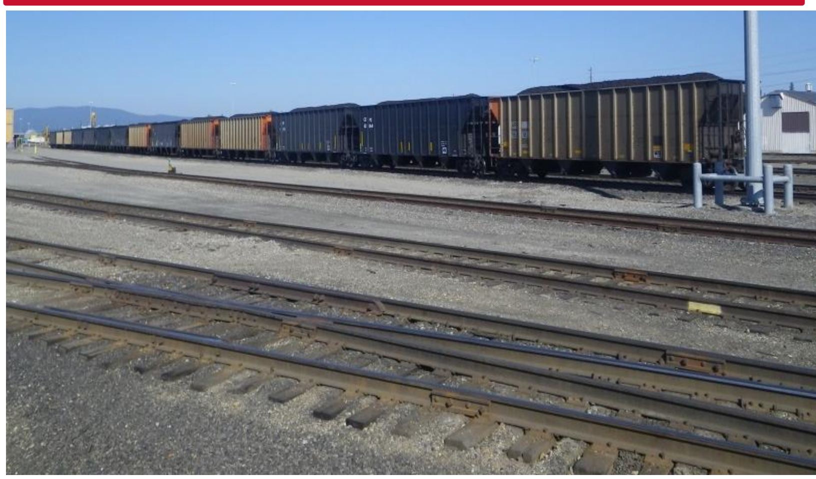


Task 7 - Technical Appendix: Freight Model Documentation

FMATS Freight Mobility Plan

Prepared for: DOT&PF, FMATS
Prepared by: HDR
October 2016

Fairbanks, Alaska

1 Table of Contents

Tables

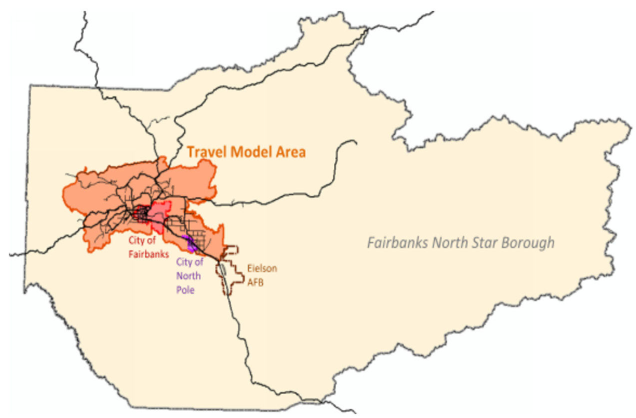
Figures

1 Introduction

The Fairbanks Metropolitan Area Transportation System (FMATS) and the Alaska Department of Transportation and Public Facilities (DOT&PF) are working together to develop the Fairbanks Freight Mobility Plan (FMP). The FMP is designed to further address freight mobility needs and to strengthen the freight policies recommended in the FMATS Metropolitan Transportation Plan (MTP), looking forward to 2040.

The Fairbanks Regional Travel Demand Model (FMATS TDM) was developed and recently updated by FMATS to estimate existing and future passenger travel demand by morning (AM), afternoon (PM), and Off-peak periods. This model focused on passenger-trips using a conventional four-step modeling process – trip generation, trip distribution, mode choice, and trip assignment. This modeling system covers the incorporated areas of Fairbanks and North Pole, and a portion of the Fairbanks North Star Borough, shown in Figure 1-1.

Figure 1.1 – Freight Model Area



Source: Fairbanks Model Documentation, February 2016

In support of the FMP, a standalone freight model (referred to as the FMATS Freight Model) was developed to support the freight planning process, and in particular, to assess freight travel demand, bottlenecks, and operations using the Federal Highway Administration (FHWA) sponsored Quick Response Freight Manual II (QRFM II) techniques and procedures. The FMATS Freight Model was developed to identify existing freight movements in the region as well as future freight movements and trends in the region for 2035 and 2040. This model will also be used to support the evaluation of future conditions and assessment of the region's capacity to meet future demand (Task 7) and the identification and characterization of freight corridors and freight development zones (Task 8).

