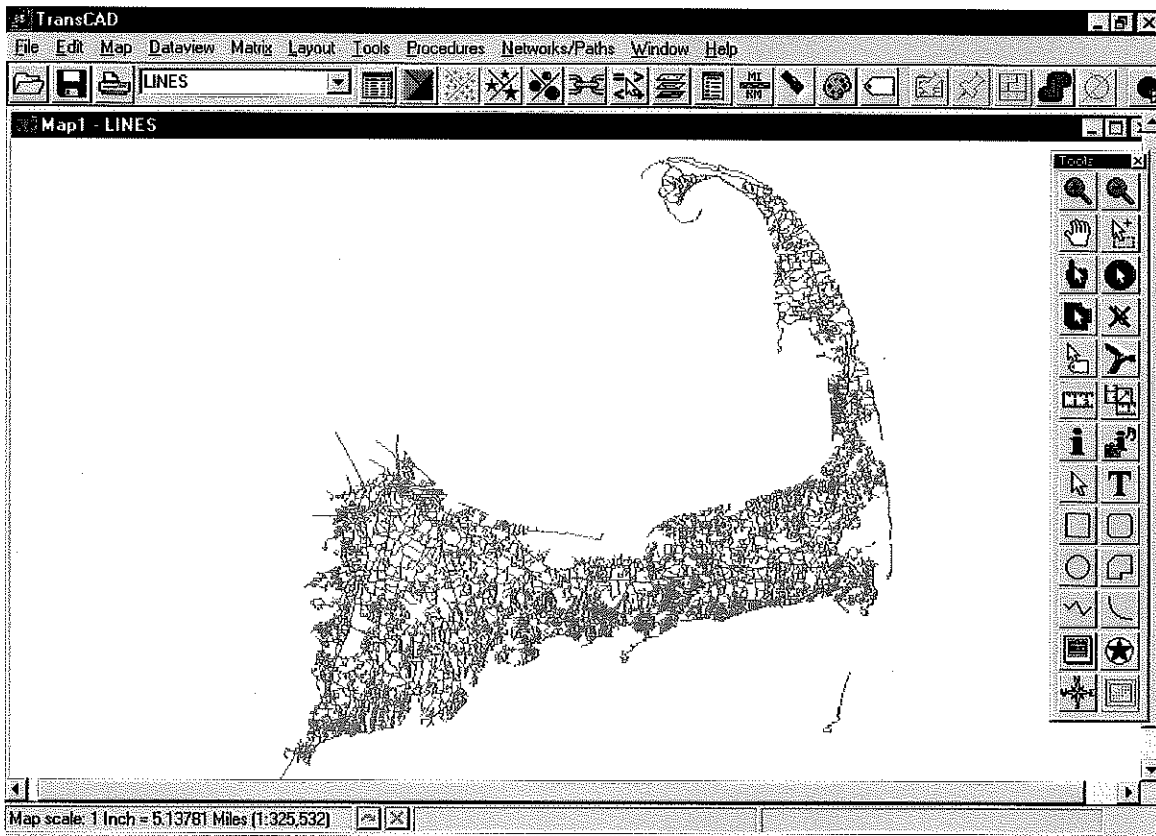


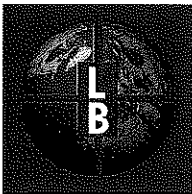
Cape Cod Commission

TransCAD Technical Assistance: Cape Cod Travel Demand Forecasting Model

Bourne Scenic Highway Study and Canal Area Study



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Functional Class 10 :



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1.0 INTRODUCTION

In 1994, the Cape Cod Commission's regional travel demand forecasting model was developed in Tmodel-2 format. Based on guidance from the Massachusetts Highway Department (MassHighway), which was based on Air Quality Conformity Analysis needs, the Cape Cod Commission converted to the TRIPS software format. This TRIPS model was operational on the Cape in the summer of 1997. Advertised software upgrades never materialized, and in March of 1999, MassHighway issued new guidance to the regional planning agencies suggesting conversion to the TransCAD software.

To assist in the conversion, MassHighway retained a consultant to build new regional models in TransCAD format. MassHighway issued further guidance suggesting that all regional model networks be built from the state's road inventory system and that all traffic analysis zones in the regional model be based on Census Block Groups (or Block Group sub-divisions). The guidance further suggested use of cross-classification trip generation, use of a minimum of three trip purposes, and use of a gravity model for trip distribution.

In June/July 1999, regional models in TransCAD format were distributed to each region. These models were functional and contained needed data, but they were not calibrated. The base year for the new model is 1997.

From a trip generation perspective, the Cape Cod Commission is in a unique situation. Unlike other areas in Massachusetts, on Cape Cod the summer traffic volumes are approximately double winter counts. This increase is due to a large share of the housing stock, which consists of seasonal homes, and an increase in activity associated with many of the year-round homes. The Cape Cod Commission wished to retain consideration of the seasonal households for calculating summer travel and continues to use the original trip generation process. However, the Cape Cod Commission did convert to the MassHighway network built from the road inventory file system.

To expedite the model calibration and upgrading as necessary for use in Cape Cod transportation projects, the Cape Cod Commission retained a consultant. In general, the consultant's tasks were to:

- develop and calibrate winter and summer models with the summer model having the ability to consider seasonal households;
- employ the model in a Bourne Scenic Highway Study; and
- employ the model in a Canal Area Traffic Study.

The following discussion reviews the development of the model and the application of the model to the referenced studies.

2.0 THE ORIGINAL TRANSCAD MODEL

2.1 NETWORK DATA SOURCE

The original Cape Cod TransCAD model was developed in June/July 1999. The specific software target for the Cape Cod model, as defined by MassHighway, is TransCAD Version 3.5. MassHighway's Road Inventory GIS (RI-GIS) served as the basis for the network and network attributes. The coordinate system for the network is State Plane meters (NAD83). The RI-GIS files used to create the networks were the 1997 year-end data files.

The RI-GIS has precise intersection coordinates and an extensive set of line attribute data. The line work in the RI-GIS files do not show grade-separated roadways, rather grade-separations are shown as intersections with an intersecting node point. Roads closer than three meters together might appear as connected lines, and divided highways in the RI-GIS might appear as a single line. Highway ramps, such as those associated with Route 6, are coded in the RI-GIS as local roads. One-way designations are not associated with these ramps.

