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DRAFT FOR REVIEW

State-of-Practice Review: Project Level Traffic Forecasting/Corridor Analysis

Prepared by the Texas A&M Transportation Institute
Prepared for the Texas Department of Transportation
August 2013

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Subtask 2.8- Improved Travel Data for Air Quality Applications

FY2013

Prepared for

Texas Department of Transportation

By

Texas A&M Transportation Institute

August 2013

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CHAPTER 1. INTRODUCTION

This report summarizes the state-of-the-practice in project level traffic forecasting in Texas and nine peer states. The project level traffic forecasting process estimates the traffic conditions used for determining the geometric design of a roadway and intersection and the number of Equivalent Single Axle Loads (ESALs) that pavement will be subjected to over the design period. This process differs from system level forecasting, as it covers a limited geographical area, and is conducted at a more detailed level. This level of traffic forecasting can be used for reconstruction projects, resurfacing projects, lane additions, bridge replacements, new roadway projects, and major intersection improvements.

This report outlines the Texas Department of Transportation's (TxDOT's) process for project level traffic forecasting. It describes the sources of the input data, the input data, techniques used, and calculations involved in coming up with the required outputs, which are then used for geometric design and environmental studies. The report also provides an overview of the state-of-the-practice of traffic forecasting in nine peer states. These states were chosen given their similarities to Texas in terms of their roadway network and number of urban areas.

This report is structured as follows. Chapter 2 reviews the Corridor Analysis traffic forecasts conducted by the Traffic Analysis Section of TxDOT's Transportation Planning and Programming Division. Chapter 3 provides an overview of the state-of-the-practice in traffic forecasting at the project/route segment level based on interviews/surveys of other states. Chapter 4 summarizes the findings of the study team and offer recommendations for additional tasks to be conducted in Fiscal Year 2014.

CHAPTER 2. TXDOT'S CORRIDOR ANALYSIS PROCESS

TxDOT's Traffic Analysis Section of the Transportation Planning and Programming (TPP) Division forecasts future traffic volumes and truck percentages on route segments "for use in planning, environmental, geometric design and pavement design"[1]. This chapter was prepared based on a review of the following documents:

- Traffic Forecasting Guidelines for Texas;
- Integrating Land Use and Planning;
- ABCs of Corridor Analysis;
- Corridor Primer;
- Corridor in Depth; and
- Calypso 5 documentation.

In addition, Mr. Bruce Uphaus (TxDOT's Traffic Analysis Section) walked the study team through a simple corridor analysis request.

This chapter attempts to document the step-by-step process that is followed when forecasting traffic and truck volumes on a route segment. It also outlines the inputs that are used.

2.1 Corridor Analysis – Step-by-Step

The Corridor Analysis process is initiated when TPP's Traffic Analysis Section receives the Traffic Data Request Form. In this Form the District provides information about the route segment (CSJ, County, Highway/Limits, District Priority, Estimated Letting Date, Existing Number of Lanes, and Proposed Number of Lanes) and the District indicates the information that is required – Basic Highway Traffic Data for Pavement Design, Vehicle Classification for Environmental Studies, Line Diagram Analysis or Complete Corridor Analysis (see Figure 2.1).


TRAFFIC DATA REQUEST FORM

DISTRICT Fort Worth COUNTY Tarrant CSJ 0902-48-186

HIGHWAY/LIMITS CS/Harrison Lane on Pipeline Rd in Hurst

DISTRICT PRIORITY 4 EST. LETTING DATE May 2012

EXISTING NUMBER OF LANES 4

PROPOSED NUMBER OF LANES 4

DISTRICT CONTACT PERSON Judy Anderson

TELEPHONE NUMBER 817-370-6710

PLEASE ATTACH AN 8-1/2"x 11"LOCATION MAP.

The following to be completed: (please mark information to be provided).

[x] 1. Basic Highway Traffic Data for pavement design. (No line diagram analysis required.)

Notes:

A. Base year / Beginning year. 2012
B. Forecasted 20 year. 2032
C. Forecasted 30 year. 2042
D. Directional Distribution (percent)
E. K-Factor.
F. Percent Trucks ADT / DHV.
G. Average Ten Heaviest Wheel Loads (ATHWLD).
H. Percent Tandem Axles in the ATHWLD.
I. One direction cumulative 18 KSA at the end of 20 years/30 years for Flexible Pavement and Rigid Pavement.
J. Slab Thickness (8" unless otherwise specified).
K. Structural Number (3 unless otherwise specified).

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[ ] 2. Vehicle classification for environmental studies (Air and Noise Analysis).

[ ] 3. Line Diagram Analysis (straight line turning movements; please provide line diagram).

[ ] 4. Complete Corridor Analysis (Includes basic highway traffic data for pavement design and environmental studies and detailed schematic turning movements; please provide detailed schematic).

NOTE: If complete corridor analysis is requested, please attach a traffic schematic diagram. Please make note of any known proposed development that will be a traffic generator.

Figure 2.1: Traffic Data Request Form

[1] Texas Department of Transportation. Not Dated. The ABCs of Corridor Analysis.

Upon receipt of this request and any supporting documentation (location map), the Traffic Section starts the Corridor Analysis.

2.1.2 Step 1 – Obtain AADT Count Data

The Traffic Analyst will first locate the appropriate count stations for the project on the most recent District Traffic (on-system facilities) or Saturation Count map (off-system facilities) to obtain the most recent traffic counts. Figure 2.2 provides a screenshot of a District Traffic Count map.

Figure 2.2: District Traffic Count Map

2.1.3 Step 2 – Calculate AADT Growth Rate

> Districts' Traffic maps provide the AADT for the main lanes AND frontage roads, whereas Tlog provides AADT for the main lanes only. When performing regression analysis, the Analyst has to choose one of the two data sources.

Once the count stations have been identified, the Traffic Analyst consults the Automatic Count Recorder Workbook to identify the beginning and ending mile points covered by the count stations. The analysts subsequently extracts the historical count data (AADT) for the past 20 years from traffic log spreadsheet (Tlog) **or** the District maps for each of the count stations. Often the Traffic Analyst is required to access older Tlog files to obtain 20 years of historical data. Figure 2.3 illustrates the columns of data that are included in the Tlog worksheet. If the historical AADT data to support a regression analysis is not available, the demographic changes in the corridor, land use patterns, and results from the MPO Travel Demand Model is used to calculate a growth rate[1].

CS Harrison Lane on Pipeline Road

2010 TLOG December Final Sheet A (2010 Traffic)

Dist	Co	Ser #	Cont	Sect	Beg Mpt	End Mpt	Length	Hwy Sys	Hwy #	Cur Yr	Cur Yr AADT	Adj Cur AADT	2009 AADT	2008 AADT	2007 AADT	2006 AADT	2005 AADT	2004 AADT	2003 AADT	2002 AADT	2001 AADT	Daily VM
2	220	1150	8	13	24.594	26.216	1.622	8	820	2010	172550	172550	167810	167660	163330	164180	185000	168270	161900	153690	155160	279876
2	220	1340	94	2	2.238	4.617	2.379	2	10	2010	27000	27000	26000	25000	26000	23000	21000	24000	24000	24000	27000	64233
2	220	1350	94	2	4.617	7.767	3.150	2	10	2010	21000	21000	22000	20000	21000	17800	14130	17200	22000	25000	25000	66150
2	220	1740	364	1	15.707	19.443	3.736	2	121	2010	160780	160780	161980	175610	176850	172780	194000	176970	179740	189380	186920	600674
2	220	1750	364	1	19.443	20.670	1.227	2	121	2010	157290	157290	151940	167420	175040	164740	191000	174130	180850	173350	167870	192994

2010 TLOG December Final Sheet B (2010 Traffic)

Des Yr	Yrly Inc Fact	Des Yr ADT	Des Yr VM	K-Fact	Dir Dist	% Trks in AADT	% Trks in DHV	Des Hr Vol	ATHWLD (Sin)	ATHWLD (Tan)	Flex (K)	Rigid (K)	FC	Pop	Yrly Gwh Fac	KP Gwh Fac	# of Trucks	% Single Unit (AADT)	% Combo Unit (AADT)	% Single Unit (DHV)	% Combo Unit (DHV)
2030	2.00	241570	391827	11.0	0.52	6.0	2.7	26573	193	60	43454	58428	1	4 I			10353	2.8	3.2	1.3	1.4
2030	2.00	37800	89926	10.5	0.62	3.1	2.0	3969	148	60	2510	2858	3	4 I			837	2.4	0.7	1.5	0.5
2030	3.50	35700	112455	10.5	0.62	3.5	2.3	3749	148	60	2471	2818	3	4 C			735	2.7	0.8	1.8	0.5
2030	2.00	225090	840936	8.0	0.55	5.2	3.4	18007	191	60	35961	48318	2	4 I			8360	2.3	2.9	1.5	1.9
2030	2.00	220210	270198	8.0	0.55	5.3	3.5	17617	191	60	35849	48174	2	4 I			8336	2.3	3.0	1.5	2.0

2010 DECEMBER FINAL TLOG CONTROL DECKS

District	County	Begining Serial	Ending Serial	ATR	MCC/VC	Leg
2	220	85	87	A301	MA 301	

Figure 2.3: Tlog Worksheets

The Traffic Analyst enters the historical AADT data for each of the count stations in the applicable columns of the Calypso worksheet (see Figure 2.4) to calculate the AADT growth rate at each of the count stations. TxDOT typically uses a growth rate that ranges between 2 and 5 percent.

