Modifications to the Vehicle Miles Travelled (VMT) Statewide Forecast Model

Washington State Department of Transportation – Economic Analysis

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Executive Summary

VEHICLE MILES TRAVELLED DATA (VMT) AND PAST FORECAST METHODOLOGY

The Washington State Department of Transportation has been producing a statewide forecast of vehicle miles travelled for more than 20 years. These forecasts are presented to the state Transportation Revenue Forecast Council (TRFC). In 2009-2010, WSDOT convened a multiagency workgroup to examine the VMT forecast methodology in order to develop a VMT forecast model. The VMT forecast has been disconnected from the fuel consumption and fuel tax revenue forecasting process since 2010.

Even with the changes made to the forecast model in 2010, that methodology still produced steep, upwardly forecasts that were not met. As a result, revisions to the 2010 model were selected by the workgroup to produce a flat forecast, which more closely matched recent history of VMT. In the long term, the 2014 forecast of VMT begins to decline slowly.

The purpose of this paper is to discuss the 2014 modifications to the VMT forecast model. Readers interested in the discussion on how the original 2010 VMT forecast model was selected can review WSDOT – Economic Analysis's April 2010 document, *Vehicle Miles Traveled (VMT) Statewide Forecast Model* at the following web site:
http://www.wsdot.wa.gov/.../VMTForecastWorkGroupSummaryMay2010final.pdf .

Forecast Methodology prior to 2010 changes: The VMT forecast used the quarterly forecast of net fuel gallons and multiplied that number by a forecast of fleet miles per gallon to get vehicle miles traveled statewide.

2010-2013 Forecast Methodology: In 2009-2010, WSDOT convened a multiagency workgroup to study, review and select a better model.

- Log-log model using the following independent variables:
  - Washington Non-agricultural Employment
  - Washington Motor Vehicle Registrations
  - Washington Gas prices
- Model considers three sets of impacts on VMT
- This forecast model still produced forecasts substantially higher than actual VMT.
- Actual VMT for fiscal year 2013 was 56.9 billion
  - 0.18% higher than 2012
    - 1.6% lower than previous forecast

Even though the 2010 VMT forecast projected better than the prior methodology, the 2010 forecast model was still over-forecasting traffic in the near term. In addition, the long term forecast did not agree with recent Washington state and national trends in traffic, current VMT research showing flattened growth rates, or the WSDOT fuel consumption forecast that also showed flat to slow declining growth.

2014 Modified Statewide VMT Forecast Methodology

The 2014 methodology used the forecast model with less history of VMT and provided a basis for VMT projections which were flat and represented the last 20 years of VMT actual experience. In the 2010 review, we considered truncating the history of VMT for forecasting purposes but at that time we had two primary concerns. First, we wanted to have more years of slow growth in VMT experience to make sure the recent history was sufficient and a solid basis on which to forecast the future. Second, in 2010 we were still in the Great Recession and just beginning to come out of it and we were unsure where VMT would go after the recession.

Now, four years later, that question has been answered by the fact that in the ensuing years, VMT continues to be flat, even as the economy grows. This is due in part to increased use of telecommuting and public transit, driving habits of younger drivers and more people walking. Studies have also shown that even though the vehicle fleet continues to grow, vehicle ownership is nearing saturation, so it has a smaller impact on VMT. Some studies also observe that much of the VMT growth in the last two decades of the 20th century was related to women entering the workforce. This is now moderating.

WSDOT looked at alternative forecast models for projecting VMT. The 2014 modified statewide econometric VMT forecast model was determined after considering various forecast model specifications.

The revised forecast model is a first differenced log-log functional form which includes the log of the following independent variables:

- Washington non-agricultural employment
- Washington motor vehicle registrations
- Washington gas prices

The 2014 modified model also uses truncated history. The previously used history for the independent and dependent variables included periods of extremely high growth rates in employment, registrations and VMT, which are no longer occurring. Due to the nature of the regression models, this created unsustainable and unreasonably high growth rates.

- From 1966 -1990, Average Annual Growth Rate (AAGR) was 4.5%
- From 1991-2001, AAGR was 2%
- From 2002-2013, AAGR was 0.5%

Conclusions

Before the 2014 VMT model revisions, the VMT projections showed steady upward growth, while the gasoline consumption model showed flat, then declining growth. Now, although the

two models are independent of each other, they show similar trends of low short term growth, then a year over year decline in the long-term. This consistency between the two forecasts makes sense that the factors causing us to have slower VMT would be the same factors which cause individuals to use less fuel each year.

- Prior forecast model results were not consistent with
    - Near-term trend in statewide traffic
    - National trends in traffic
    - Current VMT research showing flattening of VMT
    - WSDOT current fuel consumption forecast

- Consistently over-forecasted VMT

- Analysis of Dependent and Independent Variables showed significant Unit Root issues
    - Augmented Dickey-Fuller test recommended use of 1st difference functional form
        - Adds stability to the forecast model results

Chapter 1: Vehicle Miles Travelled Forecast Background

Vehicle miles travelled (VMT) in Washington state is calculated each year by the Washington State Department of Transportation's Transportation Data and GIS Office. Statewide VMT statistics are available annually as a result of WSDOT federal reporting activities. WSDOT produces an annual VMT estimate as part of its Highway Performance Monitoring System (HPMS) data submittal to the Federal Highway Administration (FHWA).

