Georgia Department of Transportation (GDOT) Statewide Travel Model Peer Review Report

September 2012

TMIP

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U.S. Department of Transportation
Federal Highway Administration

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1.0 Introduction

1.1 Disclaimer

The views expressed in this document[1] do not represent the opinions of the Federal Highway Administration (FHWA) and do not constitute an endorsement, recommendation or specification by FHWA. The document is based solely on the discussions that took place during the peer review meeting sessions and supporting technical documentation provided by Georgia Department of Transportation (GDOT). The GDOT peer review was convened as one 2.5-hour online virtual meeting held on August 3, 2012 and one in-person 8-hour meeting held at the GDOT headquarters on **September 5, 2012**.

1.2 Acknowledgements

FHWA wishes to acknowledge and thank the peer review panel members for volunteering their time to participate in the peer review of the GDOT Statewide Travel Demand Model and for sharing their valuable experience.

The Peer Review Panel Members were:

- Vidya Mysore, Systems Traffic Modeling Manager at Florida DOT
- Karen Faussett, State Model Specialist at Michigan DOT
- Stephen Lawe, Chief Executive Officer at Resource Systems Group Inc. (RSG)
- Keith Killough, Director of Transportation Analysis at Arizona DOT
- Guy Rousseau, Travel Surveys and Transportation Model Development Manager at the Atlanta Regional Commission (ARC)

Brief biographies for each of the peer review panel members are presented in Appendix C.

1.3 Report Purpose

This report summarizes the results of a peer review of the GDOT travel model with a focus on recommendations for GDOT. The peer review was supported by the Travel Model Improvement Program (TMIP), which is sponsored by FHWA. The peer review of a travel model can serve multiple purposes, including identification of model deficiencies, recommendations for model enhancements, and guidance on model applications. Given the increasing complexities of travel demand forecasting practice and the growing demands by decision-makers for information about policy alternatives, it is essential that travel forecasting practitioners have the opportunity to share experiences and insights. The TMIP Peer Review Program provides a forum for this knowledge exchange.

GDOT's overall goal for model improvement and motivation for seeking a TMIP peer review is to continuously maintain and apply a model that is representative of the state of the practice in travel demand forecasting and equips the agency with the support that is needed for informed decision making in the state. To that end, the peer reviewers spent one day responding to specific questions from GDOT and its planning partners. The results of that discussion and recommendations from the panel are presented in this report.

[1] The report was finalized in May 2013.

1.4 Report Organization

This report is organized into the following sections:

- *Georgia Department of Transportation* – an introduction to the demographics, land use and transportation characteristics of the state, GDOT's planning responsibilities, and their goals for the peer review.
- *Development of the GSTDM* – provides a historical context of travel modeling at GDOT, including previous model development efforts and GDOT's current model improvement efforts.
- *Model Improvement Plan* – provides a brief summary of the plans to update the GSTDM with regard to data collection and modeling priorities.
- *Topics of Interest to GDOT* – detailed descriptions of the GSTDM and highlighted topics for the peer review panel's review.
- *Peer Review Panel Response to Technical Questions* – provides a detailed synopsis of the panel's analysis and recommendations.
- *Panel Discussion and Recommendations* – provides a general summary of the peer review panel's recommendations to GDOT, including prioritized next steps.

In addition, the report includes four appendices:

- *Appendix A* – list of peer review participants
- *Appendix B* – peer review meeting agenda
- *Appendix C* – biographies for each of the peer review panel members
- *Appendix D* – summary of the current GSTDM
- *Appendix E* – summary of GDOT response and activity following the peer review

2.0 Georgia Department of Transportation Overview

2.1 Georgia Department of Transportation Responsibilities

GDOT was created in 1972 to plan, construct, maintain, and improve Georgia's roads and bridges. GDOT provides planning and financial support for other modes of transportation, including mass transit and airports. GDOT also facilitates administrative support to the State Road and Tollway Authority and the Georgia Rail Passenger Authority.

A majority of GDOT's resources are directed toward maintaining and improving the State's network of roads and bridges including the development of the GDOT Statewide Travel Demand Model (GSTDM). The GSTDM is an objective, analytical tool developed to assist in transportation policy making and infrastructure investment decisions, as well as aid in long-range planning. The model can be used to analyze the impact of modal diversion between people and goods, aid in the identification of changes in land use and socioeconomics, and determine alternative modes of personal travel. GSTDM also includes a freight component to assess commodity flows.

The GSTDM is designed for application in a variety of transportation planning studies and projects, including testing of project alternatives, preparing updates to Statewide long-range transportation plans, and assessing the impact of large scale corridor improvements such as interstate widening, corridor toll system analysis, construction of new facilities, and improvements to existing facilities. Additional policy-level uses include freight diversion analysis between truck and rail, intercity passenger rail ridership forecast development, and high speed rail alternative analysis.

Due to the representation of network and other spatial detail, localized transportation improvements such as intersection improvements and turn lanes analysis cannot be evaluated by the GSTDM. Therefore, the GSTDM is not intended to be used within Metropolitan Planning Organization (MPO) modeling areas. However, the GSTDM may be beneficial to MPOs in the update of individual MPO travel demand models through the provision of external and pass-through travel information.

2.2 Regional Characteristics

Georgia contains one-hundred fifty-nine (159) counties and fifteen (15) metropolitan planning organizations (MPOs). As mentioned above, the State has experienced substantial growth that has overextended the transportation system. Between 1980 and 2012, the US Census Bureau reports a population growth of 81.6 percent. Population growth over each decade is provided in Table 1.

Table 1: Georgia State Population Growth: 1980 - 2012[2]

Year	Population	Growth from Previous Year Listed
1980	5,463,105	N/A
1990	6,478,216	18.6%
2000	8,186,453	26.4%
2010	9,687,663	18.3%
2012 (Estimate)	9,919,945	2.4%%

[2] United States Census Bureau. http://www.census.gov/

According to the 2007-2011 American Community Survey (ACS) Five-Year Estimates Georgia has a civilian labor force of 4.29 million with a median state income of $49,736. Table 2 summarizes the commute-to-work mode distribution, as reported by the ACS.

Table 2: Commute-to-Work Mode Distribution for the State of Georgia[3]

Mode	Percent
Car, Truck, or Van – Drive Alone	78.8%
Car, Truck, or Van – Carpool	11.1%
Public Transportation (Excluding Taxi)	2.2%
Walk	1.6%
Other Means	1.7%
Work at Home	4.6%

The State of Georgia has an area of just under 59,420 square miles. Interstate-75 facilitates north-south movement for the entire state, while Interstate-95 provides north-south travel for the eastern portion of the state. Interstate-16 and Interstate-20 provide west-east connections across the State, while Intertate-85 connects the southwest and northeast. Interstate-185, Interstate-475, Interstate-575, and Interstate-985 provide shorter highway segments, while Interstate-285 functions as a Beltway around the City of Atlanta.

Georgia hosts Hartsfield-Jackson International Airport, one of the busiest airports in the world with a total of 44,414,121 enplanements in the 2011 calendar year, the number one rank in the United States.[4] Hartsfield-Jackson International Airport also ranked thirteen (13) in national all-cargo weight with a total of 2,655,614,700 pounds of landed cargo weight.[5] In addition to Hartsfield-Jackson International, there are eight other significant commercial airports within the State.

Two deep water seaports are located in Georgia, the Port of Brunswick and the Port of Savannah. Port Bainbridge on the Apalachicola River and Port Columbus on the Chattahoochee River are smaller ports within the State.

3 2007-2011 American Community Survey 5-Year Estimates. American Fact Finder. http://factfinder2.census.gov

4 Federal Aviation Administration Calendar Year 2011 Passenger Boarding Data. http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/media/cy11_primary_enplanements.pdf

5 Federal Aviation Administration Calendar Year 2011 All-Cargo Data. http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/media/cy11_cargo.pdf

3.0 Development of the Georgia Department of Transportation GSTDM

3.1 Introduction

This section of the report provides an overview of the development of the GSTDM, including a history of the model, a description of the model's components and functionality prior to the peer review, and a list of items to accomplish through the peer review.

3.2 History of GSTDM

The population of Georgia grew by fifty percent (50%) between 1990 and 2010 and eighteen (18%) between 2000 and 2010. The increasing population has placed a strain on the transportation network to a momentous degree, and the Office of Planning at GDOT is tasked with providing the best technical information available to policy makers to address the growing transportation needs.

The GSTDM is the first truly functioning model for the State of Georgia. The model was built by GDOT's consultant, Atkins, in 2010 with a base year of 2006. The GSTDM has been applied to a variety of major Statewide and corridor studies, including the:

- Freight and Logistics Plan[6],
- Connect Central Georgia Study[7],
- I-75 North Corridor Study[8],
- Atlanta-Athens Connectivity and Mobility Study[9], and
- Dahlonega/SR 52 Subarea Study[10].

3.3 Current GSTDM

The development of the GSTDM was completed in late 2010 after one year of development. The validated base year is 2006, and the model has three future years: 2020, 2040, and 2060. The base year was established as 2006 due to data availability. GDOT is preparing the model for an update to base year 2010.

The model includes two sub-level models: freight and passenger. Both sub-models exercise the four-step modeling process, including trip generation, trip distribution, mode choice, and traffic assignment. Both models run each step independently, with the exception of traffic assignment which assigns truck and auto passenger vehicles collectively to reflect congested highway conditions.

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[6] Final report may be accessed via: http://www.dot.ga.gov/informationcenter/programs/georgiafreight/logisticsplan/Documents/Plan/GAFreightLogistics-FinalReport-Task5.pdf

[7] Project website may be accessed via: http://www.dot.ga.gov/informationcenter/programs/studies/Pages/ConnectCentralGeorgia.aspx

[8] Project website may be accessed via: http://www.dot.ga.gov/informationcenter/programs/studies/i75study/Pages/I75North.aspx

[9] Project website may be accessed via: http://www.dot.ga.gov/informationcenter/programs/studies/atlantaathens/Pages/default.aspx

[10] Final report may be accessed via: http://www.dot.ga.gov/informationcenter/programs/studies/Documents/DahlonegaSR52SubareaStudy/SR52_MMP_FinalReport.pdf

The primary estimation data source for the passenger model is the 2009 National Household Travel Survey (NHTS) including Georgia Add-On Data. The freight model utilizes Transearch data from Global Insights.

The GSTDM is able to perform the following analytical functions:

- Forecast intercity person and freight travel patterns;
- Calculate daily highway vehicle volumes on highways and interstates for both passenger and freight vehicles;
- Evaluate major land use and economic policy impacts on person and goods movements;
- Analyze major highway improvements outside MPO area limits, including major corridor improvements;
- Determine freight traffic shift between highway and rail;
- Evaluate general impacts of new rail-truck intermodal facilities; and
- Provide general intercity intermodal freight movements for rail-truck, truck-port-rail, public passenger airports, and ocean ports.

Appendix D contains specific details regarding the development, functionality, and validation of the GSTDM.

3.4 Georgia Department of Transportation Goals for Peer Review

The primary ambition for the GDOT modeling team's application for participation in the TMIP Peer Review Program was to obtain feedback prior to the 2010 model base year update. GDOT requested an expert review panel with hands-on statewide multi-modal model experience to provide constructive comments that would allow GDOT to improve the GSTDM and gain insight regarding the model's ability to inform policy-level issues. The GDOT modeling team's objective for the peer review meeting was to facilitate a venue through which the panel members could identify the limitations and deficiencies of the model and identify strategies for resolving any such limitations.

3.5 Previous Peer Reviews

The peer review Meeting convened in September of 2012 was the first peer review session conducted for GDOT regarding the Statewide Travel Demand Model.

4.0 Model Improvement Plan

GDOT is in the process of updating the model to a new 2010 base year. The effort is in its preliminary stages with data collection and network preparation as immediate priorities.

4.1 Data Collection Plan

In light of the availability of Decennial Census information, complete demographic and employment information sets will be available for inclusion in the 2010 update. Additionally, GDOT has acquired the Regional Economic Model (REMI) that will also be utilized for population and employment forecasting.

4.1 Georgia Department of Transportation Priorities for Model

GDOT's vision is to create a model that is proficient in the following areas:

- Analysis of the impacts of modal diversion between people and goods, major changes in land use and economic policies, and alternative modes of person travel
- Analysis of future transportation investment and strategy impacts

To achieve a model capable of these tasks, GDOT staff proposed a prioritized list of topics for the panel to consider, acknowledging both limited time and resources for new model development initiatives. This initial list, presented below, of GDOT identified priorities framed the peer review discussion, and the panel provided recommendations predominantly based on these agency stated priorities.