In travel demand forecasting models, grade separations must appear as unconnected (crossing) links, roads close together and inappropriately connected must be separated apart, and divided highways should be shown as one-way pairs. Some network editing had been completed by MassHighway's consultant prior to the distribution of the new models to the regional agencies. However, more extensive editing was required.

The attributes brought forward into the Cape Cod TransCAD model from the RI-GIS are shown in Table 1.

Table 1: TransCAD Network Line Attributes	
TransCAD Variable Name	Description
ID	TransCAD requires that each line segment has a unique identification number. When the networks were built, network identifiers were established such that each region has a unique set of numbers. For the Cape Cod network the identifier sequence numbers begin at 2,000,000.
Length	The distance is calculated by TransCAD based on the coordinate system. The units are miles.
Dir	Direction. A value of 0 indicates two-way travel. A value of 1 indicates one-way. For one-way, the travel direction is indicated in the endpoint file as the A node-to-B node direction. The travel direction can also be seen by turning the arrows on in the map display.
Measured Distance	From the GIS system road inventory file. This is the fifth wheel measured distance in miles.
Street_Name	Street name as listed in GIS.

Route_Num	Primary and secondary route numbers as listed in the GIS.
Functional Class	<p>These are based on data provided by the GIS system. The functional classification codes are as follow:</p> <p>ROADS INSIDE THE REGION:</p> <p>0 = Local Road, not in model 1 = Interstate 2 = Rural Principal Arterial and Urban Extension 3 = Rural Minor Arterial and Principal Arterial Extension 4 = Other Urban Principal Arterials 5 = Urban Minor Arterial and Rural Major Collector 6 = Urban Collector and Rural Minor Collector 7 = Ramp - this category is not in the GIS and was manually coded during network editing 8 = undefined (reserved for future use) 9 = undefined (reserved for future use) 10 = Local Road included in model</p> <p>ROADS OUTSIDE THE REGION:</p> <p>70 = Local Road not in model (outside of region) 71 = Interstate (outside of region) 72 = Rural Principal Arterial and Urban Extension 73 = Rural Minor Arterial and Principal Arterial Extension 74 = Other Urban Principal Arterials 75 = Urban Minor Arterial and Rural Major Collector 76 = Urban Collector and Rural Minor Collector 77 = Ramp - this category is not in the GIS and was manually coded during network editing 78 = undefined (reserved for future use) 79 = undefined (reserved for future use) 80 = Local Road included in model</p> <p>ZONE CONNECTORS</p> <p>90 = External Zone Connector 99 = Internal Zone Connector</p>
Town_Code	The town code integers are consistent with the GIS town code names.
Serial_Number	Used to uniquely identify each roadway segment as per this instance of the GIS database. The serial number is also used to cross-reference the road inventory database against other GIS databases.
Lanes	The number of lanes reflects the number of lanes per direction. This is different from the GIS number of lanes which reflects the cross-section number of lanes. A maximum of five lanes per direction is allowed in the database.
PostedSpeed	This field is based solely on the speed/capacity lookup table discussed in that section.
Fed_Area	<p>This field represents the area type and this data comes from the GIS road inventory file. It has the following values:</p> <p>0 = No Data 1 = Urban City 2 = Urban Town 3 = Rural Town</p>
Acc_Con	<p>This field represents the type of access control. Its source is the GIS and has the following values:</p> <p>0 = No Access Control Data 1 = Full Access Control 2 = Partial Access Control 3 = No Access Control</p>
Terrain	<p>This field represents the terrain type and was taken from the road inventory part of the GIS. It has the following values:</p> <p>0 = No Terrain Data Exists 1 = Level Terrain 2 = Rolling Terrain 3 = Mountainous Terrain</p>
Divided	<p>This field identifies whether the roadway is divided or not. These data were taken from the inventory part of the GIS. This data field is only useful when a divided roadway is represented by a single line in the GIS. Most divided roads are shown as one-way pairs. This data field has the following values:</p> <p>0 = No divided data exists 1 = Roadway is Divided 2 = Roadway is not divided</p>
Travel_Width	This field is from the road inventory part of the GIS. The units are in feet and this defines the total pavement width (shoulder to shoulder)
Road_Number	This is the road inventory number used in the GIS. When combined with the town ID code, it uniquely defines each roadway in the state.
Time	The TransCAD model requires a travel time. This data field is calculated by the user. The calculation is to divide the Length by the speed and then multiply the product by 60 to convert the units to minutes.

Hourly_Cap_LOSE	Hourly Capacity for Level of Service E from speed/capacity lookup table.
Daily_Cap_LOSE	This field is filled out by multiplying the Hourly_Capacity by a conversion factor. This multiplication is handled by the speed/capacity lookup table. The multipliers to convert hourly capacity to daily capacity follow: Class 1 Multiplier = 13 Class 2 Multiplier = 10 Class 3 Multiplier = 10 Class 4 Multiplier = 10 Class 5 Multiplier = 9 Class 6 Multiplier = 9 Class 7 Multiplier = 13 Class 8, unused Class 9, unused Class 10 Multiplier = 8
Hourly_Cap_LOSC	Hourly capacity for Level of Service C as calculated based on Level of Service E capacity, that is, LOSE capacity X 0.75
Daily_Cap_LOSC	This field is filled out by multiplying the Hourly_Capacity by a conversion factor as shown above.

7
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A speed/capacity lookup table was used to assign free flow speed and capacity attributes to the network. Use of a lookup table greatly expedited the development of the network. The speed/capacity table is based on the Highway Capacity Manual. The lookup table is sensitive to functional classification, number of travel lanes, area type, and topography. Model users can over-ride the speed/capacity and manually code values for links.

The TransCAD networks have been tested by MassHighway's consultant by building paths and by checking an initial assignment. One-way roads in these files reflect information coded in the RI-GIS. Placement of interchanges and ramp directions were coded by an automated process and thus require checking.

The recommended practice for use of the RI-GIS networks is that all roads functionally classified as collectors or higher should be included in the regional models. Local roads, as needed for network continuity, should also be added to the network by the regional planning agencies.

