure they are all there.

## 1. Getting Started



5. Click on the GETTING STARTED menu tab to choose a study area and forecast year for this model run.
  - ▶ Confirm that your Input Path setting is pointing to the appropriate NEMR directory location where you downloaded the NEMR TD&I Model. ◀
  - ▶ Confirm that your Output Path setting is pointing to the “**Output**” Directory. ◀
  - ▶ Confirm that your External Path setting is pointing to a directory where you can write output files ◀
  - ▶ In the Study Area box, choose “**Boston**” to indicate you will be using the Boston-Providence-Worcester MAC model ◀
  - ▶ In the Forecast Year box, choose “**2040**” to indicate you will be developing trip projections for the Year 2040. ◀

## 2. Trip Generation Steps



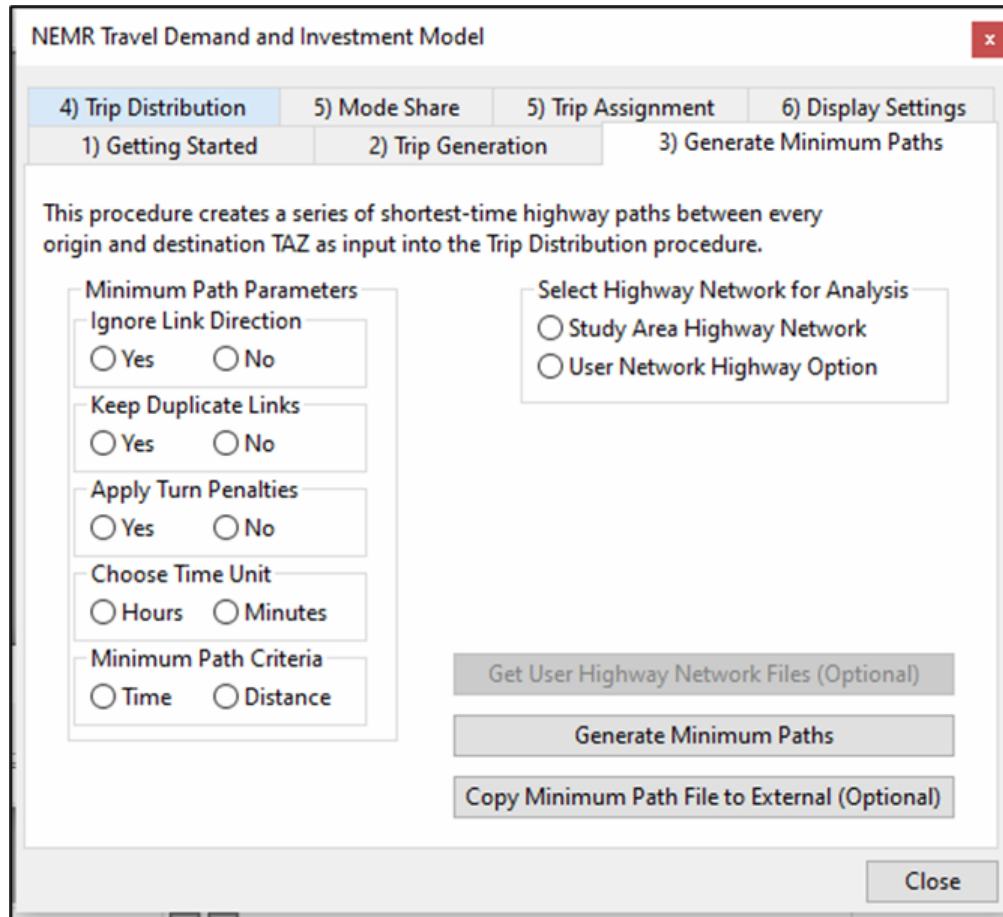
6. Next, click on the TRIP GENERATION menu tab to choose which population and employment projections you will be using and which trip purpose type you will be generating trips for.

► For the purposes of this example, choose the “**Current Growth Trends**” option ◀ *Chapter 4 in this manual explains the differences between the three forecast options.*

☀ If instead of the one of the three default projection methods, you wish to use your own, choose the “**User Projections**” option. Then, click on the **Get User Projection File** command bar to retrieve your own set or population and job projections. Click on the **Generate and Balance Trip Productions and Attractions** command bar. This will tell TransCAD to use the NCHRP 365 Trip Generation method to convert your Boston-area population and employment forecasts into home-based work trip productions and attractions. It will also ensure that the number of productions exactly equals the number of attractions.

