Comprehensive Truck Size and Weight Limits Study

November, 2013

Modal Shift Analysis

Final Draft Project Plan/Schedule

U.S. Department of Transportation
Federal Highway Administration

FINAL DRAFT PROJECT PLAN/SCHEDULE

1.1 Task Objective

The modal shift analysis task *(Modal Shift Analysis, U.S. Department of Transportation (USDOT) Comprehensive Truck Size and Weight Limits Study (CTS&WLS)* will provide estimates of the changes in a base case of modal freight activity under existing federal truck size and weight regulations that might be expected to occur as a result of changes in federal truck size and weight regulations. In order to estimate these changes in freight activity, a "base case" will be established as a first step using commodity flow data for each mode being considered in the analysis. The base case will reflect modal shares of total base-year freight volumes and vehicle miles of travel (VMT) by truck configuration by commodity and origin-destination under current federal truck size and weight limits. After the base case is established, the consideration will be given to several scenario cases of changes in federal truck size and weight regulations. For each of the scenarios considered, estimates on the changes in freight transportation activity will be identified, including:

- Shifts of truck freight tonnage from the base case configuration to a scenario configuration. These shifts are referred to as intra-modal shifts.
- Shifts of truck travel from lower class highways to higher class highways due to easing of more restrictive federal size and weight regulations in the base case than State regulations applicable off the Interstate System.
- If a scenario's parameters include a more restricted highway network for the alternative configuration(s) being examined, shifts of truck travel from lower class highways to higher class highways due to shifts in truck volumes to scenario configurations that are allowed only on the more restricted highway network than base case configurations.
- Shifts of freight tonnage transported by a non-highway mode (*e.g.*, rail, water) in the base case to truck in a scenario. These shifts are referred to as inter-modal shifts.

The shifts described above will be reflected in a change from the base case to the scenario case in the volume of truck travel (measured as VMT) and the distribution of that VMT by truck configuration, highway functional class and gross vehicle weight. These changes in trucking activity, along with any commensurate changes in rail, water, and other freight activity, will be used in other tasks to estimate scenario impacts on highway safety, traffic operations with special attention on congestion, infrastructure wear and tear, energy consumption, the environment, and on the economy. Specifically, impacts will be estimated as the difference between impacts from base case movements by various freight modes and impacts from scenario case activity.