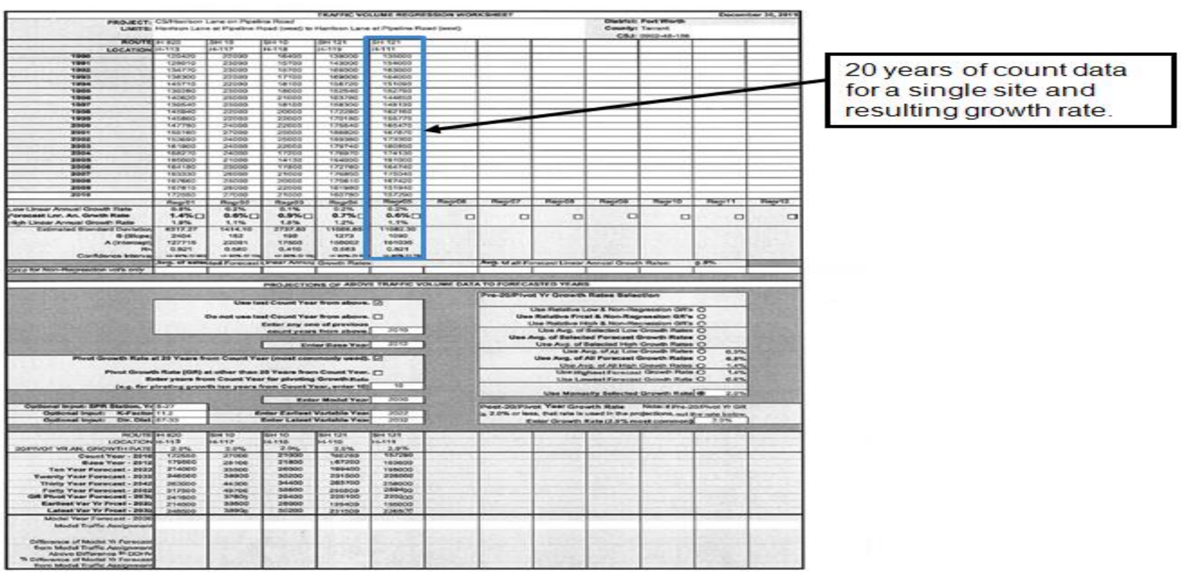

Figure 2.4: Calypso Worksheet for Calculating AADT Growth Rate

2.1.4 Step 3 – Obtain ATR Site and Vehicle Classification Data

The Traffic Analyst consults the Tlog Control Deck to determine from which ATR station the Tlog data are obtained and the associated manual count/vehicle classification station to use. The criteria for selecting a vehicle classification and ATR station are:

- the station should be geographically as close as possible to the project/route segment and
  - the traffic counts should be comparable. Stations where the counts are less than half or more than double that of the project should be avoided.
  - The stations should be on the same facility type as the project/route segment[1].

From the ATR site, the analyst obtains an information sheet that is included in the response to the District Request (see Figure 2.4 below).

High Hourly Volumes for 2010

all Roadbeds

Route: SH0180 **District:** Fort Worth **County:** Tarrant **City:** Arlington
Station: A301 **Location Description:** 2.7 miles west of FM0157, Arlington
Roadbed: ML **Collection Type:** Vehicle Count **AADT:** 18,948

Ordinal High Hour	Date	Day of Week	Ending Hour	Volume	K Factor	Percent Directional Distribution	Peak Direction
1st	12/09/2010	Thursday	06 pm	2,171	11.5	0.60	West
2nd	04/26/2010	Monday	08 am	2,141	11.3	0.68	East
3rd	09/29/2010	Wednesday	06 pm	2,125	11.2	0.63	West
4th	09/10/2010	Friday	05 pm	2,108	11.1	0.57	West
5th	12/03/2010	Friday	06 pm	2,085	11.0	0.61	West
6th	04/26/2010	Monday	09 am	2,082	11.0	0.67	East
7th	04/29/2010	Thursday	06 pm	2,071	10.9	0.66	West
8th	03/26/2010	Friday	06 pm	2,062	10.9	0.61	West
9th	09/10/2010	Friday	06 pm	2,052	10.8	0.56	West
10th	12/01/2010	Wednesday	06 pm	2,049	10.8	0.62	West
15th	06/04/2010	Friday	06 pm	2,023	10.7	0.54	West
20th	09/01/2010	Wednesday	06 pm	2,015	10.6	0.62	West
25th	05/03/2010	Monday	06 pm	2,002	10.6	0.65	West
30th	02/17/2010	Wednesday	06 pm	1,989	10.5	0.62	West
35th	10/15/2010	Friday	05 pm	1,981	10.5	0.55	West
40th	04/21/2010	Wednesday	06 pm	1,973	10.4	0.62	West
45th	12/03/2010	Friday	05 pm	1,972	10.4	0.62	West
50th	04/16/2010	Friday	06 pm	1,964	10.4	0.62	West
75th	05/24/2010	Monday	06 pm	1,947	10.3	0.64	West
100th	11/16/2010	Tuesday	06 pm	1,927	10.2	0.61	West
125th	08/30/2010	Monday	06 pm	1,907	10.1	0.60	West
150th	03/04/2010	Thursday	06 pm	1,880	9.9	0.62	West
175th	05/11/2010	Tuesday	06 pm	1,864	9.8	0.63	West
200th	01/27/2010	Wednesday	06 pm	1,846	9.7	0.63	West

The information contained in this report is provided by the Transportation Planning and Programming Division and is intended for use within the department. The accuracy is limited to the validity of data as of the

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Report Generation Date: April 11, 2011

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Figure 2.4: ATR Site Data

From the Classification Count Station (Manual Count Station), the Traffic Analyst obtains the vehicle classification data. This data sheet is also printed and included in the response to the District (see Figure 2.5).

