Accuracy Assessment of Traffic Forecasts

Presentation to the NCMUG
April 27th, 2021

Connetics Transportation Group

Speakers

David Schmitt, AICP

Director

Ashutosh Kumar

Senior Project Manager

Special Thanks

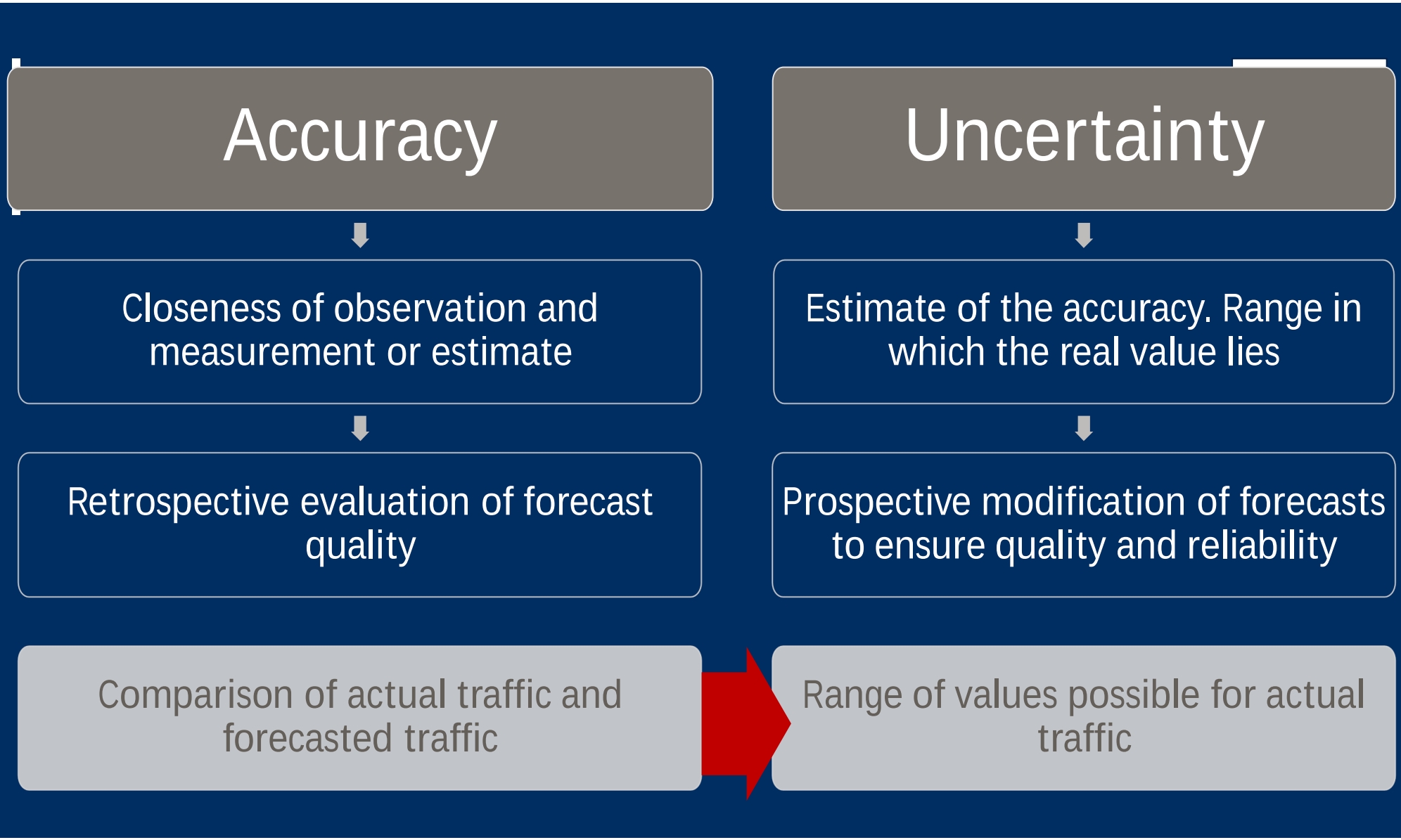
- University of Kentucky
  - Dr. Greg Erhardt
  - Jawad Hoque
  - Dr. Mei Chen
  - Dr. Reginald Souleyrette
- Marty Wachs, UCLA
- Florida Department of Transportation, District 4
- H.W. Lochner

Agenda

Highlights from NCHRP 934: Traffic Forecasting Accuracy Assessment Research

Application for FDOT, District 4

Traffic Forecasting Accuracy Assessment Research (NCHRP 934)


Accuracy
Uncertainty
Closeness of observation and measurement or estimate
Estimate of the accuracy. Range in which the real value lies
Retrospective evaluation of forecast quality
Prospective modification of forecasts to ensure quality and reliability
Comparison of actual traffic and forecasted traffic
Range of values possible for actual traffic

Research Questions and Approach

How accurate are traffic forecasts? — Dave Schmitt

- Method: Statistical analysis of actual vs forecast traffic for a large sample of projects after they open.
- Output: Distribution of expected traffic volume as a function of forecast volume.

What are the sources of forecast error? — Dave Schmitt

- Method: "Deep dives" into forecasts of six substantial projects after they open.
- Output: Estimated effect of known errors, and remaining unknown error.

How can we generate an expected range of outcomes? — Jawad Hoque

- Method: Estimate uncertainty in future forecasts from accuracy of past forecasts.
- Output: A range of forecasts.

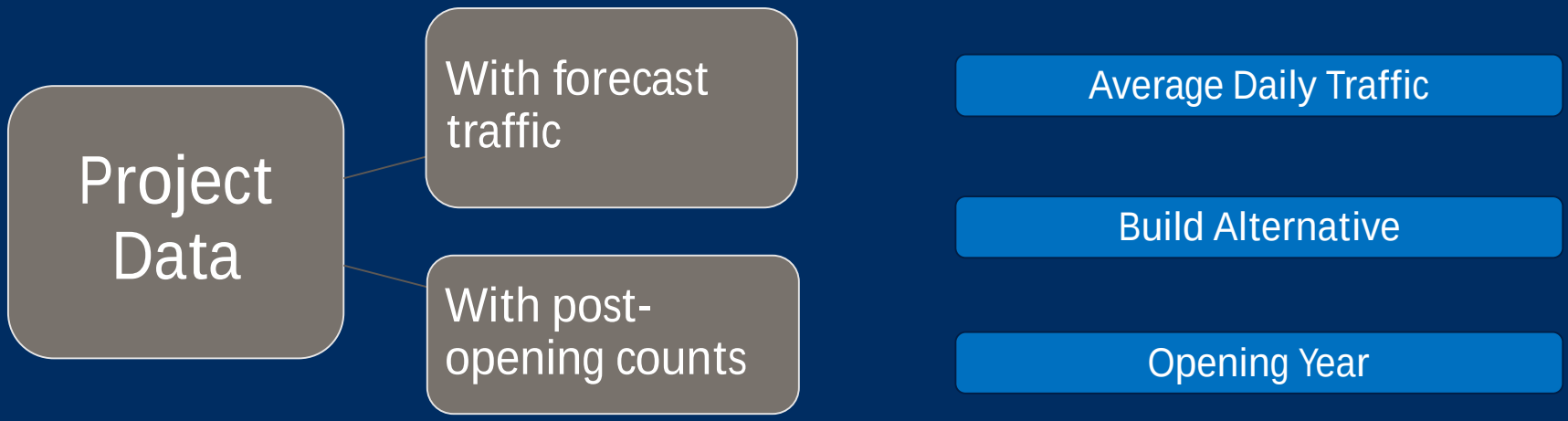
How can we improve forecasting practice? — Greg Erhardt

- Method: Derive lessons from this research and review with practitioners.
- Output: Recommendations for how to learn from past traffic forecasts.