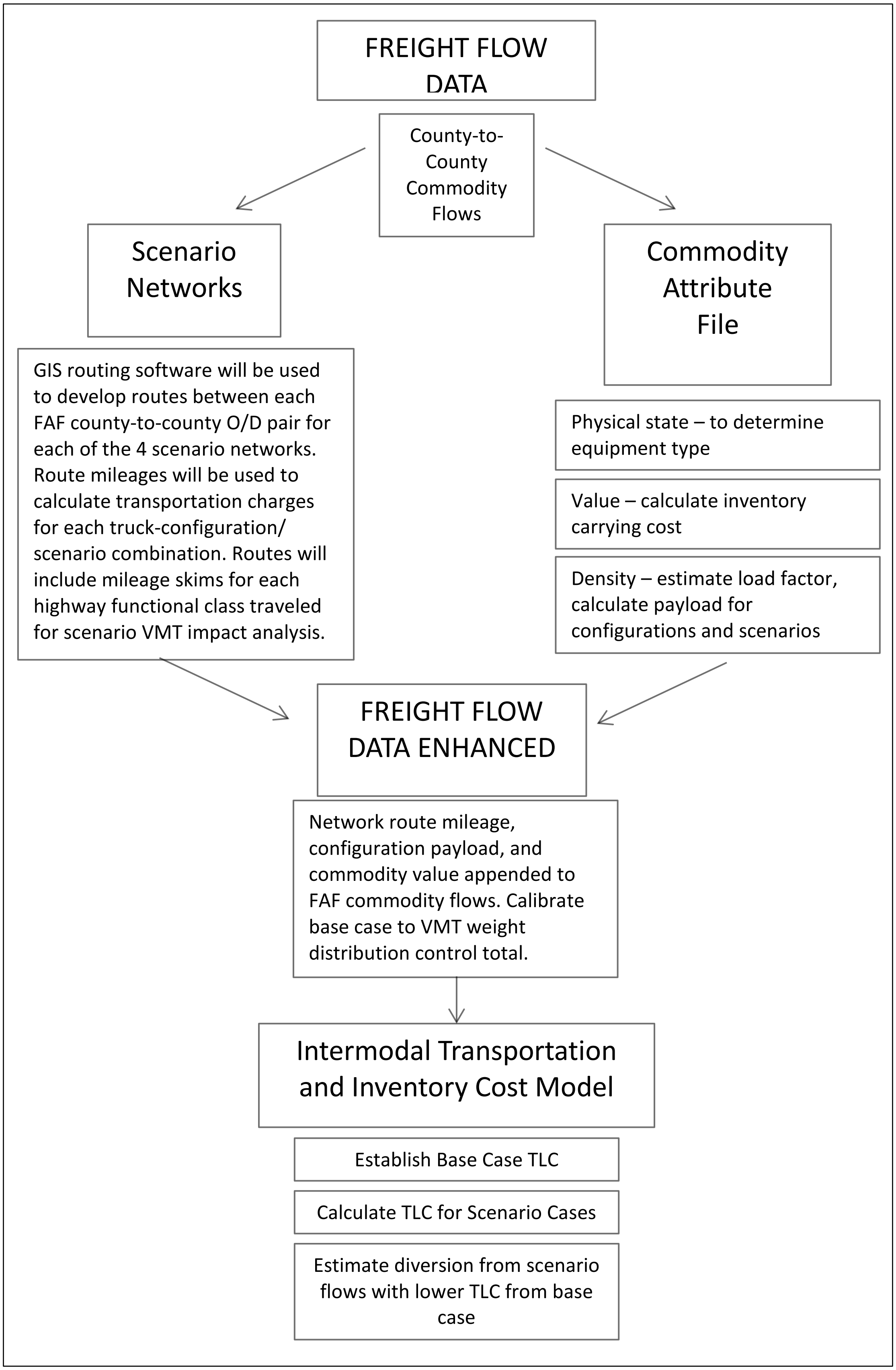
1.2 Task Approach

Each case (the base case and each scenario case) will be analyzed through a series of subtasks to estimate total logistics costs for each shipping alternative being considered for each freight flow in the analysis. The subtasks include:

- Freight flow data by commodity, origin-destination, and mode
- Estimation of shipment size for each shipping alternative
- Truck flow assignment to various highway networks
- Freight assignment to highway equipment, including: body type, configuration and payload
- Calculation of total highway travel by body-type, configuration, highway network and vehicle operating weight
- Calculation of base case transportation costs from origin to destination for each shipping alternative
- Calculation of base case non-transport logistics costs for each shipping alternative
- Calculation of scenario transportation costs from origin to destination for each shipping alternative
- Calculation of scenario non-transport logistics costs for each shipping alternative
- Freight assignment to shipping alternative based on total logistics costs
- Evaluation of base case and scenario case freight volumes on highway infrastructure, safety, environment, energy consumption and the economy.

Figure 1 on the following page illustrates the mode shift methodology. Each step is explained in subtask detail following **Figure 1**.

FIGURE 1: Mode Shift Methodology



Subtask: Freight Flow Data

Commodity flow data for truck from Federal Highway Administration's (FHWA) Freight Analysis Framework (FAF) database will be used; disaggregation of the data to the county level will be prepared by the Oak Ridge National Laboratory.

Subtask Detail: Non-Highway Mode Freight Flows

Shifts from rail and water modes to highway modes will be considered under this part of the Study. The suitability of FAF data for these two modes for use in the study will be evaluated as part of this effort. Rail moves in the FAF data are based on the Surface Transportation Board (STB) Public Use Waybill file, but the Carload Waybill Sample contains more accurate route distances. Comparisons will be made to determine how significant the difference is and the implications for estimates of modal shifts. For the purposes of this Project Plan, it is assumed that FAF data is best suited to estimate freight movements for both rail and water.

Rail traffic will be analyzed as two distinct modes in considering the potential for diversion to alternative truck configurations and scenarios being considered for this study: 1) Rail carload traffic; and 2) Rail intermodal traffic. Truck and rail competition for carload traffic and intermodal traffic are very different. Carload traffic requires rail sidings for loading and unloading at both origin and destination, while intermodal traffic is picked up and delivered by highway at both ends of the move, with truck and rail serving as substitutes for the line-haul portion of the move. Carload capacities are generally several multiples of what a single truck configuration can haul and often consist of multiple cars or make up an entire "unit" train of 100 cars or more. Intermodal shipment sizes are similar, if not identical, to highway shipment sizes – the intermodal box will move on both rail and highway networks, and its utilization for hauling freight is interchangeable with highway-only equipment. The commodities that move by rail carload are generally lower value, bulk commodities (*e.g.*, coal, non-metallic minerals, ores) or special commodities requiring specialized equipment and special handling (*e.g.*, chemicals). The commodities that move by highway are generally higher value and are more sensitive to the on-time service performance advantage that highway has over rail carload.