2 Model Development

A sketch planning freight travel demand model was developed to represent the FMATS region using the FHWA Quick Response Freight Manual II (QRFM II)[1]. Existing and future transportation network, zonal, socioeconomic, and general travel pattern data from the FMATS TDM were used as key inputs in the development of the FMATS Freight Model. These data, in combination with QRFM II truck trip generation, trip distribution, trip assignment techniques, and truck classification counts identified throughout the regional transportation network, were used to develop and validate the existing FMATS Freight Model. In combination with future socioeconomic and transportation network already identified by FMATS for 2040 conditions, the core modeling components of the FMATS Freight Model will also be used to develop future 2035 and 2040 freight forecast fro the region. Key modeling features are presented below.

2.1 Roadway Network

The FMATS Freight Model used the existing (2014) roadway network from the FMATS TDM to represent current roadway characteristics. Major roadway network attributes included roadway (e.g., link) length, functional classification, and number of lanes by direction, posted speed, area type, auxiliary lanes, and center turn lanes. The intersection and zonal connector (e.g., node) layer contained in the FMATS Freight Model are consistent with the network and Traffic Analysis Zone (TAZ) system contained in the FMATS TDM. Free flow travel times were calculated using the link-length and posted speed limits in the network. Capacities for each roadway were determined based on the functional classification, area, and terrain types contained in the FMATS TDM networks.

2.2 Traffic Analysis Zone

The FMATS Freight Model area is comprised of 465 Traffic Analysis Zones (TAZs), consistent with the FMATS TDM. Inter-regional through travel to and from the FMATS TDM/Freight Model study area was represented by six gateway zones at major road crossings of the model boundary.

2.3 Socioeconomic Data

The FMATS TDM existing condition socioeconomic data was used to develop the QRFM II model components of the FMATS Freight Model, including population and employment data by TAZ. This data was used to generate freight trips in the region. Socioeconomic data outside of the modeling area were represented by available freight counts located on gateway roadways at the region’s boundary.

2.4 Trip Generation

Truck trips were generated in the FMATS Freight Model by TAZ using trip generation rates based QRFM II procedures using household and employment by industry data. Table 2-1 shows the truck trip generation rates adapted from the QRFM II for use in this model.

[1] Quick Response Freight Manual II, U.S. Department of Transportation Federal Highway Administration, 2007

Table 2.1 - Truck Trip Generation Rates

Generator	Single Unit Truck (6+ Tires) FHWA Classes 5 thru 7	Multi-Unit Truck FHWA Classes 8 thru 13
Industrial (trips/employee)	0.242	0.104
Retail (trips/employee)	0.253	0.065
Office (trips/employee)	0.068	0.009
Households (trips/household)	0.099	0.038
Source: Table 4.1, FHWA Quick Response Freight Manual II, 2007		

The FMATS TDM was structured to categorize employment into different types including retail, medical, education, service, government, military, other, and student. QRFM II procedures contain trip generation rates available for only four categories- industrial, retail, office and households which are comparable to FMATS TDM employment categories. The FMATS TDM employment categories were grouped together to match QRFM II trip generators. For example, the employment categories of 'Other' and 'Military' related trips were assumed as 'Industrial' in the FMATS Freight Model, QRFM II procedures. The FMATS TDM employment types related to 'Service', 'Government', 'Medical', and 'Education' were categorized into 'Office' while calculating the freight trips. The trips generated by single and multi-unit truck types were aggregated as 'truck' trips. The employment types of 'Retail' and 'Households' were used from the FMATS TDM socioeconomic dataset without any change to calculate the number of truck trips because these two categories were consistent in the QRFM II procedures and the FMATS model.

The truck trips at gateway locations into and out of the region were split into productions and attractions by single and multi-unit truck types and added to the generated trips computed from QRFM II. The FMATS Freight Model trips by productions and attractions were balanced. In the majority of travel demand modeling systems, trip productions are generally considered a better predictor of travel behavior than trip attractions, therefore trip productions are typically held constant and trip attractions are adjusted to meet the trip productions during this balancing step. The FMATS Freight Model was used to estimate about 14,000 daily truck trips within the modeling area including through trips between the external gateways.