7. The NEMR TD&I Model will automatically save the results of the Trip Generation step to the Boston- area Trip Generation Productions and Attractions Output file. (Optional): If you also want to copy the results to a location where they can be independently accessed, click on the **Copy P&A File to External Location** command bar, and then follow the appropriate prompts to name and save your file.

### 3. Trip Distribution Steps



8. Click on the GENERATE MINIMUM PATH menu tab. This set of procedures will create a set of minimum path “skim trees” consisting of the minimum time or distance path between every origin and destination zone in your study area. As currently implemented, all NEMR TD&I Model minimum paths are based on highway travel times and/or distances. For this example, we will allow two-way travel on all highway links, not impose any turn penalties, and keep track of the minimum time path in minutes.

- ▶ Choose “Yes” to the [Ignore Link Direction](#) option ◀
- ▶ Choose “Yes” to the [Keep Duplicate Links](#) option ◀
- ▶ Choose “Yes” to [Turn Penalties](#) ◀
- ▶ Choose “Minutes” as your [Time Unit](#) ◀

► Choose “**Shortest Time**” as your Minimum Path Metric ◀

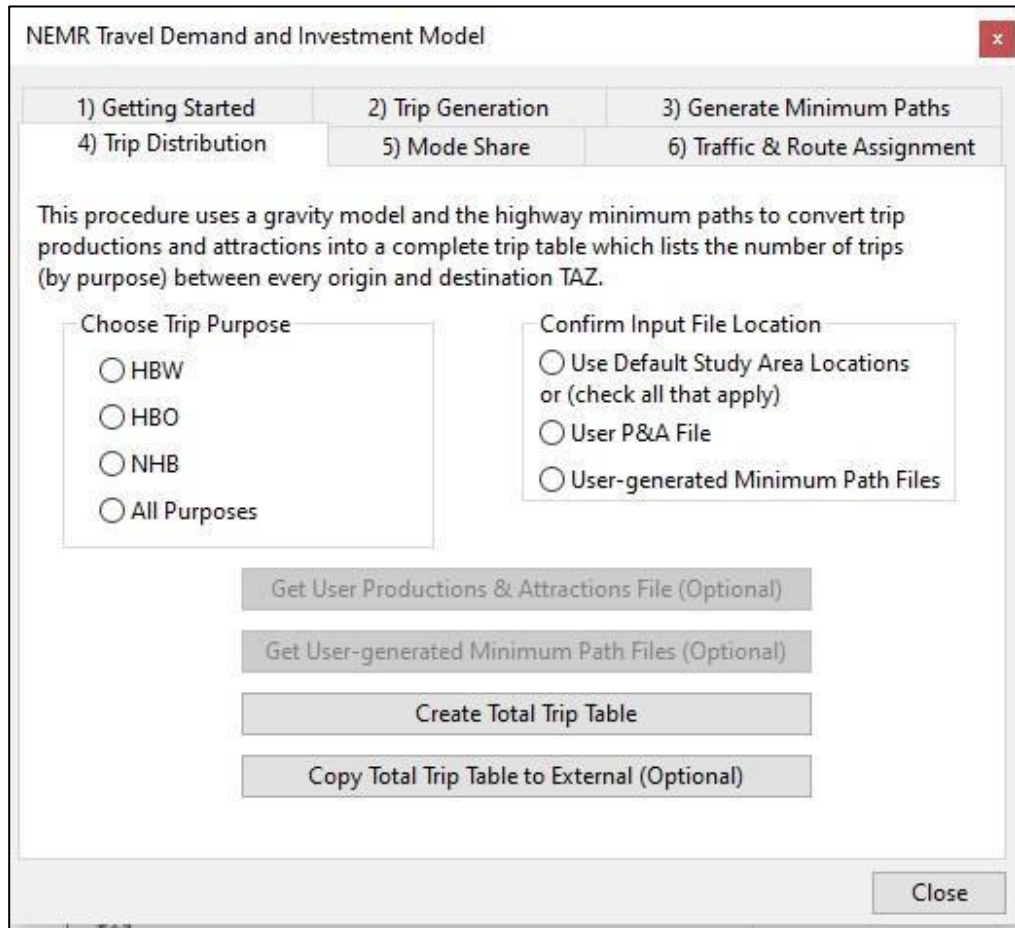
9. In the Highway Network Selection box, choose “**Study Area Highway Network**” to indicate that you will be using the Boston area highway network to build the minimum path skim trees.