Rail carload traffic will be further broken down into two analysis methodologies – one for traffic serviced by short-line/regional, Class II and Class III, rail carriers and one for the Class I rail carriers. Again, truck and rail competition are very different depending on the size of the rail network and customer base. Smaller, short-line and regional railroads serve a small number of customers over short distances, either hauling product to a Class I rail network connection, or hauling limited, often specialized commodities over short distances. The rail network of small carriers are usually lines that were once part of a Class I rail network, but could not be operated profitably under the cost structure of the Class I Rail Carriers. Trucks compete more effectively with these small rail operators for the short-haul specialized commodity traffic, where the loss of a single customer could force the rail operator out of business. The Carload Waybill Sample includes some but not all moves by Class II and Class III rail carriers. Shipments included in the Waybill will be analyzed using the Intermodal Transportation and Inventory Cost Model (ITIC), but shipments not in the Waybill will be analyzed more qualitatively based on available information.

For analysis of mode shifts of rail intermodal traffic, with guidance provided by the Federal Rail Administration (FRA), an expected drayage distance to proxy the truck move for each origin and destination to a rail intermodal terminal will be developed.

Waterway traffic to be considered for the study will be developed in consultation with the Maritime Administration (MARAD). Short-sea shipping potential to reduce highway truck travel is currently being considered for public funding. A 2006 case study of four short-sea shipping corridors developed transportation rates for short-sea shipping that may be relevant for this study in estimating its market share potential with existing federal size and weight limits and how that potential would change under increased size and weight limits. An evaluation of short-sea shipping rates used in this study will be conducted regarding its applicability to the current Study.

Subtask Schedule and Product: A complete freight flow database for truck, rail, and water will be developed in December, 2013. This database will be in an appropriate format for use in subsequent tasks that require these data.

Subtask: Freight Flow Assignment to Highway Network

The assignment of freight flows to highway networks provides the mileage base for estimating the transportation costs of moving freight from origin to destination by truck. Truck rates are determined by distance, shipment weight, equipment type, and special handling requirements of the commodity. These rates are generally quoted in dollars/cents per mile.

The project statement of work stipulates that four highway networks are to be analyzed in the study: the Interstate System; the National Highway System; the Principal Arterial System and NHS Intermodal Freight Connectors; and the National Truck Network. It is anticipated that at least some longer combination vehicles (LCVs) included in the analysis will be restricted to higher classification highways (*i.e.*, those with limited access and egress) resulting in more circuitous LCV routings than for some freight flows in non-LCVs traveling on a denser highway network. For those configurations limited to higher-order systems, scenarios will assume that staging areas will be necessary to allow those vehicles to assemble and disassemble for entry to and exit from the restricted network. The capital and operating cost of staging areas will be incorporated into the freight rates for those configurations that require the facilities.

Because infrastructure design standards and traffic operations vary across highway functional classifications, information on functional classification of truck travel in each case analyzed is necessary to assess the impacts of truck travel on safety, infrastructure, traffic operations, energy consumption, and the environment required for the Comprehensive Truck Size & Weight Limits Study (CTS&WLS).

Subtask Detail: County-to-County Flows

There are some 3,000 county level jurisdictions in the United States, giving rise to a potential of some 4.5 million unique (unordered) county pairs. An unknown fraction of these pairs have freight flows between them. For each of the four highway networks included in the analysis, network routes will be generated for each county pair for which a freight flow exists in the data. In those cases where a restricted LCV network is not continuous between an origin and destination (O/D) county pair, the off-network mileage for a continuous route over unrestricted network links will be accumulated separately from the restricted LCV network mileage. This off-network mileage will be used in estimating the costs of off-network transportation to move the multiple trailers of an LCV as single trailers over the unrestricted network links.

The network routings between counties will be developed using GIS software – *e.g.,* Transcad, ESRI. For each route generated, the output will include, at a minimum, the identification of each of the two counties in the pair and the miles of travel along the generated route by highway classification.

Subtask Schedule and Product: A complete highway network assignment for base case and scenario traffic moving between each origin and destination pair will be completed in December, 2013.

Subtask: Freight Assignment to Highway Equipment

The assignment of freight to highway equipment is a key component of determining transportation costs. Specialized equipment, such as tankers, has higher capital costs and higher empty-to-loaded mileage ratios than general freight equipment, such as dry vans. These differences in capital costs and operating characteristics result in differences in the per-mile rates charged by operators of specialized equipment.

Like differences in equipment body types, differences in equipment configurations also affect capital costs and operating characteristics. A twin or triple LCV configuration requires the additional capital of the added trailer(s) and may require a change in driver operations to efficiently move trailers between staging areas and off-network points of pickup/delivery.