Large-N Analysis

Question: How accurate are traffic forecasts?

- Method: Statistical analysis of actual vs forecast traffic for a large sample of projects after they open.
- Output: Distribution of expected traffic volume as a function of forecast volume.



Forecast Accuracy Database

6 states: FL, MA, MI, MN, OH, WI + 4 European nations: DK, NO, SE, UK

Total: 2,600 projects, 16,000 segments

Open with Counts: 1,300 projects, 3,900 segments

Category	Field	Data Source								Recommended for 08-110 DB
		Ohio DOT	Wisconsin DOT	Michigan DOT	Virginia DOT	Florida DOT-D4	Florida DOT-D5	Minnesota	Kentucky TC	
Meta	Number of records	6,229	458	9	1,160	143	50	2,179	n/a	
	Number of unique projects	2,466	132	7	39	134	31	110		
File Format(s) Provided	Cumulative Spreadsheet or database (flat file)	√	√	√	√	√		√		
	Cumulative Database (relational)						√			√
	ESAL or technical reports			√	√		√		√	
Project Identification Fields	Project identification number or code	√	√	√	√	√	√	√	√	√
	Description, including facility name	√		√	√	√	√	√	√	√
	Location									
	County	√	√			√	√	√	√	√
	Mile Post	√					√			
	Other Type of Location							√	√	
	Facilty type or functional class	√	√	√	√		√	√		√
	Segment identification codes	√			√	√	√	√		√
	Length						√	√		
	Project cost									
	Area type									
	Type of improvement	√		√	√					√
Forecast Value Fields	Forecaster (person, agency, company)	√	√	√			√		√	
	Year Forecast Made	√	√	√		√	√	√	√	√
	Forecast year(s)							√		√
	Opening Year	√		√		√	√			√
	Interim Year					√	√			√
	Design Year	√		√	√	√	√		√	√
	Unlabeled Year		√							√
	Forecast value									√
	AADT forecast	√	√	√	√	√	√	√	√	√

Large N Analysis- Methodology

Compared the earliest post-opening traffic counts with forecast volume

Percent difference from forecast:

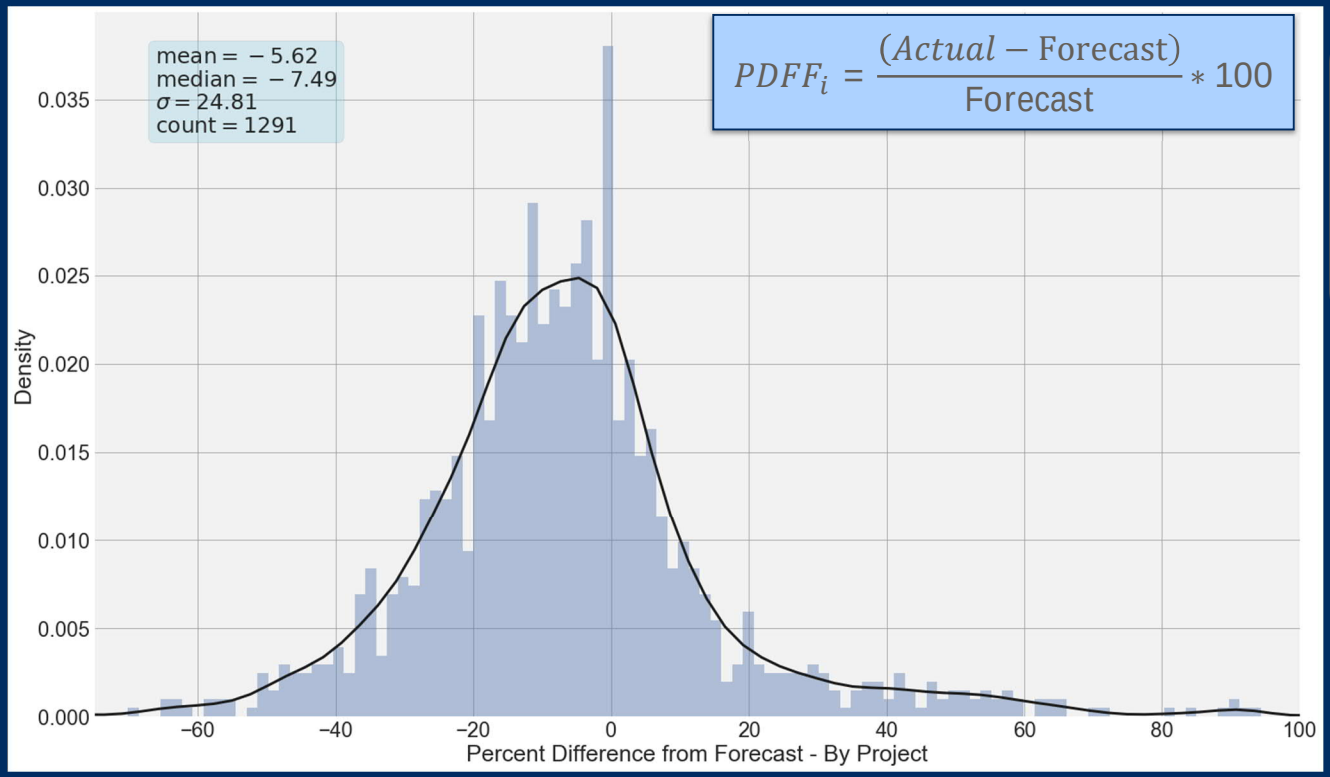
$$\frac{Actual\ Count - Forecast\ Volume}{Forecast\ Volume} * 100\ \%$$

Level of Analysis

- Segment Level
- Project Level

Expressing the percent difference relative to the forecast is forward-looking, and a useful measure of uncertainty before a project opens.

How Accurate Are Traffic Forecasts?