- Highest GDOT Priorities
    - Detailed assessment of model structure and organization
    - Review of data sources and suggestions for missing and/or additional sources
- Medium GDOT Priorities
    - Examination of assumptions and parameters for potential improvement
    - Analysis of the model's ability to address policy issues, both existing in the model and advisable for inclusion
- Lowest GDOT Priorities
    - Identification of performance-based issues that the model cannot currently answer in the context of MAP-21

GDOT requested an objective assessment of their modeling needs with respect to both the state of the practice and the modeling goals of the agency. GDOT sought advice for a systematic approach to conducting model enhancements and technical guidance to foster modeling processes that are able to address various policy and investment questions.

GDOT, along with its partner agencies, will critically assess the feedback from the peers when prioritizing its model development plan. While the advice of the peers is invaluable, there are many factors to work through when considering a model improvement strategy. Therefore the recommendations of the peers will be regarded as recommendations for GDOT and its partners to consider.

5.0 Topics of Interest to Georgia Department of Transportation

Prior to the peer review meeting, GDOT staff identified the following areas as focus for the meeting's discussion in its application to the peer review program and the pre-peer review meeting held virtually on August 3, 2012:

- Detailed assessment of the model's structure and organization;
- Review of data sources and identification of additional data for inclusion in the model;
- Integration with economic models;
- Examination of assumptions and parameters for potential improvement;
- Factors for analysis of rail and highway freight split, aside from cost;
- Inclusion of air freight;
- Incorporation of managed lanes;
- Guidance on current model functionality;
- Appropriate levels of integration with MPO models;
- Analysis of the model's ability to address policy issues, both existing in the model and advisable for inclusion;
- Identification of performance-based issues that the model cannot currently answer in the context of MAP-21; and
- Identification of possible model deficiencies.

5.1 Model Structure and Organization

One of GDOT's top priorities for the panel review was a detailed analysis of the model's structure and organization. The following section will provide further specifics with regard to the general modeling framework and potential topics for discussion.

5.1.1 Traffic Analysis Zone and Network Structures

The GSTDM includes a total of 1,715 Travel Analysis Zones (TAZs) located in Georgia, with boundaries determined by census tracts and major highways. Georgia's TAZs were created using census tracts and the highway network as a means for delineating boundaries. The model's TAZs extend to all forty-eight (48) contiguous states, with varying degrees of detail.

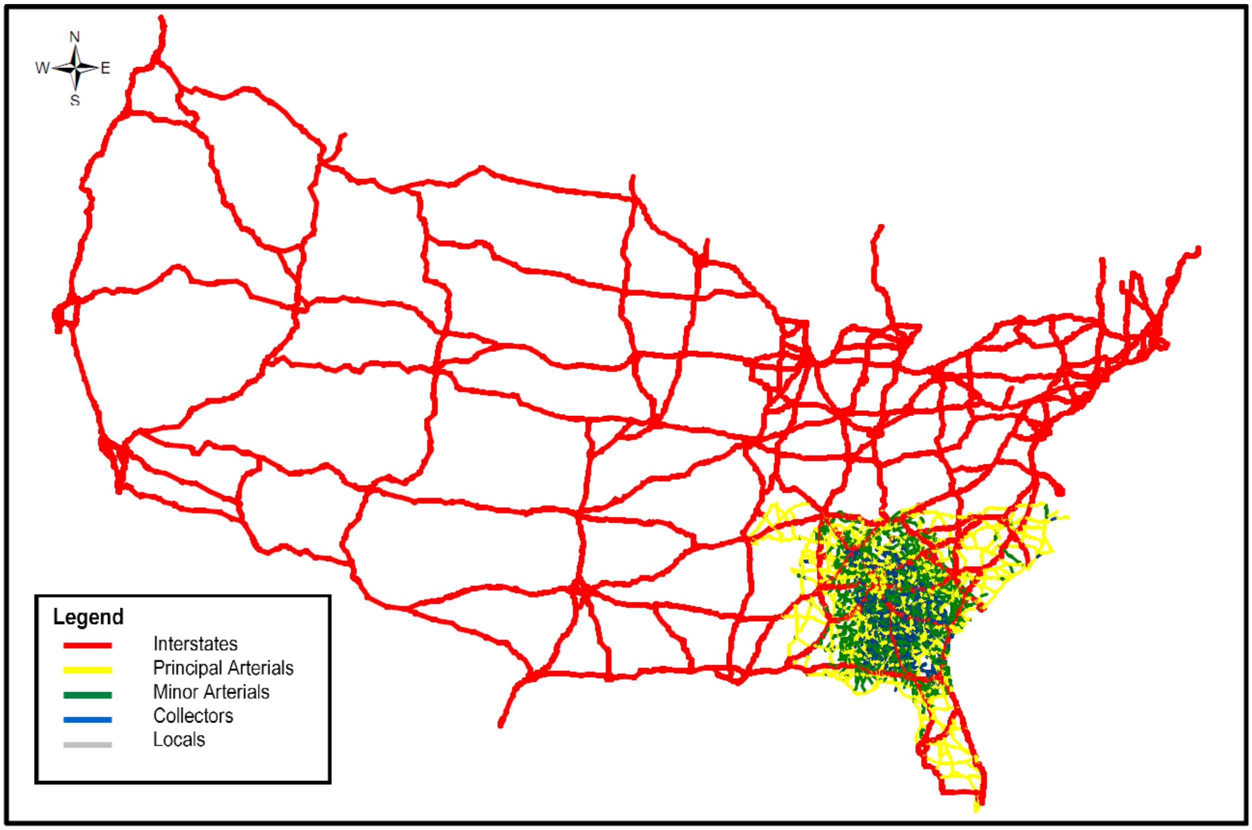
There are three (3) additional tiers of TAZs outside Georgia. Census tracts are used as boundaries for TAZs in counties immediately adjacent to Georgia Stateline boundaries. The next tier consists of states surrounding Georgia for which counties and regional planning councils (RPCs) are used as TAZ boundaries. In the final tier, state boundaries are used to demarcate TAZs. There are a total of 2,242 TAZs in the GSTDM. The freight model also utilizes the TAZ structure to analyze Transearch data at an aggregated level.

Similar to the TAZ structure, the level of detail in the highway network diminishes as the network expands from Georgia in three tiers. The GSTDM's highway network includes the following tiers:

(1) Interstates, major and minor arterials, and collectors within the State of Georgia;
(2) Network interstates and major and minor arterials extend in a 50-mile buffer outside the Georgia State border;
(3) Interstates and major arterials in the networks of Georgia's adjacent states; and
(4) Only interstates in the remaining forty-three (43) continental United States.

The network centerline mileage totals 18,589 within the State of Georgia alone and reaches 80,426 miles in total. The federal functional classification system is used in the highway network and comprised of twelve classes ranging from "rural interstate" to "urban local" roads. The model highway network is depicted in Figure 1 below.

Figure 1: GSTDM Base Year Highway Network by Functional Classification



The freight portion of the GSTDM includes highways, railroads, pipelines, and waterways on both a regional and national structure. The railway network has its finest level of detail within the State and decreases in detail the farther it reaches from Georgia.

5.1.2 General Model Structure

The GSTDM consists of two four-step models, one for freight and one for passenger travel, in which the generation, distribution, and mode choice steps run independently. Once the two separate models reach assignment, freight and passenger trips converge, proceed through a feedback loop, and undergo public transport assignment. The feedback loop is included within the passenger model to take congested travel times from highway assignment and feed those times back into the passenger model. It was incorporated in the model to ensure the model accurately reflects congestion in the highway network. The feedback loop is iterative and requires the mode choice model to run within each loop, causing the model run time to increase substantially. Therefore, a single mode split process was incorporated to replace the full mode choice process in intermediate feedback loops and reduce the model run time. Once the final iteration of the feedback loop concludes, a completed mode choice is run.

The passenger model is a trip-based model, while the freight model is commodity-based and later converted to annual tonnage flow to daily freight truck trips. The GSTDM represents average weekday daily traffic (AWDT) conditions. A single, 24-hour time period is applied to highway assignment. Daily congested time is a weighted average of peak and off-peak, or free flow, travel times with additional weight allocated to free flow times. The freight model does not include travel times in congestion for trip distribution. Freight applies a weighted average between congested and free-flow times during the assignment process.

5.1.3 Freight Model Structure

The freight model in the GSTDM employs the FHWA's Quick Freight Response Freight Manual method. The model includes employment classified by manufacturing sector employment types to specific production and consumption markets.

The freight model uses a linear regression analysis to determine productions and attractions for sixteen (16) commodity groups based on Transearch county-to-county commodity flows. A traditional gravity model, which uses distance as travel impedance, is used to distribute the annual tonnage flows by commodity type. The mode choice model uses a cost-based incremental logit model in which base year shares by mode for each commodity were developed from Transearch data. The mode shares then provide a base pivot point from which alternative shares are forecasted depending on mode costs as a result of system-wide change. The five modes for commodity flow include: truck, carload, intermodal (mode change between truck and rail), air, and water.

Annual tonnage flow is converted to daily freight truck trips using a payload factor obtained from VIUS 2002 data. The factor varies by commodity type and distance range, and it is assumed that there are three-hundred six (306) working days per year. Payload factors will be further discussed in Section 5.4.

5.1.4 Passenger Model Structure

The passenger mode choice model is a nested logit model that predicts shares between auto and public transport, which includes air, train, and high-speed rail. Mode choice is only applied to long distance trips and inter-city travel within Georgia. Assumed modal splits are then used for the calculation of internal-external, external-internal, and through trips.

The passenger model includes auto, conventional train, high speed rail, and air modes and uses a nested logit model application to calculate share between these modes. Only internal trips or trips with one trip end in Georgia are applied to the mode choice model. A single mode split with fixed auto passenger share, developed using 2009 NHTS and Georgia Add-on data (7,000 additional surveys), is applied to long distance internal-to-external trips, which are defined as trips made outside of the RPC regions. Air trips only include direct flight service for trips at least one-hundred (100) miles long. Conventional train and high speed rail trips only included inter city trips at least fifty (50) miles long.

Because the survey data from NHTS do not provide a sufficient sample to develop statewide coefficients, the logit model coefficients were borrowed from the "Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study." Mode constants were calibrated to match adjusted shares in the American Travel Survey. Data including Federal Aviation Administration (FAA) boarding data, AMTRAK boarding data, and the American Travel Survey were used to aid in the development of coefficients for long distance travel related to Georgia.

As described in Section 5.1.2, a feedback loop is included within the passenger model to take congested travel times from the highway assignment and feed the congestion back into the passenger model. Because the feedback loop is iterative, each time requiring the mode choice model to run, a single mode split process replaces the full mode choice process in intermediate feedback loops to reduce the model run time.

5.2 Data Sources

GDOT requested a thorough analysis of data sources and identification of additional sources for model inclusion. The sources in the current model are briefly summarized, as follows:

Socioeconomic Data:

- US Census – used for population and households.
- Bureau of Economic Analysis – used for county and state level employment totals. There are 19 employment types and 16 commodity groups.
- Georgia Department of Labor – used for employment distribution patterns at the sub-county level. Surrounding states used Census County Business Patterns data.

Transportation Network:

- National Highway Planning Network (NHPN) – includes 48 contiguous United States.
- Georgia Road Characteristics file – used to validate against NHPN for functional class and number of lanes.
- National Transportation Atlas database – used for rail part of the network.

Model Estimation Data:

- 2009 National Household Travel Survey (NHTS) and Georgia Add-On data – used for passenger model.
- Transearch commodity flow data – used for freight model.

Validation and Calibration Data:

- GDOT traffic count database.
- Vehicle Inventory and Use Survey (VIUS) – payload factor used for converting tonnage to freight truck trips.
- American Travel Survey – used for long distance travel validation.
- Federal Aviation Administration (FAA) airline origin and destination survey.
- AMTRAK boardings and operating and financial data.
- Transearch commodity flow data.
- 2009 National Household Travel Survey (NHTS) and Georgia Add-On data.

The following section outlines the data sources used in both the freight and passenger models in greater detail.