Limited truck count data by roadway functional classification were available within the modeling area. Additional local data and/or surveys summarizing truck trips in the region were not conducted and available for use in model development. The total number of truck trips generated from QRFM II was calibrated using the "Origin-Destination Matrix Estimation" (ODME) technique, a built-in algorithm in the TransCAD modeling software (this software is used to apply both the FMATS Model and FMATS Freight Model). Regional and state agencies without specific available data often use ODME procedures to estimate or simulate passenger and freight trip tables. ODME procedures are commonly used by agencies in circumstances with limited available data. Available truck counts for regional roadways were used to develop the ODME trips. ODME produces rough estimates of the total trips within the model area. The ODME results show a rough estimate of about 20,000 daily truck trips which is about 30-percent higher than the QRFM II estimated trips. Limited truck count data is likely the contributing factor of this large variation.

2.5 Trip Distribution

QRFM II gravity (e.g., distribution) procedures were used to estimate truck trips between TAZs based on the truck trip productions and attractions developed in the previous step. The transportation network was used to provide travel distance impedances in the FMATS Freight Model to identify truck destination choices. Intrazonal travel times were used to represent the average travel time for trucks trips that remained or travelled within one particular TAZ. The FMATS Freight Model estimated intrazonal times as 50 percent of the travel time to the nearest adjacent TAZ. An average truck trip length of 10 miles was calculated from the model results. Truck survey data is not available to provide a direct comparison between the observed and calculated truck trip lengths. However, comparing the size of the model area, 10-mile trip lengths appear reasonable as trucks conduct both short- and long-distance deliveries.

2.6 Trip Assignment

The FMATS Freight Model "User Equilibrium" traffic assignment procedure within the TransCAD modeling software was used to assign the distributed (e.g., output from the previous trip distribution step) truck trips to the FMATS roadway network. Daily truck flows were estimated and assigned to the network using this assignment procedure. The equilibrium assignment method is intended to account for congestion and delay to assign vehicles (cars and trucks) to the roadways that provide the fastest travel times from origin to destination within the network. The FMATS Freight Model was set for a maximum of 50 iterations for the trip assignment, with the model often reaching equilibrium with fewer than 50 iterations. The relationship of congested speed and Volume to Capacity Ratio (VC) was defined using the Bureau of Public Roads (BPR) formula already being used in the FMATS TDM with the same set of values of Alpha and Beta. No feedback loops were built into the FMATS Freight Model. Feedback loops help to reroute the traffic based on congested travel time. The FMATS Freight Model is a stand alone model, estimating truck trips without passenger autos. Congestion becomes critical when traffic volume exceeds the overall roadway capacity. Congestion is not an issue in this truck-only model, hence, the feedback loop was not used.

3 Validation and Reasonableness Checking

The purpose of existing model validation and reasonableness checking is to confirm the ability of the FMATS Freight Model to replicate existing travel demand conditions and to also better predict future truck movements and travel behavior by comparing its predictions to independent observations. The FHWA Travel Model Validation and Reasonableness Checking Manual, Second Edition (2010) and the Ohio Department of Transportation's Ohio Certified Traffic Manual (2007), are the two main references used in the FMATS Freight Model validation process. Validation and reasonableness checks were used to assess each model component and compare its prediction to observed behavior.

3.1 Truck Counts

While Fairbanks has a limited number of historical truck counts available for truck modeling, the FMATS Freight Model was validated using 2014 truck counts. There were 103 roadway locations in the FMATS transportation network in which vehicle classification counts (including trucks) was reported in the Alaska HPMS (2014). Alaska Annual Traffic Report summarized daily truck counts by the percentage of annual average daily vehicles at the key locations[2]. This section provides a comparison of model predicted traffic volumes with observed truck counts.