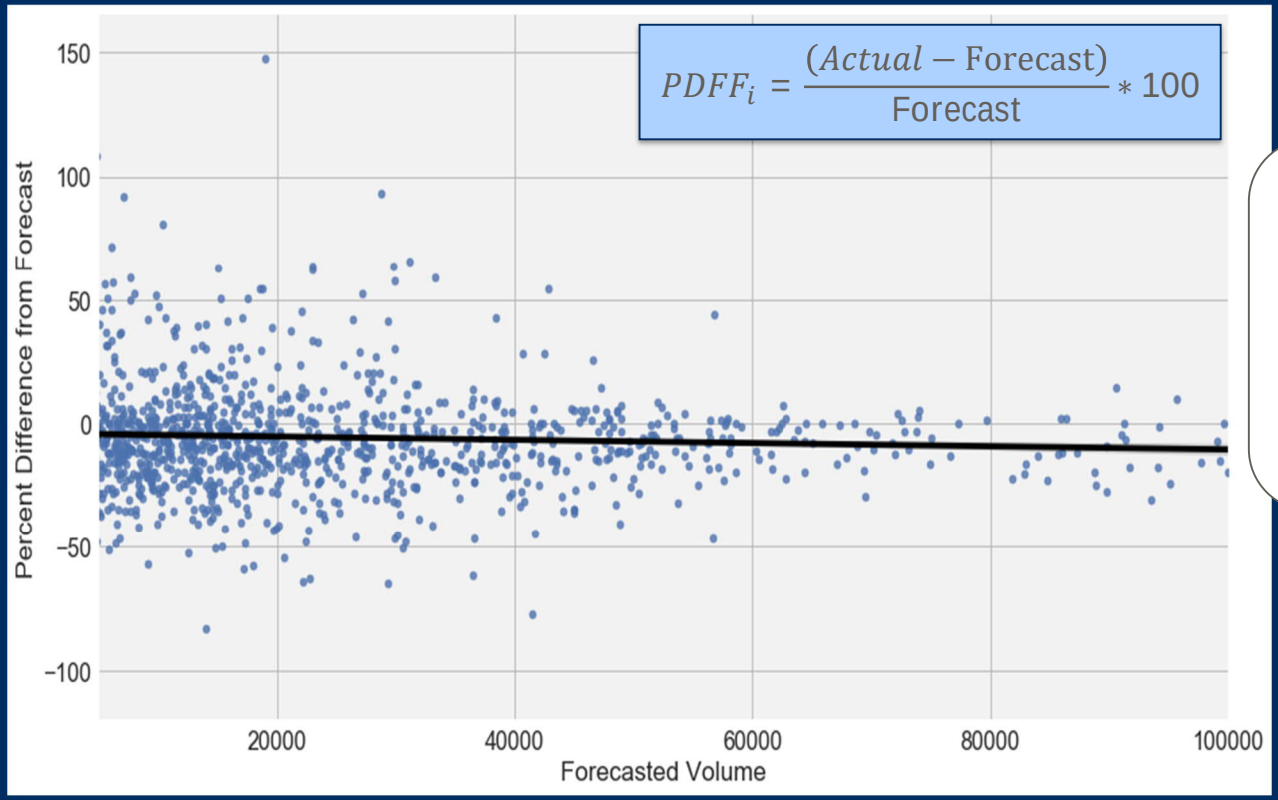


On average, the actual traffic volume is about 6% lower than forecast.

On average, the actual traffic is about 17% different from forecast.

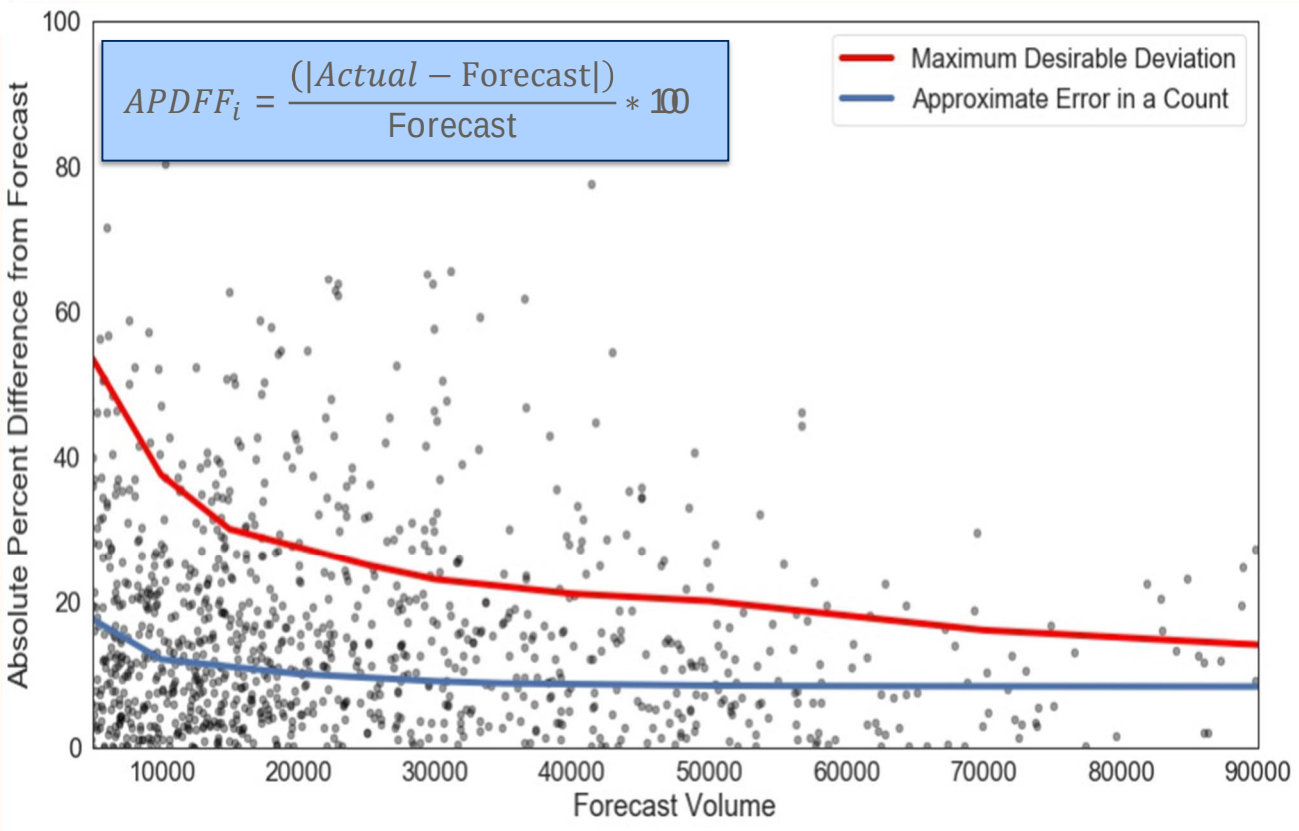
(absolute value of differences)

How Accurate Are Traffic Forecasts?



Traffic forecasts are more accurate, in percentage terms, for higher volume roads.

How Accurate Are Traffic Forecasts?



Source: Hoque, Jawad Mahmud, Gregory D. Erhardt, David Schmitt, Mei Chen, Ankita Chaudhary, Martin Wachs, and Reginald Souleyrette. "The Changing Accuracy of Traffic Forecasts." *Transportation*, in-review.

NCHRP Report 255: maximum desirable deviation of a traffic assignment model from base year traffic counts.

84% of forecasts fell within the maximum desirable deviation, and 47% of forecasts had less deviation than expected of traffic counts.

95% of forecasts reviewed are "accurate to within half of a lane."