5.2.1 Socioeconomic Data

The GSTDM includes socioeconomic data from the US Census, including the Census County Business Pattern; the Bureau of Economic Analysis; and the Georgia Department of Labor. The US Census was used to determine population and households. The Bureau of Economic Analysis was used for county and state level employment totals, and the Georgia Department of Labor was utilized for employment distribution patterns at the sub-county level. The Census County Business Patterns data were used for employment distribution in states outside of Georgia.

Employment data are categorized into 19 aggregated types based on North American Industry Classification System (NAICS) employment classifications. Employment types are critical to the functions of the freight model because they create a relation between commodity production and consumption by industry sectors and provide detail with regard to various manufacturing sectors. The nineteen (19) employment types include:

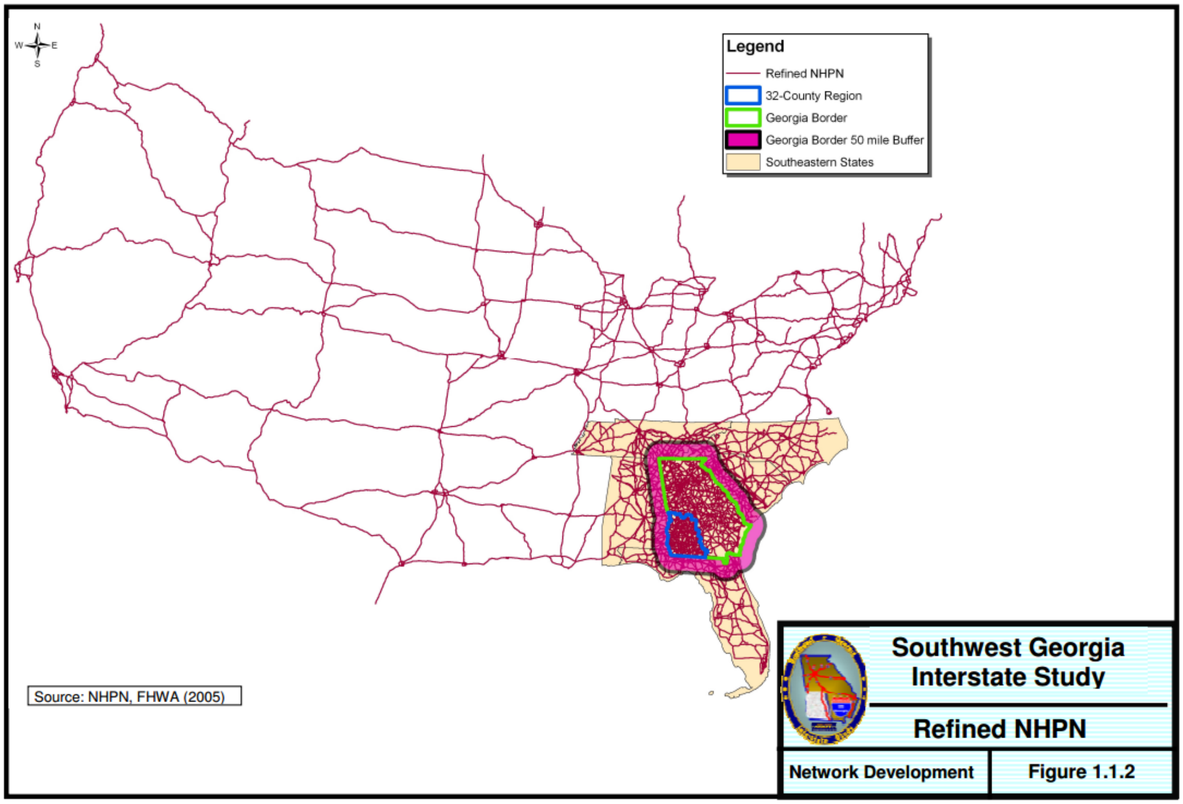
- Agricultural,
- Mining and Mineral Product Manufacturing,
- Food Processing,
- Textile and Apparel Manufacturing,
- Wood Product Manufacturing,
- Paper Manufacturing and Printing,
- Chemical Manufacturing,
- Petroleum and Coal Products Manufacturing,
- Plastics and Rubber Products Manufacturing,
- Miscellaneous Manufacturing,
- Primary Metal Manufacturing,
- Fabricated Metal Product Manufacturing,
- Machinery Manufacturing,
- Electrical Equipment and Appliance Manufacturing,
- Utilities and Construction, Retail Trade,
- Wholesale Trade,
- Transportation and Warehousing,
- Services, and
- Government.

5.2.2 Transportation Network Data

The GSTDM was created by enhancing the network of the Southwest Georgia Interstate Study Model (SWGIS) developed in 2009. The SWGIS highway system used National Highway Planning Network (NHPN) data to build a network that expands to all forty-eight (48) continental states. The GSTDM acquired its tiered network concept from the SWGIS. The SWGIS detailed network encompasses thirty-two (32) counties in the study region. The SWGIS network includes the remaining one-hundred twenty-seven (127) counties in Georgia but uses less detail than for those counties in the study region, as illustrated in Figure 2.[11] Updated NHPN and Georgia Road Characteristics (RC) file data were used to enhance this existing SWGIS highway network structure to create the GSTDM.

[11] The Southwest Georgia Interstate Study Technical Memorandum on Highway Network Development may be accessed via: http://www.dot.ga.gov/informationcenter/programs/studies/SWGAInterstate/Documents/ModelDevelopment/Development%20of%20Network.pdf

Figure 2: Southwest Georgia Interstate Study Model Network



The railway network incorporates data from the National Railway Network and National Transportation Atlas database. Similar to the highway network, the railway network includes all forty-eight (48) contiguous states and centers detail in areas within and around Georgia. The rail network entails the same network coding configuration as the highway network, including centroids and centroid connectors.

Special generators are included in the network for only the freight model. These specific generators include metropolitan Atlanta intermodal yards, and Chatham County, which includes the Port of Savannah. Special generator rates are based on total employment.

5.2.3 Model Estimation Data

The passenger model uses 2009 NHTS data with Georgia Add-On Data. A total of 7,000 household records from the NHTS database were applied to the model, of which the majority of results are located in urban areas.

Truck and commercial vehicle data were taken from a Transearch commodity flow database purchased from Global Insight. This data includes flows internal, external, and through the State of Georgia. The 2008 Freight Analysis Framework (FAF) data were not included because the FAF database is established on larger regions rather than counties, and only three of the regions are located in Georgia.

5.2.4 Validation and Calibration Data

The model employs traffic counts at the Stateline, external station, MPO boundary, screenline, and link level. Statewide traffic counts were obtained through the GDOT traffic count database. Truck counts outside of Georgia were obtained through Transearch data.

The Vehicle Inventory and Use Survey (VIUS) was used in the development of payload factors to convert tonnage to truck trips, while Transearch commodity flow data was used to validate freight trip length and vehicle miles traveled.

The passenger model's distribution validation was based on the NHTS geo-coded trip matrix. The passenger model constants are also calibrated to adjusted mode shares to parallel the American Travel Survey for long distance trips. Additionally, FAA airline origin and destination survey and AMTRAK boardings, operating, and financial data provided information with regard to long distance travel. Transit modes were validated at the public transport route level.

5.3 Integration with Economic Models

As mentioned in Section 4.1, GDOT obtained the REMI model for population and employment forecasting. Best practices regarding the integration and application of the REMI model into the GSTDM was a priority for GDOT in the peer review.

5.4 Assumptions and Parameters

GDOT also requested the review of the assumptions and parameters associated with the model, which relates directly to travel market analysis in both the freight and passenger models. Due to the large scale of the model, the GSTDM has a diverse platform of modes and markets for analysis.

5.4.1 Passenger Trips

The GSTDM includes four trip types: home-based work (HBW), which are work trips with one end at a home location; home-based other (HBO) trips, which are non-work trips with one end at a home location; non-home based (NHB) trips, which are non-work trips with both ends at a non-home location; and commercial truck, which are non-freight, short distance truck trips.

Trip rates for productions were obtained using cross-classification analysis. The 2009 NHTS Georgia Add-On Data were used to obtain trip production rates by income, urban/rural area, and household size. Short and long internal-to-internal trip rates are summarized in Tables 3 and 4, respectively. Internal-to-external short and long trip rates are provided in Tables 5 and 6. A regression equation was created for commercial truck trip production. Regression equations were also developed for trip attractions based on employment numbers.

Table 3: Internal-to-Internal Short Trip Rates

Income	Area	Persons/HH	HBW	HBO	NHB
Low	Urban	1	0.245	1.955	0.973
		2	0.658	3.523	1.667
		3	1.667	5.375	3.208
		4	1.154	7.769	5.026
	Rural	1	0.136	2.318	1.273
		2	0.891	2.609	1.804
		3	1.200	4.636	3.455
		4	1.056	6.278	4.333
Non-Low	Urban	1	0.264	2.078	1.086
		2	0.798	3.648	2.000
		3	1.399	5.057	2.889
		4	1.391	8.079	3.792
	Rural	1	0.278	1.773	1.170
		2	0.723	3.329	2.184
		3	1.384	4.516	3.204
		4	1.393	7.202	4.199

Table 4: Internal-to-Internal Long Trip Rates

Income	Area	Persons/HH	HBW	HBO	NHB
Low	Urban	1	0.001	0.036	0.005
		2	0.002	0.063	0.009
		3	0.003	0.083	0.020
		4	0.005	0.060	0.154
	Rural	1	0.045	0.016	0.010
		2	0.043	0.087	0.130
		3	0.003	0.045	0.040
		4	0.167	0.667	0.056
Non-Low	Urban	1	0.003	0.013	0.010
		2	0.005	0.041	0.017
		3	0.009	0.041	0.054
		4	0.015	0.127	0.036
	Rural	1	0.002	0.032	0.021
		2	0.022	0.104	0.042
		3	0.007	0.095	0.087
		4	0.022	0.081	0.059

Table 5: Internal-to-External Short Trip Rates

Income	Area	Persons/HH	HBW	HBO	NHB
Low	Urban	1	0.005	0.010	0.036
		2	0.018	0.045	0.027
		3	0.020	0.020	0.030
		4	0.026	0.179	0.103
	Rural	1	0.002	0.015	0.005
		2	0.002	0.020	0.010
		3	0.182	0.022	0.012
		4	0.015	0.025	0.015
Non-Low	Urban	1	0.010	0.024	0.021
		2	0.038	0.065	0.033
		3	0.089	0.035	0.073
		4	0.038	0.036	0.074
	Rural	1	0.008	0.030	0.011
		2	0.007	0.042	0.024
		3	0.015	0.050	0.042
		4	0.031	0.048	0.028

Table 6: Internal-to-External Long Trip Rates

Income	Area	Persons/HH	HBW
Low	Urban	1	0.008
		2	0.045
		3	0.025
		4	0.077
	Rural	1	0.045
		2	0.020
		3	0.091
		4	0.056
Non-Low	Urban	1	0.016
		2	0.046
		3	0.051
		4	0.051
	Rural	1	0.015
		2	0.035
		3	0.052
		4	0.070

Internal-external short trips consist of all trips crossing the State boundary for each of the trip purposes. 2009 NHTS data were analyzed and stratified to fit these market segments and distributed geographically to estimate the corresponding trip rates per purpose.

To capture the variation between northern and southern Georgia in terms of economic characteristics and travel behavior, “trip rate density” measures were calculated based on employment, population, and travel time to adjacent zones. These measures were applied to statewide average trip rates from the NHTS survey. Different trip density measures were obtained based on whether the trip was considered to be short or long distance.

It was discovered that the passenger model is more sensitive to times and congestion than distance. Therefore, it was determined that seventy-five (75) minutes represents a sufficient range to capture travel time within the Atlanta region and could function as the cut-off threshold between short and long distance trips. Internal-to-internal long distance trips are divided into home-based work, home-based other, and non-home based. Long distance internal-to-external trips are aggregated into one purpose rather than by the four individual market segments.

The model has limited capability to forecast long distance external-to-internal travel. TAZs located outside Georgia are substantially larger in size; therefore, sufficient data were not available to support external-to-internal long distance travel model estimation.

External-to-external trips represent travel in which both ends are located outside the State of Georgia. External-to-external trips are obtained from a separate trip table comprised of aggregated total passenger vehicle trips from the SWGIS. These trips are not categorized into a market segment and can be considered as a portion of the non-resident and visitor trips in the model.