☀ Alternately, if you would prefer to use an alternative highway network to construct your minimum paths, choose the “**User Network Option**”, and then click on the **Get User Highway Network Files** to indicate the appropriate file path where your network can be found. Note that any user-specified networks must reference the same traffic analysis zone (TAZ) numbers as the default Boston study area highway network..

10. Review all your selections to make sure they are correct, and then click on the **Generate Minimum Paths** command bar to generate a full set of highway minimum paths. Note that this process may take some time to complete.
11. (Optional): If you want to copy the set of minimum paths to an external file location, click on the **Copy Minimum Path File to External Location** command bar, and then follow the appropriate prompts to name and save your file. *Make a note of the location of your exported file.*
12. You should now be ready to run the Trip Distribution procedure. This procedure uses a gravity model to connect trip productions and trip attractions to form a set of complete trips for every origin and destination pair in your study area.
13. Click on the TRIP DISTRIBUTION menu tab.
14. In the Choose Trip Purpose box, choose which trip purpose you will use the gravity model to create a trip table for. ► In the current case, choose “**HBW**” to indicate you will be creating a trip table of Home-based Work trips. ◀
15. The Confirm Input File Locations box allows you to choose which trip productions and attractions and which minimum path skim trees you will use as input into the gravity model.

► Choose “**Use Default Study Area File Locations**” to indicate you will be using the Boston area productions and attractions file and minimum path files developed in the previous steps ◀.

☀ If instead of the default Boston area productions and attractions and minimum path files generated in the previous steps, you wish to use your own, choose “**User P&A File**” and/or the “**User-generated Minimum Path Files.**” Then, depending on which options you chose, click on the **Get User Production & Attractions File** command bar and/or the **Get User-generated Minimum Path** command bar. Note that the Trip Distribution process will only work properly if your user-generated files have the same zone and variable structure as the default Boston area files.



16. Review all your selections to make sure they are correct, and then click on the **Create Total Trip Table** command bar to run TransCAD’s Trip Distribution procedure. Note that this process may take some time to complete.
17. (Optional): If you want to copy the total trip table to an external location, click on the **Copy Total Trip Table to External Location** command bar, and then follow the appropriate prompts to name your file. *Make a note of the location of your exported file.*



#### 4. Mode Share Calculations

NEMR Travel Demand and Investment Model

1) Getting Started    2) Trip Generation    3) Generate Minimum Paths  
4) Trip Distribution    5) Mode Share    6) Traffic & Route Assignment

This procedure uses local mode share survey results to divide the total trip table created in the previous step into one or more modal trip tables.

Choose Mode to Generate Modal Trip Table

Highway or Car (NEMR/MAC Study Areas)  
 Intercity Rail (NEMR only)  
 Commuter Rail (MAC only)  
 Subway/Light Rail (MAC only)  
 Metro Area Bus (MAC only)

Modify Default Mode Share Table (Optional)

Increase mode shares  
 Decrease mode shares

by How Much (choose only one)

5    10    15    20    25  
 30    50    100    200

Import User Mode Share Table (Optional)  
Calculate Modal Trips  
Copy Modal Table to External Location (Optional)  
Close

18. Click on the MODE SHARE menu tab. This set of procedures will all allow you to apply a series of mode share percentages to the total trip table created in the previous Trip Distribution step to generate a series of mode-specific trip tables. Depending on the study area, these mode share percentages are derived either from the 2017 National Household Travel Demand Survey or from travel surveys administered by local metropolitan planning organizations (MPOs).
19. In the Choose Mode box, click on the mode you wish to develop the trip table for. ► In the current case, choose “Metro Area Bus” ◀ Note that you can only develop one modespecific trip table at a time.