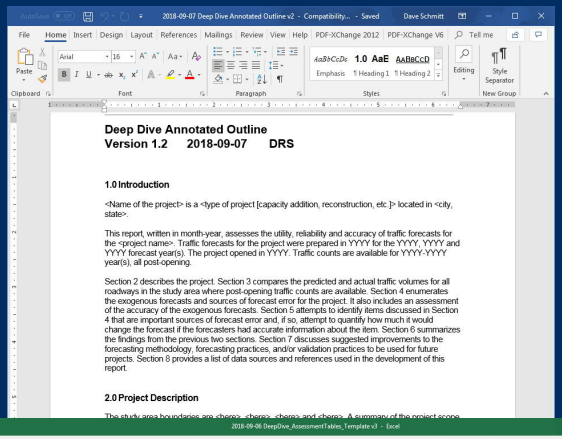
What Factors Affect Forecast Accuracy?

Traffic forecasts are more accurate for:

- Higher volume roads
- Higher functional classes
- Shorter time horizons
- Travel models over traffic count trends
- Opening years with unemployment rates close to the forecast year
- More recent opening & forecast years

Deep Dives- Methodology

- Collect data:
  - Public Documents
  - Project Specific Documents
  - Model Runs
- Investigate sources of errors as cited in previous research:
  - Employment, Population projections etc.
- Adjust forecasts by elasticity analysis
- Run the model with updated information


Deep Dive Annotated Outline
Version 1.2 2018-09-07 DRS

1.0 Introduction

<Name of the project> is a <type of project [capacity addition, reconstruction, etc.]> located in <city, state>.

This report, written in month-year, assesses the utility, reliability and accuracy of traffic forecasts for the <project name>. Traffic forecasts for the project were prepared in YYYY for the YYYY, YYYY and YYYY forecast year(s). The project opened in YYYY. Traffic counts are available for YYYY-YYYY year(s), all post-opening.

Section 2 describes the project. Section 3 compares the predicted and actual traffic volumes for all roadways in the study area where post-opening traffic counts are available. Section 4 enumerates the exogenous forecasts and sources of forecast error for the project. It also includes an assessment of the accuracy of the exogenous forecasts. Section 5 attempts to identify items discussed in Section 4 that are important sources of forecast error and, if so, attempt to quantify how much it would change the forecast if the forecasters had accurate information about the item. Section 6 summarizes the findings from the previous two sections. Section 7 discusses suggested improvements to the forecasting methodology, forecasting practices, and/or validation practices to be used for future projects. Section 8 provides a list of data sources and references used in the development of this report.

2.0 Project Description

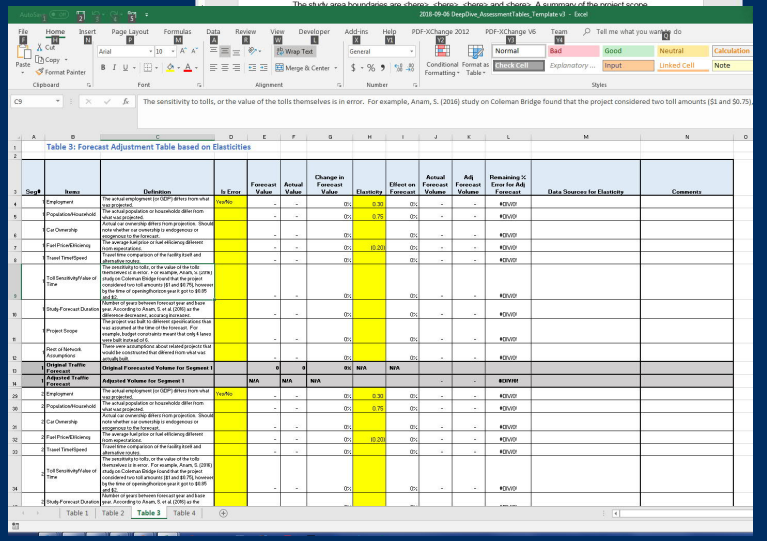


Table 3: Forecast Adjustment Table based on Elasticities

Deep Dive Conclusions

- The reasons for forecast inaccuracy are diverse.
- Employment, population and fuel price forecasts often contribute to forecast inaccuracy.
- External traffic and travel speed assumptions also affect traffic forecasts.
- Better archiving of models, better forecast documentation, and better validation are needed.

What are the Limitations?

- Project documentation often does not record relevant information—those projects where we had reproducible model runs were more successful.
- These are only a few examples. Can they be generalized?

Continued and consistent data collection is needed to overcome these limitations.

How to Generate Uncertainty Envelopes

The other option of producing better forecasts is employing what (Ascher, 1979) calls “outsider’s approach” and Kahneman and Tversky (1977) calls “reference class forecasts”.

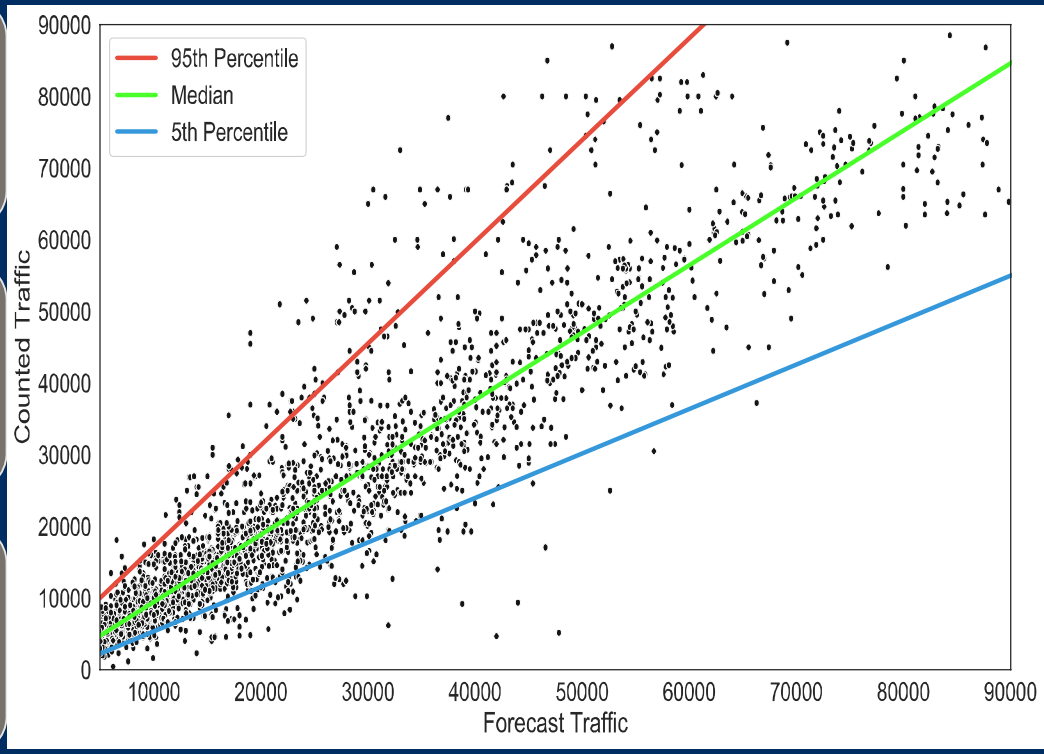
Using the base-rate and distribution results from similar situations in the past to adjust forecasts.