2.2 ZONE DATA SOURCES

MassHighway established that internal traffic analysis zones should be based on Census Block Groups and that external traffic zones should be placed where collector or higher functionally classified roads cross regional boundaries.

The zone boundaries and data were provided to the regions by MassHighway as part of the initial model structure. The two principal elements of the internal zone data files are the zone boundary polygons and the population/employment attributes. The zone boundary polygons come from the

1995 Census TIGER File CD. These boundary files were read from the TIGER CD directly by TransCAD. A unique ID was assigned to each zone. A code consisting of state, county, tract, and Block Group numbers uniquely identifies each zone.

The population statistics used in the model are household cross-classification matrices based on household size and auto availability. The Block Group cross-classification matrix columns are labeled as zero auto households, 1 auto households, 2 auto households, 3 auto households, and 4 or more auto households. The rows of the matrix are labeled as 1 person households, 2 person households, 3 person households, and 4 or more person households. The matrix has 20 cells. For each internal zone, each matrix cell must have a value equal to or greater than zero. For each zone, the number of households within each category must be determined.

The household data in the model for 1997 are from the Caliper Data CD U.S. Block Groups Version 2 which was developed from the U.S. Census Block Group data summaries. For each Block Group, the Caliper CD identifies the total population, the total number of households, the average household size, and the average autos available. The Caliper Data CD does not contain a cross-classification matrix as required by the trip generation process. The U.S. Census also does not identify such a matrix at the Block Group level. Such detail in the Census would compromise personal privacy. However, this cross classification data matrix does exist in the Census at the County level.

A TransCAD macro was prepared by MassHighway's consultant which would generate the needed cross-classification data at the Block Group level zone system.

Generating a detailed household cross-classification matrix at the Block Group level is a common challenge for urban model development. The most widely applied strategy for developing this matrix is to estimate it based on published Block Group statistics. The published Block Group statistics used to estimate the matrix are total households, average household size, and average auto availability. A county seed auto availability and average household size cross-classification matrix were also required. These variables served as the basis for computing the needed Block Group cross-classification matrix for regional models.

The format of the completed zonal data file for each region is labeled tazhne1.dbf and is shown in Table 2.

Table 2: Internal Zone Data File Fields	
ID	M2PER1AU
F97_POP	M2PER2AU
F97_HOUS	M2PER3AU
F97_TOT_AO	M2PER4AU
F97_POPHH	M3PER0AU
F97_AOHH	M3PER1AU
F97_1PER	M3PER2AU
F97_2PER	M3PER3AU
F97_3PER	M3PER4AU
F97_4PER	M4PER0AU
M1PER0AU	M4PER1AU
M1PER1AU	M4PER2AU
M1PER2AU	M4PER3AU
M1PER3AU	M4PER4AU
M1PER4AU	
M2PER0AU	

In addition to population, household, and auto availability data, zonal employment data are also needed. The employment data selected for use by MassHighway are as follows:

1. Retail
2. Service
3. Education
4. Health
5. Entertainment
6. Manufacturing
7. Other

The employment data were obtained from the Caliper CD previously referenced and from the CTPP statewide and urban element files. The seven categories of employment data were developed by consolidating the 18 employment categories in the CTPP Part B data. The 18 categories and the resulting consolidations are:

1. Agriculture, forestry, and fisheries
2. Mining
3. Construction
4. Manufacturing, nondurable goods
5. Manufacturing, durable goods
6. Transportation
7. Communications and other public utilities
8. Wholesale trade
9. Retail trade
10. Finance, insurance, and real estate
11. Business and repair services
12. Personal services
13. Entertainment and recreation services
14. Health services
15. Educational services
16. Other professional and related services
17. Public administration
18. Armed Forces

1. Retail = Category 9
2. Service = Categories 7,10,12,16, and 17
3. Education = Category 15
4. Health = Category 14
5. Entertainment = Category 13
6. Manufacturing = Categories 4,5,8, and 11
7. Other = Categories 1,2,3,6 and 18

The 1990 zonal employment data were expanded to 1997 based on the estimated employment on the Caliper CD. The Caliper CD provides both 1990 and 1997 employment by the county place of residence. A county growth factor from 1990 to 1997 was calculated and used to expand 1990 zonal employment data, by place of work, to 1997.

In addition to population and employment data, an area type for each zone was needed. These area types are consistent with the RI-GIS. Consequently the zone area type was tagged from the highway link layer.

Land use data obtained from an older Cape Cod Commission TRIPS model were coded on the TAZ layer. Based on the Regional trip generation formula, the other data fields on the TAZ layer include productions and attractions for three trip purposes.

The final column labels in the 1997 TAZ database are presented in Table 3.

Table 3: 1997 TAZ Database	
ID	
Area	
Code	
AREATYPE	(1=urban city, 2=urban town,3=rural)
F97_HOUS	(1997 total household)
F1PER0AU	(1 Person HHs and 0 Autos)
F1PER1AU	
F1PER2AU	
F1PER3AU	
F1PER4AU	
F2PER0AU	(2 Person HHs and 0 Autos)
F2PER1AU	
F2PER2AU	
F2PER3AU	
F2PER4AU	
F3PER0AU	(3 Person HHs and 0 Autos)
F3PER1AU	
F3PER2AU	
F3PER3AU	
F3PER4AU	

F4PER0AU	(4 Person HHs and 0 Autos)
F4PER1AU	
F4PER2AU	
F4PER3AU	
F4PER4AU	
F97RETAIL	
F97SERVICE	
F97EDUCATI	
F97HEALTH	
F97ENTERTA	
F97MANUF	
F97OTHER	

In TransCAD, the network and zones are stored as different data layers. The network is stored in the link layer and the nodes are stored in the endpoints layer. These two layers are brought together with zone connectors. TransCAD has a built-in macro, which connects zones to a network by generating centroids on the endpoints layer and connectors on the link layer. Conditions for these connections can be user-defined. For the zone connectors in the regional models, the conditions step precluded zone connectors to local roads or limited access roads. One zone connector was added per zone. When the zone connectors were established, a travel time of 3 minutes and 10 minutes was assumed for internal and external zone connectors, respectively. At each point where a road that is functionally classified as collector or higher crosses the region's boundary, an external boundary zone is created. These boundary points generate productions and attractions and serve as origins or destinations for external-external trips. The productions and attractions for each external boundary zone are calculated based on observed average daily traffic (ADT). External-external trips are also a function of ADT. To prepare data for these external zones, the data collected during the 1997 field reviews was examined. These data provided external-external trips for most of the major movements through the region. Some of the data files also had 1997 count data. The state's annual count program was also examined for data. The external-external trip table was updated from the older Cape Cod Commission regional model.