☀ The NEMR TD&I Model also gives users the option to import their own mode share tables or to modify an existing mode share table by increasing all the mode share percentages by a fixed amount. To import your own mode share table, click on the **Import User Mode Share Table** command bar and locate the table you wish to import.

20. In this example, we will be increasing the share of commuter bus trips by 50% above their default values. *Note that you can also choose to decrease your trip shares.*

▶ In the [Modify Existing Mode Share Table](#) box, choose the percentage you wish to increase the current mode share percentage by. In the current example, choose “50%” ◀

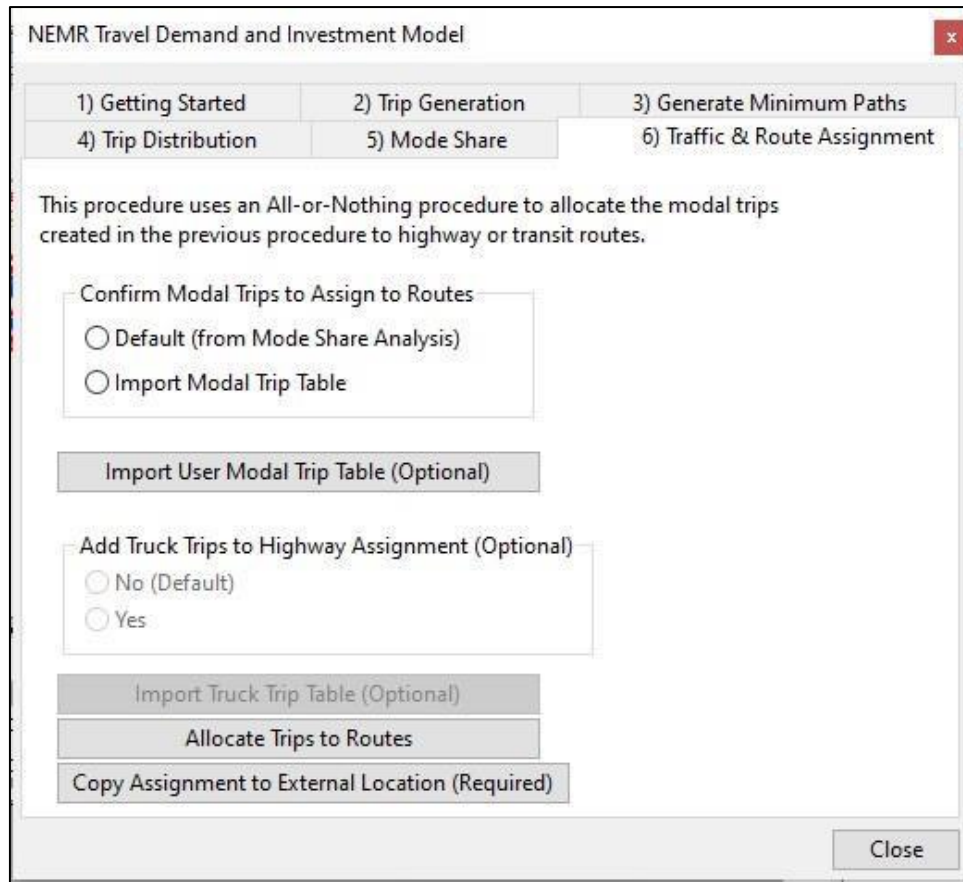
▶ Then choose “**Increase mode shares**” ◀.

This will have the effect of increasing the current commuter rail mode share by 50% for all origin destination pairs. So, for example, if the current commuter rail mode share between an origin-destination pair is 10%, increasing it by 50% will bring the commuter rail mode share up to 15% ( $10\% * (1+50\%)$ ). Note that this will not affect the mode share of any other mode.

21. Review all your selections to make sure they are correct, and then click on the **Calculate Modal Trips** command bar to calculate a trip table for your mode of choice. This is the trip table you will allocate to a route in the next step.