Quantile Regression
A method to both measure accuracy & estimate uncertainty envelopes

Draw line through the middle of the cloud: regression.

Draw a line along the edge of the cloud: quantile regression.

Quantifying uncertainty is as simple as inputting values in a spreadsheet and drawing lines.



Measuring accuracy and estimating uncertainty windows using Quantile Regression

Model Form

$$y_i = \alpha + \beta\hat{y}_i + \gamma X_i\hat{y}_i + \varepsilon_i$$

- Multiplicative effect instead of additive
- Estimate separate α, β and γ for different percentile values (95^{th}, 80^{th}, 50^{th}, 20^{th}, 5^{th}).
- Coefficients signify the effect of the explanatory variables on different percentile values of actual observation (traffic or transit ridership).
- Example, coefficient of -0.25 on unemployment rate on the 95^{th} percentile model means with each unit increase in unemployment rate, the 95^{th} percentile actual traffic value decreases by 0.25 units.

Quantile Regression Models

Simple Model

- Actual Traffic Count as a function of Forecast Traffic
- Detects bias

Inference Model

- Actual Traffic Count as a function of forecast traffic as well as other statistically significant explanatory variables
- Performance Metric

Forecasting Model

- Actual Traffic Count as a function of forecast traffic as well as other statistically significant explanatory variables that are known at the time of forecast.
- Uncertainty envelope