5.4.2 Freight Trips

Only long distance and through trips are considered to be freight trips and calculated within the freight model. When short distance internal trips are made by commercial vehicles, they are considered to be “commercial truck” rather than freight trips.

There are sixteen (16) commodity groups in which a freight trip can be classified in the freight model, including:

- Agriculture
- Mining
- Food
- Textile
- Wood
- Paper
- Chemical
- Petroleum
- Rubber and Plastic
- Stone
- Primary Metal
- Fabricated Metal
- Machinery
- Instruments
- Wastes
- Miscellaneous Freight

Based on commodity group, freight trips are divided into distance ranges. By coupling commodity tonnage per truck, also known as the payload factor, and travel distance, annual tonnage flows can be calculated into daily truck trips by market. It is assumed that there are six working days per week, and therefore 306 working days per year. Table 7 summarizes payload factors by commodity and distance range as applied in the GSTDM.

Table 7: Payload Factor by Distance Range and Commodity

Commodity Group	Distance Ranges (miles)				
	<50	50-100	100-200	200-500	>500
Agriculture	9	10	14	17	19
Mining	10	15	18	19	19
Food	7	10	14	16	19
Textile	11	11	13	15	22
Wood	9	14	15	15	15
Paper	8	10	15	19	20
Chemical	11	11	14	17	15
Petroleum	10	14	16	22	22
Rubber & plastics	8	10	12	17	17
Stone	12	16	17	17	18
Primary metal	4	10	13	16	18
Fabricated metal	3	3	7	11	14
Machinery	6	9	12	15	18
Instruments	5	6	7	13	19
Wastes	8	10	14	17	17
Miscellaneous freight	7	11	15	17	17

5.5 Rail and Highway Freight Split

In its application for peer review, GDOT acknowledged cost as a significant variable in the mode shift between rail and truck freight movement. However, GDOT requested additional advice with regard to variables that impact the shifts between these two modes and methods for incorporation in the GSTDM.

5.6 Air Freight

Both air and water commodity mode shares remain constant while shifts between truck and rail are dynamic. GDOT showed an interest in discussing more advanced methods of handling air freight in the model.

5.7 Managed Lanes

The links within the highway network include codes to identify tolls in trip assignment. Therefore, it is possible to test toll road alternatives using the GSTDM. GDOT recognizes the potential to expand its vision for future model application capabilities, including the modeling of managed lanes, and requested the panel's recommendations for this type of modeling in the GSTDM.

5.8 Model Functionality

GDOT requested that the panel focus on current model functionality as a priority for the peer review, which directly relates to the model's calibration and validation efforts.

As described in Section 5.2.4, the data used for validating and calibrating the GSTDM included the GDOT traffic count database for highway counts, the VIUS for freight data, the American Travel Survey for long distance trip data, the FAA airline origin and destination survey for long distance trip data, AMTRAK boardings and operating data for long distance trip data, Transearch for freight data, and 2009 NHTS with additional Georgia Add-On Data for passenger trip data.

The GSTDM documentation reports the following overall volume-to-count ratios and deviation percentages for the passenger model:

- Screenline Volume-to-Count: 1.02, 2% Deviation (Max. Desirable Deviation: 5%)

- MPO Boundary Volume-to-Count: 1.03, 3% Deviation (Max. Desirable Deviation: 7%)
- Stateline Summary Volume-to-Count: 0.83, 17% Deviation (Max. Desirable Deviation: 11%)

GDOT reported that the passenger model exhibited an overall -4% difference in vehicle miles traveled (VMT) on all links and root mean square errors (RMSEs) of fifty-eight percent (58%) for rural facilities, seventy-eight percent (78%) for urban facilities, and ninety-two percent (92%) for all facilities. The overall model RMSE is between the urban and rural values, but because percent RMSE is calculated by dividing the RMSE by the associated average count, it is possible for the overall assignment percent RMSE to be larger than both the rural and urban values. Although total RMSE and average counts fall between the urban and rural values, the percent RMSE does not due to a non-linear relationship in the variables involved.

The average count in rural areas is kept relatively low by a large number of low volume count locations. The rural percent RMSE is relatively low because the model accurately represents rural traffic volumes, which is reflected in the low RMSE. The urban percent RMSE is relatively low because the average urban traffic count is driven very high by the presence of a limited number of very high traffic count locations in the Atlanta region. The total RMSE is more than three times greater than the rural RMSE, but the total average traffic count is only two times greater than the rural average traffic count. This non-linear relationship in the RMSE and traffic counts causes the total percent RMSE to be higher than the rural and urban values.

Figure 3 illustrates the R-squared value of 0.91 in a link volume scatter plot, indicating that the model reasonably reflects base year travel. Figure 4 is a plot of the maximum desired deviation curve with the assigned model volumes.

Figure 3: 2006 Link Volume Scatter Plot

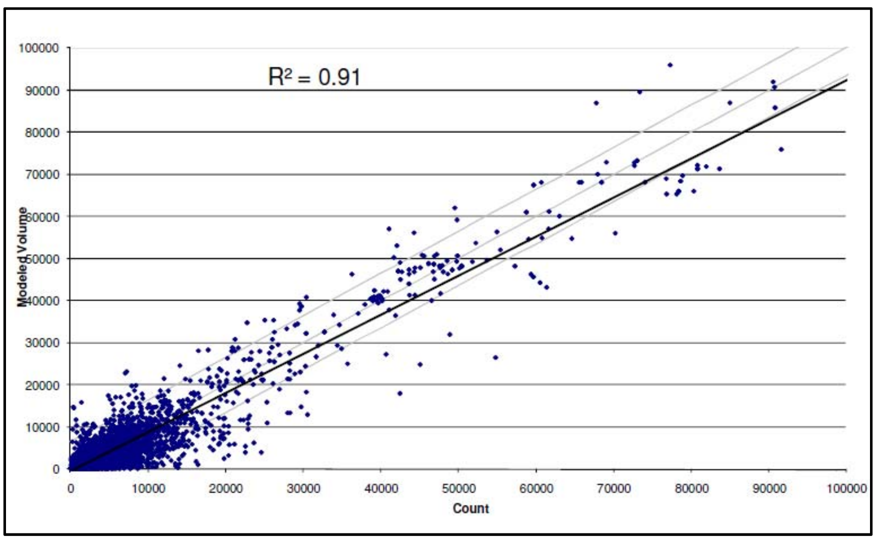
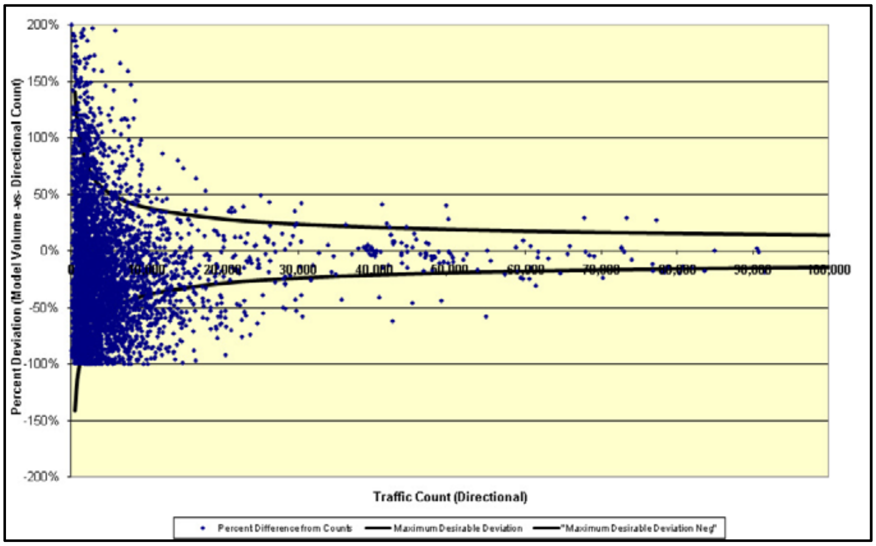


Figure 4: 2006 Link Volume Maximum Desired Deviation Scatter Plot



In the freight model, the truck VMT RMSE was reported at 25%, and the difference in truck VMT to Transearch counts was 4%. The R-squared values for each commodity in the trip length validation ranged from 0.82 to 0.99. Again, it was noted that an error must have occurred in calculating the RMSEs and R Squared values due to the apparent inconsistency. Further information to support the GSTDM model validation is provided in Appendix D.

5.9 Integration with MPO Models

In the development of the GSTDM, GDOT modified the MPO modeling process by placing an emphasis on statewide application and facilitating additional mode choice options. The model is not intended for application within metropolitan MPO modeling areas because its focus is based on a state and regional scale rather than the smaller scale that an MPO project would require. For example, studies like detailed personal and vehicle travel patterns and demands, identification of future bottlenecks, or detailed intermodal freight movements within MPO areas would require application of the respective MPO model rather than the GSTDM. With this understanding of the model's capability in mind, GDOT requested that the panel examine appropriate levels of integration for the GSTDM and MPO models.

5.10 Consideration of Policy Issues

The GSTDM has been applied in a variety of studies throughout the State of Georgia, ranging from larger state-based projects to corridor and subarea studies. GDOT would like to maintain and expand the uses of the GSTDM, particularly its ability to address policy issues. GDOT provided a summary of the previous and current applications of the GSTDM to provide the panel with an understanding of its existing capacity to address policy issues and prompt ideas for advancement.

5.10.1 Existing Applications

The GSTDM is the best tool available for interregional and statewide analyses in Georgia. The model's existing components allow for a variety of studies including freight, interstate, and intermodal projects. As mentioned previously, the model is not intended for application in studies with analysis areas in MPO modeling areas. Because the model encompasses a large area, studies that require a more significant level of detail are discouraged from applying the GSTDM.

The model is currently being used in the Connect Central Georgia Study, an east-west corridor study to assess safety, mobility, and connectivity spanning across Georgia from the Alabama Stateline to the South Carolina Stateline. The Connect Central Georgia Study area includes thirty-one (31) counties; four (4) major Georgia cities including: Columbus, Macon, Warner Robins, and Augusta; and three (3) major military bases including, Fort Benning, Robins Air Force Base, and Fort Gordon.

The GSTDM was used in the Georgia Freight and Logistics Plan to evaluate and prioritize freight improvement project recommendations from 2010 to 2050. The Georgia Freight and Logistics Plan study required use of only the freight component of the model.

The GSTDM was also applied to the I-75 North Study, a corridor evaluation to develop a Strategic Improvement Plan between Atlanta and Chattanooga, Tennessee; the Atlanta-Athens Connectivity and Mobility Study, a corridor study to evaluate travel patterns and activity centers between two metropolitan regions in the State; and the Dahlonega/SR 52 Subarea Study, a study to assess congestion along the State Highway. Each of these studies required models larger than their respective MPO models for application in the study due to the significant impacts the projects would have on areas outlying the limits of the MPO model. In these instances it was helpful to have the larger scale GSTDM for interregional analysis.

5.11 Performance-Based Modeling in the Context of MAP-21

GDOT requested that the panel review the GSTDM in relation to its ability to address performance based issues. The identification of performance measures that the model currently cannot answer in the context of MAP-21 was identified as a potential topic for discussion.

5.12 Model Deficiencies

Through the analysis of the topics provided above, GDOT anticipated additional identification of potential improvements for the GSTDM. By reviewing the model structure, data sources, assumptions, parameters, validation, and applications, the panel would be able to identify areas in which the GSTDM exhibited specific deficiency and potential for enhancement.

GDOT expressed interest in identifying short term needs that could be addressed in the near term given existing resources. GDOT also expressed a desire to develop subsequent contracts for mid and long term modeling needs in order to maintain a continuous and ongoing model improvement effort.

6.0 Peer Review Panel Response to Technical Questions

6.1 Model Structure and Organization

Following the detailed assessment of the model's structure and organization, the panel first recommended that in the short term it would be beneficial for GDOT to improve their model documentation so that it would be easier for readers to understand the model structure and applications. Other recommendations are provided in this section by area of relevance.

6.1.1 Traffic Analysis Zone and Network Structures

The panel commended GDOT on the general 'telescoping' of detail in the model zone system and network and the use of the halo zones around the state of Georgia, in particular, as a strength of the GSTDM.

The panel also recommended that in the midterm GDOT review the balance between the level of detail or density between the highway network and TAZ system in the model, noting that almost all statewide models go through a trial and error process to find the proper balance between the network and zonal structure, but that the GSTDM had a high ratio of network miles to the number of TAZ compared to some other statewide models.