22. (Optional): If you want to copy the modal trip table to an external location (for later use, or so that you can generate a mode trip table for a different mode or purpose), click on the **Copy Modal Trip Table to External Location** command bar, and then follow the appropriate prompts to name your file. *Make a note of the location of your exported file.*

## 5. Trip and Route Assignment



23. Click on the TRAFFIC & ROUTE ASSIGNMENT menu tab. This set of procedures will allow you to allocate the highway, rail, and bus trips generated by the Mode Share Calculator to particular highway, rail, and bus links routes. The current version of the NEMR TD&I Model is limited to an “all-or-nothing assignment,” meaning that all trips are assigned to the shortest route regardless of congestion levels or available capacity. Users wanting to use a different route assignment method should do so in TransCAD. Unless otherwise indicated, all trip assignments cover a 24-hour period. Note that the MAC Model options do NOT give you the option of adding truck trips to your highway assignments.

24. In the Confirm Modal Trips to Assign to Routes box, you can choose either the **Default Option** to indicate you will be using the modal trip table calculated in the previous Mode Share step, or the **Import User Modal Trip Table** to indicate you will be using a different modal trip table. ▶ In the current case, choose “**Default**” to indicate you will be using modal trip table created in Step 23. ◀

☀ If instead of the **Default Option** you had chosen to import a modal trip table of your own, you would now click on the **Import User Modal Trip Table** command bar.

25. Because the MAC Models do not allow users to allocate truck trips to highway links along with car trips, skip over the Add Freight Trip Option, and click on the **Allocate Trips to Routes** command bar. TransCAD will then begin the route allocation process, which, depending on the size of your study area and highway or networks, may take several minutes. Currently, the only available assignment method is “all or nothing,” meaning that all trips are allocated to the shortest highway path or transit route(s) regardless of congestion levels or available capacity.
26. The NEMR TD&I Model gives users the option of preparing and saving multiple route allocations and saving the results in a location of the user’s choice. Accordingly click on the **Copy Route Assignment Results to External Location** command bar and choose the file location where you wish to save your route assignment results. *Make a note of this location.*
27. You have now completed a run of the **NEMR TD&I Boston MAC Model**.  
CONGRATULATIONS!
28. To allocate a different set of modal trips to a highway or transit network, go back to **Step 19** and begin the mode share calculation and route assignment procedures anew. Note that these additional model runs may overwrite some of your previous files, so be sure to specify different **File Export** locations for your new runs.

## 6. Displaying Your **Bus** Route Assignment Results in TransCAD

31. Minimize the GISDK window in which you are running the NEMR TD&I Model. Maximize the TransCAD interface window, and click on **File Menu**:

- ▶ Open the Boston bus network map file (**BOSBus.dbd**) in TransCAD. ◀
  - ▶ Locate and open the Traffic Assignment table you saved in Step 27 (**40BOSHBWbus.bin**) ◀
32. Click on the TransCAD **View Menu** and make the **Streets Map** file your primary TransCAD window.
33. Click on the TransCAD **Planning Menu** and choose **Assignment Utilities > Create Flow Map**:
- ▶ For the Line Layer, select the **Street Map** file (**BOSBus**) opened in Step 31, above ◀
  - ▶ For the Flow Table, select the **Traffic Assignment** table (**40BOSHBWbus.bin**) opened in Step 31 ◀
  - ▶ For the Flow Field, select the appropriate the **Total Flow field** (from Traffic Assignment table), most likely Tot\_Flow ◀
  - ▶ For the V/C Field, select **None** (optional if V/C Field has been calculated by user) ◀
34. Click on **OK** to display your Route Assignment Flow Map. It will look something like the map below. The line colors and labels can be edited using the **Display Manager** and **Map** toolbars provided within the TransCAD user interface. Additional line layers can also be added to this flow map using the TransCAD interface. In the example below, the Bus routes have been adjusted to a dark red. The varying line thicknesses reflect passenger usage across different bus links. An additional background line file (**BOSMACZones.dbd**) has been added as a **Map Layer** for context. The gray opaque fill and thin black boundary linestyles are selected as **Display Manager** options.

Create a Traffic Flow Map ? X

**Layer and Flow**

Line Layer: NEMRStreet

Flow Table: test\_drive15NEMRHBW

Dual Fields

**Flow**

Flow Field: Tot\_Flow

Show Flow Labels

Use 1000 Separator (,)  Skip Flows under: 10

Color: [ ] Size: [ ] Format: [ ]

**V/C**

V/C Field: None

Max. V/C: 1.8 Size of Intervals: 0.25

From: [ ] to: [ ] via: [ ]

OK Cancel Reset