3.0 THE CALIBRATED BASE MODEL

The Cape Cod region is unique. Summer daily vehicle miles of travel (VMT) is nearly double the winter VMT. Both population and employment increase significantly during the summer. The housing stock consists of year-round homes, which are occupied year round, and homes which are occupied only during the summer, late spring, and early fall. There are also seasonal homes which lack insulation and heating for other than summer use.

There are issues regarding household occupancy levels. Homes that are occupied year round have more residents in summer months than winter.

On the employment side, there is permanent employment where jobs exist year round, and there are seasonal jobs and seasonal employers.

Cape Cod experiences the greatest presence of CO and NoX during the summer. The model should be used to estimate traffic during the summer to assure accurate emissions estimates. The staff at the Cape Cod Commission has considered seasonal housing and employment and prepared a summer PM peak period model for the regional air quality analysis. Given the unique characteristics on the Cape, this appears to be the best strategy for the foreseeable future.

In contrast, the regional model supplied by MassHighway has been designed to predict 24-hour volumes using year round housing and employment.

In addition to the model calibration and validation issues faced by regional planning agencies in Massachusetts, the Cape was also faced with the need to re-code zonal demographics and employment and to completely revise the trip generation process supplied by MassHighway to consider summer conditions.

3.1 HIGHWAY NETWORK EDITING

The first step in the network editing process was to review the zone connectors which had been established using the TransCAD automated process. These zone connectors were drawn to the closest road having a functional classification of collector or higher. This meant that many connectors were attached directly to Route 6. These connections were all relocated.

Following corrections to the obvious zone connector problems, other zone connector issues were examined. The basic problem is that the automated zone placement process doesn't place the connector in the best location from a traffic loading point perspective. Also, the use of a single loading point per zone is usually not good practice. It is desirable in most cases to have 2-3 zone connectors per zone.

Following the zone connector corrections, the next focus area was Route 6. Many of the interchanges were not properly coded. Ramps were missing and the direction of travel on many ramps was incorrect.

There were many cross-roads associated with Route 6 that should have been grade-separated but were shown as at-grade intersections. These were corrected.

In addition, a new functional class 5 17 was assigned to ramps at the interchange of Route 25/North Bourne Rotary and at the interchange of Route 6/Sagamore Rotary Bridge. These ramps were considered different from other diamond interchange ramps because they don't have stop/yield sign control. The new functional class ramps have higher capacity than the general ramps with functional class = 7. The speed/capacity lookup table and the macro were modified to incorporate the change.

Following these initial changes, the model was tested by building paths. The paths selected by the model were manually checked. Through this process, there were many gaps in the network which were found and corrected. These gaps occur when two nodes in the RI-GIS are close together but not connected. They usually are the result of omissions in the GIS editing operation.

When the networks were originally built from the RI-GIS, a snap distance of three meters was used. If two nodes are separated by a distance of three meters or less they are combined into a single node. There were many nodes along roadway mainlines which were greater than three meters in separation, yet less than 10 meters. These are difficult to visually detect within the GIS system, and can only be found during an assignment.

The network attributes in the RI-GIS were checked for consistency. The checking was performed by color coding link attributes, using TransCAD, and checking for inconsistencies. There were many gaps in the attributes where a line existed to represent the road, yet the line attributes were not consistent with roads connected at either end.

The last network characteristic that received specific attention were one-way roads. Particularly in Hyannis, there were many roads shown as one-way with an incorrect travel direction.

3.2 ZONE STRUCTURE REFINEMENT

The original traffic analysis zones (TAZ) were based on census Block Groups. In the original model, Bourne Dale DCPC District contained two TAZs. At the request of the Cape Cod Commission, two TAZs were split into four. TransCAD map editing procedures were used to perform the zone splitting. In addition, a TAZ that existed on both sides of canal was split into two zones. The demographic data for the split zones in the 1997 model were allocated based on zonal area.

In the original model, external zone numbers follow the last internal zone. To provide a flexibility to add more internal zones, the external zones were re-numbered starting from 1000.

Three external zones, which were not included in the old model but which have a functional class of collector, were added to the model.

Since the centroid ID has to exactly match the zone ID, a TransCAD macro was created to change the centroid ID on the endpoints layer for the modified TAZs.

3.3 TRIP GENERATION

Following the completion of the network adjustments, attention focused on the trip generation process. The MassHighway trip generation process was enhanced with the Cape Cod Commission trip generation.

The land use data, such as year-round households and seasonal households, were obtained from the older Cape Cod Commission TRIPS model and coded into the TAZ database layer. Trip

generation equations from the Cape Cod Commission's earlier model were examined. The equations are:

$$HBWP = 0.05V3 + 0.03V4 + 0.18V5 + 0.24V6 + 0.05V8$$

$$HBWA = 0.20V3 + 0.10V4 + 0.06V5 + 0.04V6 + 0.02V8$$

$$HBNWP = 0.10V3 + 0.17V4 + 0.25V5 + 0.05V6 + 0.35V7 + 0.08V8$$

$$HBNWA = 0.12V3 + 0.18V4 + 0.17V5 + 0.04V6 + 0.10V7 + 0.08V8$$

$$NHBP = 0.03V3 + 0.03V4 + 0.17V5 + 0.04V6 + 0.2V7 + 0.28V8$$

$$NHBA = 0.03V3 + 0.03V4 + 0.14V5 + 0.03V6 + 0.05V7 + 0.28V8$$

In the preceding equations:

V3 = Year Round Household (datafield: SumYRRNDHU)

V4 = Seasonal Household (datafield: SumSEASONAL)

V5 = Retail Employment (datafield: SumRETAIL)

V6 = Non-Retail Employment (datafield: Sum[NONRET'L])

V7 = Beach Parking (datafield: SumBEACHPKG)

V8 = Hotel (datafield: SumHOTEL)

The productions and attractions generated by the above equations are on the TAZ layer and named as **HBWP_CAPE COD COMMISSION**, **HBWA_CAPE COD COMMISSION**, **HBNWP_CAPE COD COMMISSION**, **HBNWA_CAPE COD COMMISSION**, **NHBP_CAPE COD COMMISSION**, and **NHBA_CAPE COD COMMISSION**. Rather than using these equations directly, the new Cape Cod Commission trip generation process was updated.