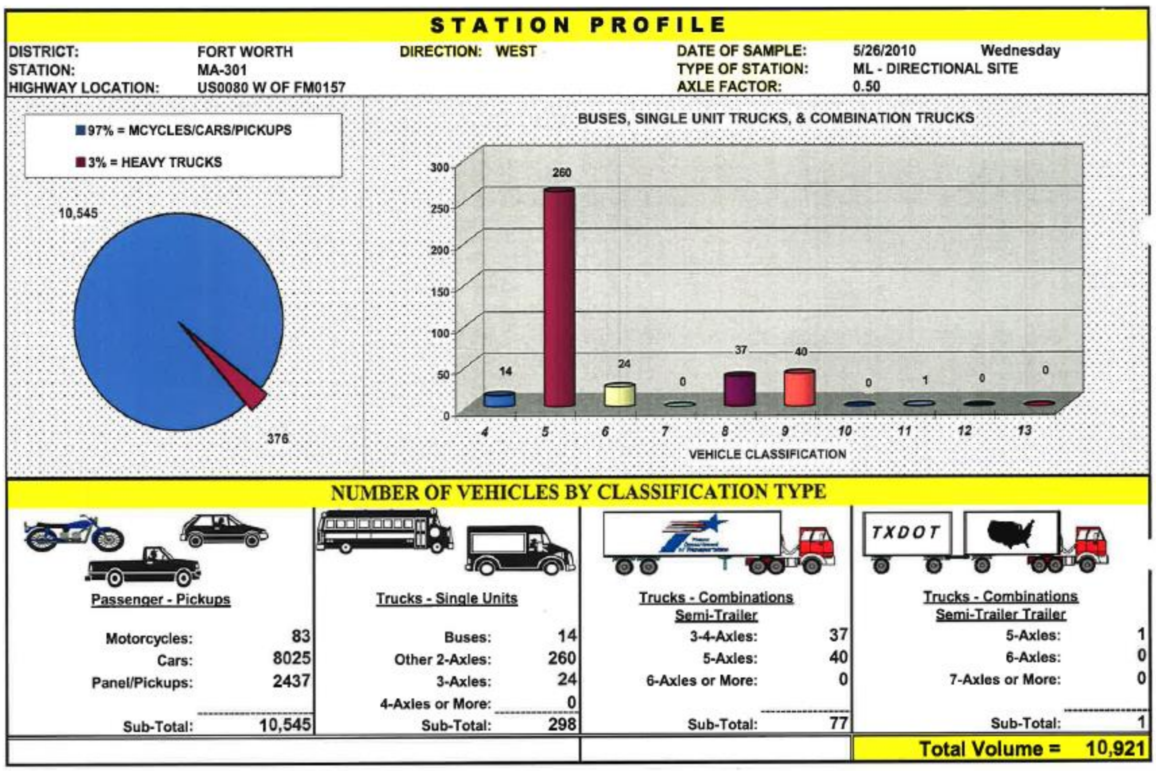

Figure 2.5: Vehicle Classification Data

2.1.5 Step 4 – Complete CARS Worksheet

The Traffic Analyst subsequently enters the data obtained in Step 1, Step 2, and Step 3 in the Excel based CARS (in-house) worksheet.

The Traffic Analyst enters the count data obtained in Step 1 and the growth rate calculated in Step 2 in the CARS worksheet (see Figure 2.6). Based on the entered count data and growth rate, the base and forecast ADTs are calculated.

Corridor Analysis Worksheet: 1 Section, 2 Forecast Years

Project:	Pipeline Road	Date for Memorandum	1/6/2012
Rd Type	FM	District	Fort Worth
Project	CS Harrison Lane on Pipeline Road	County	Tarrant
Limits	Harrison Ln Intersections along Pipeline Rd	CSJ	0902-48-186
		Analyst	MKK

Date:	Request: 10/11/2011	Received:	10/14/2011	Started:	12/28/2011	Completed:	12/30/2011
District Contact:	Judy Anderson				Phone #:	817-370-6710	

	Year	ADT's		% Trks ADT	% Trks DHV
Count:	2009	15530		4	3
Base	2012	16500	# Trks	660	
Forecast	2032	22700			
Forecast	2042	25800			

Figure 2.6: Step 1 and 2 Data

The Traffic Analyst subsequently enters the ATR Site (see Figure 2.4) data in the CARS worksheet. Specifically, the Traffic Analyst enters the:

- SPR station number,
- The year of the data,
- Peak hour K-factor,
- The Directional Distribution in the 30th design hour, and
- The K-factor in the 30th design hour (see Figure 2.7).

Corridor Analysis Worksheet: 1 Section, 2 Forecast Years

Project:	Pipeline Road	Date for Memorandum	1/6/2012
Rd Type	FM	District	Fort Worth
Project	CS Harrison Lane on Pipeline Road	County	Tarrant
Limits	Harrison Ln Intersections along Pipeline Rd	CSJ	0902-48-186
		Analyst	MKK

Date:	Request: 10/11/2011	Received:	10/14/2011	Started:	12/28/2011	Completed:	12/30/2011
District Contact:	Judy Anderson				Phone #:	817-370-6710	

	Year	ADT's		% Trks ADT	% Trks DHV
Count:	2009	15530		4	3
Base	2012	16500	# Trks	660	
Forecast	2032	22700			
Forecast	2042	25800			

SPR Station	A-301	MC Stn:	MA-301	Dir:	E/W	Year	2010
Year	2010	ADT:	20993	% Axle Factor	2.21		
Peak Hour	11.5	% Trks	3.5	% Single Axle	0.84		
DD	62	# Trks	745	Medium	565		
100-DD	38						
K-Factor	10.5						

Figure 2.7: ATR Site Data In CARS Worksheet

Next the Traffic Analyst enters the vehicle classification data in the CARS worksheet. When the directional data are provided, the Traffic Analyst needs to add the number of trucks in each direction. Specifically, the Traffic Analyst enters the number of vehicles by classification type on the right hand side of the worksheet. The spreadsheet calculates the number of trucks, the percentage trucks, number of single axles, number of tandem axle sets, the axle factor, and the percent single axles.

MANUAL COUNT DESIGN DATA - FHWA FORMAT

Station Number MA-301 **Direction** E/W **Year** 2010

Optional Misc. Info. (loc., etc.) US0080 W of FM0157

Type of Truck		Number of Trucks	Single Axles Mult.		Tandem Axle Sets Mult.	
Single Units						
Buses	4	27	2	54	0	0
2-D	5	500	2	1000	0	0
3-Axle	6	60	1	60	1	60
4-Axle	7	0	1	0	1	0
Single Trailer						
3-4-Axle	8	76	2.5	190	0.5	38
5-Axle	9	81	1	81	2	162
6-Axle	10	0	1	0	2	0
Multi-Trailers						
5-Axle	11	1	5	5	0	0
6-Axle	12	0	4	0	1	0
7-Axle	13	0	3	0	2	0
Total		745		1390		260

(Singles + Tandems) / Total Trucks = Axle Factor	2.21
(Singles Axles / (Singles + Tandems))	0.84

Light Duty Vehicles	Motorcycles	158
	Passenger Cars	15468
	Pickup or Van	4622
Single Units	Buses	27
	Other 2 Axle	500
	3 Axles	60
	4 Axles or more	0
Single Trailer	3-4 Axles	76
	5 Axles	81
	6 Axles or more	0
Multi-Trailers	5 Axles or less	1
	6 Axles	0
	7 Axles or more	0

Light	20248
Medium	565
Heavy	180
Trucks	745
Total Vehicles	20993
%T of Tot. Veh.	3.5
Num. of Trucks	745
Axle Factor	2.21
% Single Axles	0.84

Figure 2.8: Manual Count Data In CARS Worksheet

2.1.6 Step 5 – Calculate Pavement Variables

To calculate flexible and rigid pavement loadings, average of the ten heaviest wheel loads (ATHWLD), and percent tandem axles within the ATHWLD, the Traffic Analysts enters the following outputs from the CARS worksheet into ROADTEST 68, a mainframe program used by TxDOT (see Figure 2.9):

- Base Year and Forecast Year
- ADT Count Data from District Traffic or Saturation Count map
- Growth Factor calculated as the:

  [(Forecast Year ADT/Base Year ADT)-1]/Design Period
- Percent Trucks
- Design Period, which is typically 20 years, but can be longer
- The default values for Structural Number (SN) is 3 and the slab thickness is usually specified as 8
- WIM station - The number of the particular WIM site on that road segment which accesses the weight table for that particular site. If WIM site is not located on the selected road segment then average of all the WIM site's weight tables is used.
- Truck Axle Factor – the ratio of single axles and tandem axles sets per truck on the route segment. The Truck Axle Factor equals

  (single axles + tandem axle sets)/ Total Trucks
- % Single Axle Trucks - the percent of single axles on the route segment. The percent single axles equals

  (single axles/ (single + tandem axles))*100

```
                         K.  I.  P.  S.

                     LOCATION DESCRIPTION
Harrison Lane on Pipeline Road in Hurst_______________________________
                                                        PGM    FACIL
YEAR1 YEAR2  ADT    PERCENT TRKS  GROWTH RATE  YEARS DISTRIB TYPE   S.N.  SLAB
 12 - 32   16500_       4.00          1.879_      20    NO_     C     03    08
                   EX: 10.1%      EX: 9.333              OR YES

WEIGHT STA  C OR T     AXLE FACTOR  SINGLE AXLE
  99999       T           2.21          .84
                      EX: 2.25      EX: .50 -->USE TRAILING ZERO

 2007 AVAILABLE WEIGHT STATIONS - 074,142,502,506,518,519,523
                                  524,525,527,528,529,530,531
                                  532,800,808
 WEIGHT STATIONS NOT IN AVERAGE -
                   ENTER TO PROCESS CURRENT RECORD
                              THEN.....
                          PF2 TO SUBMIT JOB

              PF4 TO EXIT THIS PROGRAM WITH NO ACTION
```