The statewide VMT estimate is based on traffic volume statistics collected from permanent counters and other short-term counts and combined with local government short-term counts that are reported to WSDOT. WSDOT's Transportation Data and GIS Office provides a calendar-year estimate of statewide VMT and WSDOT- Economic Analysis converts that CY estimate total to a fiscal-year estimate based on an examination of seasonal traffic patterns statewide for VMT.

WSDOT has been producing a statewide forecast of VMT for more than 20 years and presenting the forecasts to the Transportation Revenue Forecast Council (TRFC). In 2009-2010, WSDOT convened a multiagency workgroup to examine the VMT forecast methodology in order to develop a VMT forecast model. The VMT forecast has been disconnected from the fuel consumption and revenue forecasting process since 2010.

This workgroup was formed to review the department's VMT forecast to address the following:

- An actual forecast model for Washington VMT had never been developed
- In light of the more recent trend of national and Washington VMT flattening, the accuracy of the past steep upward trending forecast was being questioned
- Consultants and legislative staff have requested estimates for a VMT-related tax as a new transportation revenue source
- Capital planning purposes required an updated and accurate projection of VMT statewide
- Enactment of Engrossed Second Substitute House Bill 2815 in 2008 established Washington statewide per capita VMT in order to reduce greenhouse gas emissions (RCW 47.01.440 2008 c. 14 § 8) where the baseline 2020 VMT was set at 75 billion VMT benchmark, consistent with the February 2008 VMT forecast for 2020.

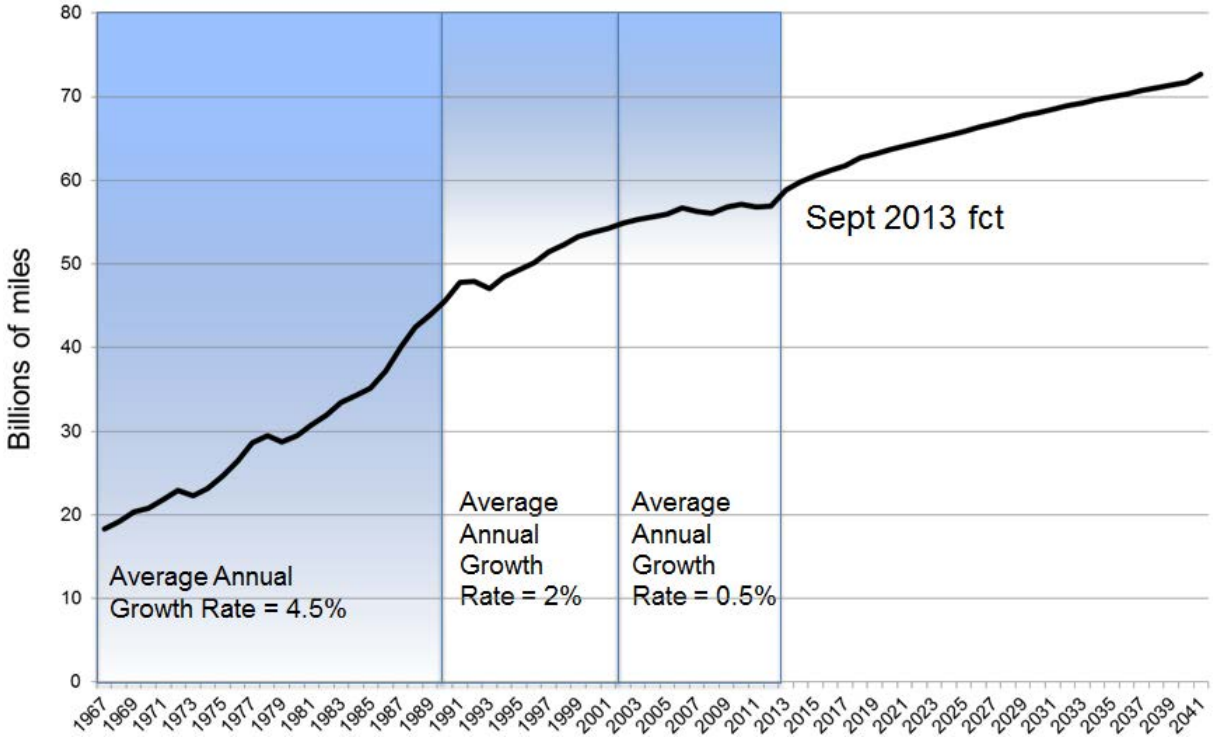
Even with the changes made to the forecast model in 2010, that methodology still produced steep, upwardly forecasts that were not met. As a result, revisions to the 2010 model were selected by the workgroup to produce a flat forecast, which more closely matched recent history of VMT. In the long term, the 2014 forecast of VMT begins to decline slowly.

The purpose of this paper is to discuss the 2014 modifications to the VMT forecast model. Readers interested in the discussion on how the original 2010 VMT forecast model was selected can review WSDOT – Economic Analysis's April 2010 document, *Vehicle Miles Traveled (VMT) Statewide Forecast Model* at the following web site:
http://www.wsdot.wa.gov/.../VMTForecastWorkGroupSummaryMay2010final.pdf .