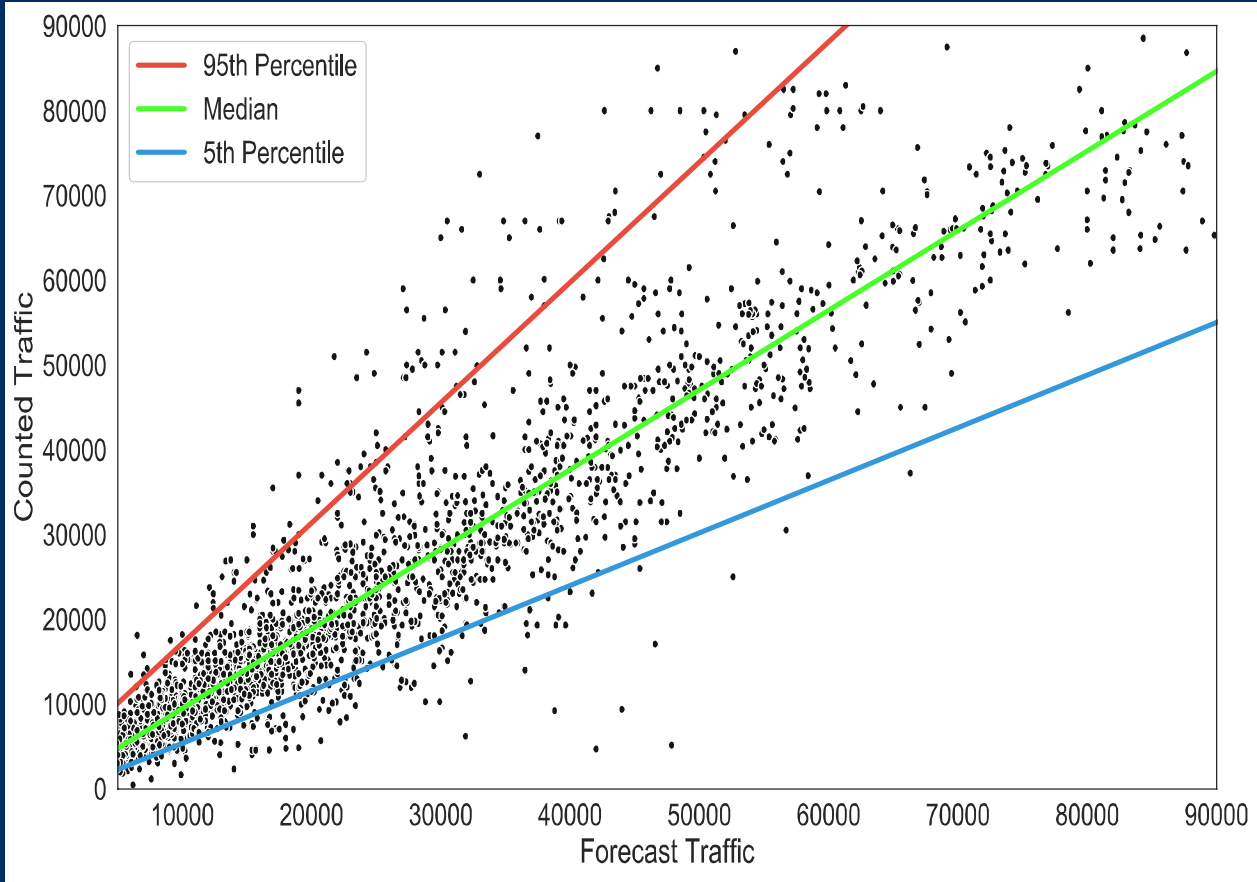
Simple Model

$A_{95th} = 2940 + 1.42F + \varepsilon$

$A_{50th} = 37 + 0.94F + \varepsilon$

$A_{5th} = -826 + 0.62F + \varepsilon$

A= Actual Traffic
F= Forecasted Traffic

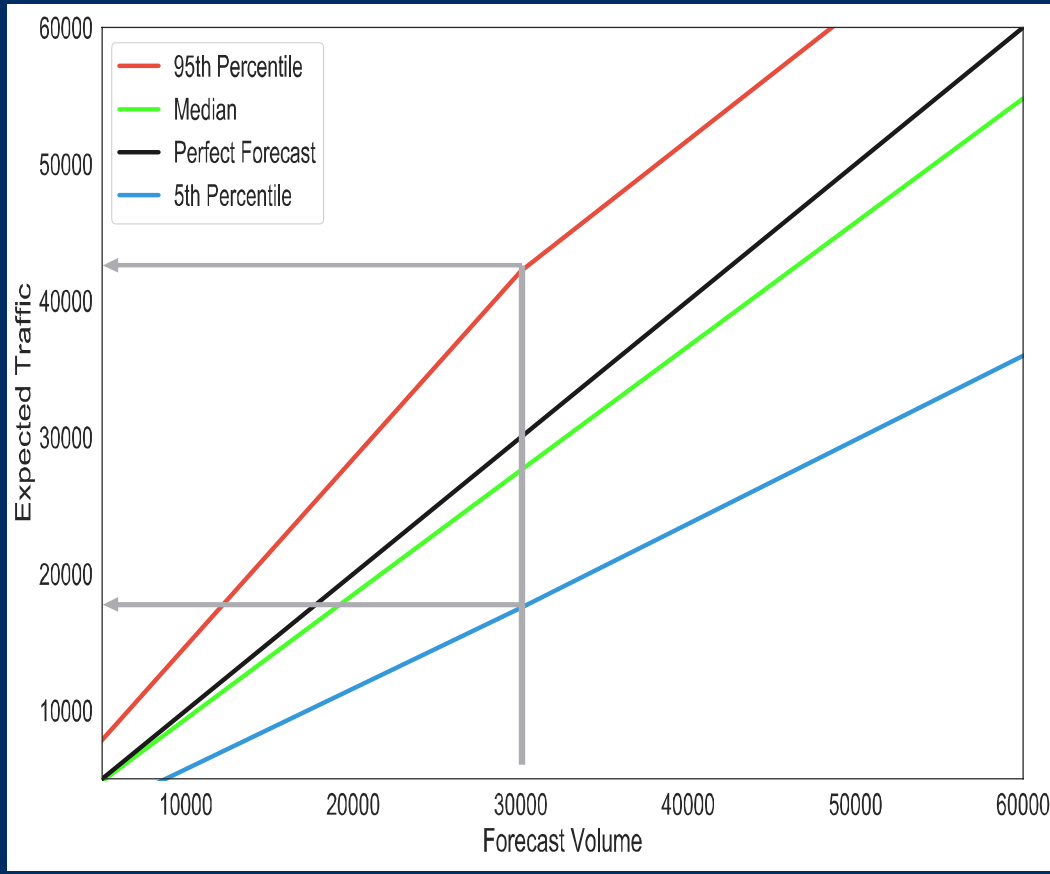


Results- Factors Affecting Forecast Uncertainty

	5th Percentile	50th Percentile	95th Percentile
Pseudo R-Squared	0.475	0.739	0.830
	Coef.	Coef.	Coef.
(Intercept)	-182.267	255.551	976.786
Adjusted Forecast	0.705	0.891	1.254
Control for forecasts values over 30,000 ADT	0.024	-0.004	-0.413
Unemployment Rate in the Year Forecast was Produced	-0.006	0.002	0.010
Control variable for Forecasts Produced Before 2010	-0.007	0.0002	0.003
Forecast Horizon	0.006	0.008	0.020
Control Variable for Project on a New Road	0.093	-0.008	-0.090
Control Variable for Forecasts done using Travel Demand Model	0.068	-0.008	-0.101
Control Variable for Project on Higher Functional Class	-0.150	-0.062	-0.116
Control Variable for Project on Collector or Local Roadway	-0.212	-0.126	-0.321

Uncertainty Envelope

- Forecast produced in the year 2018
- Unemployment rate at State level in 2018 is 4%
- Forecasting the traffic for 2028 i.e. forecast horizon of 10 years
- The project is a new construction project on a Minor Arterial
- Forecast is done using a travel demand model.



Resources & Publications

- Guidance Document & Research Report
  - https://www.nap.edu/catalog/25637/traffic-forecasting-accuracy-assessment-research
- Quantile Regression Spreadsheet
  - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_934_QuantileRegressionModels.xlsx
- Archiving Software
  - https://github.com/uky-transport-data-science/forecastcards
- Data
  - https://github.com/uky-transport-data-science/forecastcarddata

"The Changing Accuracy of Traffic Forecasts"

Hoque, J.M., Erhardt, G.D., Schmitt, D. *et al.* The changing accuracy of traffic forecasts. *Transportation* (2021). https://doi.org/10.1007/s11116-021-10182-8

"Estimating the Uncertainty of Traffic Forecasts from their Historical Accuracy"

Hoque, Erhardt, Schmitt, Chen & Wachs. Transportation Research Part A: Policy and Practice. Volume 147. 2021. Pages 339-349. ISSN 0965-8564. https://doi.org/10.1016/j.tra.2021.03.015.

Application for FDOT, District 4

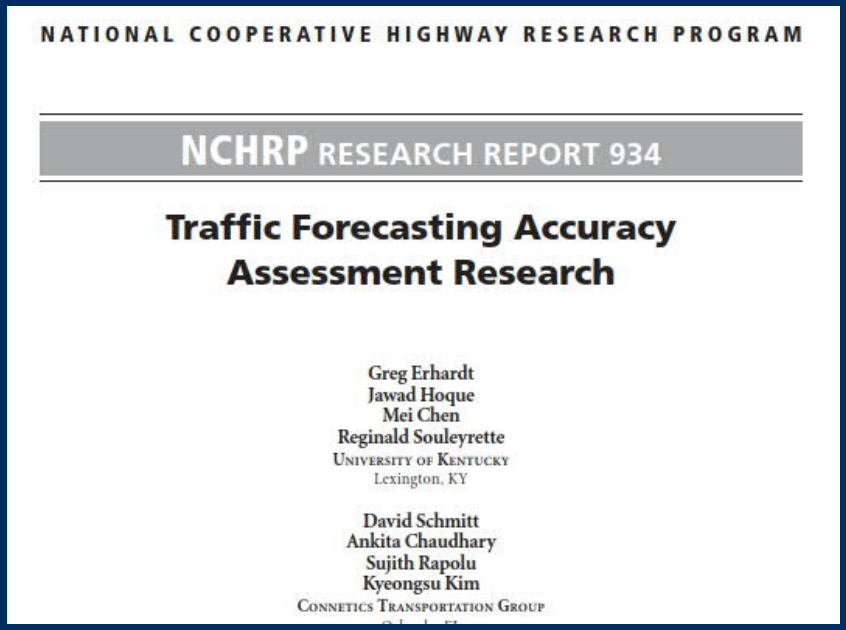
Motivation & Objectives

- D4 develops dozens of traffic forecasts every year
  - Forecast reports are archived on a regular basis
  - Accuracy of the forecasts are accessed from time to time, using actual/realized traffic counts (previous assessments done in 2010 and 2014)
- Opportunity to utilize the archived data to enhance D4's forecasting process

- Assess the accuracy of recent forecasts
  - Identify areas of improvements
- Apply lessons learned from the rich data set of forecasts
  - Quantify uncertainty in the forecasts and assist district reviewer estimate potential error range in project forecasts

Methodology

- Adopt guidance from the NCHRP 934 report (developed with D4 contributions)
- Utilize rich archived data and professional experience of seasoned D4 staff
- More emphasis on **products that are easily reproducible and applicable**
- Opening year forecasts assessed for accuracy


NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP RESEARCH REPORT 934

Traffic Forecasting Accuracy Assessment Research

Greg Erhardt
Jawad Hoque
Mei Chen
Reginald Souleyrette
University of Kentucky
Lexington, KY

David Schmitt
Ankita Chaudhary
Sujith Rapolu
Kyeongsu Kim
Connetics Transportation Group

Key Tasks

Data Gathering

Gather forecast reports developed since 1999 and develop a database of D4 traffic forecast

Data Analysis

Analyze data and develop an automated routine to create an interactive report that can be easily updated by FDOT staff when including future projects