Another important consideration in assigning freight to highway equipment is the payload weight. Weigh-in-Motion (WIM) data show that over seventy percent of travel by 5-axle tractor-semitrailer configurations is at gross vehicle weights of 70,000 pounds or less, even though this configuration is legal up to 80,000 pounds At the other end of the spectrum, over eight percent of 5-axle travel is at gross vehicle weights in excess of 80,000 pounds. The WIM distributed VMT data for every state, including states without grandfathered limits in excess of the 80,000 pounds federal weight limit, and those that allow travel at weights above 80,000 pounds. Some of this traffic is operating legally under state permit and some is operating illegally. The process of assigning freight to highway equipment in the base case will include calibrating the result to approximate existing WIM data for VMT and weight distributions by vehicle configuration.

Subtask Detail: Cargo-Unit Body Type

The discontinued Vehicle Inventory and Use Survey (VIUS) provides the best available source of information on the operating characteristics of trucks by equipment type. The survey included information on commodities carried, typical payload weight, number of axles, cargo-unit body type, number of trailers, and empty miles. Although the survey was last conducted in 2002, because federal size and weight limits have generally remained unchanged since then, the information is still useful and will be used in assigning commodity types by cargo-unit body type.

Subtask Detail: Configuration

Much of the truck travel in the U.S. is in configurations that do not fall within the parameters of traffic that is a candidate for shifting from one truck configuration to an alternative configuration being considered in the study – *e.g.,* 3-axle tractor-semitrailer and 3-axle single-unit truck configurations operating at bridge formula limits currently have higher legal weight alternative configurations options, and don't utilize them. In addition, several of the alternative configurations being analyzed in the CTS&WLS already operate in some areas of the country.

In developing the CTS&WLS Study's base case, traffic will be assigned from the commodity flow data used in the study to yield distributions of truck VMT by configuration and functional class that approximate existing data for truck VMT distributions. Base case traffic that is designated as having a higher weight legal alternative configuration in the base case – *e.g.,* 3-axle tractor-semitrailer, 3-axle single-unit truck at 60,000 pounds or less in the base case – will not be evaluated for a shift in scenario cases. Likewise, traffic assigned to one of the alternative configurations in the base case will not be considered for a configuration shift to a lower cube or weight configuration in scenario cases, although it may be assigned a higher payload weight in the base case configuration in the scenario case than in the base case.

Subtask Detail: Payload

In conjunction with the assignment of commodity flow volumes by configuration and functional class described above, commodity specific payload factors will be developed for each equipment type (cargo body type and configuration). Commodities are commonly classified as "weigh-out" or "cube-out", as determined by whether they fill the cubic capacity of the cargo carrying unit before reaching the maximum legal gross vehicle weight (cube-out) or reach the legal gross vehicle weight limit before filling the cubic capacity of the cargo carrying unit (weigh-out). Commodities with densities of 13 pounds per cubic foot or greater, which is most commodities, are technically "weigh-out" commodities for a 5-axle tractor-semitrailer (3-S2) configuration limited to 80,000 pounds gross vehicle weight, yet national weight distributions developed from weigh-in-motion data for 3-S2s indicate that over 70 percent operate at 70,000 pounds gross vehicle weight or less. About a fourth of those loads weigh less than 35,000 pounds and can be attributed to empty backhauls. The balance represents partial loads and "floor-out" commodities that fill the floor space but not the full interior height of the trailer. Payload factors will represent the typical payload of the commodity as a percentage of the maximum payload the configuration can legally carry. These factors will vary by cargo body type, where bulk equipment types generally utilize a higher percentage of maximum allowable payload than general freight equipment. The maximum payload will be the calculated as the federal weight limit for the configuration minus the vehicle tare weight. Commodity specific payload factors will be scaled by commodity density and payload information from the VIUS.

Subtask Detail: Freight Assignment to Highway Equipment

Commodity specific characteristics of the three freight assignment parameters described above, cargo-unit body type, configuration and payload, will be catalogued in a database of commodity attributes. The commodity attribute database will include VIUS information on the distribution of commodity VMT by equipment configuration, cargo-unit body type and typical payload, as well as commodity density and value characteristics.