Trends in Washington's VMT Forecast Model

Figure 1 is Washington's actual and forecasted VMT since 1967, with forecasts for years 2014 and beyond based on the September 2013 projections. Cursory examination of Figure 1 shows that there are three distinct historical periods for VMT. From 1967 to 1990, the average annual growth rate (AAGR) was 4.5%. This reflects the rapid expansion of the interstate highway system and economic growth in the region. From 1991 to 2002, the AAGR was 2%. This reflects a relatively mature highway system and continued, but slower economic growth in the region. From 2003 to the present, VMT flattened out, showing an AAGR of only 0.5%. Even with this well-documented history showing slower growth, and modifying the forecast downward in recent years, the 2013 VMT forecast still called for growth more closely resembling the period from 1991 to 2002, averaging just under 2% per year.

FIGURE 1. TOTAL VEHICLE MILES TRAVELLED 1967 - 2041 (SEPTEMBER 2013 FORECAST)



Literature Review on VMT Trends

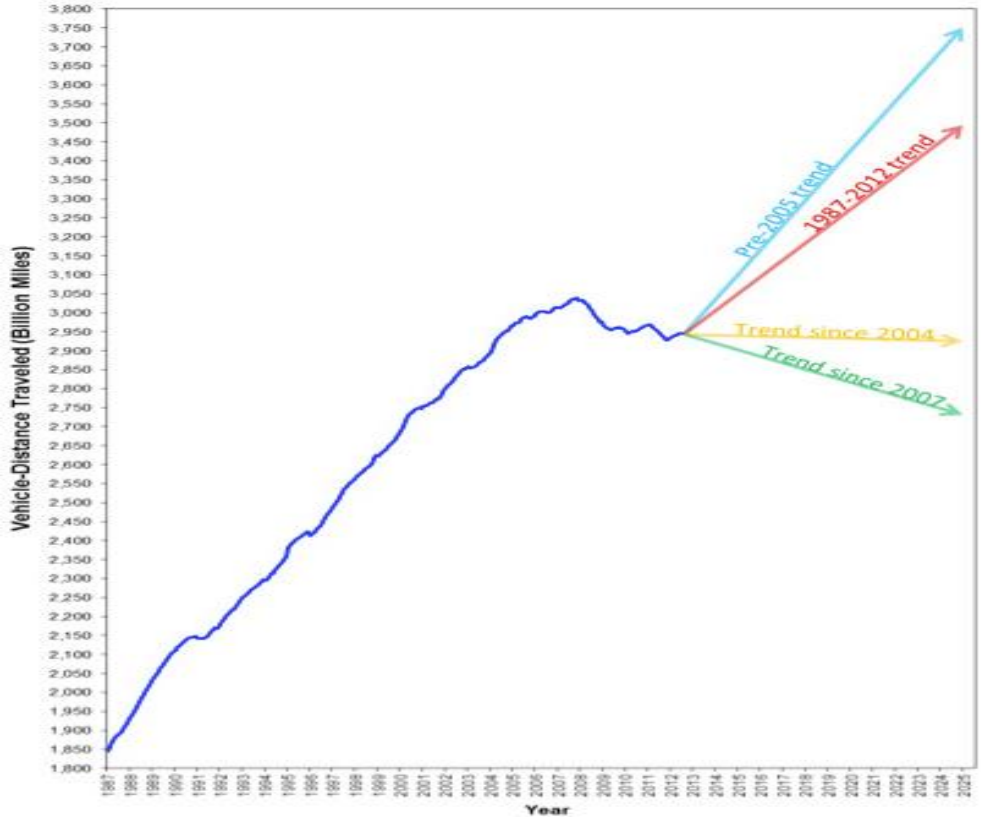
This trend in lower and flattening growth rates is not limited to Washington state. It is at least a national trend, and may well be a phenomenon experience in international post-industrial, developed nations. Polzin, (2006), Polzin et al. (2004a), Polzin et al. (2004b), and the East-West Gateway Council of Governments (2008) are among those who have noticed the flattening of national and regional VMT growth and have speculated why that growth has moderated. More recently, the Transportation Research Institute of the University of Michigan reported that, nationally, VMT per driver, per capita, and per vehicle all peaked in 2004, well before the 2008

recession (Sivak, 2014). Sivak argues that the VMT reductions "reflect fundamental, noneconomic changes in society," including: increased use of telecommuting and public transportation, increased urbanization, and demographic changes in the age composition of drivers.

The Brookings Institute (Puentes) also made similar findings in its 2013 report. In addition to including increased use of telecommuting and public transit, and observations about driving habits of younger drivers, Puentes also says more people are walking. Puentes also observes that even though the vehicle fleet continues to grow, vehicle ownership is nearing saturation, so it has a smaller impact on VMT. Puentes goes a step further than Sivak and offers that much of the VMT growth in the last two decades of the 20th century was related to women entering the workforce. This is now moderating.

The Victoria Policy Institute (Litman, 2014) also agrees with the above studies. Litman also suggests increased internet shopping, telecommuting and car sharing may also reduce VMT more in the future. In this study they highlight a Baxandall 2012 study that illustrates the different trends in US VMT given the different trend periods (Figure 2). This study illustrates that the future trend line for VMT is most optimistic when the history of VMT is prior to 2005. The future trend for US VMT is most pessimistic when the recent history since 2007 is used for setting the future trend.