In the new model, summer productions and attractions for Cape Cod Commission were assembled from two parts. The first part is generated by year-round household and employment data as used in the general MassHighway regional planning models. In the TAZ layer, these data fields are named as **HBWP**, **HBWA**, **HBNWP**, **HBNWA**, **NHBP**, and **NHBA**. These are average year-round productions and attractions. The second part of the trip generation process uses seasonal household and seasonal employment and is called seasonal productions and attractions. Seasonal data were obtained from the old Cape Cod Commission TRIPS model. By examining and comparing these data with other data sources, it was found that the seasonal

employment data was not valid for use. Therefore, a regression model with only seasonal households for productions was used. The seasonal attractions were balanced based on productions. Moreover, because the seasonal households rarely generate home based work trips, the regression models were developed for HBNW and NHB only with a total of 5.25 trips generated per seasonal household. The equations used are:

$$\begin{aligned}\text{HBNW seasonal production} &= 3.83 \times \text{Seasonal Household} \\ \text{NHB seasonal production} &= 1.42 \times \text{Seasonal Household}\end{aligned}$$

Seasonal productions and attractions on the TAZ layer are named as **HBWP_SEASON**, **HBWA_SEASON**, **HBNWP_SEASON**, **HBNWA_SEASON**, **NHBP_SEASON**, and **NHBA_SEASON**. By adding the year-round and seasonal Ps and As, the summer total Ps and As can be calculated. These totals are in datafields **HBWP_TOT**, **HBWA_TOT**, **HBNWP_TOT**, **HBNWA_TOT**, **NHBP_TOT**, and **NHBA_TOT**.

The above productions and attractions are for summer weekday daily trips. To convert the daily model into a summer weekday PM peak hour model, the hourly factors in Table 4 were applied. The lookup table was developed based on NCHRP Report #180. Because the model represents the PM peak hour, the factors for hour 16 to hour 17 were used.

Table 4: Hourly Factor Lookup Table

HR	FL_ALL	FL_HBW	FL_HBN	FL_HBO	FL_NHB	DEP_ALL	RET_ALL	DEP_HBW	RET_HBW	DEP_HBNW	RET_HBNW	DEP_HBO	RET_HBO	DEP_NHB	RET_NHB
0	0.70	0.40	0.70	0.70	0.60	0.35	0.35	0.40	0.00	0.35	0.35	0.35	0.35	0.30	0.30
1	0.20	0.20	0.30	0.30	0.20	0.10	0.10	0.20	0.00	0.15	0.15	0.15	0.15	0.10	0.10
2	0.80	0.00	0.00	0.00	0.00	0.40	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.10	0.20	0.10	0.10	0.00	0.05	0.05	0.20	0.00	0.05	0.05	0.05	0.05	0.00	0.00
4	0.10	0.40	0.00	0.00	0.10	0.05	0.05	0.40	0.00	0.00	0.00	0.00	0.00	0.05	0.05
5	1.00	2.70	0.50	0.50	0.40	0.50	0.50	2.70	0.00	0.25	0.25	0.25	0.25	0.20	0.20
6	3.20	7.90	2.00	2.00	1.50	1.60	1.60	7.90	0.00	1.00	1.00	1.00	1.00	0.75	0.75
7	8.90	19.20	5.80	5.80	6.60	4.45	4.45	19.20	0.00	2.90	2.90	2.90	2.90	3.30	3.30
8	4.10	9.20	3.40	3.40	4.00	2.05	2.05	9.20	0.00	1.70	1.70	1.70	1.70	2.00	2.00
9	3.20	3.00	3.00	3.00	3.60	1.60	1.60	3.00	0.00	1.50	1.50	1.50	1.50	1.80	1.80
10	3.90	0.70	4.40	4.40	5.60	1.95	1.95	0.70	0.00	2.20	2.20	2.20	2.20	2.80	2.80
11	4.10	0.60	4.40	4.40	6.30	2.05	2.05	0.60	0.00	2.20	2.20	2.20	2.20	3.15	3.15
12	5.20	2.10	4.00	4.00	10.20	2.60	2.60	0.70	1.40	2.00	2.00	2.00	2.00	5.10	5.10
13	4.80	2.00	4.80	4.80	7.20	2.40	2.40	0.60	1.40	2.40	2.40	2.40	2.40	3.60	3.60
14	4.90	3.80	4.20	4.20	6.90	2.45	2.45	0.60	3.20	2.10	2.10	2.10	2.10	3.45	3.45
15	6.70	6.30	6.20	6.20	8.00	3.35	3.35	0.60	5.70	3.10	3.10	3.10	3.10	4.00	4.00
16	9.30	13.70	8.10	8.10	8.00	4.65	4.65	0.60	13.10	4.05	4.05	4.25	4.25	4.00	4.00
17	8.50	12.40	8.00	8.00	6.20	4.25	4.25	0.60	11.80	4.00	4.00	4.00	4.00	3.10	3.10
18	6.40	3.70	8.50	8.50	4.70	3.20	3.20	0.60	3.10	4.25	4.25	4.25	4.25	2.35	2.35
19	7.90	2.30	11.20	11.20	6.30	3.95	3.95	0.60	1.70	5.60	5.60	5.60	5.60	3.15	3.15
20	5.90	1.60	7.90	7.90	5.80	2.95	2.95	0.60	1.00	3.95	3.95	3.95	3.95	2.90	2.90
21	4.80	2.90	6.00	6.00	3.90	2.40	2.40	0.00	2.90	3.00	3.00	3.00	3.00	1.95	1.95
22	3.20	2.80	3.90	3.90	2.40	1.60	1.60	0.00	2.80	1.95	1.95	1.95	1.95	1.20	1.20
23	2.10	1.90	2.60	2.60	1.50	1.05	1.05	0.00	1.90	1.30	1.30	1.30	1.30	0.75	0.75