Figure 2.9: ROADTEST 68 Input Screenshot

The output from the ROADTEST 68 program is the total forecasted number of ESALs, Average Ten Heaviest Wheel Load (ATHWLs), and Percent Tandems in ATHWL (see Figure 2.10).

```
                              TEXAS DEPARTMENT OF TRANSPORTATION
RDTEST                             RDTEST68  -  130113                            VER 2.0 FEB 84


        CALCULATION OF EQUIVALENT 18-KIP SINGLE AXLE LOAD APPLICATIONS FOR FLEXIBLE PAVEMENT DESIGN

           HARRISON LANE ON PIPELINE ROAD IN HURST                            12-32

                    BEGINNING AVERAGE DAILY TRAFFIC        16500.

                    ENDING AVERAGE DAILY TRAFFIC           22701.

                    INCREASE IN TRAFFIC PER YEAR             310.

                    PER CENT INCREASE IN TRAFFIC PER YEAR    1.88

                    PER CENT TRUCKS                          4.00

                    DESIGN YEARS                            20.00

                    STRUCTURAL NUMBER                          3.

            EQUIVALENT 18-KIP SINGLE AXLE LOAD APPLICATIONS FOR FLEXIBLE PAVEMENT DESIGN

                    TWO DIRECTION                        3291311.

                    ONE DIRECTION (TO NEAREST 1000)       1646000


            AVERAGE OF TEN HEAVIEST WHEEL LOADS DAILY (POUNDS).   11700

            PER CENT TANDEMS IN THE ATHWLD                           40
```

Figure 2.10: ROADTEST 68 Output

2.1.7 Step 6 – Populate Traffic Analysis for Highway Design Form

The Traffic Analyst enters the ROADTEST 68 output in the CARS worksheet (see Figure 2.11).

OUTPUT DATA FROM KIPS: ENTER FOR TAHD FORM

	1	2
ATHWLD	11700	11800
% T in ATHWLD	40	40
FLEXIBLE	1646000	2664000
RIGID	1793000	2902000

Figure 2.11: ROADTEST 68 Output in CARS Worksheet

Once the ROADTEST 68 output is entered in the CARS worksheet, the Traffic Analysis for Highway Design Form is automatically populated (see Figure 2.12).

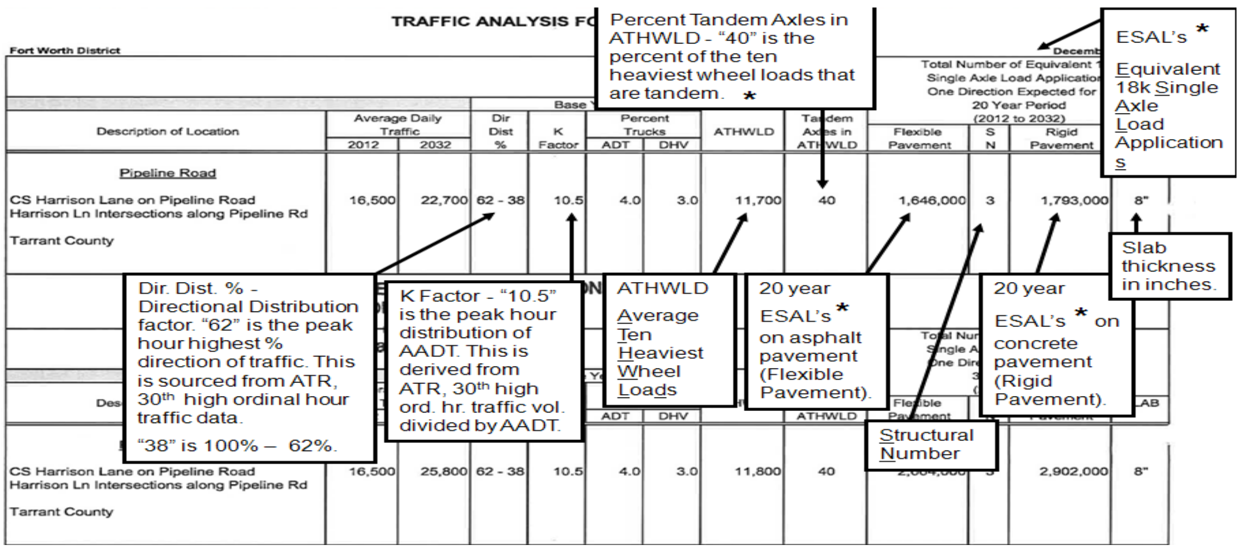

Figure 2.12: Traffic Analysis for Highway Design Form

The focus of the project/route segment level traffic forecasts is to estimate the number of ESALs a corridor/route segment will be subjected to over the design life of the facility.

2.1.8 Step 7 – Calculating Turning Movements

Turning movements are also calculated in the Calypso program. In case of a four legged intersection, each approach is assigned a different turning proportion. If observed turning flows or information from a previous project is available for a particular approach, that approach is analyzed first. A proportional method is used as a starting point for the analysis if no other data is available to begin the process for the four way intersection. This method simply allocates the node volume from the low leg to the other legs proportional to the volume of the other three legs. So the problem is the reduced from a four-legged intersection to a three-legged intersection. After balancing the turning movements, the growth rate calculated through regression analysis, is applied to forecast turning movements into the future.

CHAPTER 3. PEER STATE-OF-PRACTICE REVIEW

The study team conducted a peer state-of-the practice review by interviewing nine peer states about their Corridor Analysis process. States similar to Texas in terms of the size of their road network and number of major metropolitan areas were identified. The study team compiled a list of peer states that were shared with the Traffic Analysis Section. The study team reviewed the available manuals and guidelines for forecasting traffic at the project/route segment level. Most of the manuals and guidance obtained were recently updated and available from the DOT's websites. In addition, the study team conducted telephone interviews with representatives of the agencies responsible for Corridor Analysis at the project/route segment level.

During the telephone interviews, the study team asked a number of questions to gain an understanding of:

- If and how the agencies conduct traffic volume forecasts at the project/route segment level (e.g., tools used);
- If and how the procedure differed between planned projects/route segments in urban and rural areas;
- Data inputs used;
- If and how truck traffic is forecasted;
- If and how ESALs are forecasted; and
- If and how turning movements are forecasted.

The study conducted telephone interviews with the following states: California, Colorado, Illinois, Indiana, Michigan, New York, Ohio, Washington, and Wisconsin. In addition, Florida provided the study team with their Project Traffic Forecasting Handbook 2012 and Minnesota provided the study team with their MnDOT Procedure Manual for Forecasting Traffic on Minnesota's Highway Systems. All remaining questions from the study team were answered via e-mail. This Chapter provides a summary of the interview findings.

3.1 Peer State-of-the-Practice Review: Summary

Table 3.1 summarizes the information obtained through the interviews with peer State Departments of Transportation (DOTs). As can be seen, most State DOTs use a Travel Demand Model to forecast traffic for planned urban projects/route segments. In two states (Michigan and Wisconsin), the results from the Travel Demand Model are compared with the traffic forecast obtained by applying a growth rate obtained from historic trend analysis. This is done to establish the reasonableness of the model output. In rural areas, most State DOTs use historic trend analysis to calculate a growth rate that is applied to current traffic counts to forecast traffic on planned projects/route segments. In the states that use either a Regional Travel Demand Model or a statewide model (California, Michigan, and Ohio) to forecast traffic for a planned rural project, historical trend analysis is still conducted to verify the reasonableness of the model. Florida DOT is the only state that only uses historic trend analysis if model data do not exist or if it is anticipated that the proposed project will not divert traffic or it can be demonstrated that the traffic growth follows historical trends.

From Table 3.1, it can also be seen that most State DOTs estimate turning movements in accordance to the guidance provided in NCHRP 255. Two DOTs are using the services of MIOVISION for major intersections and interchanges. MIOVISION uses video cameras to record turning counts for a particular intersection and then use proprietary software to balance the movements. In all cases the growth rate (determined from the Travel Demand Model or historic trend analysis) is applied to the current turning movements to estimate future turning movements.

Most states estimate truck ADT percentages from vehicle classification count data. Most DOTs also do not estimate ESALs or other parameters for pavement design. The exception is Michigan DOT that uses an Excel spreadsheet with pre-set formulas to calculate axle factors and number of ESALs.