3.2 Truck Volumes

Existing (2014) daily truck volumes assigned in the FMATS Freight Model using QRFM II procedures is presented in Table 3-1, including the percentage of daily truck volumes by roadway. College Road, Steese Expressway, Airport Way, Peger Road, Richardson Highway, Parks Highway, and Johansen Expressway carry between 13,000 and 25,000 daily traffic movements, the most heavily traveled corridors in the region. Many of these corridors carry the highest percentages and number of trucks in the region as well. These regional and local highways included:

- Richardson Highway at 3 Mile (8% trucks / 1,991 trucks – based on 2011 data);
- Steese Expressway north of Farmers Loop Road (13% trucks / 1,793 trucks);
- Johansen Expressway east of University Avenue (5% trucks / 1,005 trucks – based on 2013 data);
- Parks Highway west of Lathrop Street (7% trucks / 936 trucks); and
- Parks Highway at Chena Bridge (6 trucks / 927 trucks – based on 2011 data).

While several regional and local roadways also carry high percentages of truck traffic, this does not translate to high truck volumes due to the relatively low totals of overall traffic on these facilities. These roadways include Old Steese Highway north of Hagelbarger Road (24% trucks / 326 trucks), Anderson Road west of Airport Road (23% trucks / 38 trucks), and Richardson Highway south of Eielson AFB Access Road (14% trucks / 318 trucks). Daily truck volume estimates generated by the FMATS Freight Model were compared at these key locations for reasonableness. The estimated number of truck volumes are within zero-percent of actual truck counts at the key locations; highly reasonable results.

The truck percentage was calculated to the AADT (2014) for all 103 locations where data is available. Actual truck percentages were compared to the estimated trucks by QRFM II procedures reflected in the FMATS Freight Model. It shows both actual truck counts and QRFM II estimated truck percentages are about 7-

[2] Alaska Annual Traffic Report 2013 thru 2014, Alaska DOT&PF, 2015

percent to 2014 AADT, suggesting that there are limited variations of truck percentages between truck counts and modeled estimated truck percentages.

Table 3.1 - Daily Traffic Volumes and Truck Percentages at Key Locations, 2014

Location	2014 Average Daily Traffic	2014 Truck %- Daily Trucks	Daily Observed Trucks	Daily Model Truck Flow	%-Difference
10th Avenue West of Steese Expressway	2,980	8%	239	294	(23%)
College Road at Bentley Mall	13,249	3%	397	399	(1%)
Old Steese North of Hagelbarger Rd	1,355	24%	325	215	34%
Farmers Loop Road West of Steese Expressway	6,625	3%	199	243	(22%)
Steese Expressway North of Trainor Gate Rd	22,375	8%	1,791	1,942	(8%)
Steese Expressway North of Farmers Loop Rd	13,785	13%	1,792	1,671	7%
Anderson Road West of Airport Rd	165	23%	36	N/A[3]	N/A
Airport Way West of Steese Expressway	16,183	4%	647	646	(0%)
Peger Road at Chena Bridge	14,323	7%	1,002	732	27%
Cushman Street North of Chena Bridge[1]	7,067	4%	283	214	24%
Phillips Field Road at Railroad Tracks	5,120	7%	209	376	(5%)
Barnette Street North of Chena Bridge	6,960	3%	209	230	(10%)
Richardson Highway South of Eielson AFB Access Rd	2,270	14%	318	N/A[3]	N/A
Richardson Highway at Moose Creek[2]	7,373	12%	908	936	(3%)
Richardson Highway at 3 Mile[2]	24,885	10%	2,611	2903	(11%)
Parks Highway West of Lathrop St	13,367	7%	936	883	6%
Parks Highway at Chena Bridge[2]	15,445	9%	1,429	1399	2%
Johansen Expressway E of University Ave[2]	20,104	6%	1,145	1387	(21%)
OVERALL	**191,196[4]**	**7%**	**14,122**	**14,470**	**0%**

[1] Converted to one way in 2013; [2] Numbers are reported in HPMS 2014; [3]Not a model network;
[4]Number excludes volumes not in the model network

3.3 Cutline Validation

Cutlines (often referred to as screenlines) provide a comparison of modeled volumes to observed traffic or truck counts along a corridor containing multiple roadways. Figure 3-1 shows the cutline locations used in this analysis in the region. Table 3-2 shows a comparison of modeled truck volumes and observed truck counts for roadways crossing each cutline. This table shows, that for all cutlines, the difference between the estimated and observed traffic is within the cutline validation guidelines outlined by FHWA as shown in Figure 3-2.