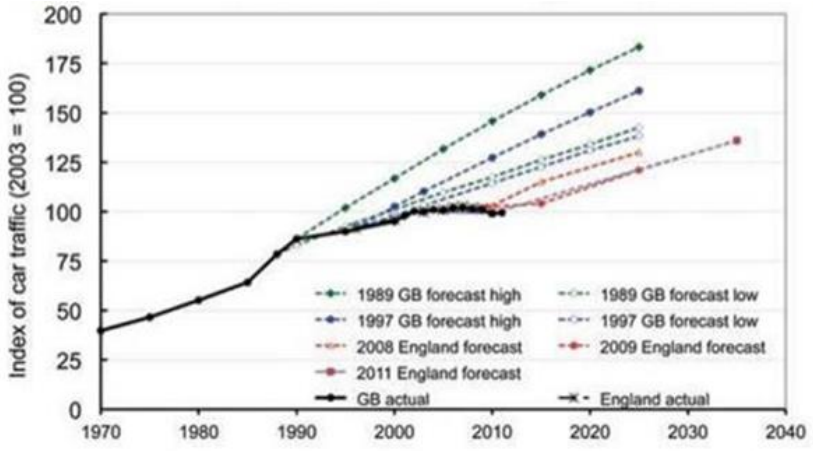
FIGURE 2. US VEHICLE MILES TRAVELLED TRENDS (BAXANDALL, 2012 IN LITMAN, 2014)



Dutzik et al. completed a report in the spring 2013 which also illustrated past trends and national forecasts of VMT. This report revealed how much the Energy Information Administration had been continuing to bring down their national forecasts of VMT since 2006. Overly optimistic forecasts of VMT are a problem at the national level as well.

Litman also shows that VMT growth and the problems of overforecasting VMT is not just a phenomenon of Washington state or the United States. Great Britain's VMT also slowed after 1990 and peaked in 2007, but VMT forecasts still show growth at pre-1990 rates (Figure 3). These forecasts have continued to be brought downward as the history of travel continues to be flat.

FIGURE 3. BRITISH TRAVEL FORECASTS AND ACTUAL GROWTH (GOODWIN, 2012 IN LITMAN, 2014)



Great Britain (GB) vehicle travel growth rates slowed after 1990, peaked in 2007, and subsequently declined, but official travel forecasts continued to predict steady growth based on pre-1990 trends.

Chapter 2: Forecast Model Modifications Considered

As mentioned previously, even though the 2010 VMT forecast projected better than the prior methodology, the 2010 forecast model was still over-forecasting traffic in the near term. In addition, the long term forecast did not agree with recent Washington state and national trends in traffic, current VMT research showing flattened growth rates, or the WSDOT fuel consumption forecast that also showed flat to slow declining growth. This 2014 VMT forecast model review did not evaluate any new independent variables due to the fact that an extensive examination of numerous economic variables[1] was performed in the forecast model review in 2009/2010. This 2014 forecast model review examined key assumptions pertaining to the dependent variable and the functional form of the econometric model.

We tested the dependent and independent variables for Unit Root issues, which we did not do in the previous first workgroup review. We found using the Augmented Dickey-Fuller Test that the dependent and independent variables had stationarity issues. The results of the Dickey-Fuller Test recommended using the first differencing functional form for the forecast model (Figure 4).

FIGURE 4. RESULTS OF AUGMENTED DICKEY-FULLER TEST

Null Hypothesis: VMT has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.708562	0.4205
Test critical values:	1% level	-3.577723	
	5% level	-2.925169	
	10% level	-2.600658	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(VMT)
Method: Least Squares
Date: 09/29/14 Time: 12:54
Sample (adjusted): 1967 2013
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
VMT(-1)	-0.013508	0.007906	-1.708562	0.0946
D(VMT(-1))	0.385154	0.136619	2.819188	0.0072
C	1068634.	377719.6	2.829173	0.0070

R-squared	0.241096	Mean dependent var	877702.1
Adjusted R-squared	0.206601	S.D. dependent var	821588.1
S.E. of regression	731812.9	Akaike info criterion	29.90614
Sum squared resid	2.36E+13	Schwarz criterion	30.02423
Log likelihood	-699.7943	Hannan-Quinn criter.	29.95058
F-statistic	6.989186	Durbin-Watson stat	1.825837
Prob(F-statistic)	0.002313		

Null Hypothesis: EE_WA has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.928933	0.7738
Test critical values:	1% level	-3.520307	
	5% level	-2.900670	
	10% level	-2.587691	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EE_WA)
Method: Least Squares
Date: 09/29/14 Time: 12:56
Sample (adjusted): 1968 2042
Included observations: 75 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EE_WA(-1)	-0.003224	0.003470	-0.928933	0.3561
D(EE_WA(-1))	0.854716	0.106253	8.044138	0.0000
D(EE_WA(-2))	-0.443189	0.106023	-4.180100	0.0001
C	32038.91	10752.71	2.979612	0.0039

R-squared	0.490140	Mean dependent var	39922.88
Adjusted R-squared	0.468597	S.D. dependent var	37592.66
S.E. of regression	27404.07	Akaike info criterion	23.32663
Sum squared resid	5.33E+10	Schwarz criterion	23.45023
Log likelihood	-870.7486	Hannan-Quinn criter.	23.37598
F-statistic	22.75134	Durbin-Watson stat	2.063049
Prob(F-statistic)	0.000000		

We rejected first differencing in the 2009-2010 workgroup because first differencing created a series that lowered growth even more than we thought feasible and we did not realize the variables really needed to be first difference to create a stable forecast. Figure 5 compares the September 2013 forecast with the September 2014 forecast using the same methodology but

[1] 2010 review examined the following economic variables in VMT forecast model: fuel consumption: gas prices; percentage change in fuel prices; "dummy" variable for large fuel price changes; Washington motor vehicle registrations; Washington employment; Washington unemployment rate; Washington personal income; Washington personal income per capita; Washington wages and salaries; total and driver aged population; labor force and population density; in-driver population; in-migration population and total and interstate lane miles

including revised economic variables and another new forecast of first differencing the log-log forecast model equation.