Uncertainty Analysis

Develop a process to define potential uncertainty in a forecast

Forecast Database

- Forecasts stored in Excel
- Includes forecasts developed after 1999

SUMMARY OF ALL D4 TRAFFIC PROJECTIONS

143 SELECT REPORTS CONDUCTED FROM 2008 THROUGH 2014

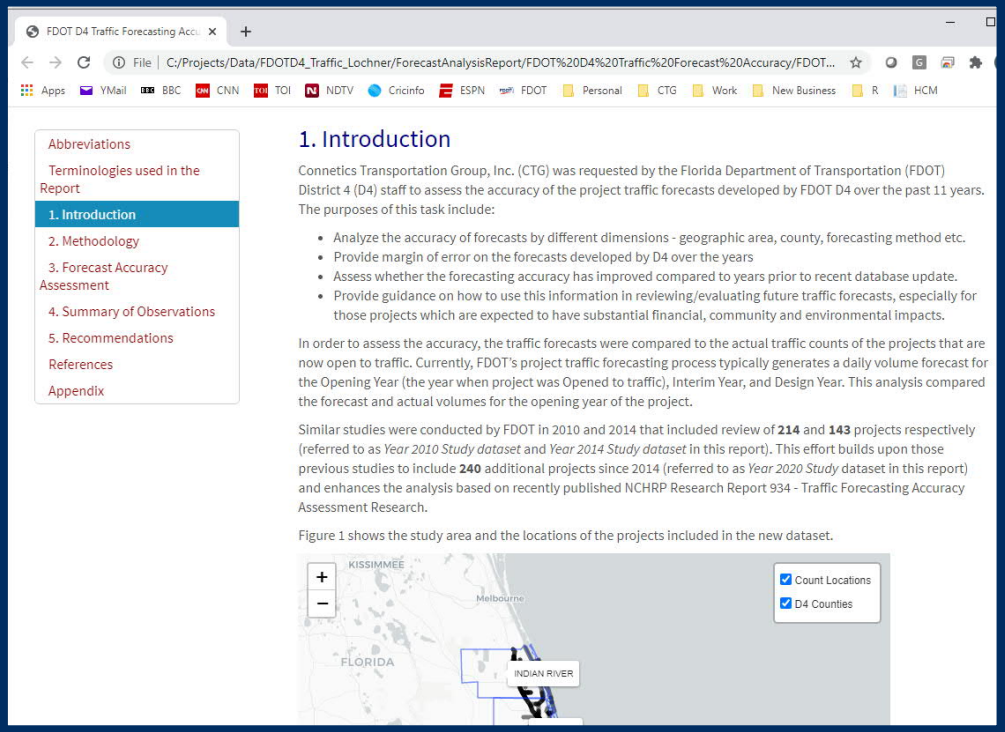
GENERAL ROADWAY INFORMATION				TYPE OF STUDY	DATE	EXISTING YEAR		PROJECTIONS		FORECASTED DATA			COUNT STATION	ACTUAL DA		
Segment/ Intersection	Roadway ID	County	Roadway Segment	Operational/Planning Study	Date of Report	Report's Existing Year	Report's Existing Year AADT	Year Open to Traffic	Year Open to Traffic AADT	Number of Forecasting Years	Future Forecasted Year (Opening Year)	Future Forecasted AADT (Opening Year)	FDOT/ County	Actual AADT	Forecasted Actual AA Differen	
SR 5/US 1 from 11 Street to Silver Beach Road	93020000	Palm Beach	SR 5/US 1 from 11 Street to Silver Beach Road	Traffic Projection Report	04/23/08	2008	26,800	2013	29,200	5	2013	29,200	930755	23500	5,700	
SR A1A from Azalea Terrace to (MP 4.030)	86030000	Broward	SR A1A from Axalea Terrace (MP 2.011) to S. of Sheridan Street (MP 4.0)	Traffic Projection and 18-Kip	06/23/08	2007	23,500	2012	29,100	5	2012	29,100	865042	23000	6,100	
SR A1A from Azalea Terrace to (MP 4.030)	86030000	Broward	SR A1A from Axalea Terrace (MP 2.011) to S. of Sheridan Street (MP 4.0)	Traffic Projection and 18-Kip	06/23/08	2007	20,500	2011	24,100	4	2011	24,100	865166	19800	4,300	
SR A1A from Cordova Road to Eastof Eisenhower Boulevard	86180000	Broward	Cordova Road to East Eisenhower Boulevard	Traffic Projection Report and 18-Kip	09/15/08	2008	44,300	2013	47,700	5	2013	47,700	865306	41000	6,700	
SR 708 from Old Dixie Highway to 1100 feet east of Old Dixie Highway	93012000	Palm Beach	SR 708 Blue Blvd from Dixie to US 1	Traffic Projection and Turning Movement	03/11/08	2007	27,500	2013	30,100	6	2013	30,100	930071	16600	13,500	
SR 70 Okeechobee Road Virginia Avenue from East of Jenkins Road (MP 21.600) to US 1 (MP 25.255)	94030000	St. Lucie	SR 70 from Jenkins Road to Virginia Avenue	Traffic Projection and 18-Kip	11/12/08	2008	34,000	2012	39,200	4	2012	39,200	940742	27000	12,200	
SR 70 Okeechobee Road Virginia Avenue from East of Jenkins Road (MP 21.600) to US 1 (MP 25.255)	94030000	St. Lucie	SR 70 from Okeechobee Road to US 1	Traffic Projection and 18-Kip	11/12/08	2008	25,200	2012	30,300	4	2012	30,300	940032	21000	9,300	
SR 804 from East of Hagen Ranch Road (MP 2.760) to West of Jog Rod (MP 3.360)	93200000	Palm Beach	from Hagen Ranch Road (MP 2.76) to Jog (MP 3.36)	Traffic Projection, and 18-Kip	10/14/08	2007	32,500	2012	37,400	5	2012	37,400	935201	41000	-3,600	
SR 802 East of Congress Avenue (MP 7.200) to West of Lake Osborne Drive (MP 8.010)	93180000	Palm Beach	SR 802 East of Congress Avenue (MP 7.200) to West of Lake Osborne Drive (MP 8.010)	Traffic Projection, and 18-Kip	10/14/08	2007	23,500	2012	25,500	5	2012	25,500	930025	24500	1,000	3.92%
SR 811 from Hillsboro Boulevard to SW 18 Street (Boca Raton)	86170000	Broward	SR 810 to Broward and Palm Beach County Line	Traffic Projection, and 18-Kip	08/13/08	2007	15,500	2012	23,900	5	2012	23,900	860490	15600	8,300	34.73%
SR 713 St. Lucie County from SR 614/Indrio (MP 7.5) to North of Spanish Lakes Blvd (9.5)	94003000	St. Lucie	Kings Hwg from Indrio Road (MP7.5) to North of Spanish Lakes Blvd(MP 9.5)	Traffic Projection and Turning Movement	05/14/08	2008	12,800	2013	15,600	5	2013	15,600	940269	9000	6,600	42.31%

County	# Records
All D4 Counties	597
Broward	279
Palm Beach	161
Martin	49
St. Lucie	67
Indian River	41