Figure 3.1 – FMATS Freight Model Cutline Locations

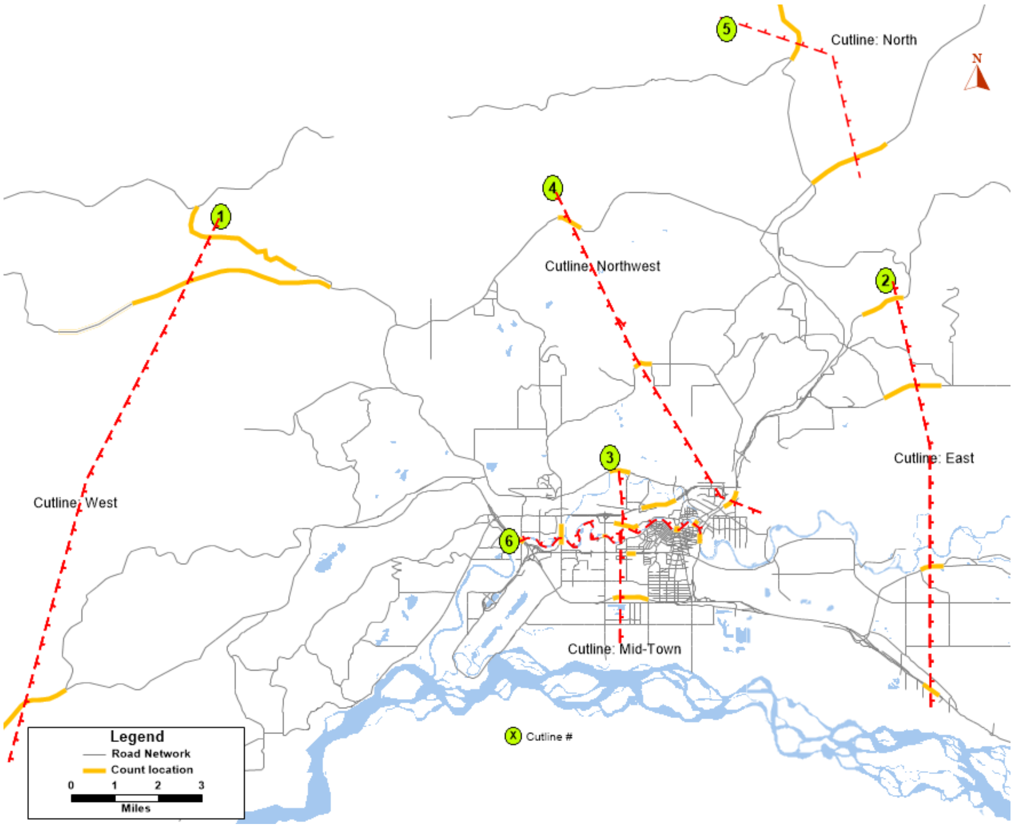
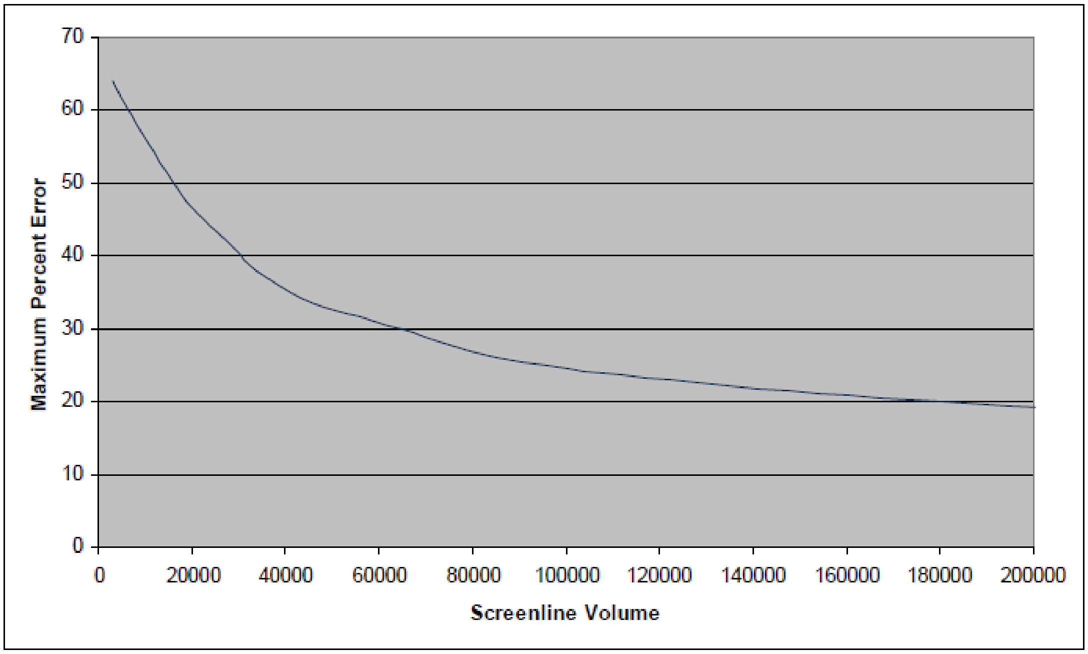