Table 3.1: Peer State-of-the-Practice Review

States	Method/Model in Urban Areas	Method/Model in Rural Areas	Turning Movement Estimate	Pavement Variables
California	Regional Travel Demand Model used to calculate traffic growth rate.	Regional Travel Demand Model used to calculate traffic growth rate. Reasonableness checked against historical growth rate. Professional judgment used when large discrepancy in growth rates.	Use TURN 32 (based on NCHRP 255 guidelines) to estimate turning movements. Apply growth rate to forecast turning volumes	Truck estimates obtained from vehicle classification counts. Use Highway Design Manual to determine pavement thickness.
Florida	Regional Travel Demand Model used to calculate traffic growth rate.	If model data do not exist or it is not anticipated that the proposed project will divert traffic or it can be demonstrated that the traffic growth follows historical trends, then historic trend analysis is used to forecast future traffic.	Use TURNS5-V02 (based on NCHRP 255 guidelines) to estimate turning movements.	Truck estimates based on vehicle classification counts. Truck growth factor for a specific FDOT vehicle classification station is calculated using regression analysis.
Illinois	Traffic forecasting delegated to MPO. MPO uses Travel Demand Model to forecast future ADT and calculate a growth rate.	Illinois DOT uses historic trend analysis in areas not covered by MPO model.	Turning movements calculated by DOT/Consultants.	DOT/Consultant base truck estimates on vehicle classification counts. Currently developing a truck model to better forecast truck traffic.

Indiana	Historic trend analysis to determine traffic growth rate. New road with no historic count data, then use Travel Demand Model.	Historic trend analysis to determine traffic growth rate.	Uses the services of MIOVISION. MIOVISION uses video cameras to record turning counts for a particular intersection and then use proprietary software to balance the movements and come up with turning movement estimate. Apply historic growth rate to turning movements.	Determine percentage of AADT that is commercial vehicles (Class 4 and higher). Indiana DOT uses MEPDG.
Michigan	Use MPO Travel Demand model and historic trend analysis (17 years of historic data). Compare estimated growth rates. If large discrepancy, tend to rely on historic trend analysis.	Use Statewide model and historic trend analysis. Compare estimated growth rates. If large discrepancy, tend to rely on historic trend analysis.	MDOT uses MIOVISION for heavy traffic intersections. Simpler method for rural intersections.	Use Excel spreadsheet with pre-set formulas to calculate axle factors and number of ESALs (based on vehicle classification data).
Minnesota	Use MPO Travel Demand model to estimate traffic growth rate. Conduct reasonableness checks and review with MPO.	Use historic trend analysis, but incorporates socio-economic factor. Look at employment, population, households, and workforce at the county level and apply a factor to forecasted volumes to reduce traffic projections.	Use NCHRP 255 guidelines to calculate turning movements	Based on vehicle classification data. -

Ohio	Use Urban Travel Demand Model. Determine need for model updates (look at land use assumptions, changes to trip table). Traffic growth rate determined from model output.	Use Statewide Model and historic traffic counts (in-house application) if proposed project is not expected to divert traffic or result in significant traffic growth. Necessary adjustments according to NCHRP 255 guidelines. If significant traffic growth is expected, statewide model is updated to reflect network changes, zones are sub-divided, and land use changes are incorporated. Model growth rate compared with historic trend analysis. Necessary adjustments according to NCHRP 255 guidelines.	Use NCHRP 255 guidelines to calculate turning movements	Based on vehicle classification counts. Only provide truck percentages. Pavement engineers convert to ESALs.
Washington	Use Activity Based Model from Puget Sound Regional Council. Changes/updates to model depend on relevance and sensitivity of the planned project.	Look for similar functional class in similar area to identify reasonable growth rate.	Use micro-simulation model for intersection analysis. Level of effort (counts, adjacent intersection studies, and future development) depends on relevance and importance of project.	Do not calculate ESALs or other pavement variables

Wisconsin	Use MPO Travel Demand model in urban areas to calculate traffic growth rate. Also, use historic trend analysis. If different by more than 10 percent, conduct checks.	Automated "State Tool" for state maintained network. Tool incorporates GIS and historic traffic counts. Allow for different regression techniques (Box-Cox regression, simple linear, etc.) and select best fit based on R-square value.	Use Wisconsin tool (spreadsheet) to calculate turning movements.	Percentage trucks calculated from classification counts. Regional offices calculate ESALs and pavement variables.

3.2 California

In California, traffic forecasting at the project/route segment level is delegated to the various Caltrans Districts. There are no statewide guidelines on how to do this level of traffic forecasting. Moreover, it is felt that the Traffic Analysts at the Districts are more knowledgeable of local land use and demographic changes and therefore better equipped to conduct project/route segment traffic forecasts. It is also felt that no statewide model would be accurate in forecasting project/route segment level traffic.

To forecast traffic, District 6 calculates a standard incremental growth rate that is applied to a base year traffic volume. The techniques/level of effort used to calculate the growth rate is, however, dependent on the level of detail required for the project. Typically, the growth rate is determined from the Regional Travel Demand Model. Typically, the network is changed and the land use data is updated. District 6 changes the network files to account for all the approved and the pending projects that might impact traffic on the proposed project. Updated land use data are also obtained from the cities and to reflect current and near-term development, as well as the General Plan 2035. In terms of the California Air Quality Environmental Act, Caltrans is required to consider all near-term approved and land use developments pending approval in the 2035 planning horizon in their Regional Travel Demand Model. In the case of a simple project, the land use information is not updated in the model. Rather, trips associated with a specific land use development are added to the traffic forecasted by the model.

In situations, where there is a potential concern about the accuracy of the model estimated growth rate, District 6 calculates the growth rate based on historical trend analysis of available traffic counts. This situation typically occurs in rural areas/non-urban areas of the state where cordons/gateways can have a significant influence on the traffic forecast. The historical growth rate is then compared with the growth rate estimated by the Regional Travel Demand Model. This comparison is conducted to verify the reasonableness of the model estimate. Engineering judgment is used when there is a significant discrepancy between the historical growth rate and the model estimated growth rate.

In addition to the growth rate, the model also estimates Average Daily Traffic (ADT) for the morning and evening peak periods. No truck traffic forecasts are conducted with the Regional Travel Demand Model. Manual and classification counts are used to forecast truck traffic post-processor. Traffic count data are also used to determine the K-factor and directional distribution factors. Current K and D factors used by the cities and counties are the starting point of the analysis.

Pavement variables, such as pavement thickness, are calculated using the Highway Design Manual algorithms. Turning movements can be estimated from the model, but District 6 uses TURN32, which employs the standard method describe in NCHRP 255. The growth in turning volumes are estimated using the model estimated growth rate. Professional judgment is also applied.

NCHRP 255 Chapter 8, Turning Movement Procedures

The appropriate turning movement procedure is determined by the:

- Availability of future year turning volume forecasts;
- Availability of directional or non-directional volume forecasts. Directional turning volumes are specific to each direction of travel. Non-directional turning volumes represent two-way volumes passing between adjacent links;
- Availability of actual base year turning movement counts;
- Availability of base year turning movement assignments;
- The desired time period (e.g., peak hour, 24.hour); and
- The number of intersection approaches.

The three types of turning movement procedures are:

1. Factoring, which includes the use of either the Ratio Method or Difference Method;
2. Iterative, which includes separate Directional and Non-directional Volume Methods; and
3. "T" Intersection, which includes separate Directional and Non-directional Turning Movement Methods.

In some cases the analyst must combine two or more procedures to arrive at a reasonable turning movement estimate.

3.3 Florida

The travel demand models used by the Florida DOT for traffic forecasting have been developed using the modeling standards (the Florida Standard Urban Transportation Modeling Structure (FSUTMS)) set forth by the Florida Model Task Force. Based on the modeling structure, the Metropolitan Planning Organizations (MPOs) develop and maintain their individual models, but these models are part of larger regional models to account for the increase in interregional travel. The FDOT District and the District Planning Office, in coordination with each of the local MPOs, are responsible for the development of these regional models. These regional models are typically used to forecast the traffic growth rate. FDOT's traffic forecasting procedure at the project/route segment level is illustrated in Figure 3.13.

If model data do not exist or it is not anticipated that the proposed project (for example, a resurfacing project) will divert traffic or it can be demonstrated that the traffic growth follows historical trends, then historical trend analysis is used to forecast future traffic.