In addition to summer conditions, it was the desire of the Cape Cod Commission staff to have the capability to also develop winter PM peak hour volumes. It was assumed that seasonal households do not produce winter trips. Average year-round trips are reduced by a certain percentage due to lower occupancy rates. Eighty percent of year-round productions and attractions were used as winter productions and attractions. For external stations, because it is known from traffic counts that the winter traffic volume is 54 percent of the summer volume, external Ps and As were factored to 54 percent of the summer Ps and As. The winter Ps and As are named as **HBWP_WINTER**, **HBWA_WINTER**, **HBNWP_WINTER**, **HBNWA_WINTER**, **NHBP_WINTER**, and **NHBA_WINTER** on the TAZ layer. P2 1/1

3.4 TRIP DISTRIBUTION

A gravity model was used as the basis for the trip distribution process. TAZs are categorized into three area types: urban city, urban town, and rural town. Each area type has different land use density and a different intrazonal travel time. During model calibration, the intrazonal travel times were determined to be 6, 5.5, and 4 minutes for the three area types.

Table 5 lists the friction factors developed and calibrated for the distribution.

The gravity model calibration was performed based on the trip length travel time frequency distributions. The 1990 Census Transportation Planning Package (CTPP) was used to determine the mean trip length for the work trip. Other trip purposes were adjusted according to differences in trip length and trip purpose as reported by the Transportation Research Board Report No. 365.

3.5 TRAFFIC ASSIGNMENT

Vehicle occupancy rates used to factor the person trip table to vehicle trips were taken from Transportation Research Board Report No. 365 (for HBW, the rate equals 1.12 persons per vehicle, for HBNW and NHB, the rate is 1.56 persons per vehicle). An equilibrium traffic assignment process was used. The speed/delay function used in the assignment process was the Bureau of Public Roads (BPR) delay curve. The Alpha and Beta parameters were set universally for all links as $\text{Alpha}=4$ and $\text{Beta}=1.5$.

Table 5: Friction Factor Lookup Table

TIME	HBW	HBNW	NHB
1	10000	20000	7000
2	9000	18200	6500
3	8800	16965	6000
4	7500	15480	5000
5	6600	14000	4000
6	2300	3300	1400
7	2300	3300	1400
8	2300	3300	1400
9	2300	3300	1400
10	2300	3300	1400
11	1900	2400	900
12	1500	1650	700
13	1300	1150	520
14	1100	910	400
15	800	800	320
16	700	500	250
17	600	400	200
18	460	300	175
19	420	250	150
20	380	200	130
21	325	180	100
22	280	130	80
23	250	110	70
24	230	100	60
25	210	75	50
26	180	65	45
27	165	55	40
28	140	45	35
29	130	40	30
30	116	35	26
31	100	30	23
32	85	25	21
33	80	23	18
34	75	19	17
35	70	17	15
36	65	17	13
37	60	15	12
38	57	13	10
39	51	12	10
40	45	10	9
41	43	8	9
42	35	7	8
43	33	7	8
44	27	6	7
45	25	5	7
46	22	5	7
47	20	4	6
48	18	4	6
49	17	4	5
50	16	4	5
51	15	4	5
52	13	3	5
53	11	3	4
54	10	3	4
55	10	3	3
56	9	3	3
57	9	3	3
58	9	2	3
59	8	2	3
60	7	2	3
61	5	2	3
62	5	2	2
63	5	2	2
64	5	2	2
65	5	2	2
66	4	2	2
67	4	2	2
68	4	2	2
69	3	1	2

3.6 MODEL CALIBRATION

The model calibration process requires traffic counts as the basis for comparison. The Cape Cod Commission has a traffic count database of approximately 600 locations. This database is a point file of locations, and a table of current and historical traffic count data.

Because the TransCAD traffic assignment volumes are associated with the link layer, the traffic count data were imported into TransCAD and overlaid to the link layer. Having the Cape Cod Commission count program volumes in TransCAD is a tremendous benefit to the calibration process. However, it was difficult and time consuming associating a point data file with links. After overlaying, there was still extensive manual editing.

The greatest effort associated with the manual cleanup was relating the directional link flows to the proper travel direction in the TransCAD link layer file. This problem was principally associated with the RI-GIS base file, more so than the Cape Cod Commission traffic count database. The Cape Cod Commission data file maintained a consistent storage format in terms of showing eastbound then westbound, and northbound and then southbound flow. However, in the RI-GIS file, the primary and reverse direction of travel on two-way links was determined based on how the line was originally created basically user preference. Consequently, there was a considerable amount of manual labor associated with relating the traffic count direction to the link direction. A flag data field called D_AB was created. If the D1 and D2 directions are consistent with AB and BA flow, there is no value in the D_AB data field. Otherwise, a value of 1 was recorded in the data field so the count direction could be transposed.

The assignment was calibrated based on screen line traffic flows and an overall comparison of the assignment and observed travel. Three screenlines were identified on Outer Cape, Mid Cape, and Upper Cape areas. The results of the screen line calibration are presented in Table 6.

During the model calibration process there was some difficulty with Route 28. In some areas, the model was over assigning. In other areas, the assignment was close to observed counts. Further investigation concluded that there are local roads used to circumvent Route 28. When the local roads were added into the network, the traffic volumes began to compare favorably with the observed counts.

Table 6: Screenline Calibration Results

	Location	Total Model Assignment	Total Traffic Counts	Total Ratio
ScreenLine 1	Rt28, North of Rt151 & Rt28 Interchange	1669	1419	1.18
ScreenLine 2	East of Yarmouth, along Bass River	1848	1893	0.98
ScreenLine 3	Rt6, South of Rt6 & Rt28 Rotary	2853	2582	1.1

The percent error for different functional classifications of the assignment calibration are shown in Table 7. All of the numbers are under the threshold defined in the guideline published by The Federal Highway Administration entitled Calibration and Adjustment of System Planning Models.