Truck freight volumes from the commodity flow data will be "loaded" to base case configurations according to commodity attributes. This process will generate the number of truck trips between origins and destinations necessary to transport the commodity flow data volumes. Applying route mileages between origins and destinations generated in the highway network assignment subtask to the truck trips data will provide an estimate of truck VMT by configuration, distributed by gross vehicle weight. This result will be calibrated to approximate existing WIM data by configuration through iterative adjustments to commodity attribute configuration and payload values. This process will likely necessitate applying a distributed range of commodity specific payload factors to achieve the WIM target weight distributions. Existing WIM data indicates that 8.5 percent of five axle (3-S2) VMT operates at weights in excess of 80,000 pounds. The iterative calibration of the freight assignment subtask will result in a similar percentage of base case 3-S2 VMT operating above the nominal federal weight limit, as well as other configurations operating above nominal federal limits.

Subtask Schedule and Product: A complete assignment of the various types of commodities to different types of highway equipment and operating weight distributions will be developed by early-January, 2014.

Subtask: Calculation of Base-Case Transportation Costs

Truck rates are determined in large part on the mileage between origin and destination, the equipment used to transport the shipment and any special handling requirements to transport the commodity. The market truck rate data used by FHWA in mode shift estimates in previous size and weight analyses will be evaluated and updated as necessary for use in this CTS&WLS.

Consultation with FRA and MARAD will be conducted to develop transportation rates for base case rail and waterway traffic that will be analyzed for potential diversion to highways as a result of changes to federal truck size and weight limits. It is expected that FRA's experience will be used in developing rail rates for rail-competitive truck traffic in their ITIC analyses of truck-to-rail diversion of tolling and positive train control, as well as MARAD's work on developing rates in its 2006 report of four case studies.

Subtask Detail: Market Truck Rate Data

The truck rate data FHWA obtained for the Strategic Multimodal Analysis project consists of single trailer dry-van truckload rates between points in the US as assigned to 113 market areas. These rates reflect lane imbalances where they exist, with head-haul/outbound rates higher than back-haul/inbound rates. The possibility of obtaining a more current database of truckload market-based freight rates will be investigated, but if unable to do so, will utilize the existing data.

Truckload market-based freight rates will be updated and supplemented to reflect price differentials between dry-van trailers and specialized trailers (*e.g.,* flatbed, tanker, refrigerated), differences in empty-to-loaded ratios between dry-van and specialized trailers and the additional capital cost of multi-trailer configurations.

Origins and destinations of the commodity flow database will be mapped to their respective markets in the truck rate database. The output of this subtask will be a database of truck rates for each origin-destination pair differentiated by trailer type and configuration.

Subtask Detail: Calculation of Base-Case Transportation Costs

Base-case transportation costs for truck volumes will be calculated by application of the truck rate database to the base case truck loads developed in the Freight Assignment to Highway Equipment subtask.

Base-case transportation costs for traffic on other modes that would potentially divert to highway modes under increased federal truck size and weight regulations will be developed collaboratively with FRA and MARAD. The costs developed for these modes will be used to develop total logistics costs for the rail or waterway move that will be used for comparison against truck total logistics costs in determining the mode selected in scenario cases.

Subtask Schedule and Product: A complete base case transportation cost estimate for each mode and each origin-destination pair will be developed in January, 2014.

Subtask: Calculation of Base-Case Non-Transport Logistics Costs

Non-transport logistics costs are those costs associated with the ownership of inventory. They include inventory carrying costs, storage, loss, damage and obsolescence. FHWA's ITIC Model will be utilized to estimate these cost.

Subtask Detail: Application of ITIC to Base-Case

Various versions of ITIC model will be reviewed, including the ITIC-IM version developed by FRA for estimating diversion from highway to rail, and the version used in FHWA analysis for the Western Governors LCV Uniformity and Strategic Multimodal Analysis studies. Updated and improved coding and algorithms developed by FHWA and FRA will be incorporated into the version used previously for FHWA studies in order to do a complete analysis of mode shifts resulting from the changes in federal truck size and weight regulations being considered in the CTS&WLS. The logic for estimating shipper responses to small changes in total logistics costs associated with changes in federal truck size and weight limits will receive particular attention.

Once the ITIC model is updated, the base case freight volumes will be loaded into the model, including the transportation costs estimated in the previous subtask. The non-transport logistics costs estimated in ITIC will be added to the transportation costs to establish base case total logistics, against which total logistics costs for alternative configuration scenarios will be assessed for intra- and inter-modal shifts of traffic.

Subtask Schedule and Product: A complete base case non-transport logistics cost estimate for each commodity movement by each mode between each origin-destination pair will be developed in January, 2014.

Subtask: Calculation of Scenario Transportation Costs by Highway for Each Alternative Configuration Being Considered

Each of the alternative configurations to be evaluated in the study increases the cargo carrying capacity of trucks and is expected to decrease the transportation costs per ton of freight per mile traveled. For some of the alternative configurations, the cost reduction per ton per mile of travel will be partially offset by more circuitous routing on higher classified highways than the base case configuration traveled, as well as assembling and disassembling LCVs at staging areas for access/egress to/from restricted LCV highway networks.