597 Total Records!

Interactive Report in RMarkdown HTML

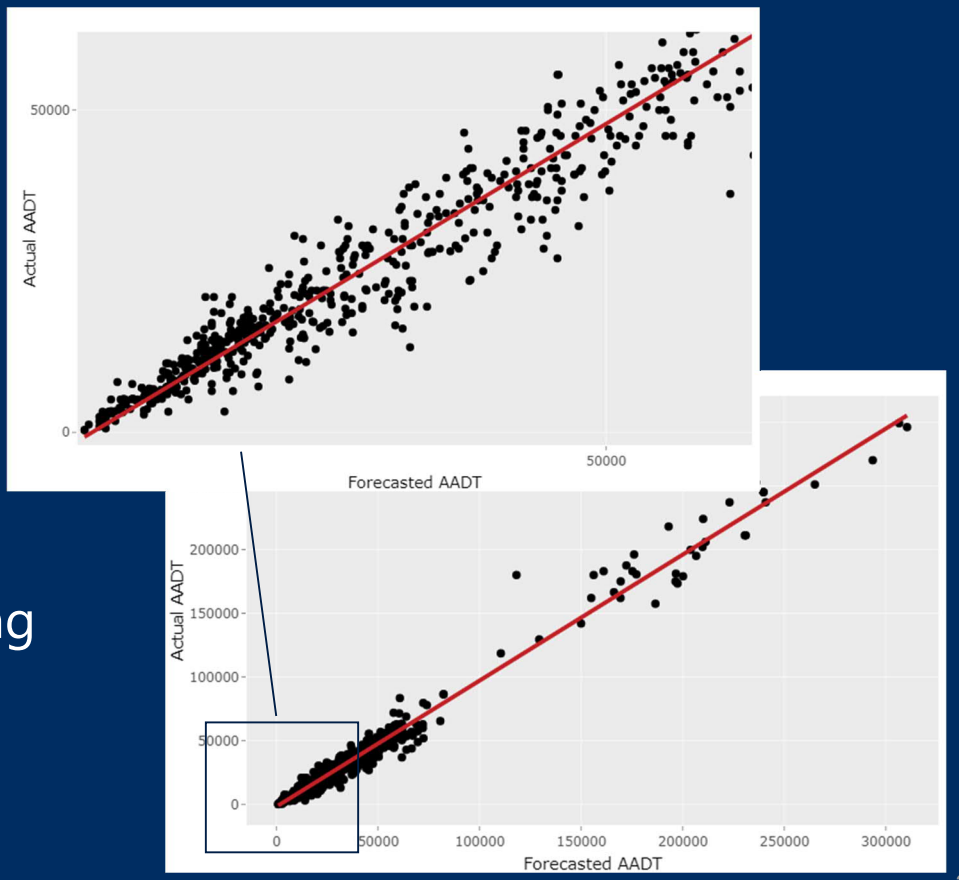
- Reads the forecast Excel database
- Analyzes the data – develops interactive tables and maps in a HTML report
  - D4 staff can easily monitor the accuracy in house on a more frequent basis (e.g., every year)
- Provides recommendations to further improve the forecasting process



Districtwide Observations

Attributes	Value
# Records	597
Mean of PDFF (MPDFF)	-7.2%
Median of PDFF	-6.2%
MAPDFF	**15.4%**
Standard Deviation of PDFF	19.7%

- Evidence of over-estimation in opening the year forecast
- Forecasts ~15% off the actual counts



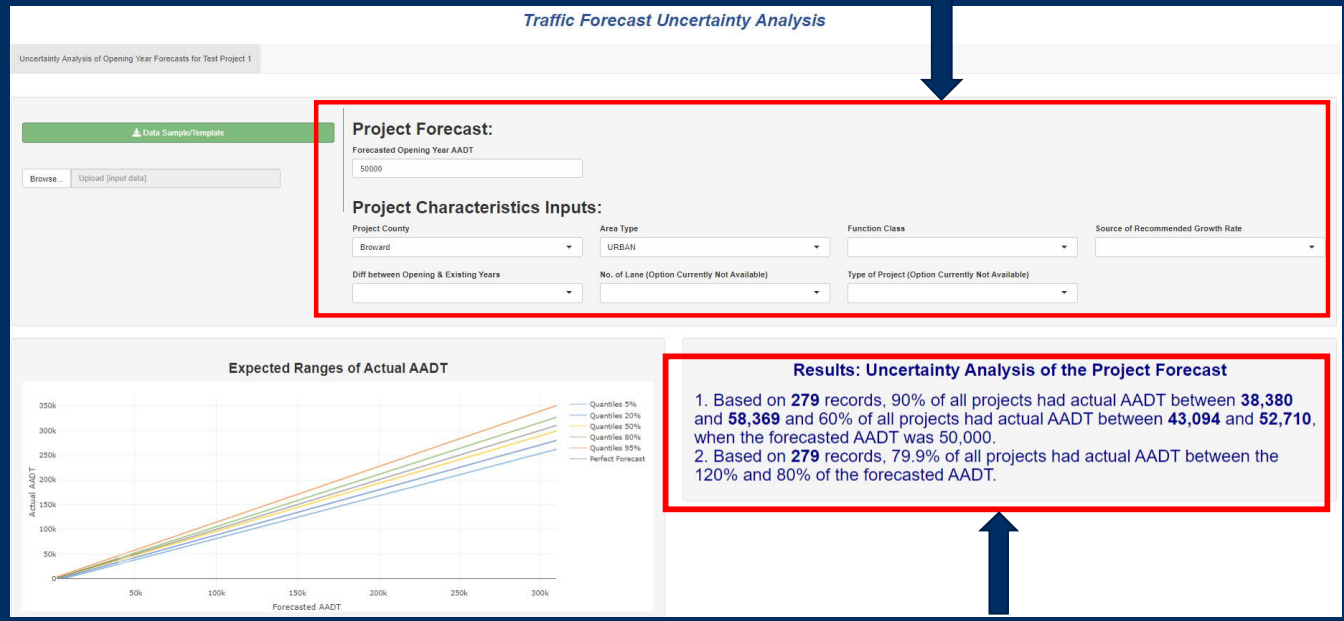
Additional Observations

- On an average, the D4 forecasts are within ~**15%** (MAPDFF) of the actual traffic volumes
- Greater accuracy for the urban areas, high volume and short-term forecasts
- Improved accuracy for the most recent set of forecast data (2020 dataset)
- Slightly better accuracy of D4 forecasts compared to the database developed for NCHRP 934 report
- Regional models are very relevant to the D4 forecasting decision making process

Uncertainty Assessment: Web Application

- Developed a process to **quantify uncertainty** in a forecast to assist D4 in traffic forecast reviews
  - Process based on *NCHRP 934 Traffic Forecasting Accuracy Assessment*
  - Uncertainty range desirable if a "lane call" is involved
  - Requires house-training of the methodology

FDOT reviewer defines characteristics of the project here



Application bounds the uncertainty based on prior project experience

Next Steps

- Utilize the findings from this assessment to enhance D4's forecasting / modeling process
- Train the uncertainty methodology for D4 project application
- Enhance this assessment based on continued application and inputs from other D4 departments
- Develop process to understand potential impacts of uncertainty on traffic operations analysis of future studies

Questions?

Thank you!