6.1.2 General Model Structure

The panel suggested that some simplification of the model structure, such as passenger rail, commodity generation equations, feedback loop and treatment of congested speeds, etc., could potentially be advantageous.

In the mid-term, the panel suggested considering a variety of structural changes to the model including alternative, possibly two-way, integration with ARC's model, as well as further stratification by income (especially if rail passenger or pricing studies are contemplated).

Destination choice models were also suggested as a possible mid-term improvement, citing evidence that they can provide significant improvements over gravity models, especially at the statewide level.

The panel also proposed that in the midterm GDOT consider a time-of-day model for assignment, and also explore the possibility of dynamic traffic assignment into the GSTDM in the long term. These models would aid in the development of more temporally detailed forecasts.

Other long term suggestions from the panel with regard to the general model structure included consideration of integration with a land-use forecasting and allocation model, similar to PECAS, Urbansim, or a simpler land-use allocation model, and possible reconstruction of an entirely new model, either trip or activity based, for the GSTDM.

6.1.3 Freight Model Structure

The panel commended the architecture of the freight model as one the GSTDM's most pronounced strengths. In light of the merits identified in the model, the panel provided insights as to further improvement for freight forecasting in midterm years.

The panel recommended consideration of multiple scenarios for freight forecasting- ranging from low, medium and high- using multiple forecast years.

The panel also suggested GDOT may consider pivoting off of base year commodity flows and/or using FAF forecasts and American Transportation Research Institute (ATRI)[12] GPS data in the midterm. All of these suggestions stem from the recognition of the challenges associated with modeling and forecasting freight movement. The pivoting approach simply uses models to predict only the change in freight movements relative to the base rather than the actual movements themselves in their entirety. This approach is thought to produce better forecasts in many cases, especially in near/mid-term rather than long term forecasts. The recommendations regarding FAF and ATRI point out valuable additional data sources for enhancing and validating the freight model and its components. The panel noted that while Transearch is widely used and generally respected, that recently some evidence may be emerging to suggest that FHWA's free FAF data may be more realistic than Transearch in some cases. It was noted that comparisons are difficult, however, due to differences in the definitions of freight movements (linked/unlinked). It was also noted that ATRI's very large sample of truck GPS data has been helpful for refining other statewide truck forecasts and freight models. For long term application, the panel supported investigating the inclusion of logistics and supply chain freight modeling similar to that being undertaken currently by Florida DOT.

Other possible simplifications that the panel suggested may be helpful included removing at least the PT rail assignment (since Amtrak schedules could be used rather than skims) until such a time that their ultimate use became clear and they could be refined with that end use in mind. It was also observed that long distance passenger mode choice models almost always need to be refined as part of a high speed rail or similar special study before it they yield reliable and realistic forecasts. It was further observed that removing these components could likely result in substantial run time reductions. The panel also recommended that GDOT consider whether it felt it could accurately forecast employment for the detailed industry sectors currently used in the model and possibly consider a simplified employment scheme.

6.1.4 Passenger Model Structure

After reviewing the model structure and general processes, the panel determined that in the midterm it would be constructive for GDOT to explore the possibility of a destination choice model. When the GSTDM was initially developed, the NHTS data were not yet available, but the model was later calibrated to NHTS data. However, estimating destination choice models from the NHTS data could offer substantial improvement over the gravity models, not only at reproducing the NHTS travel patterns, but also Census CTPP and LEHD commute flows and other origin-destination flow information.

6.2 Data Sources

Another principle task posed to the panel by GDOT was the review of data sources and identification of additional data for inclusion in the model. The panel identified a variety of data sources for GDOT to consider from short to long term timeframes.

6.2.1 Socioeconomic Data

In the short term, the incorporation of REMI into the model and use of its employment forecasts was recommended to provide a stronger and more consistent employment database throughout the State of Georgia. Additionally, the panel distinguished further stratification by income or

[12] ATRI is a non-profit research organization with an emphasis on the trucking industry. The ATRI website can be accessed at: www.atri-online.org

value of time, particularly for application in passenger rail or pricing studies, as a midterm priority for the GSTDM.

6.2.2 Validation and Calibration Data

In the short term, the panel advocated the acquisition of additional traffic counts, including non-GDOT traffic counts. The panel also suggested as future possibilities, INRIX data on speeds, and AirSage data on origin-destination flows. The panel also identified NHTS Add-On, Census's CTPP and ACS Journey to Work, and LEHD data as important freely available sources to enhance validation efforts and urged their use for further validation of OD flows.

In addition to the GSTDM's currently employed Transearch data, the panel endorsed the inclusion of FHWA's FAF data, which include comprehensive national freight movements and may be useful in comparison to Transearch for calibration, and the panel also noted American Transportation Research Institute (ATRI) data on truck OD flows as a great data source to support improvements in the midterm. The establishment of a carrier survey and data program was also advised as a midterm data collection priority.

Obtaining additional household survey data with an emphasis on rural areas was established as a long term priority. The majority of the NHTS samples were focused in urban areas, creating a need for additional rural household data for validation purposes.

6.3 Integration with Economic Models

The panel lauded GDOT's acquisition of REMI and included its integration into the model as one of the short term recommendations. The integration of REMI into the freight model would provide district level commodity production and consumption totals by industry. As mentioned in Section 6.2.1, REMI would also facilitate a more consistent employment database for the entire State of Georgia.

6.4 Assumptions and Parameters

The panel's focus on the examination of assumptions and parameters led to analysis of the long distance travel and illuminated potential model adjustments as well as the possible need to revisit the commodity generation equations.

6.4.1 Passenger Trips

The panel expressed concern that the 75-minute cut-off between short and long distance trips may be problematic, as a time versus mileage cut-point for long distance trips may yield knife-edge effects in the model whereby the same origin-destination set classified as "long" in some runs and "short" in others, specifically between forecast years. The panel recommended that GDOT review the National Cooperative Highway Research Program (NCHRP) 08-84 Rural and Long Distance Travel Parameters for Statewide Models for potential application in the GSTDM and consider shifting to a distance-based criterion.

There was also some discussion of the accessibility-based trip density adjustments. The panel made a number of comments on these. On the one hand, the panel applauded the continuous nature of the approach as superior to the more common discrete stratification by area type. However, the panel also noted some concern about whether part of the difference in auto travel by area type being addressed by these factors may actually be the result of shorter trip lengths or lower auto or drive alone mode shares in urban areas; if so, it may be better to adjust distribution or mode choice rather than generation.

6.4.2 Freight Trips

The panel expressed concern about the complexity of the specification of the commodity generation equations and noted that there may be indications of some over-specification in these models. Thought should be given as to the accuracy of the detailed industry sector employment forecasts needed to support these models and produce reasonable results. Simpler specifications using fewer employment categories may produce more reasonable results. Further validation and specifically, sensitivity analysis, would be required to verify whether or not the truck model is over-specified. For instance, comparing freight generation and/or truck assignments between two future land use scenarios in which employment is simply shifted between detailed industry sectors.

6.5 Rail and Highway Freight Split

The panel acknowledged the complexity of freight mode choice decisions, which involve both shippers and carriers. The panel also recognized the intricacies associated with representing the many factors, aside from cost, influencing freight mode choice decisions. Identifying these factors is a challenge with which many DOTs struggle. The panel expressed optimism that the supply chain freight modeling Florida DOT is currently developing for their statewide model may ultimately provide a more adequate tool, for addressing freight mode split, and eventually replace the incremental logit model approach in use in GDOT and many DOT's statewide models. The panel recommended that GDOT explore the possibility of shifting to this approach as a possible long term model improvement.

6.6 Air Freight

The panel did not recommend any changes to the current modeling of air freight in the GSTDM freight model.

6.7 Managed Lanes

The panel suggested that considerable work, such as stratification of demand by income throughout the model, from generation through assignment, would be necessary in order to address tolling and managed lanes within the model and also noted that special stated preference surveys or other studies on traveler's values of time may also be necessary. Further, the panel suggested that MPO models may be the better tool for addressing such projects, since they would presumably generally be within urban areas and the MPO models would be assumed to be better able to represent congestion more accurately.

6.8 Model Functionality

The panel advocated a simpler, streamlined model with a more intensive validation to improve the GSTDM's functionality and usefulness for planning. The panel noted that while GDOT should generally be commended on the structure of their model, that more complex model structures require more validation and that a complex model structure is not ultimately helpful if it does not produce a better validated or more properly sensitive model.

The first and most urgent observation of the panel with regard to model functionality and validation was that a number of the model's validation statistics appeared to be miscalculated (e.g., total assignment RMSE can't be higher than both rural and urban; truck assignment errors seemed inconsistent with general model errors and comparable models). While noting that such mistakes can be easy to make, the panel recommended that these validation statistics be corrected / clarified as soon as possible and that their ability to comment on the model's validation was limited due to these concerns.

The panel did note that the overall assignment errors appeared to be higher than expected for a statewide model, but this could be due to a miscalculation. The panel noted that it would be helpful to be more explicit about exactly what and how many counts were used to calculate various assignment error statistics. For instance, the panel referenced various states that report assignment errors specifically for state jurisdictional facilities or only on trunk lines and noted that most statewide models focus fairly exclusively on error statistics within the state. The panel also expressed some concern about the truck model validation statistics because they should generally be expected to be higher than the overall or auto errors. This apparent issue also may be due to a need to better clarify the exact definition of the errors reported. If it is not, however, it may indicate over-specification. An over-specified model may have extremely low error statistics, but can exhibit highly unreasonable behavior in forecasting and alternatives analysis.

Further validation of individual model components was also an important recommendation of the panel for the near term, in order to better understand the strengths and weaknesses of the model. The panel recommended further comparisons to NHTS data and the use of additional traffic data, (primarily additional traffic counts, but also potentially speed data or other OD flows from AirSage in the future). The panel specifically recommended further validation of distribution and suggested the use of Census's CTPP, ACS and LEHD information on commuter origin-destination flows as well as NHTS. Several types of tests and comparisons were suggested including OD scattergrams, district-to-district level comparisons using a small enough number of districts that analysts could really review and digest the distribution and to ensure adequate sample size. It was noted in the peer review that some such district level comparisons may have been made in validation, but they were not documented. Statistics such as r-squared and log likelihood ratios were also suggested as helpful for validating distribution.

Pending concerns on validation statistics noted above, the panel tentatively concludes the model is capable of forecasting daily highway vehicle volumes (passenger cars, medium and heavy freight trucks) on state highways and interstates. It can evaluate the impact of changes in land-use and economic policies on person and goods movements. The statewide model can be used to evaluate major highway improvements outside the MPO areas since it is complementary to the MPO models. It is not intended to be used within MPO model areas. It can also predict the shift between highway and rail freight.

As mentioned earlier, the statewide model is only applicable outside MPO areas and it is recommended that the MPO models be used to evaluate changes within the MPO areas. The model cannot forecast traffic volumes on lower levels of highway facilities since local and most of the collector roads are not included. It can only be used to forecast traffic on interstates, state highways, principal and minor arterials and only a few collectors. Due to the representation of network detail, localized transportation improvements such as intersection improvements and turn lanes analysis cannot be evaluated by the statewide model. Finally, the model has limited capability to forecast long distance external (to Georgia) travel. This is because the zones outside Georgia are quite large and there were not sufficient data available to support external long distance travel model estimation.

6.9 Integration with MPO Models

The panel advocated further integration of the GSTDM with the Atlanta Regional Commission's (ARC) model under the assumption that the MPO model's assignment would provide a more accurate representation of short auto trips and congestion in the Atlanta area. In the midterm, the panel suggested GDOT/ARC consider two-way integration between their models such that GDOT's model would use the ARC model's short distance trips in the Atlanta area while the ARC model would use long distance and freight trips from GDOT's model. Additionally, the

GDOT statewide model could be used as a definitive source of external-external trip patterns for ARC since all external stations in the ARC model are included in the statewide model. This sort of integration would make best use of each model's strengths to mitigate each model's limitations. It was noted that there are several ways that this sort of integration can and to some extent has been accomplished with various statewide and urban models in other states. Both Utah and Florida were cited as examples of different approaches.

During the peer review, GDOT expressed concern with MPO socioeconomic data in terms of reliability, not necessarily referring to ARC. The panel's consensus was that consistent sources are of the highest preference for statewide modeling data. It was noted that incorporating REMI in the model would provide a homogenous employment source across MPOs, which further emphasizes the value of integrating REMI into the GSTDM.