FIGURE 5. COMPARISON OF ALTERNATIVE UNTRUNCATED VMT FORECASTS

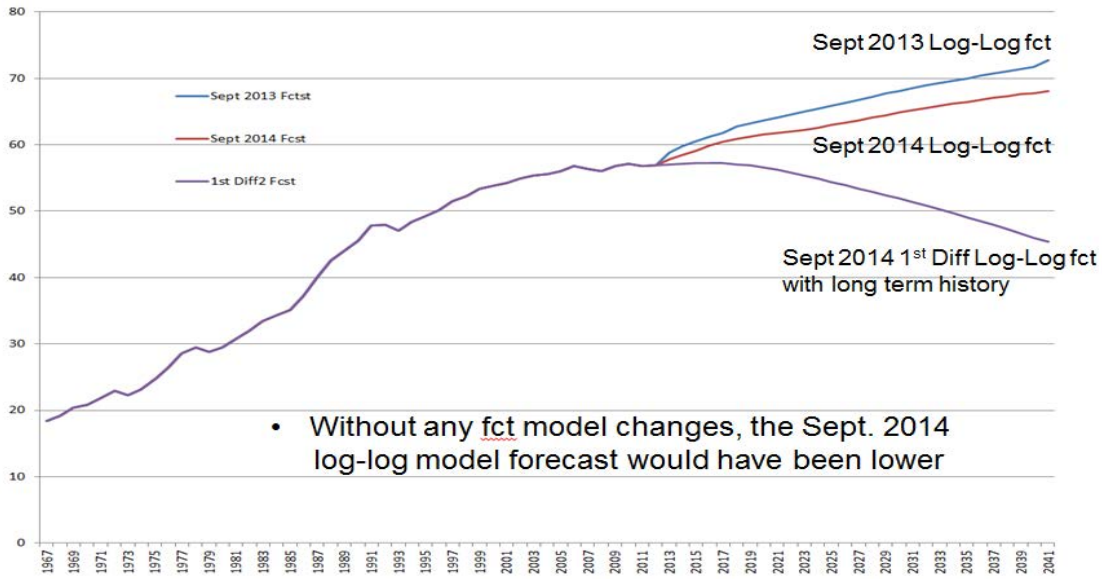
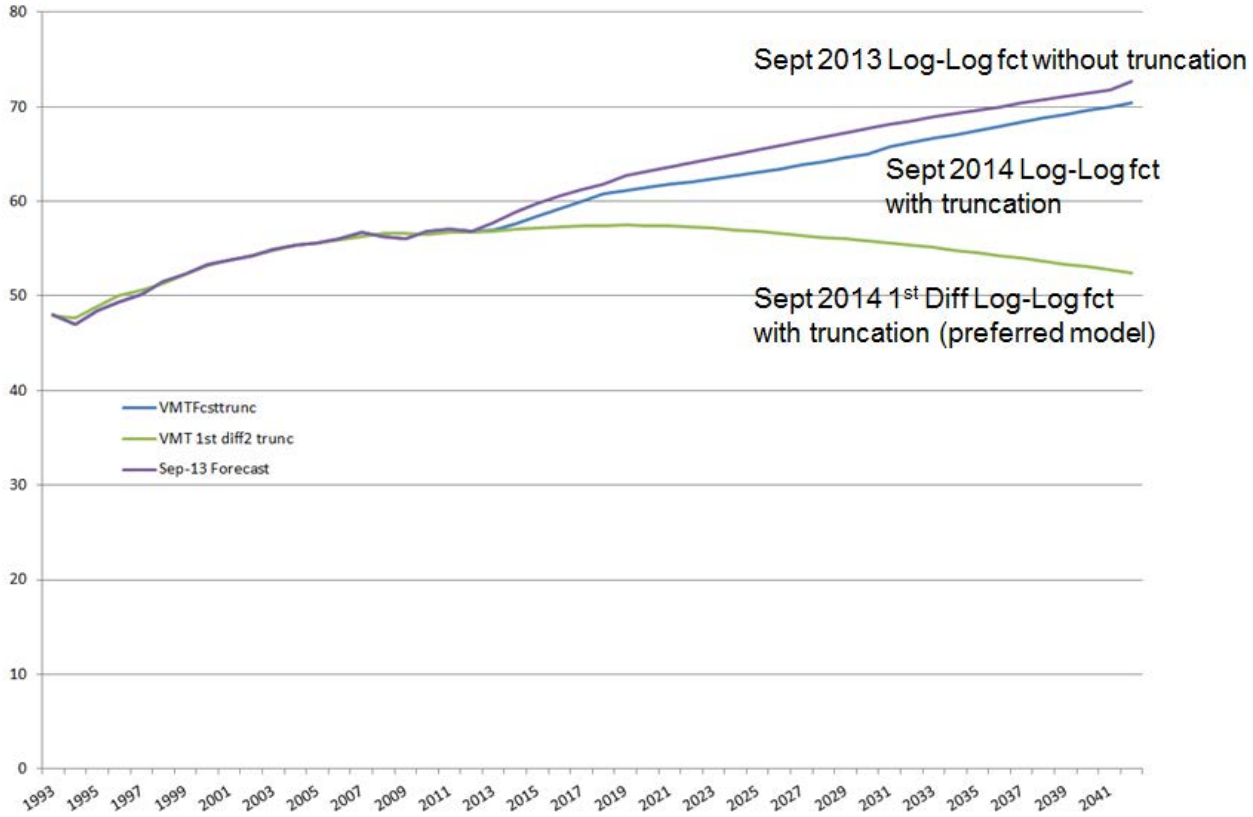