Table 3.2 - Cutline Summary

Cutline	# Record	Truck Count	Model Flow	Flow/ Count	Difference	% Difference	Max Desirable Deviation	Within Target
1-West	3	257	304	1.18	47	18%	61%	Yes
2-East	4	2,087	2,679	1.28	592	28%	61%	Yes
3-Mid Town	4	3,093	2,880	0.93	213	7%	61%	Yes
4-Northwest	3	1,311	1,898	0.91	118	9%	61%	Yes
5-North	2	586	672	1.15	86	15%	61%	Yes
6-Chena River	7	6,333	5,173	0.82	1,160	18%	61%	Yes
OVERALL	**23**	**13,667**	**13,606**	**1.00**	**61**	**0%**	**55%**	**Yes**

Source: HDR, September 2016

Figure 3.2 – Cutline Validation Guidelines

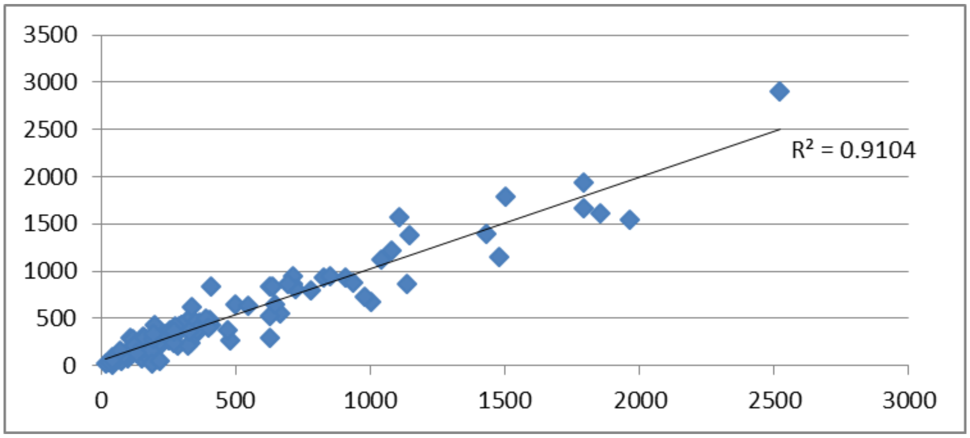


Source: Calibration and Adjustment of System Planning Models, FHWA, December 1990.