Table 7: Percent Error by Functional Classification

Functional_Class	Definition	Percent Error
Functional_Class 2	Rural Principal arterial and Urban Extension	5 Percent
Functional_Class 3	Rural Minor Arterials and Principal Arterial Extension	8 Percent
Functional_Class 5	Urban Minor Arterials and Rural Major Collector	6 Percent
Functional_Class 6 & 7	Urban and Rural Collector and Ramps	20 Percent

*Note: Percent Error = (Assignment - Counts) / Counts

Because the two transportation studies for which the TransCAD model is used are focused on the Canal area more effort was put into into calibrating the Cape Cod Canal area. The calibration results are shown in Table 8.

Table 8: Canal Area Calibration Results

Street Name	Actual Traffic Counts		Model Assignment	
	EB & NB	WB & SB	EB & NB	WB & SB
MEETING HOUSE LANE	639	540	683	558
MEETING HOUSE LANE	319	321	284	404
OLD PLYMOUTH ROAD	112	153	8	11
OLD ROUTE 3A	254	207	279	274
HERRING POND ROAD	126	88	80	76
HEAD OF THE BAY	185	246	351	336
CRANBERRY HIGHWAY	954	1448	752	1021
CRANBERRY HIGHWAY	880	1262	906	1194
SAINT MARGARETS	146	83	121	113
BUZZARDS BAY BYPASS	146	83	373	659
BUZZARDS BAY BYPASS	649	640	489	768
BUZZARDS BAY BYPASS	704	466	659	373
ROUTE 25	1680		1573	

Overall Percent Error= 0.1%

4.0 BOURNE SCENIC HIGHWAY STUDY

The first study identified by Cape Cod Commission was the Bourne Scenic Highway Study.

Tasks included the following three elements:

- develop five models for five land use scenarios;
- conduct summer and winter assessment for each scenario; and
- prepare maps and charts for the scenarios and assessment.

4.1 FIVE LAND USE SCENARIOS

The five scenarios vary based on the land use alternatives in the 1997 base year and the 2025 forecast year for the Bournedale DCPC District. Cape Cod Commission provided land use information for the four TAZs in the Bournedale District. The Cape-wide land-use forecasts were from MISER and Caliper (Applied Geographic Solutions) data sources. The five scenarios are defined as:

Scenario 1: 1997 Existing Development

Scenario 2: 1997 Existing and Approved Subdivisions

Scenario 3: 2025 Existing and Approved Subdivisions

Scenario 4: 2025 Buildout

Scenario 5: 2025 Alternate Buildout

4.2 SUMMER AND WINTER ASSESSMENT

The methodology for summer and winter trip generation was discussed earlier. For each scenario, summer and winter productions and attractions were written to the same TAZ layer database. Summer Ps and As are shown in the data fields labeled **HBWP_TOT**, **HBWA_TOT**, **HBNWP_TOT**, **HBNWA_TOT**, **NHBP_TOT**, and **NHBA_TOT**. Winter Ps and As are in the data fields **HBWP_WINTER**, **HBWA_WINTER**, **HBNWP_WINTER**, **HBNWA_WINTER**, **NHBP_WINTER**, and **NHBA_WINTER**. There are five TAZ geographic files (with a dbd extension) which include the unique land use data and productions and attractions for the five scenarios. Although all files may share the same data field names, the data may vary. All scenarios use the same base 1997 highway network. The output files included trip assignments for all scenarios in winter and summer. The TransCAD files associated with the scenarios are summarized in Table 9, the summer assessment, and Table 10, the winter assessment

Table 9: Summer Assessment for Bourne Study

Bournedale Study Reference	SCENARIO 1	SCENARIO 4	SCENARIO 2	SCENARIO 3	SCENARIO 5
Analysis Year	1997	2025	1997	2025	2025
TransCAD Map File	97.map	25.map	97_approved.map	25_approved.map	25_alt.map
TAZ File	97_TAZ*.*	25_TAZ*.*	97_TAZapproved*.*	25_TAZapproved*.*	25_TAZalt*.*
Balanced P & A File	97_balance.bin	25_balance.bin	97_appbalance.bin	25_appbalance.bin	25_altbalance.bin
Demographic Data	Capewide: NO CHANGE; Bournedale:1997 Existing HH and Employment	Capewide: Standard Forecast ² ; Bournedale:Buildout HH and Employment	Capewide: NO CHANGE; Bournedale:Add Approved, Unbuilt Housing and 1997 Employment	Capewide: Standard Forecast; Bournedale: Add Approved, Unbuilt Housing and 1997 Employment	Capewide: Standard Forecast; Bournedale: Alternate HH Buildout and 1997 Employment
Highway Network	Existing	Existing	Existing	Existing	Existing
Highway Geographic File	BASE_HY*.*	BASE_HY*.*	BASE_HY*.*	BASE_HY*.*	BASE_HY*.*
Network File	Bourn.net	Bourn.net	Bourn.net	Bourn.net	Bourn.net
Turn Penalty Table	Turnpen.dbf	Turnpen.dbf	Turnpen.dbf	Turnpen.dbf	Turnpen.dbf
Travel Time Matrix	Skim.mtx	Skim.mtx	Skim.mtx	Skim.mtx	Skim.mtx
Friction Factor Table	Newfflook.dbf	Newfflook.dbf	Newfflook.dbf	Newfflook.dbf	Newfflook.dbf
Friction Factor Matrix	Fric.mtx	Fric.mtx	Fric.mtx	Fric.mtx	Fric.mtx
PA Matrix	97_PA.mtx	25_PA.mtx	97_app_PA.mtx	25_app_PA.mtx	25alt_PA.mtx
PM Peak Hour OD Matrix	97_OD.mtx	25_OD.mtx	97_app_OD.mtx	25_app_OD.mtx	25alt_OD.mtx
Traffic Assignment	97_Assign.bin	25_Assign.bin	97_app_assign.bin	25_app_assign.bin	25alt_assign.bin