Figure 5 shows several things. First, when we used updated independent and dependent variables in 2014 with the exact same model specification as used in 2013, the VMT forecast was a parallel shift downward in the forecast results. Second, as previously mentioned, the log-log forecasts are aggressive and seem to ignore recent history, but a first differenced log-log model, while flat in the short term, may be too aggressive in the long term decreasing VMT. For, this reason, we decided to examine forecast models using truncated histories of the dependent and independent variables. We determined that having VMT history beginning in 1993 produced more realistic VMT forecasts. Utilizing a long-term history in the forecast model brings into the forecast historical time periods of high VMT growth that we do not anticipate seeing again in the future.

Figure 6 compares the VMT forecast models using the shorter truncated history for VMT. Using the forecast model with less history of VMT provided a basis for VMT projections which were flat and represented more recent, last 20 years, of VMT actual experience. In the 2010 review, we considered truncating the history of VMT for forecasting purposes but at that time we had two primary concerns. First, we wanted to have more years of slow growth in VMT experience to make sure the recent history was sufficient and a solid basis on which to forecast the future. Second, in 2010 we were still in the Great Recession and just beginning to come out of it and we were unsure where VMT would go after the recession. Now, four years later, that question has been answered by the fact that in the ensuing four years, VMT continues to be flat, even as the economy grows.

FIGURE 6. COMPARISON OF ALTERNATIVE TRUNCATED VMT FORECASTS



Chapter 3: September 2014 Statewide VMT Forecast Model

Final Statewide VMT Forecasting Model

Figure 7, below, shows the final September 2014 VMT forecast model which incorporates the first differencing of the original workgroup VMT forecast model and truncating the history for both dependent and independent variables. The difference between the September 2013 and 2014 VMT projections grows over time so by the end of the forecast horizon or by FY 2040, the 2013 forecast projections are nearly 25% higher than the new 2014 projections.