Predictions of future truck volumes are often based on historic traffic counts. The truck growth factor for a specific FDOT vehicle classification station is based on historic trend analysis. FDOT calculates the square root of the mean of the squared residuals (root mean square) to determine the prediction error. If the result of this analysis is reasonable, then the calculated truck growth factor is used to forecast future truck volumes. More detailed analysis is conducted if truck growth is expected to differ from the historic pattern. This analysis include consideration of historical trends (area-wide or project location specific), land use changes, and an evaluation of competing roadways.

Future year turning movements is calculated with the TURNS5-V02 program. The program develops future year turning movements based on one of two methods. The first method allows the user to enter an existing year AADT and specify a simple growth rate for three other periods (normally project opening, mid-design year, and design year). The second method allows the user to input an existing year AADT and model the forecast year AADT. The program interpolates or extrapolates for the three other periods (normally project opening, mid-design year, and design year). The program allows for smoothing to ensure reasonable results. The program calculates AADT and DHV.

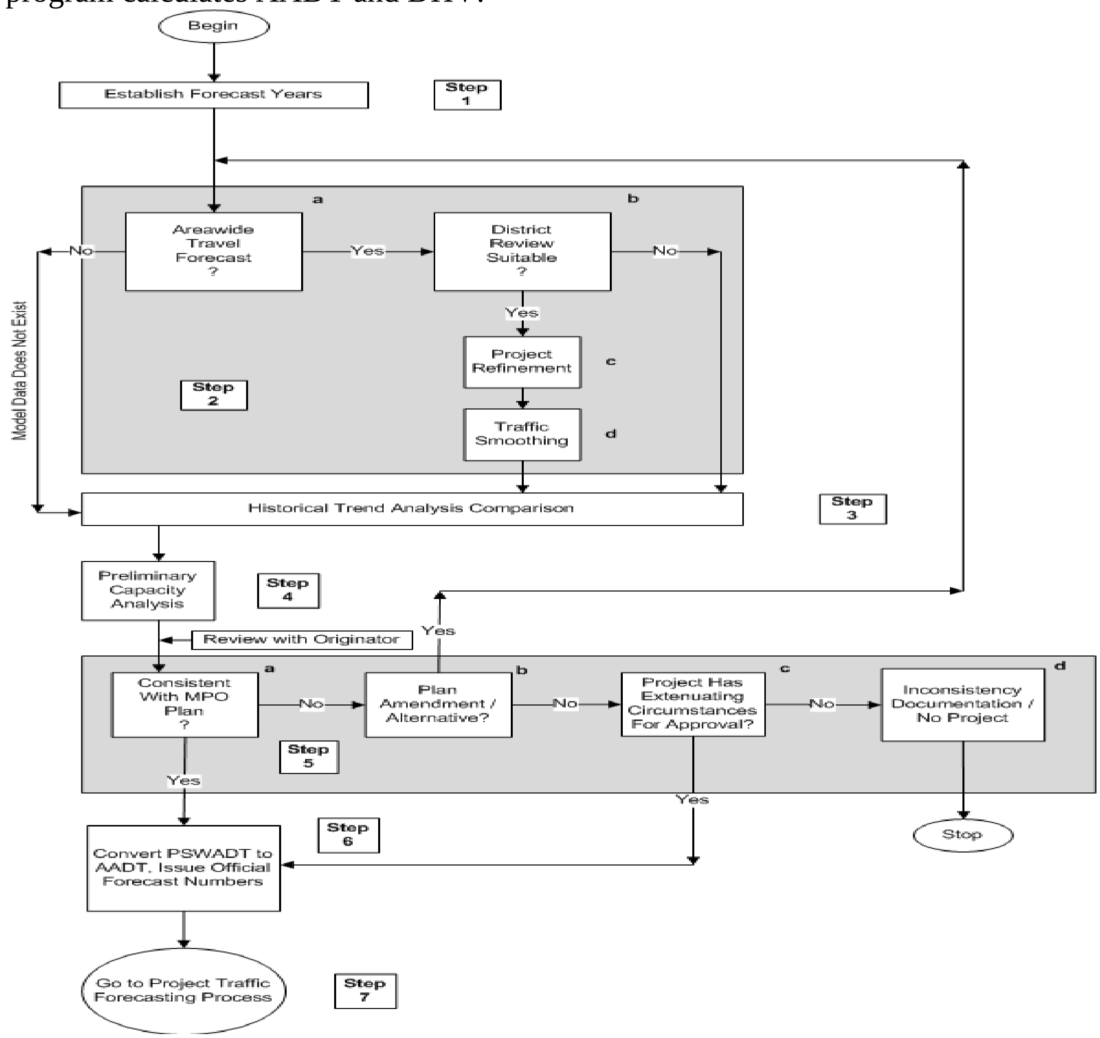

Figure 3.13: FDOT's Traffic Forecasting Process

3.4 Illinois

In Illinois, project/route segment level traffic forecasting is delegated to the MPOs. In urban areas, the MPO Regional Transportation Model is used to provide an expectation of future traffic (specifically ADT). The MPOs provide the future ADT value to the Illinois DOT or their consultants. No peak hour volumes, turning movements, or truck percentages/classification[2] estimates are provided. The Illinois DOT or their consultants calculate the K-factor, directional distribution, peak hours, and truck percentages from traffic count data.

The Regional Transportation Model is used, because land use, household, employment, and demographic data are considered in the ADT forecasts. The model is typically run twice per year and it forecasts to 2040. If it is a major project, the MPO will update the model to reflect upcoming developments and any network changes. The model is then run for the built and no-built scenario. The model can also be run for different alternatives. In some cases, professional judgment is used to adjust the results and in some cases the Illinois DOT or their consultants have adjusted the traffic forecasts if it was felt that not all development were considered in the traffic forecast.

The MPOs typically have three potential roles when it comes to traffic forecasting at the project/route segment level: (1) the MPO can forecast the ADT for the Illinois DOT and their consultants (as discussed above); (2) the MPO can verify the ADT forecasts produced by consultants, and (3) the MPO can provide the consultant with all the input data (household, employment, land use, and trip tables given the built and no-built scenario) to allow the consultants to refine their traffic forecasts.

In rural areas of the state that are not included in an MPO boundary, the Illinois DOT relies on historic trend analysis to calculate a growth rate for traffic forecasting purposes.

3.5 Indiana

Indiana DOT uses historic trend analysis to determine a traffic growth rate that is subsequently applied to the traffic count information to forecast traffic at the project/route segment level. The traffic data used is generated by Indiana DOT's Statewide Coverage Count Program. The Indiana DOT representative estimated that there are more than 19,000 count locations in the state.

Indiana DOT only uses their Travel Demand Model to forecast traffic on a new location project for which no historical count information are available. In the latter case, the model is run to determine the current year and the future year traffic on the planned project.

Indiana DOT uses the services of MIOVISION Technology to calculate turning movements at major intersections or interchanges. MIOVISION uses a system of video cameras to record the turning movements at a particular intersection. Proprietary software is subsequently used to determine turning movements by vehicle class and time period. The growth rate obtained from the trend analysis is applied to the turning movements produced by MIOVISION to forecast the turning movements into the future.

The only parameter determined for pavement design is the estimated percentage of AADT that is trucks (FHWA Class 4 or higher). This is the only variable that is required since the DOT uses the Mechanistic-Empirical Pavement Design Guide (MEPDG) for pavement design.

[2] The MPO is currently developing a truck model to ensure more robust truck forecasts.

3.6 Michigan

Michigan DOT has a statewide model, an urban Travel Demand Model for each MPO, and 17 years of traffic count and classification data at their disposal to conduct traffic forecasting at the project/route segment level. In urban areas, Michigan DOT compares the growth rate calculated from historical trend analysis (17 year regression analysis) with the growth rate predicted by the MPO Travel Demand Model. If there is a significant discrepancy between the two growth rates, then the analysts tend to rely on the growth rate established from historic trend analysis. In rural areas, Michigan DOT compares the growth rate calculated from historic trend analysis with the growth rate calculated from the traffic forecast by the statewide model. Similarly, given a large discrepancy between the growth rates, the growth rate calculated from historic trend analysis is usually preferred.

For turning movements at major intersections or interchanges, Michigan DOT uses the services of MIOVISION Inc. to develop current turning movements and to forecast these movements into the future. A simpler method is, however, used for rural intersections.