Calculation of scenario costs will follow the same process used to calculate base case costs – assignment of commodity flow to equipment type, configuration and payload. Equipment assignment in the scenario is the same cargo-body assigned in the base case. The configuration assignment is determined by the alternative configuration(s) being considered in the scenario.

Subtask Detail: Scenario Payload

Payloads for scenario will be calculated from the payload factors developed for the base case described previously. For scenarios with single trailer alternative configurations – *e.g.,* 88,000 pounds, 5-axle tractor-semitrailer – mode shifts from base case configurations to be considered will be limited to traffic that approaches the existing 80,000 pounds federal weight limit. For example, a base case 5-axle tractor-semitrailer with a gross vehicle weight of 50,000 pounds will not be considered for mode shift to the 88,000 pounds 5-axle tractor-semitrailer alternative configuration.

For multi-trailer configurations, payloads will capped at the lower of the weight limit allowed on the alternative configuration and the weight increase from the base case configuration that is proportional to the increase in cubic capacity from the base case configuration. Using the 5-axle tractor-semitrailer example from above, the approximately 30,000 pounds payload would be legal on each trailer of a turnpike double configuration of two trailers having the same length as the base case trailer. In this case, the scenario payload would be twice that of the base case.

Subtask Schedule and Product: A complete transportation cost estimate for movements of each commodity by each mode (including scenario vehicles) between each origin-destination pair will be developed in January, 2014.

Subtask: Calculation of Scenario Non-Transport Logistics Costs

The process for calculation of non-transport logistics costs for scenario cases is identical to the process for calculation of those cost for the base case described previously. Once calculated, scenario non-transport logistics costs are added to transportation costs to generate total logistics cost for the scenario case being evaluated. These costs are stored in the ITIC model for comparison with base case total logistics costs.

Subtask Schedule and Product: Complete non-transport logistics cost estimates for movements of each commodity by each mode (including scenario vehicles) between each origin-destination pair will be developed by February, 2014.

Subtask: Freight assignment to mode based on total logistics costs

Once base case and scenario case total logistics costs have been calculated, the two costs can be compared and a decision made as to which mode the traffic would use in the base case and in the scenario case. For each case, truck volumes are summarized by configuration, highway functional class, and gross vehicle weight. As previously discussed, the base case result is calibrated to yield approximate VMT and weight distributions of existing available data.

Scenario truck volumes are similarly summarized, providing scenario VMT distributed by highway functional class and weight.

Appendix A illustrates an example of VMT analysis output results for three configurations by functional class, base and scenario cases, and weights. These VMT results are summarized in **Tables 1 and 2**.

TABLE 1: MODE SHIFT EXAMPLE - VEHICLE CLASS SUMMARY

Vehicle Class	VMT				
	Base Case	Share of Total (%)	Scenario	Share of Total (%)	% Change on VC
CS5	120,265,894,135	98.0%	74,184,983,133	64.6%	-38.3%
CS6	2,292,533,161	1.9%	13,978,668,642	12.2%	509.7%
DS8+	147,162,257	0.1%	26,652,177,084	23.2%	18010.7%
Total	122,705,589,552	100.0%	114,815,828,859	100.0%	-6.4%

TABLE 2: MODE SHIFT EXAMPLE - FUNCTIONAL CLASS SUMMARY

Highway Functional Class		VMT				
		Base Case	Share of Total (%)	Scenario	Share of Total (%)	% Change on FC
Rural	Interstate	37,662,793,121	30.7%	37,595,485,996	32.7%	-0.2%
	Other Principal Arte	20,897,225,593	17.0%	21,054,972,705	18.3%	0.8%
	Minor Arterial	6,601,138,274	5.4%	3,959,971,528	3.4%	-40.0%
	Major Collector	5,123,182,147	4.2%	3,364,531,007	2.9%	-34.3%
	Minor Collector	887,335,589	0.7%	591,820,452	0.5%	-33.3%
	Local	1,893,623,455	1.5%	1,245,718,620	1.1%	-34.2%
	All Rural	73,065,298,179	59.5%	67,812,500,309	59.1%	-7.2%
Urban	Interstate	23,509,176,295	19.2%	24,299,090,663	21.2%	3.4%
	Freeways/Express	9,124,769,856	7.4%	10,139,976,699	8.8%	11.1%
	Other Principal Arte	11,852,073,966	9.7%	8,818,538,124	7.7%	-25.6%
	Minor Arterial	4,104,113,392	3.3%	2,964,334,609	2.6%	-27.8%
	Collector	679,537,266	0.6%	500,792,419	0.4%	-26.3%
	Local	370,620,600	0.3%	280,596,036	0.2%	-24.3%
	All Urban	49,640,291,374	40.5%	47,003,328,550	40.9%	-5.3%
Total Rural and Urban		122,705,589,552	100.0%	114,815,828,859	100.0%	-6.4%

Subtask Schedule and Product: Complete base case and scenario case mode assignments, output VMT by configuration, highway functional class and weight group will be developed by early February, 2014.