Figure 7. Comparison of September 2013 and 2014 VMT Forecasts

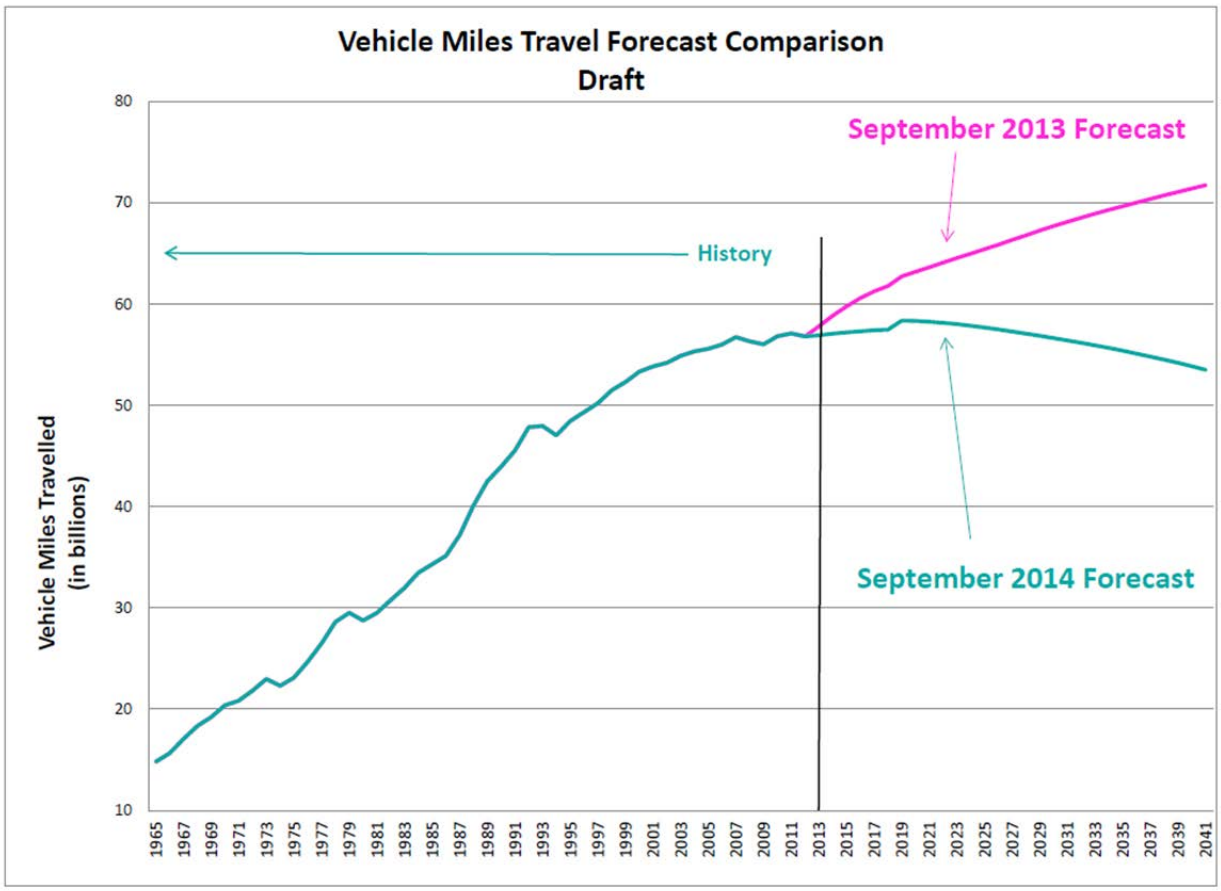


Figure 8 provides the final statistics for the first differenced log- log VMT forecast model. Both the non-agricultural employment and the motor vehicle registrations are positively correlated with VMT with non-agricultural employment having the highest regression coefficient of the three independent variables. The nominal gas price variable is negatively correlated with VMT so as gas prices rise in the future as they are projected to, this is a negative drag on the VMT forecast in the long-term. The unit root and serial correlation problems have been removed from this forecast model as the Durbin Watson statistic is close to 2.

FIGURE 8. FIRST DIFFERENCE LOG-LOG SEPTEMBER 2014 VMT FORECAST MODEL STATISTICS

Dependent Variable: DLOG(VMT_B)
Method: Least Squares
Date: 09/05/14 Time: 13:46
Sample (adjusted): 1993 2013
Included observations: 21 after adjustments
Convergence achieved after 21 iterations
MA Backcast: 1991 1992

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(EE_WA_B)	0.082469	0.097030	0.849930	0.4107
LOG(GASPRICES_B)	-0.011911	0.003714	-3.207415	0.0069
DLOG(MV_REG_B)	0.062078	0.134615	0.461153	0.6523
C	0.015135	0.004257	3.554881	0.0035
AR(1)	-0.072810	0.154178	-0.472249	0.6446
AR(2)	-0.568951	0.127588	-4.459284	0.0006
MA(1)	-0.186435	0.343024	-0.543505	0.5960
MA(2)	0.364757	0.326634	1.116716	0.2843

R-squared	0.679493	Mean dependent var	0.008238
Adjusted R-squared	0.506912	S.D. dependent var	0.011592
S.E. of regression	0.008140	Akaike info criterion	-6.501719
Sum squared resid	0.000861	Schwarz criterion	-6.103805
Log likelihood	76.26804	Hannan-Quinn criter.	-6.415361
F-statistic	3.937250	Durbin-Watson stat	2.042226
Prob(F-statistic)	0.015954		

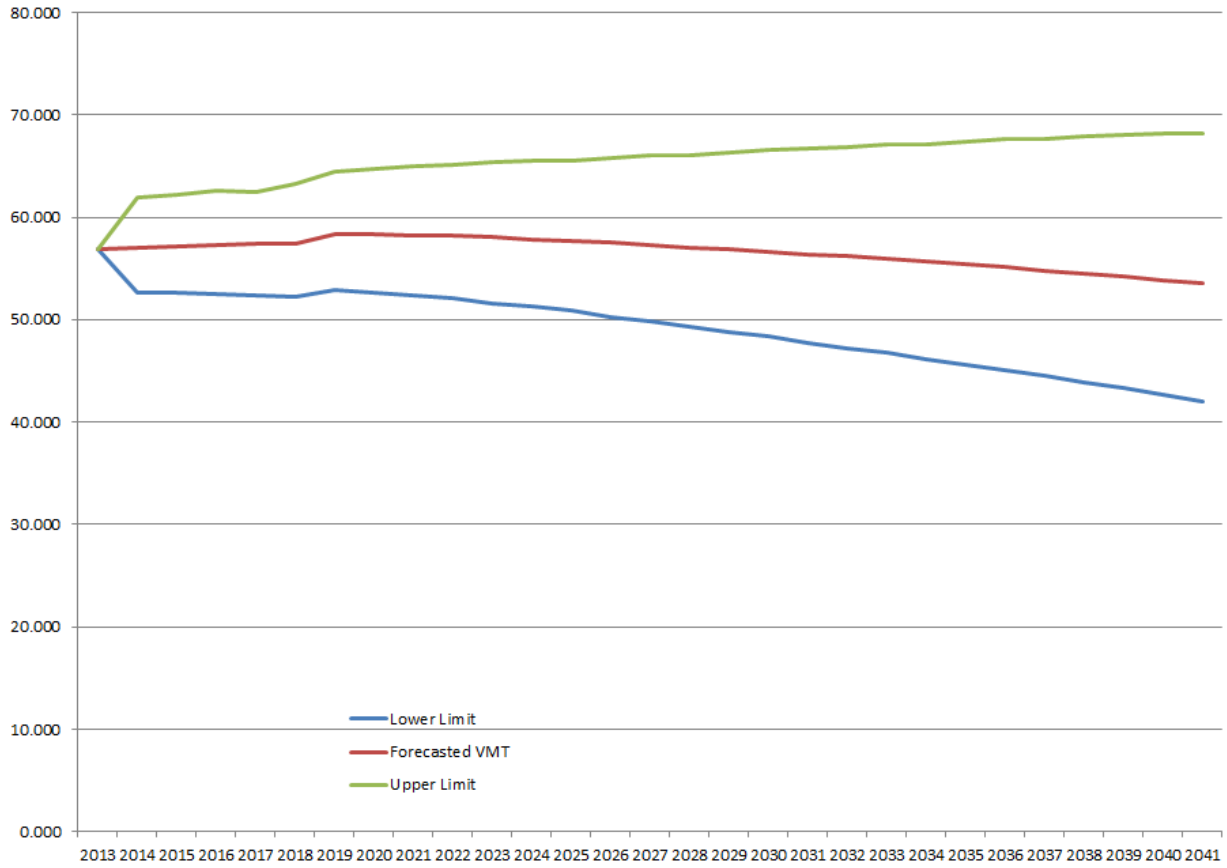
Inverted AR Roots	-.04+.75i	-.04-.75i
Inverted MA Roots	.09+.60i	.09-.60i