6.10 Consideration of Policy Issues

The panel stressed that GDOT should clearly define the purpose and objective of the GSTDM as a way to direct and then prioritize future updates and/or improvements to the model. The panel also emphasized the importance for GDOT to identify intended planning applications for which future model developments could then be focused.

The panel provided examples including and in addition to GSTDM's current functions to elicit further deliberation of possibilities for model application. The panel's suggestion of important planning priorities which may be addressed by statewide models included:

- Scenario evaluations,
- Improved connectivity,
- Congestion relief,
- Freight movements,
- Safety improvement,
- Environmental feasibility, and
- Potential toll revenue.

The panel noted that the GSTDM has some ability to address most of the above, may require improvements to support specific types of studies.

6.11 Performance-Based Modeling in the Context of MAP-21

The panel did not recommend any changes to the current modeling of performance measures to better address requirements of MAP-21 since the requirements of MAP-21 were not finalized at the time of the peer review. It was noted in post-review comments from the panel that GDOT may find value in incorporating reliability as a way of addressing MAP-21 in the GSTDM, as MAP-21 focuses on congestion management, safety, and system reliability in transportation planning. Innovative methods for the incorporation of travel time reliability in assignment and skimming procedures, such as SHRP 2 C04 and L04, should be considered by GDOT as a way to meet MAP-21 performance measures guidance.

6.12 Model Deficiencies

One of the panel's general observations was that GDOT's willingness / desire to refine the model is one their strengths which will inevitably eventually lead to a high quality statewide model. A key part of this is GDOT's willingness and desire to identify any possible deficiencies in the model, so that they might be addressed.

As noted in Section 6.4, both low truck assignment errors and the complex commodity generation equations lead to some concern among the panel that the truck model, or certain components of the truck model, may be over-specified. An over-specified model may have extremely low error statistics, but can exhibit highly unreasonable behavior in forecasting and alternatives analysis. Further validation and specifically, sensitivity analysis, would be required to verify whether or not the truck model is over-specified. For instance, comparing truck assignments between two future land use scenarios in which employment is simply shifted between detailed industry sectors.

Improved documentation and further validation efforts recommended by the panel were aimed at addressing these possible deficiencies. It is important to note that the above issues were identified as possible deficiencies which require further investigation. Those further efforts may reveal that neither corresponds to an actual deficiency in the model.

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7.0 Panel Discussion and Recommendations

After reviewing GDOT's application for peer review, participating in the virtual pre-peer review meeting on August 3, and engaging in the peer review meeting on September 5, the panel was able to sort through its findings and provide responses to all of the questions and topics addressed in these meetings.

The following summarizes the panel's discussion on the topics of interest to GDOT and the panel's recommendations to GDOT. This summary follows the panel's final presentation to GDOT at the conclusion of the peer review on September 5, 2012.

7.1 General Comments

The panel began with two topics of general observation or comment. First, the panel encouraged GDOT to continue to take ownership of their model. It was clear that GDOT staff had begun to use the model and was enthusiastic about its further use and enhancement. The panel urged GDOT to clearly identify the intended applications for the model. The panel provided a number of examples of possible uses for the model and planning priorities it could potentially address, including:

- Scenario Evaluations
- Project Prioritization
- Major Capital Investment Studies
- Connectivity Improvements
- Congestion Relief
- Freight Movements
- Safety Improvement
- Environmental Feasibility
- Potential Toll Revenue
- Generation of Performance Measures for MAP-21

The analysis needs should inform the design of a model, along with resource and data considerations. Based on what the panel heard about analysis needs, the panel felt that the GDOT's core analysis needs include:

- Statewide analysis needs
    - Truck Demand
    - Long Distance Travel
    - Long Range Planning
- Key policies
    - Pavement Preservation
    - High Speed Rail
    - Toll Roads
- Complex and important behavior/segments
    - Trucks

- Non-Resident Travel
- Intercity Travel

The first order of business for GDOT is to ensure that the model is useful for Statewide planning and the DOT's core responsibilities. The above list represents the panel's view of the most important policies and market segments for the DOT to address reliably in the model. The panel felt strongly that the DOT should focus on achieving a model that handles the things in the list above well *at a Statewide scale*, and only then, the model might be useful for more refined corridor analysis needs. The priority for the model must be to ensure that macro travel patterns are modeled reliably for all major traveler segments, in response to the most critical set of transportation policies and investments.

The second general recommendation from the panel was that GDOT invest in model training and/or a model users group. It was noted that GDOT could leverage the existing Georgia MPO meetings with a modeling track which would benefit its modelers as well. Statewide webinars on modeling topics were mentioned as another possibility and GDOT was encouraged to take advantage of TMIP's other resources such as their email listserv, webinars, etc.

Additionally, the panel recognized GDOT's enthusiasm regarding the model as an important and positive development but also noted that GDOT staff relied on Atkins to answer many questions about the model that it would be important to enhance in-house staff capabilities with the model. The panel suggested that while it is reasonable to rely on consultants for development and maintenance of the model, it is also important that in-house staff have a deep enough understanding to fully evaluate consultants' work.

7.2 State of the Practice

The panel framed their recommendations by first describing the state of the practice for statewide travel models. The panel members included managers of three other statewide models and a developer of several other statewide models. As a group they felt that they could speak reasonably well to the general state of the practice in statewide models. They noted six characteristics of the state of the practice for statewide models:

7.2.1 Person Trips and Goods Movements

The state of the practice for statewide models is to estimate automobile demand based on person trips and to derive truck demand estimates from goods movements. The GSTDM already has fully implemented a dual passenger and freight demand architecture as serves as a great example of the state of the practice in this regard.

7.2.2 Halo Zone around the State

Statewide models now typically are expected to include networks and zone systems which include much if not all of the contiguous United States with gradually decreasing detail further from the state. The GSTDM has precisely this design and serves as a good example of the state of the practice in this regard, as well.

7.2.3 Separate Long and Short Distance Passenger Trips

Long distance passenger trips are typically dealt with in statewide models using their own dedicated market segment with its own component models. The GSTDM also implements this approach, with special component models for long distance trips throughout the demand model. The panel did suggest some adjustments to the definition of long trips in the GSTDM (See Section 6.4.1) but overall thought the GSTDM conformed to the state of the practice.

7.2.4 Separate Peak and Off-Peak Travel Times

The panel asserted that the state of the practice for statewide models now includes separate peak and off-peak travel times and assignments although they did also note that daily assignments are still not uncommon either. They clarified that peak and off-peak speeds are importantly different from the congested and free-flow speeds currently used in the GSTDM, and that work would be necessary to update the model to use peak and off-peak times throughout the model. Thus, the GSTDM does not conform to the emerging state of the practice in this regard, but the panel noted that there are also still a number of statewide models in use with designs similar to the GSTDM.

7.2.5 Validation of All Model Components

The panel emphasized that clear validation of all model components is the accepted state of the practice for statewide models. In particular, the panel noted the importance of validating the OD flows produced by the distribution models, suggesting both district-to-district level error statistics and OD scattergrams as common ways of demonstrating validation at this level. Documentation of the GSTDM's validation was notably lacking in this regard and for several other component models. Although matching average trip lengths and trip length distributions were documented, the panel noted that these, while important, are not enough to demonstrate that a distribution model is validated, especially at the statewide level. The panel made various recommendations in connection with this issue to help GDOT achieve the state of the practice in this regard.

The subsections above identify areas in which the model requires additional work to better reflect the state of the practice in statewide modeling efforts, while also highlighting areas where the GSTDM is in-line with or exceeds the state of the practice.

The panel underscored the strengths of the GSTDM to illustrate areas that meet or exceed the state of the practice. These areas include:

- Freight Architecture,
- Use of Continuous Accessibility Measures,
- Halo Zone Structure beyond the State of Georgia,
- GDOT's Commitment to the Model's Development and Improvement,
- Acquisition of REMI, and
- GDOT's Willingness and Desire to Refine the Model.

The panel wanted to recognize these strengths and that in these areas the GSTDM either serves as a good example of the state of the practice or has exceeded it, as with the use of continuous accessibility measures.

7.3 Recommendations

While GDOT had requested some prioritization of potential model improvements, the panel noted that it was difficult to prioritize improvements apart from a clear understanding of how GDOT hopes to use the model. GDOT's intended future use of the model should guide the model improvement priorities. The panel therefore tied recommendations of some improvements, such as stratification by income, to GDOT's interest in particular model applications (toll revenue forecasting, in that case).

After a meticulous review of the GSTDM the panel made recommendations divided into items for short, mid, and long term consideration. Short term recommendations should be considered within the next one to two years. Midterm recommendations should be examined within three to five years, while long term recommendations may not be administered until five or more years.

7.3.1 Recommended Shorter-Term Priorities

The panel feels that GDOT should focus on the following priorities in the next one to two years:

1. **Identify intent and objectives for model application** (See Section 7.1)
2. **Improve model documentation**
3. **Further validate individual model components** (generation, distribution, mode choice, assignment – See also Sections 6.8, 6.12 and 7.2.5)
4. **Simplify and streamline the model where possible** (possibly remove Amtrak assignment, consider fewer employment sectors, etc., again see Section 6.1.3)
5. **Integration with REMI** (employment controls as well as commodity production and consumption comparisons, see Section 6.3)
6. **Review NCHRP 08-84 Rural and Long Distance Travel Parameters for Statewide Models** (the report was in publication at the time of the peer review)

7.3.2 Recommended Mid-Term Improvements

Over the next three to five years, the panel recommended GDOT consider the following:

1. **Examine balance of network detail and TAZ detail** (see Section 6.1.1)
2. **Incorporate FAF and ATRI data** (see Section 6.1.3)
3. **Investigate over-specification in the freight model** (see Section 6.4.2)
4. **Consider two-way integration with ARC model** (see Section 6.9)
5. **Examine pivoting off of base year commodity flows or using Transearch forecasts** (see Section 6.1.3)
6. **Explore multiple scenarios for freight forecasts, ranging from low to medium to high, and multiple forecast years**
7. **Include further stratification by income and value of time, particularly with regard to passenger rail or pricing studies** (see Sections 6.4.1 and 6.7)
8. **Consider destination choice models** (see Section 6.1.4)
9. **Examine time of day assignment** (see Section 7.2.4)
10. **Establish carrier surveys and a data program**

7.3.3 Recommended Longer-Term Improvements

The panel also identified potential improvements for GDOT to consider over the longer term (beyond the next five years):

1. **Acquire additional household survey data with a focus on obtaining rural information**
2. **Explore statewide dynamic traffic assignment**

3. **Explore land-use forecasting and allocation modeling, including PECAS, Urbansim, or a simpler model** (could potentially leverage ARC's PECAS model development efforts or adopt a simpler but parcel-based approach similar to Florida's)
4. **Develop discrete mode choice for all purposes**
5. **Consider rebuilding the model from scratch to a new trip- or activity-based model** (it was noted that Ohio and Oregon are now using activity-based statewide models but trip-based models remain standard for statewide models at this time)
6. **Investigate supply chain freight modeling** (similar to that being developed in Florida, piloted by FHWA in Chicago)

Appendix E: Post Peer Review Activity descries the responses and steps taken by GDOT following these recommendations from the Peer Review.

Appendix A List of Peer Review Panel Participants

This section contains a list of the peer review participants, including the panel members, local agency staff, and TMIP documentation support staff.

A.1 Peer Review Panel Members

Panel Member	Affiliation
Vidya Mysore	Systems Traffic Modeling Manager at Florida DOT
Karen Faussett	State Model Specialist at Michigan DOT
Stephen Lawe	CEO at Resource Systems Group, Inc.
Keith Killough	Director of Transportation Analysis at Arizona DOT
Guy Rousseau	Travel Surveys and Transportation Model Development Manager at ARC

A.2 Local Agency and Partner Agency Staff

Name	Affiliation
Matthew Fowler	Georgia DOT
Habte Kassa	Georgia DOT
Phil Peevy	Georgia DOT

A.3 Consultant Staff

Name	Affiliation
Zhang Huang	Atkins
Chris Simons	Atkins
Steve Noble	Atkins
Patti Schropp	Atkins

A.4 TMIP Peer Review Support Staff

Name	Affiliation
Vince Bernardin	TMIP, Resource Systems Group, Inc.