Truck estimates are based on classification counts and adapted given large truck traffic generators near the proposed project. Currently, ESAL numbers are predicted using a spreadsheet with embedded formulas. The analyst enters the percentage of trucks in each vehicle class (obtained from vehicle classification data), the number of trucks, and the growth rate, and the spreadsheet calculates the axle factors and the number of ESALs. Michigan DOT is, however, moving towards the MEPDG for estimating truck impacts.

Michigan DOT has a system of “Service Drives” parallel to their freeways that link driveways. Traffic is forecasted on these Service Drives. Michigan DOT does have traffic counts for Service Drives, but as expected traffic is significantly lower on these Service Drives than on the freeways. Michigan DOT generally uses historical data to forecast traffic on the Service Drives. A major challenge in using their Travel Demand Models or Statewide model is obtaining the correct traffic split between the freeway and Service Drive.

Michigan DOT also observed that the agency has been tempering estimated growth rates based on historic trend analysis. The state has been faced with declining employment, declining housing, and declining growth, which requires the tempering of growth rates to reflect the economic downturn in the state.

3.7 Minnesota

In the larger metropolitan areas of Minnesota, such as the Twin Cities Metro area, MnDOT relies on the urban area Travel Demand Model to predict future traffic volumes. MnDOT stated that historic trend analysis does not provide reliable forecasts in these areas given the development of new special generators or major land use changes during the forecast period. MnDOT thus uses a Travel Demand Model to forecast traffic for projects in cities with a population of more than 50,000. The output of the Travel Demand Model is, however, checked for reasonableness and adjusted given the guidelines contained in NCHRP 255.

Historic trend analysis is used in areas of Minnesota that is not covered in an urban Travel Demand Model and where the development of a Travel Demand Model is not deemed feasible. The use of historic trend analysis has been complicated by the recent reduction in VMT growth in the state. Between 2004 and 2012, traffic volumes have thus remained fairly constant. MnDOT is thus considering different time periods when conducting trend analysis (e.g., past 20, 15, 10, and 5 years) to account for different scenarios. MnDOT has also started to consider socioeconomic factors when conducting trend analysis. The analyst reviews county employment, population, households, and workforce data and can apply a factor to the forecasted traffic volumes to temper the forecasts in situations of declining economic activity. Apart from the economic situation in the state, VMT has also reduced due to an increase in retirements, under 50 year old drivers choosing a different mode of transportation, and rising fuel prices.

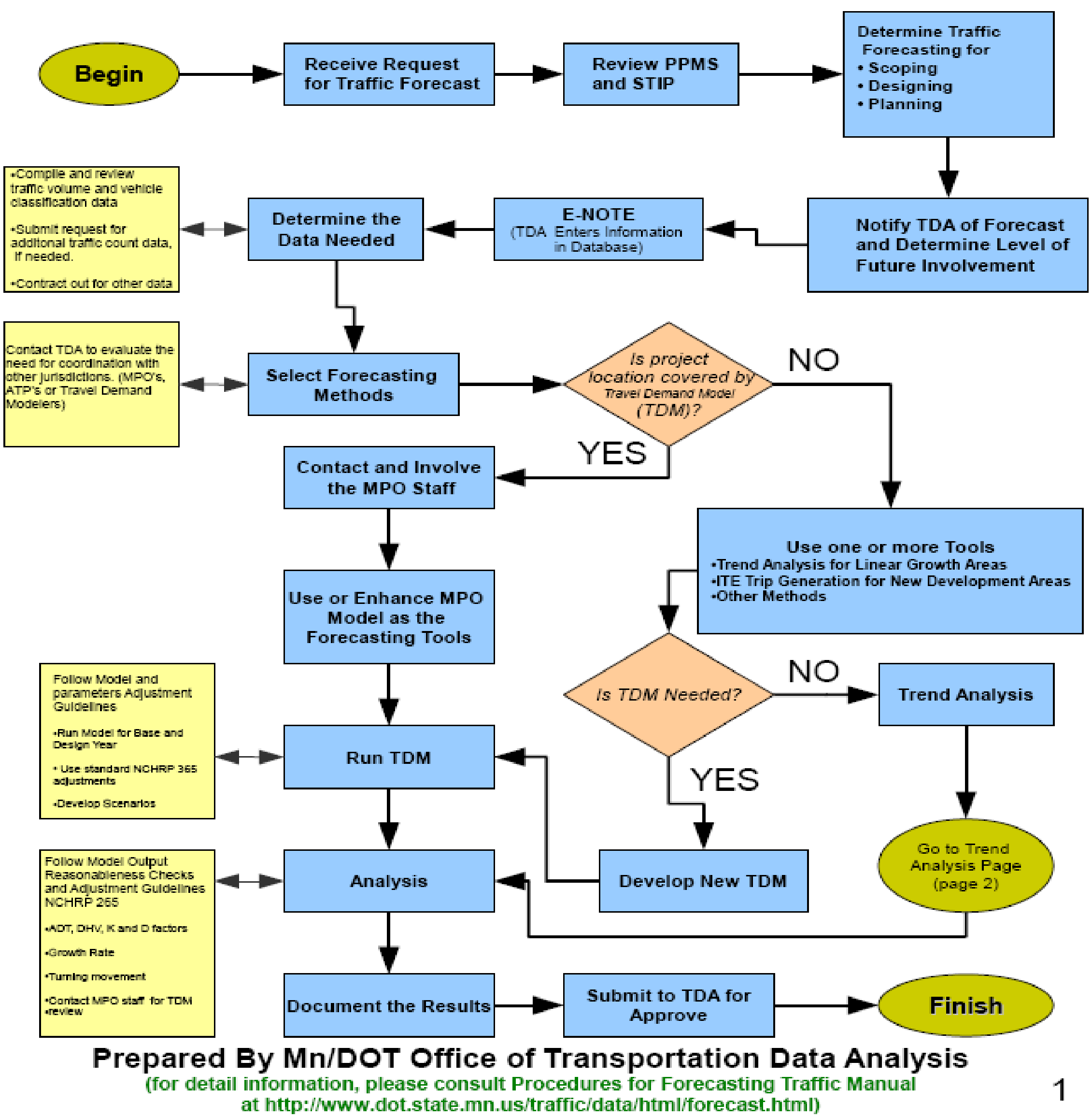

Figure 3.14: Traffic Forecasting Process for MnDOT Projects

3.8 Ohio

The method used to forecast traffic at the individual project level varies depending on the complexity and the location (urban or rural) of the project. In the case of a simple project (resurfacing) on a rural state route where it is assumed that the project design will not be affected by the traffic forecast, an in-house application is used to forecast traffic for the planned project. The in-house application compares the traffic forecast produced by Ohio DOT's Statewide Travel Demand Model and the traffic growth rate calculated using regression analysis of historic count data (trend analysis). If there is a large discrepancy between the growth rates, adjustments are made to the growth rate produced with the regression analysis based on the guidance provided in NCHRP 255. If the project design is, however, sensitive to the traffic forecast and if traffic diversion is anticipated, then the analyst will refine the statewide model to reflect network changes, sub-divide the model zones, and incorporate any land use changes. The model is run and the traffic predicted is used as the basis for determining a growth rate. This growth rate is, however, also checked against the growth rate calculated from historic trend analysis and adjustments may be needed before a final growth rate is adopted. In the case of very complex rural projects with network impacts, Ohio DOT performs smoothing procedures and may apply different growth rates on different sections. All turning movements are calculated in a spreadsheet developed by Ohio DOT in accordance with the guidance provided in NCHRP 255. For complex projects, AM and PM peak ADTs, K-Factor, and D-Factor are provided.

In urban areas, covered by an MPO, project level traffic forecasting is conducted with the urban Travel Demand Models. Ohio DOT will review the traffic forecasting request received to determine the level of model adjustments required. These vary, but typically include a review of the land use assumptions or changes to the trip table. The analyst will then use the refined model to forecast traffic and to determine the traffic growth rate. This growth rate is reviewed and adjusted if necessary according to the guidance provided by NCHRP 255. The final growth rate is applied to current year traffic counts. According to Ohio DOT, the strength of the Travel Demand Models lies in their prediction of traffic given the built and no-built scenarios. In urban areas, the urban area Travel Demand Model is used for traffic forecasting, but sometimes if it is a simple project, the Travel Demand Model predicted growth rate may be compared with the growth rate obtained from historic trend analysis. For most urban projects, 24 hour ADT, AM and PM peak ADTs, K-Factor, D-Factor, and truck percentages are provided. Turning movements are calculated in a spreadsheet developed by Ohio DOT in accordance with the guidance provided in NCHRP 255.