The September 2014 VMT forecast confidence band is shown in Figure 9. The confidence band indicates that as the forecast goes out further in the future, there is more uncertainly with the VMT forecast and the confidence band widens between the upper and lower limits. This is the case for most all forecast model results, the further out one forecasts, the less reliable the projections become.

The changes made to the forecast methodology in 2014 explain most of the forecast to forecast differences. However, there are other factors that brought down the 2014 VMT forecast from last year. First, the actual VMT for 2013, came in lower than forecasted, so the 2014 forecast starts at a lower level. Second, differences in independent variables account for some forecast to forecast differences. First, employment projections since the previous forecast were higher, however, this is offset by lower forecasted vehicle registrations and higher projected fuel costs. The higher fuel costs drive much of the VMT downturn in the long-term of the forecast horizon.

The decision to truncate history, however, may be the most important factor in explaining the recent forecast changes. The extremely high VMT growth rates of the 1960s, 1970s, and 1980s are ignored in this new forecast. The lower growth rates of the 1990s and 2000s now drive the future projections.

FIGURE 9. CONFIDENCE INTERVALS FOR 1ST DIFFERENCE LOG-LOG SEPTEMBER 2014 VMT FORECAST MODEL



STATEWIDE VMT FORECAST COMPARED TO STATEWIDE FUEL CONSUMPTION

In comparing the September 2014 VMT forecast to the fuel consumption forecast even though the two econometric forecast models are separate and distinct, the results are quite similar. In a very simplistic world, one should expect that as VMT increases, fuel consumption should increase and as VMT decreases, fuel consumption should decrease. This is not always the case and the magnitude of the movement of VMT and fuel consumption is not always consistent. For example in FY 2008, VMT fell by -0.76% while overall fuel consumption grew by 1.9%. In FY 2011, VMT grew by 0.5% while total fuel consumption grew by 1.6%.

Once a separate VMT model was developed in 2010, the forecast model results, between the two statistics, were no longer connected. Shortly after the VMT model was developed in 2010, the Forecast Council developed new fuel consumption models using first differencing log-log regression models and truncated history. The revised November 2010 fuel consumption forecast models produced very flat gas consumption with declines in the long-term and diesel consumption forecasts had positive growth rates but they were higher growth rates in the near-term and got slower in the long-term. Before the 2014 VMT model revisions, the VMT projections showed steady upward growth, while the gas consumption model showed flat, then declining growth. Now, although the two models are independent of each other, they show similar trends of low short term growth, then a year over year decline in the long-term. This

consistency between the two forecasts makes sense that the factors causing us to have slower VMT would be the same factors which cause individuals to use less gasoline each year.

Appendix A

September 2014 Vehicle Miles Travelled Forecast - Total and Light Duty Vehicles

Fiscal Year	Total VMT (Billion Miles)	% Change Total VMT	Light Duty VMT (Billion Miles)
2000	53.32		47.33
2001	53.83	1.0%	47.78
2002	54.20	0.7%	48.11
2003	54.89	1.3%	48.72
2004	55.33	0.8%	49.12
2005	55.59	0.5%	49.26
2006	55.99	0.7%	49.54
2007	56.74	1.3%	50.05
2008	56.31	-0.8%	49.75
2009	56.01	-0.5%	49.55
2010	56.81	1.4%	50.26
2011	57.08	0.5%	50.56
2012	56.79	-0.5%	50.36
2013	56.90	0.2%	51.07
2014	57.07	0.3%	51.23
2015	57.19	0.2%	51.33
2016	57.31	0.2%	51.44
2017	57.40	0.2%	51.52
2018	57.47	0.1%	51.58
2019	58.34	1.5%	52.36
2020	58.32	0.0%	52.35
2021	58.25	-0.1%	52.28
2022	58.15	-0.2%	52.19
2023	58.02	-0.2%	52.07
2024	57.86	-0.3%	51.93
2025	57.67	-0.3%	51.76
2026	57.48	-0.3%	51.59
2027	57.28	-0.3%	51.41
2028	57.07	-0.4%	51.22
2029	56.86	-0.4%	51.03
2030	56.63	-0.4%	50.83
2031	56.39	-0.4%	50.61
2032	56.17	-0.4%	50.42
2033	55.92	-0.5%	50.19
2034	55.66	-0.5%	49.95
2035	55.38	-0.5%	49.71
2036	55.10	-0.5%	49.45
2037	54.80	-0.5%	49.19
2038	54.50	-0.6%	48.92
2039	54.19	-0.6%	48.63
2040	53.86	-0.6%	48.34

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