Appendix B Peer Review Panel Meeting Agenda

Below are the agendas for the pre-peer review meeting and the peer review meeting.

B.1 Model Pre-Peer Review Virtual Meeting

August 3, 2012 (90 Minutes)	
General Topics for Discussion	Peer Review Focus Items
	Model Introduction • Model Purpose and Needs • Model Capability and Constraints • Model Input Data Sources • Model Components • Freight & Passenger Models
	Open Question and Answer Forum Between Panel and GDOT

B.2 Model Peer Review Meeting

September 5, 2012	
8:30 – 9:30 a.m.	Introduction, Review of Model and Previous Questions
9:30 – 10:00 a.m.	Issue Areas Dialogue: • MPO area integration • Socioeconomic data and forecasts • Passenger rail • Time of day modeling • Freight model- commodity flow handling in the model • Uses/discussion on Peer Review Team Models
10:00 – 10:15 a.m.	Break
10:15 a.m. – 12:00 p.m.	Continue on Issue Areas Dialogue
12:00 – 1:00 p.m.	Lunch
1:00 – 1:30 p.m.	Continue on Issue Areas Dialogue
1:30 – 3:30 p.m.	Peer Review Team Internal meeting
3:30 – 3:45 p.m.	Break
3:45 – 4:30 p.m.	Peer Review Team Recommendations
4:30 – 5:00 p.m.	Closing Discussion

Appendix C Peer Review Panel Biographies

This section contains a brief bio of each of the peer review panel members.

C.1 Vidya Mysore, Systems Traffic Modeling Manager at Florida DOT

Vidya Mysore is the Systems Traffic Modeling and Forecasting Manager at the Florida Department of Transportation (FDOT) for the past 17 years. Working at the FDOT central office, he oversees works with the FDOT district offices, MPOs, cities and other government agencies in Florida in the use of transportation models and provides guidance, training and technical assistance. Before joining FDOT, Vidya worked with URS Consultants, where he was responsible in developing and analyzing various toll models build for Florida's Turnpike Enterprise. Vidya holds two Master's degrees in Transportation Engineering from The Ohio State University and in Urban and Regional Planning and a bachelor's degree in Civil Engineering from Bangalore University, India.

C.2 Karen Faussett, State Model Specialist at Michigan DOT

Karen Faussett is the Statewide Model Specialist at the Michigan Department of Transportation (MDOT). She is responsible for the update and maintenance of the Michigan statewide travel demand model and leads the statewide model team. Karen was also project manager for MDOT's 2004-2005 and 2009 statewide household travel surveys. Before moving to statewide modeling, Karen spent several years developing small urban models at MDOT. Prior to MDOT, Karen worked at the Southeast Michigan Council of Governments (SEMCOG). Karen has a Bachelor of Science in Urban Planning from Michigan State University and a Master's Certificate in Project Management from The George Washington University.

C.3 Stephen Lawe, CEO at Resource Systems Group, Inc.

Mr. Lawe is the CEO overseeing the Transportation and Environment Forecasting and Planning practice at RSG. Throughout his career, Mr. Lawe has worked to ensure that the state of the modeling practice supports innovative and reasonable transportation policy. This requires a balance between model complexity and the necessity to understand, communicate, and act on the results. He has developed a wide range of tools and methods to assist policy makers understand the results of complex models. He manages a wide range of projects for national and international clients as well as state, MPO, regional, and local clients throughout the United States. In addition to his work with RSG, Mr. Lawe was an assistant professor at Vermont Law School where he taught land use and transportation policy.

C.4 Keith Killough, Assistant Director at Arizona DOT

Keith Killough is an Urban Planning graduate of the Massachusetts Institute of Technology and holds certification from the American Institute of Certified Planners. Keith has held membership on both the Passenger Travel Demand Forecasting and the Transportation Planning Applications Committees of the Transportation Research Board. He has served as the transit industry representative on the federally-sponsored Travel Model Improvement Program that provided oversight to the next-generation TRANSIMS model development project. During his career, Keith has held positions with public agencies in Boston, Detroit, and Los Angeles, and in consulting firms in Washington, D.C. and Los Angeles. In his 20 years with the Southern California Rapid Transit District and the Los Angeles County Metro, Keith was instrumental in the implementation of the Metro Red Line subway and Metro Rapid Bus. Additionally, Keith has recently served as a Director with the Southern California Association of Governments where he was responsible for technical services including modeling, data and monitoring, and information technology; and as Chief Modeler for the State of Arizona.

C.5 Guy Rousseau, Travel Survey/Transportation Model Development Manager at ARC

Guy Rousseau is the Models & Surveys Manager for the Atlanta Regional Commission (ARC), the MPO for Atlanta, Georgia, which he joined in 1998. He is responsible for model development activities and travel surveys. Before coming to ARC, he was the Principal Traffic Engineer for the City of Atlanta Department of Public Works, with responsibilities for travel modeling and traffic simulation. Mr. Rousseau has also been a transportation modeler for the MPOs in Dayton, Ohio, and Tulsa, Oklahoma, and for Jefferson Parish, Louisiana. He is a committee member of various TRB Committees and NCHRP projects, and currently is Chair of ABJ40, Travel Survey Methods. He is also the Chair of the SHRP 2 C10A project on advanced travel demand modeling and fine-grained, time sensitive networks. He is a Committee Member of the NAS/ TRB Synthesis Study on the Determination of the State of the Practice in Travel Forecasting (Special Report 288), as well as the AASHTO/CTPP Oversight Board. He has participated in Model Peer Reviews of metropolitan travel forecasting for several MPOs and State DOTs. He holds an MSCE Degree from Laval University (Quebec City) and a BSCE Degree from the University of Montreal.

Appendix D Overview of Georgia Department of Transportation TDFM

The following summarizes the current version of the GDOT model at the time of the peer review, along with data sources used in the development of the model.

D.1 Model Components

The following sections summarize models components as described in the current model documentation. The model is made up of two models, freight and passenger, which are each comprised of four primary modules that are shown in the figure below:

- Step 1: Trip Generation (Freight and Passenger Separate)
- Step 2: Trip Distribution (Freight and Passenger Separate)
- Step 3: Mode Choice (Freight and Passenger Separate) and
- Step 4: Trip Assignment (Freight and Passenger Together)

The flow chart below illustrates the steps of both the freight and passenger models and how the models interact once the model reaches assignment.

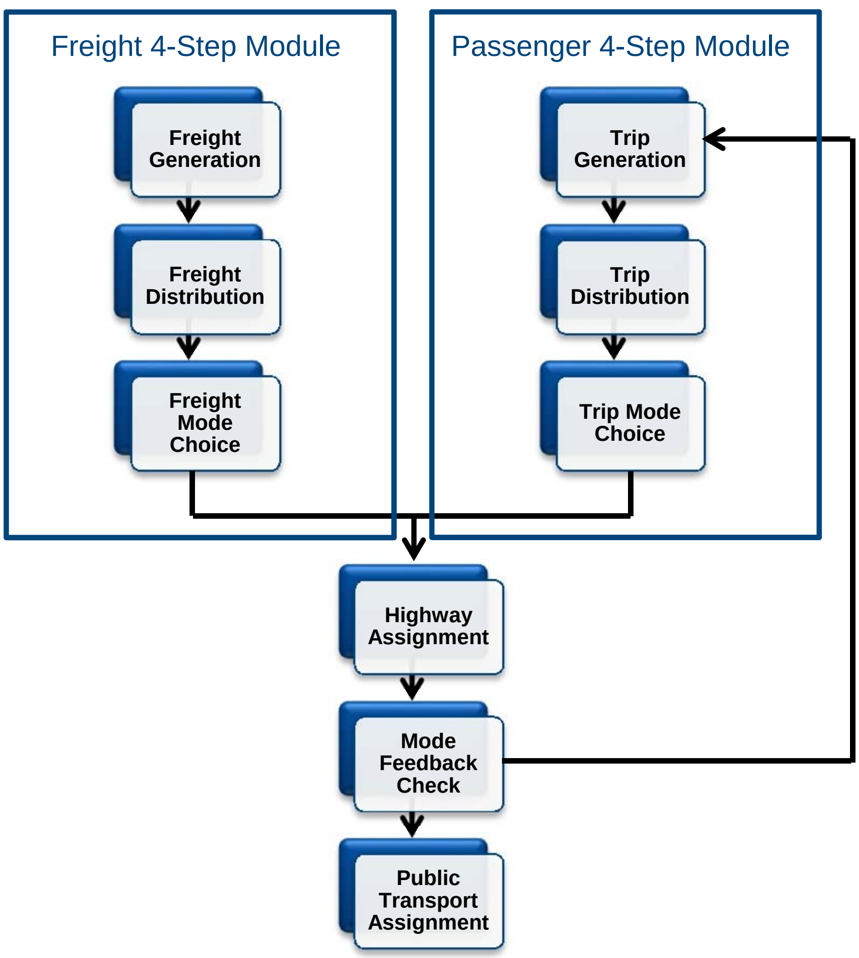

Figure: Model Flows & Structures (*Source: GDOT Statewide Travel Demand Model Presentation, 2012*)

D.2 Other Relevant Aspects of the Model

The model has two major components – Passenger and Freight. Both the passenger and freight models are traditional four-step models. They can be run in parallel through trip generation, distribution and mode choice steps but after that a combined highway assignment is done which is followed by public transport assignment (for air, train, and high-speed rail). There is also a feedback loop which feeds the congested travel times after highway assignment back to the passenger trip generation model.

D.2.1 Freight Model

The freight component of the GSTDM is based on FHWA's Quick Response Freight Manual (QRFM). Linear regression models were developed for sixteen (16) commodity groups to estimate annual tonnage productions and attractions using the Transearch county-to-county commodity flow data. Segmentations by movement type and distance were applied. Distance was used in segmentation since different commodities have different movement frequencies with respect to range and different regions have difference productivity levels. Ex - Perishable goods are more frequent in short range.

Traditional gravity model which uses distance as travel impedance was applied to distribute the annual tonnage flows. Mode choice is an incremental logit model which predicts truck and rail shares. Rail has two modes nested under it – rail only (carload) and intermodal (combination of rail and truck). This model takes into account distance and cost.

Annual tonnage flow was converted to daily freight truck trips using a payload factor obtained from VIUS 2002 data. The factor varied by commodity type and distance range. It was assumed that there were 306 working days per year. Assignment is done using the traditional equilibrium assignment method. Off-peak travel times are used during the assignment since freight demand is not as sensitive to congestion as passenger demand. Average daily freight truck volumes by volume group were used for validation. The assignment parameters for rail are assumed due to lack of data. There were a few sensitivity tests done with respect to changes in truck and rail skim costs (used as proxy for shipping costs) to test that freight model responds to changing transportation costs.

D.2.2 Passenger Model

The passenger model is independent of freight except for traffic assignment. Trip types include home-based work, home-based other, non-home-based, and commercial truck (non-freight short distance). Trip rates for productions were obtained using cross-classification. The 2009 NHTS Georgia Add-On survey data were used to obtain trip production rates by income, urban/rural area, and household size. A regression equation was used for commercial truck trip production. Regression equations were developed for trip attractions based on employment numbers.

There are differences in northern and southern Georgia in terms of economic situation and travel behavior. To capture that, "trip rate density" measures were calculated based on employment, population and travel time to adjacent zone. These were applied to statewide average trip rates from the NHTS survey. Different trip density measures were obtained based on greater/less than seventy-five (75) minutes travel time.

Trip distribution is done using the standard gravity model. Travel time for ODs is the shortest path time and intra-zonal time is half the time to the nearest zone. The distribution model was validated using 2009 NHTS geo-coded trip matrix. The mode choice model is a logit model which predicts shares between auto and public transport. It is only applied for long distance/inter-city travel. Public transport includes air, train, and high-speed rail (HSR). Mode choice model is only for long distance trips within GA. For Internal-External and External-Internal trips, assumed modal splits are used. Since NHTS data were not sufficient for model estimation, logit model coefficients were borrowed from "Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study". Mode constants were calibrated to match adjusted shares in the 1995 American Travel Survey (ATS). For air, only direct flight service and trips at least 100 miles long were captured. Model is not able to forecast air trips with transfers. For train and HSR, inter-city and trips at least 50 miles long are captured.