3.4 Trip Assignment Scatterplots

Pearson's product-moment correlation coefficient (R) is a standard statistical measure that reflects the extent of a linear relationship between two datasets. The coefficient of determination R-Square is generally interpreted as the proportion of the variance of a dependent variable attributable to variance of an independent variable. Scatterplots of modeled truck volumes versus observed truck counts, used together with R-Square summaries, were used to support the FMATS Freight Model validation. While there are no hard and fast guidelines for R-Square, values closer to 1 are better. Figure 3-3 shows a scatterplot comparing the modeled daily truck volumes compared to observed truck counts. With modeled volumes varying slightly from observed counts in addition to the high R-Square value, this indicates that the FMATS Freight Model is performing very well. The scatterplot shows modeled truck volumes correspond very well to observed truck volumes, which is reflected by a high R-Square of 0.91.

Figure 3.3 – Cutline Validation Guidelines, Scatterplot and R Squared Results



3.5 Percent Root Mean Squared Error

The Percent Root Mean Squared Error (RMSE) measures the accuracy of the trip assignment showing the average error between the truck counts and modeled truck volumes on roadways with observed counts. Percent RMSE is summarized by roadway volume group. The Ohio Certified Traffic Manual identifies acceptable ranges of percent RMSE by directional roadway (or link) truck volume group. The Ohio percent RMSE targets by group are shown in Figure 3-4. Table 3-3 shows the percent RMSE for the FMATS Freight Model truck assignment. It shows that modeled truck volumes are within acceptable ranges of the observed truck counts. The percent RMSE for trucks is 32.