Subtask: Evaluation of Base-Case and Scenario-Case Truck Volumes on Certain Factors

The estimated modal shifts resulting from the introduction of the alternative configurations as illustrated in Appendix A will impact multiple factors related to highway transportation including safety, pavement costs, bridge costs, energy consumption, the environment and the economy. Some of these impacts are likely to be positive and some are likely to be negative. Safety, pavement, and bridge impacts are analyzed in other work areas of the CTS&WLS. Impacts on energy consumption, environmental impacts, cost responsibility and productivity are included in this task.

<u>Subtask Detail: Evaluation of Fuel Consumption, Air Quality and other Environmental Impacts</u>

Fuel consumption of the various truck configurations will be evaluated at different operating weights in developing an MPG/GVW profile for each configuration. The U.S. Environmental Protection Agency (EPA) Greenhouse Gas Emissions Model (GEM) open source vehicle modeling and simulation software will be used to perform the fuel economy and emissions analysis, using GEM vehicle models to represent each configuration to be evaluated. The vehicle models will be calibrated with drag and rolling coefficients measured in previous test programs.

Outputs of the analysis will include the load specific (per ton-mile) fuel consumption, CO2, NOx, SOx, VOC, and PM emissions for each vehicle configuration. A spreadsheet model will be developed that will estimate the impacts of these outputs on the entire vehicle fleet. The spreadsheet model will apply the vehicle fuel consumption and emissions rates per vehicle-miles-traveled to a set of weighted traffic profiles. These profiles will represent the vehicle composition of the fleet, the VMT and the duty cycles traveled by these vehicles. This information will be prepared for use in fuel and emissions modeling and analysis activities and will represent the different fleet configurations and travel patterns determined in each scenario considered. The end result will be a model capable of reporting system wide changes to fuel consumption and emissions as a consequence of adopting different standards on truck size and weight (TSW).

Data from FRA's recent report, <u>Comparative Evaluation of Rail and Truck Fuel Efficiency on Competitive Corridors</u>, will be used to estimate changes in energy and emissions associated with potential diversion of traffic from rail to truck associated with the various scenarios.

To evaluate the noise pollution occasioned by the alternative configurations, the suitability of the noise analysis from the 2000 Comprehensive Truck Size and Weight Study will be evaluated for use in this project. Consultation with FHWA's Office of Planning, Environment and Realty will be conducted on the suitability of Traffic Noise Model (http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/) for assessing the difference in noise pollution from the change in VMT and vehicle configurations in the traffic mix resulting from the introduction of the alternative configurations.

Subtask Schedule and Product: A complete evaluation of the fuel consumption and air quality impacts of each scenario will be developed by March, 2014.

Subtask Detail: Evaluation of Traffic Operations Impacts

The analysis of impacts of the scenario vehicles on traffic operations will build upon the analysis of traffic operations impacts in the 2000 Comprehensive Truck Size & Weight Study. Passenger car equivalents will be estimated for each scenario vehicle based on a review of recent literature, assumptions will be documented and limitations of established methods will be discussed. As in the 2000 Study, congestion delays will be estimated reflecting operations on different types of highways in different roadway settings. The methodology for modeling traffic operations will be performed consistent with 2010 Highway Capacity Manual and the FHWA Traffic Analysis Toolbox. A Technical Memo laying out the steps to be applied in the methodology will be prepared. . The truck VMT by vehicle configuration and vehicle weight will be tested in the Study to quantify the traffic delay model for the base case truck VMT, and the change in highway operating speed by functional class will be calculated to obtain the change in delay for all highway users. This change in delay in vehicle hours is then multiplied by a time value to obtain the change in congestion costs.