Traffic assignment is an equilibrium assignment process using generalized costs which include vehicle travel time and operating costs. The vehicle operating costs for auto passenger car and freight truck are $0.12 per mile and $0.50 per mile, respectively. Values of time for the passenger and freight truck assignment are $15 per hour and $60 per hour, respectively. For short trips, congested travel times are used and for long distance and freight trips, weighted congested and free flow times are used since these are less sensitive to congestion. Validation was done using the various datasets listed in the input data sources section. Network is not detailed in small areas so high deviation was observed in small traffic counts.

D.3 Model Validation Summaries

Table D1: Network Mileage

Network Region	Mileage
State of Georgia	18,589
50-mile Georgia border buffer region	8,117
The rest of the 5 southeastern states	17,031
Outlying states	36,689
Total	**80,426**

Table D2: TAZ Summary

Region	From	To	Number of Zones
Georgia	1	1715	1,715
Census Tract Buffer	2016	2379	364
County Buffer	2380	2459	80
RPC Buffer	2460	2499	40
Other States	2500	2542	43

Table D3: Freight Gravity Model Trip Length Validation

	Frequency Distribution		Average Trip Distance - Mile	
Commodity	Coincidence Ratio	RSQ	Transearch	Model
Agriculture	0.83	0.84	824	832
Mining	0.69	0.86	263	278
Food	0.92	0.95	870	872
Textile	0.94	0.98	903	904
Wood	0.91	0.97	459	459
Paper	0.84	0.82	698	748
Chemical	0.93	0.97	1,058	1,080
Petroleum	0.84	0.91	451	441
Rubber & plastics	0.95	0.99	1,028	1,022
Stone	0.84	0.95	304	307
Primary metal	0.95	0.98	834	841
Fabricated metal	0.94	0.98	918	912
Machinery	0.92	0.96	963	954
Instrument	0.89	0.92	1,073	1,057
Waste	0.87	0.91	671	675
Fabricated metal	0.86	0.92	512	482

Table D4: Truck VMT by Functional Class

	Transearch	Model	% Diff
Freeways & Interstates	10,523,888	10,971,978	4%
Principal Arterials	2,281,299	2,437,191	7%
Minor Arterials	917,056	914,197	0%
Collectors	134,511	133,604	-
Locals	287	273	-
Total	**13,857,041**	**14,457,243**	**4%**

Table D5: Truck VMT by RMSE

	Volume Group			
RMSE	<5,000	5,000-10,000	>10,000	All Counts
	26%	26%	22%	25%

Table D6: Highway Screenline Summary

Road Name	Volume	Counts	Volume/Count	% Deviation	Maximum Desirable Deviation
1 Chattahoochee River S of	1,479,126	1,436,960	1.03	3%	9%
2 Oconee River	430,505	476,040	0.90	-10%	14%
3 Norfolk Southern RR S N/S	661,297	624,970	1.06	6%	12%
4 Norfolk Southern RR N N/S	1,743,879	1,536,700	1.13	13%	9%
5 CSX RR E/W	1,937,254	2,076,910	0.93	-7%	8%
6 Chattahoochee River N of	89,500	76,870	1.16	16%	27%
Total	**6,341,561**	**6,228,450**	**1.02**	**2%**	**5%**

Table D7: MPO Boundary/External Station Summary

Road Name	Volume	Counts	Volume/Count	% Deviation	Max Desirable Deviation
1 Albany	75,512	76,140	0.99	-1%	28%
2 Athens	126,512	110,530	1.14	14%	24%
3 Atlanta	756,264	746,640	1.01	1%	12%
4 Augusta	225,590	177,870	1.27	27%	20%
5 Brunswick	117,049	122,645	0.95	-5%	20%
6 Columbus	125,395	119,980	1.05	5%	20%
7 Dalton	250,185	208,220	1.20	20%	20%
8 Hinesville	139,451	143,739	0.97	-3%	20%
9 Macon	302,341	301,020	1.00	0%	20%
10 Rome	100,628	83,610	1.20	20%	20%
11 Savannah	192,119	248,250	0.77	-23%	20%
12 Valdosta	142,088	147,540	0.96	-4%	20%
13 Warner Robins	218,408	206,450	1.06	6%	20%
Total	**2,771,542**	**2,692,634**	**1.03**	**3%**	**7%**

Table D8: Stateline Summary

Road Name	Volume	Counts	Volume/Count	% Deviation	Max Desirable Deviation
1 North	189,639	219,254	0.86	-14%	18%
2 East	240,081	257,918	0.93	-7%	17%
3 South	143,810	158,850	0.91	-9%	21%
4 West	181,613	268,697	0.68	-32%	17%
Total	**755,143**	**904,719**	**0.83**	**17%**	**11%**

Table D9: Link Volume Validation

Model VMT			
VMT	**Rural**	**Urban**	**Total**
Interstate	12,144,693	13,230,121	**25,374,814**
Principal Arterials	7,917,536	13,066,701	**20,984,237**
Minor Arterials	7,246,429	4,722,709	**11,969,138**
Collectors	3,243,945	225,701	**3,469,646**
Locals	4,093	487	**4,580**
Total	**30,556,696**	**31,245,719**	**61,802,415**
Count VMT			
VMT (Counts)	**Rural**	**Urban**	**Total**
Interstate	12,255,428	13,336,115	**25,591,543**
Principal Arterials	7,064,022	13,801,469	**20,865,491**
Minor Arterials	7,414,298	5,652,586	**13,066,884**
Collectors	4,215,551	289,610	**4,505,161**
Locals	16,803	1,535	**18,338**
Total	**30,966,102**	**33,081,315**	**64,047,417**
Percent Difference			
VMT	**Rural**	**Urban**	**Total**
Interstate	-1%	-1%	**-1%**
Principal Arterials	12%	-5%	**1%**
Minor Arterials	-2%	-16%	**-8%**
Collectors	-23%	-22%	**-23%**
Locals	-76%	-68%	**-75%**
Total	**-1%**	**-6%**	**-4%**

Table D10: Link Volume RMSE

Percent RMSE			
Volume Group	**All**	**Rural**	**Urban**
<5,000	135	98	234
5,000-10,000	77	56	102
10,000-20,000	71	44	79
20,000-30,000	60	34	63
30,000-40,000	61	16	69
40,000-50,000	35	18	44
>50,000	40	15	41
Total	**92**	**58**	**78**

D.4 Model Data Sources

D.4.1 Household Survey

2009 National Household Travel Survey (NHTS) and Georgia Add-On Data – used for passenger model.

D.4.2 Demographic and Census Data

US Census – used for population and households.

Bureau of Economic Analysis – used for county and state level employment totals. There are 19 employment types and 16 commodity groups.

Georgia Department of Labor – used for employment distribution pattern at sub-county level. For surrounding states, this is obtained from Census County Business Patterns data.

D.4.3 Transit Counts

Federal Aviation Administration – used airline origin and destination survey.

AMTRAK – used boardings and operating and financial data.

D.4.4 Traffic Volume Data

GDOT Traffic Count Database

D.4.5 Travel Time and Speed Data

National Highway Planning Network (NHPN) – includes 48 states in contiguous US territory.

Georgia Road Characteristics File – used to validate against NHPN for functional class and number of lanes.

National Transportation Atlas Database – used for rail part of the network.

American Travel Survey – used for long distance travel validation.

D.4.6 Truck Data

Transearch Commodity Flow Data – used for freight model.

Vehicle Inventory and Use Survey (VIUS) – used for payload factor development.

Appendix E Post Peer Review Activity

The following summarizes GDOT's general response and activity subsequent to the GDOT peer review.

E. 1 Responses to Truck Assignment Inconsistency Errors

To address the Peer Review comments regarding truck assignment errors inconsistency with general model errors, the model documentation has been revised to clarify that the comparisons were based on two different validation data sources. Transearch matrices were disaggregated to the zonal level and assigned to the highway network. The resulting assigned volumes were used to calculate truck VMT validation targets, which included all highway segments in the model. A much smaller sample of 259 locations with truck traffic counts was used in truck RMSE calculations. This compares to over 5000 total traffic count locations in the model. Truck assignment comments note an inconsistency in relatively close match with VMT targets, but relatively poor match with truck traffic counts per the RMSE statistics. This noted inconsistency is not due to statistical calculation errors. The difference in the modeled accuracy compared to validation targets is mostly attributable to the significant differences in the validation target data sets, where one includes a large sample and the other a small sample.

This was not clearly stated in the documentation. GDOT expanded the table to include the number of identified truck traffic counts, and added more detailed explanation in the updated 2010 model documentation.

E.2 Documentation of 2010 Validation Efforts

Since the time of the Peer Review Panel, the base model year was updated to 2010 conditions. Based on the Panel's comments, the following information was added to the model documentation:

Freight Model Documentation

Added Following Tables, Figures and Discussion

- Figure 4-2: Trip Length Validation
- Figure 4-3: Georgia Regional Commission Districts
- Figure 4-4: Freight Commodity District to District Flows in Annual Tonnage (Transearch vs. model)
- Figure 4-5: Freight Commodity Flows between Atlanta & rest of Region (Transearch vs. model)
- Figure 4-6: Freight Commodity Flows between Savannah & rest of Region (Transearch vs. model)
- Figure 4-8: FHWA Freight Analysis Framework
- Table 4-17: Commodity Flows between the FAF districts
- Table 4-19: Percent Differences in Commodity Flows between the FAF districts by Commodity

Passenger Model

Added Following Tables, Figures and Discussion

- Table 5-8: Aggregated Trip Rates Summary
- Table 5-9: Comparison of Trip Rates between Statewide Model and 2009 NHTS Add-on

- Table 5-10: Comparison of Statewide Model Trip Average Lengths (Statewide Model, NHTS, NCHRP, Travel Survey, Other Statewide Models)
- Figure 5-12: District to District Work Trips between Model and 2009 NHTS Add-on Data
- Figure 5-13: Comparison of District Work Flows between Model and 2009 NHTS Add-on Data
- Figure 5-14: Comparison of Internal Work Trips (Mid-Georgia Region)
- Figure 5-15: Comparison of Internal Work Trips (SW-Georgia Region)
- Figure 5-16: Comparison of District Work Flows of Model with 2010 LEHD Data
- Figure 5-17: Comparison of District Work Flows of Model with ACS Data
- Table 5-18: Comparison of Auto Occupancy Rates with other Statewide Models
- Table 5-23: Link Volume Percent RMSE (modified to include number of count locations, exclude Urban and include Other Statewide Models RMSE ranges)
- Table 5-24: Traffic Count Volume Group by Facility Type and Area Type
- Figure 5-25: Location of Traffic Counts
- Table 5-25: RMSE Relative to Capacity

E.3 Other Post Peer Review Activity

GDOT developed a statewide travel demand model to evaluate the impact of major transportation infrastructure and land use investment strategies. The model provides GDOT and its planning partners the ability to evaluate changes in travel modes and patterns for people and goods.

The model was developed and calibrated for a base year of 2006 due to the availability of complete socio-economic dataset. The release of 2010 Census and acquisition of REMI data increased the urgency to update the model to 2010 base year. Therefore, the motivation for seeking a TMIP peer review panel with hands-on statewide multi modal model experience was to apply a model that is recent and representative of the state of the practice in travel demand forecasting and gain/share experiences from other states and agencies.

During the model update, some of the peer review short and mid-term recommendations are already and being implemented.

- **Improvement to GSTM documentation (short-term)**: the model documentation has been revised extensively. The document describes the development of the model with detail highway and zone system structure as well as expansion of the freight & passenger components of the model with detail discussion of trip generation, trip distribution mode choice and assignment steps. Figures and tables are now included to visualize trip length validation, trip rates summary, commodity flows between the FAF districts, comparison of auto occupancy rates with other statewide models, traffic count volume group by facility type and area type, district to district work trips between model and 2009 NHTS Add-on data, RMSE relative to capacity. Additional activities are currently underway to address some of the other peer review short-midterm recommendations which are listed below.
- **Integration with REMI (short-term):** Disaggregate the REMI SE data at the district level to the Statewide Model TAZ level and run the model set

- **Zone and network detail (mid-term):** Add more zonal and highway detail within the MPO areas including additional network refinement such as adding 2010 functional classifications and consolidating road name attributes
- **Further validate individual model components (short-term):** Perform detailed sensitivity testing of model parameters and various future SE data assumptions, evaluate the performance of the model applications and document in a separate report

GDOT expects to consider other peer review mid-term recommendations in later model updates.

NOTICE

This report is being distributed through the Travel Model Improvement Program (TMIP).

Federal Highway Administration