Figure 3.4 – Percent RMSE Analysis for the FMATS Freight Model

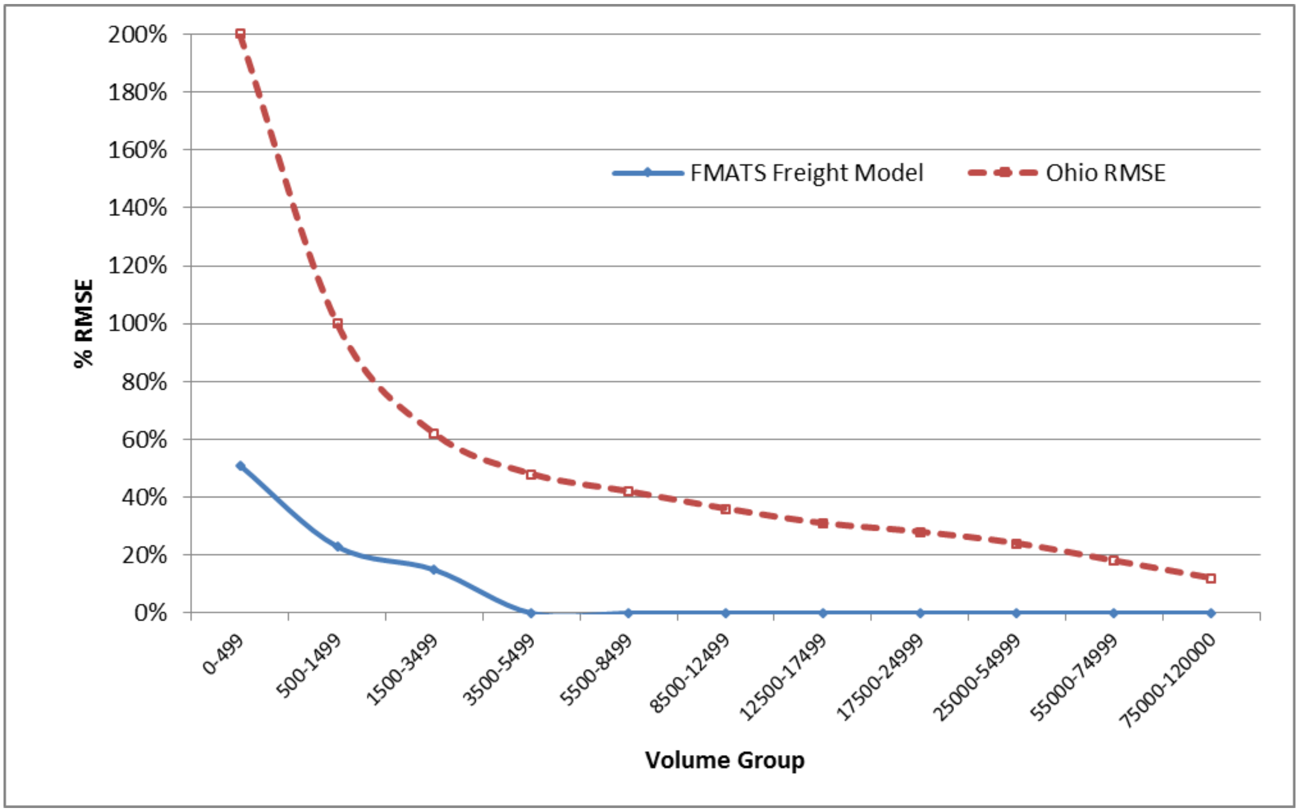


Table 3.3 - Percent RMSE by Truck Volume Group in the FMATS Freight Model

Group	# Record	Truck Counts	Model Truck Volumes	Modeled Volumes/ Counts	% Difference	Max Desirable Deviation	Within Target	RMSE
0-499	71	15,499	18,759	1.21	21%	200%	YES	49
500-1499	26	22,411	23,054	1.03	3%	100%	YES	26
1500-3499	6	11,424	11,471	1.00	0%	62%	YES	14
OVERALL	**103**	**49,334**	**53,284**	1.08	**8%**	**N/A**	**N/A**	**32**
Source: HDR, September 2016								

3.6 Summary and Conclusions

The FMATS Freight Model validation and reasonableness checking measures indicate that the model is satisfactorily predicting observed truck volumes. The model is certainly suitable for use in the Freight Mobility Plan, which is focused on identifying the future freight demand and mobility in the region. The model can also be used for other purposes such as evaluating the impacts of growth in a particular freight activity area. This model also can be used to evaluate freight growth scenarios as well as identify transportation deficiencies related to increased truck traffic. Currently, the FMATS TDM estimates auto-travel patterns which can be enhanced with this FMATS Freight Model to capture the impact of future growth of auto and trucks.

3.7 Limitations

The sketch planning freight model is a simplified trucks model based on FHWA's QRFM II procedures using a limited set of observed data. Survey data identifying truck's origin and destinations with average trip lengths, more complete/additional vehicle classification counts, detailed commodity flow information by different industries. Truck travel behavior could be collected and used to update this model to enhance its sophistication for policy analysis. QRFM II provides the procedures used to develop this standalone FMATS Freight Model without the auto-component. Building into the FMATS TDM this freight modeling system (with future enhancements) would provide FMATS with a comprehensive travel demand model consisting of auto and trucks would support more detailed policy and planning analysis if developed.

3.8 Next Step

The FMATS Freight Model will be used to estimate future number of trucks to both 2035 and 2040 and support the development of future freight conditions in the region, and support the development of project alternatives for the region through later tasks in the FMATS FMP.

4 References

Alaska Department of Transportation and Public Facilities (DOT&PF)

2015 Annual Traffic Volume Report 2012 thru 2014. Available on the internet at: http://dot.alaska.gov/stwdplng/transdata/pub/Regional_Traffic_Reports/trafficdata_reports_nor/NR_2014_Traffic_Volume_Report.pdf

2014 Annual Average Daily Traffic (AADT) GIS Map. Available on the internet at: http://dot.alaska.gov/stwdplng/transdata/traffic_AADT_map.shtml

2014 Highway Performance Monitoring System (HPMS). Available on the internet at: http://dot.alaska.gov/stwdplng/transdata/traffic_hpms.shtml

Beagan, D., Fischer, M., & Kuppam, A.

2007 Quick Response Freight Manual II. Washington, D.C.: Federal Highway Administration.

Erhardt, G., Freedman, J., Stryker, A., Fujioka, H., & Anderson, R.

2007 Ohio Long-Distance Travel Model. Transportation Research Record; Journal of the Transportation Research Board No. 2003 , 130-138.

Federal Highway Administration

2010 Travel Model Validation and Reasonability Checking Manual Second Edition

Kittelson & Associates, Inc.

2016 Fairbanks Regional Travel Demand Model Documentation, February