Table 10: Winter Assessment for Bourne Study

Bournedale Study Reference	SCENARIO 1	SCENARIO 4	SCENARIO 2	SCENARIO 3	SCENARIO 5
Analysis Year	1997	2025	1997	2025	2025
TransCAD Map File	97.map	25.map	97_approve.map	25_approve.map	25_alt.map
TAZ File	97_TAZ*.*	25_TAZ*.*	97_TAZapproved*.*	25_TAZapproved*.*	25_TAZalt*.*
Balanced P & A File	97_win_balance.bin	25_win_balance.bin	97_winapp_balance.bin	25_winapp_balance.bin	25_winalt_balance.bin
Demographic Data	Capewide: NO CHANGE; Bournedale:1997 Existing HH and Employment	Capewide: Standard Forecast ² ; Bournedale:Buildout HH and Employment	Capewide: NO CHANGE; Bournedale:Add Approved, Unbuilt Housing and 1997 Employment	Capewide: Standard Forecast; Bournedale: Add Approved, Unbuilt Housing and 1997 Employment	Capewide: Standard Forecast; Bournedale: Alternate HH Buildout and 1997 Employment
Highway Network	Existing	Existing	Existing	Existing	Existing
Highway Geographic File	BASE_HY*.*	BASE_HY*.*	BASE_HY*.*	BASE_HY*.*	BASE_HY*.*
Network File	Bourn.net	Bourn.net	Bourn.net	Bourn.net	Bourn.net
Turn Penalty Table	Turnpen.dbf	Turnpen.dbf	Turnpen.dbf	Turnpen.dbf	Turnpen.dbf
Travel Time Matrix	Skim.mtx	Skim.mtx	Skim.mtx	Skim.mtx	Skim.mtx
Friction Factor Table	Newfflook.dbf	Newfflook.dbf	Newfflook.dbf	Newfflook.dbf	Newfflook.dbf
Friction Factor Matrix	Fric.mtx	Fric.mtx	Fric.mtx	Fric.mtx	Fric.mtx
PA Matrix	97_win_PA.mtx	25_win_PA.mtx	97_winapp_PA.mtx	25_winapp_PA.mtx	25winalt_PA.mtx
PM Peak Hour OD Matrix	97_win_OD.mtx	25_win_OD.mtx	97_winapp_OD.mtx	25_winapp_OD.mtx	25winalt_OD.mtx
Traffic Assignment	97_win_Assign.bin	25_win_Assign.bin	97_winapp_assign.bin	25_winapp_assign.bin	25winalt_assign.bin

4.3 REPORT RESULTS

The final products submitted to Cape Cod Commission for this study include the following items:

- ten large-size color plots of the winter and summer weekday PM peak hour V/C ratios;

WINTER 97 & 2025

- charts of VMT for the summer and winter for Bourne Dale DCPC roadways for the five scenarios;
- charts of hourly volumes for summer and winter for Bourne Dale DCPC roadways for the five scenarios; and
- charts of V/C Ratios for summer and winter for Bourne Dale DCPC District Roadways.

5.0 CANAL AREA STUDY

This study involves an evaluation of transportation system improvements in the Cape Cod canal area. These improvements were defined by Cape Cod Commission. Tasks performed include the following:

- construct and evaluate three network alternatives; and
- generate maps for the study.

5.1 THREE HIGHWAY ALTERNATIVES

The three alternatives indicated below were developed in three TransCAD geographic files:

- Sagamore Rotary Alternative: Proposed grade separation for the Sagamore Rotary at the interchange of Rt 3 and Rt 6;
- Bourne Rotary Alternative: Proposed grade separation for the Bourne Rotary
- Sagamore and Bourne Rotary Alternative: Input both alternatives into the highway network.

The three alternatives were considered under the 2025 full build-out demographic condition. Trip assignments were performed for the three alternatives. The associated files are summarized in the Table 11. In this study, only summer PM Peak Hour modeling was used.

Table 11: Canal Study Alternatives

Canal Area Study Reference	Sagamore Rotary	Bourne Rotary	Sagamore & Bourne Rotary
Analysis Year	2025	2025	2025
<i>TransCAD Map File</i>	<i>Build1.map</i>	<i>Build2.map</i>	<i>Build3.map</i>
TAZ Structure	Bournedale Refinements	Bournedale Refinements	Bournedale Refinements
TAZ File	25_TAZ*.*	25_TAZ*.*	25_TAZ*.*
Balanced P & A File	25_balance.bin	25_balance.bin	25_balance.bin
Demographic Data	Capewide: Standard Forecast; Bournedale: Buildout HH and Employment	Capewide: Standard Forecast; Bournedale: Buildout HH and Employment	Capewide: Standard Forecast; Bournedale: Buildout HH and Employment
Highway Network	Sagamore Rotary Preferred Alternative	Bourne Rotary Preferred Alternative	Sagamore & Bourne Rotary Alternative
Highway Geographic File	25B1_HY*.*	25B2_HY*.*	25B3_HY*.*
Network File	Build1.net	Build2.net	Build3.net
Turn Penalty Table	Turnpen.dbf	Turnpen.dbf	Turnpen.dbf
Travel Time Matrix	B1_Skim.mtx	B2_Skim.mtx	B3_Skim.mtx
Friction Factor Table	Newfflook.dbf	Newfflook.dbf	Newfflook.dbf
Friction Factor Matrix	B1_Fric.mtx	B2_Fric.mtx	B3_Fric.mtx
PA Matrix	B1_PA.mtx	B2_PA.mtx	B3_PA.mtx
PM Peak Hour OD Matrix	B1_OD.mtx	B2_OD.mtx	B3_OD.mtx
Traffic Assignment	B1_Assign.bin	B2_assign.bin	B3_assign.bin

5.2 REPORT RESULTS

The final products provided to Cape Cod Commission for the Canal Area Study include the following items:

- traffic Count Map for the 1997 Summer PM Peak hour
As discussed in the Base Model Calibration section, the traffic count information was provided by Cape Cod Commission. The consultant has overlayed this information onto the highway database;
- traffic Flow Map for 2025 Sagamore Rotary Alternative;
- traffic flow Map for 2025 Bourne Rotary Alternative; and
- traffic Flow Map for 2025 Sagamore and Bourne Rotary Alternatives Combined.

The challenge for producing these maps was to show the two directional flow volumes in a readable format. TransCAD does not have a function for automatic labeling of two-directional flows. A dummy layer has been added to the link layer and a number of links have been selected to show labels.