The percentage trucks in the ADT are calculated from vehicle classification counts. These are typically 8-hour vehicle classification counts that are then expanded using statewide statistics. It is simplistically assumed that the truck percentages would remain constant in the future. The pavement designers convert the truck percentages into ESAL numbers that are subsequently used for pavement design.

3.9 Washington

Three sections in Washington DOT are involved with traffic forecasting at the project/route segment level. The section responsible for project prioritization use historic trend analysis to calculate growth rates to forecast traffic as an input in their project prioritization framework. Another section estimates the percentage trucks on the statewide network and the third section (Urban Planning Office) is responsible for modeling traffic, corridor planning, and forecasting toll traffic.

An Activity Based Model is used to forecast traffic on planned projects in the four county region covered by the Puget Sound Regional Council. Model updates or changes are a function of the relevance and sensitivity of the planned project. The Puget Sound Regional Council model include anticipated land use changes along the corridor, but this data may be updated if talking with counties and cities indicate the need to. The model is used to forecast traffic in the study corridor and to subsequently calculate the growth rate. A number of reasonableness checks are conducted. Specifically, the analysts check overall growth, trends in the area, existing traffic counts, future projects, future land use changes, and travel time and queuing in the corridor. In some cases the traffic volumes are adjusted. Turning movements are not captured well in the model. Micro-simulation is used to estimate turning movements at intersections or interchanges. The level of effort that is expended (counts, adjacent intersection studies, and incorporating future development) depends on the relevance and importance of the project.

The model output includes traffic forecasts for five time periods: 6 AM-9 AM, 9 AM-3 PM, 3 PM-6 PM, 6PM-10 PM, and 10 PM-6 AM. The model output also includes link volumes, travel time, transit ridership, and VMT and VHT at the link level.

3.10 Wisconsin

In urban areas, the Wisconsin DOT uses the MPO Travel Demand Model to forecast traffic for a planned project. In rural areas, Wisconsin DOT uses historic trend analysis to forecast traffic for planned rural projects. Wisconsin DOT uses an automated regression tool to calculate the traffic growth rate for planned projects on the State Trunk System (urban and rural). The automated regression tool incorporates GIS, historic traffic data, and allows for different types of regression analyses. The specific type of regression (e.g., linear or Box-Cox) is based on the calculated R-Square.

In urban areas, the results from the Travel Demand Model are compared to the growth rate determined from historic trend analysis. If there is a more than 10 percent difference between the traffic forecasted with the Travel Demand Model and the traffic forecasted by applying the regression based growth rate, then a number of quality checks are conducted. Wisconsin DOT primarily relies on the forecasts produced by the Travel Demand Model. Adjustments to the Travel Demand Model forecast are only made if there is a 10 percent difference with the forecasts produced from the historic trend analysis.

In general, no changes are made to the Travel Demand Model. The exception is when it is a major project and the model output is subsequently used in a micro simulation model. Socio economic and demographic changes are sometimes incorporated in the models if the information is available from the MPO or the county.

The percentage truck ADT is calculated from vehicle classification counts. In addition, the following information are obtained from the state's traffic count program:

- Peak Hour ADT
- K30
- K100
- K250
- Peak Hour truck percent
- Directional Split

Historical data is available since 1979. The state has about 12 WIMs sites, 50+ ATR sites, and more than 100 electronic count sites. Manual counts are rare and only conducted to obtain more robust vehicle classification (48 hour classification counts) data and for turning movements.

Turning movements are calculated in a spreadsheet that is quite dated. Main lane growth rates are used to forecast turning movements and movements are balanced across the legs of the intersection.

The office does not provide variables used for pavement design. The office provides the ADT, percentage trucks, and classification data. The regional offices subsequently calculate the ESAL numbers and the average heaviest wheel load variables.

CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

In Texas, traffic forecasting at the project/route segment level is based on historic traffic counts. TxDOT's Traffic Analysis Section of the TPP Division uses linear regression analysis to calculate a traffic growth rate that is used to forecast future traffic. The linear regression equations are embedded in an Excel spreadsheet – called the Calypso worksheet. ESALs are forecasted using a mainframe application called ROADTEST 68. The inputs for and outputs from this application is obtained from and entered into the CARS worksheet, respectively. Once the ROADTEST 68 output is entered in the CARS worksheet, the Traffic Analysis for Highway Design Form is automatically populated. Chapter 2 attempts to document the step-by-step process that is followed when forecasting traffic volumes and truck volumes on a route segment. Chapter 3 provides the findings of a peer state-of-the-practice review of traffic forecasting at the project/route segment level. The study team interviewed nine peer states. States similar to Texas in terms of the size of their road network and number of major metropolitan areas were identified. The study team found that most State DOTs use a Travel Demand Model to forecast traffic for planned urban projects/route segments. In two states (Michigan and Wisconsin), the results from the Travel Demand Model are compared with the traffic forecast obtained by applying a growth rate obtained from historic trend analysis. This is done to establish the reasonableness of the model output. In rural areas, most State DOTs use historic trend analysis to calculate a growth rate that is applied to current traffic counts to forecast traffic on planned projects/route segments. In the states that use either a Regional Travel Demand Model or a statewide model (California, Michigan, and Ohio) to forecast traffic for a planned rural project, historic trend analysis is still conducted to verify the reasonableness of the model. The study team also found that most state DOTs estimate turning movements in accordance with the guidance provided in NCHRP 255. Two DOTs are using the services of MIOVISION for major intersections and interchanges. MIOVISION uses video cameras to record turning counts for a particular intersection and then use proprietary software to balance the movements. In all cases the growth rate (determined from the Travel Demand Model or historic trend analysis) is applied to the current turning movements to estimate the future turning movements. Finally, most states interviewed estimate truck percentages of ADT from vehicle classification count data. Most DOTs also do not estimate ESALs or other parameters for pavement design. The exception is Michigan DOT that uses an Excel spreadsheet with pre-set formulas to calculate axle factors and number of ESALs.

In this effort, the study team obtained a basic understanding of the traffic forecasting done by peer states at the project/route segment level. It is recommended that the study team do a more detailed review of the traffic forecasting process followed by a sample of peer State DOTs to inform TxDOT's forecasting process. It is also recommended that the study team review advanced practices in this area. Finally, it is recommended that the study team review the formulas and mathematical equations embedded in the Calypso tool to see if it can be improved upon given the outcome of the detailed review of peer state practices and advanced practices documented in national literature.

APPENDIX A - TRAFFIC COUNTS CONDUCTED BY TXDOT

1. *District Traffic Counts (Coverage Counts)*

   These counts are made using Accumulative Count Recorder (ACR), consisting of single rubber tube placed across the road and connected to pneumatic counting device. The device then registers single count of every axle that crosses the tube and 24-hour raw axle count can be determined, thus creating a database used to perform linear/historical regressions.

   AADT= (24-hour raw axle count)*AF*MF

   AF= Axle Factor= number of Vehicles/ number of Axles,

   MF= Monthly/Seasonal Factor

2. *Vehicle Classification*

   Vehicles are classified into 13 types, according to the FHWA guidelines. The AVC uses 2-4 loops or piezo-loops to classify vehicle based on axle spacing. Classification sites are used to determine AADT, percent trucks, number of trucks, percent single axles and the axle factor.

3. *Automatic Traffic Recorder/ Permanent Machines*

   This continuous recording of volume data is recorded into monthly and yearly reports. These counts are used to calculate monthly/seasonal factor, peak hour factor, direction distribution and design hourly volumes.

4. *Urban and Saturation counts*

   These counts are made on 5 year cycle for 25 urban areas in the State. These counts are also made using ACRs, like coverage counts. The sites/locations are predetermined by TPP's Technical Services in conjunction with planning personnel from both the urban areas and TxDOT District office.

5. *International Bridge Counts and Border Trends*

   Data is collected by telemetry, analyzed and reports are compiled semi-annually. Data is used to determine both AADT, vehicle mix, and border trends.

6. *Weigh in Motion sites*

   There are currently 18 WIM sites operating in the state. The truck types and the actual weights collected by the WIM allows TxDOT to establish a database, which takes weights of all the single axles and the tandem axles sets and "tables" them by weight group.