Longer, heavier trucks also affect other aspects of traffic operations such as passing, acceleration (merging and hill climbing), lane changing, and intersection requirements. The magnitude of these impacts is too site-specific to model quantitatively on a nationwide basis. Using generally accepted 2010 Highway Capacity Manual procedures, three locational scenarios will be evaluated: 1) highly congested urban, 2) high speed, suburban and 3) high speed, access controlled rural. Consideration will be given to the isolated impacts of the various truck configurations operating on defined roadway geometric configurations (for example, acceleration lanes, merge areas, divergence points, work zone presence and roadway segments with signalized and non-signal controlled intersections. Assumptions and methods applied in building this analytical framework will be documented so the analysis can be reproduced. It is important to note that various travel demand patterns for the urban, suburban and rural test sections will be documented so that incremental impacts of changes in the traffic stream composition produced by the introduction of the alternative configurations can be identified in the context of varying travel demand levels, lane width attributes, roadway grade settings and roadway geometry. Findings from the evaluation of vehicle impacts in these settings will enable findings to be developed that are qualitative in nature but based upon the technical analysis performed in the three locational scenarios. Impacts will be discussed qualitatively with an emphasis on factors that affect the magnitude of impacts compared to base case vehicles. Shortcomings or weak points in this analysis will be identified and documented in a Technical Memo so that further research opportunities are understood. As this work progresses, micro-simulations similar to those used in the 2000 Comprehensive Truck Size & Weight Study may be relied upon if it becomes clear that the needs of this analysis lie outside the capabilities of the Highway Capacity Manual. At this point, the FHWA Traffic Analysis Toolbox guidelines will be applied.

Subtask Schedule and Product: A complete evaluation of traffic operations impacts of each scenario will be developed by March, 2014. This will include quantitative estimates of changes in congestion-related delay as well as qualitative assessments of how scenario vehicles would affect other aspects of traffic operations. Technical Memos that document the approach used and improvement opportunities for the methodology will be prepared.

Subtask Detail: Evaluation on Cost Responsibilities

Detailed assessments of changes in the cost responsibility for pavement and bridge improvement costs associated with the various scenarios are included in other tasks. Cost responsibility estimates from those tasks along with other quantitative and qualitative information developed in this study on costs attributable to different vehicle classes will be summarized in this subtask. This will not constitute a comprehensive highway cost allocation study, but will provide a broad overview of how costs associated with the operations of vehicles analyzed in the various scenarios are attributed to different vehicle configurations and weight groups.

Subtask Schedule and Product: A complete evaluation of the cost responsibility of the various scenario vehicles for changes in pavement and bridge costs will be developed by March 7, 2014. Summaries of the impacts of scenario vehicles on safety, traffic operations, energy consumption, emissions, and other environmental factors will also be included to present an overall picture of the relative impacts of each of the scenario vehicles.

Subtask Detail: Evaluation on Freight Transportation Costs

An evaluation of the change in Total Logistics Costs as estimated by ITIC and its transportation and non-transportation components will be conducted. Based on past studies, the largest impact on transportation costs will be on traffic currently moving by truck. The changes in transportation costs and non-transportation logistics cost for the base case and each scenario analyzed will be summarized and changes in costs for each scenario case in total and separately by the base case mode of the shifted traffic will be reported. In the case of traffic diversions from the rail mode, the evaluation will include the ability of the railroads to cover the lost contribution of diverted traffic to network fixed costs and the secondary effects of additional diversions of rail traffic due to rate increases necessary to cover that lost contribution, or rail line abandonment where the remaining traffic base cannot support fixed network costs. Analysis of these impacts on the railroads will be similar to that conducted for the 2000 CTS&WLS. FRA staff will be consulted to determine if methods used in the 2000 Comprehensive Truck Size and Weight Study need refinement.

Primary diversion on the short-line/regional rail operator will be further assessed as to secondary effects of viability of the operator to cover fixed costs of the network with remaining customer-base/business. The short-line rail industry expertise will be relied upon for this assessment.

Limited rail-to-rail competition in some long-haul rail carload traffic markets in the Class I segment of the analysis allows railroads to price their service above what they would be able to charge if competition for the traffic existed. In these markets, competition from the increased productivity offered by the Study's alternative configurations may put downward pressure on rail rates. Traffic in these markets will be assessed for potential reduction in rail rates, but generally will be assumed to be retained by the railroad.

Subtask Schedule and Product: A complete evaluation of changes in total freight logistics costs associated with each scenario vehicle will be developed by March, 2014.

<u>Subtask Detail: Impacts on Economic Productivity</u>

An evaluation of the effects of changes in federal truck size and weight limits on the productivity of different parts of the freight transportation industry will be conducted. The discussion will address direct and indirect costs and benefits of the size and weight changes, how those costs and benefits are quantified and the net direction of impacts when the various factors are considered together. This analysis will be based primarily on an assessment of industries that would benefit the most if scenario vehicles were allowed to operate and the magnitude of the reduction in total logistics costs those industries might realize. A breakout of industries most able to benefit from the alternative configurations and to the extent possible, the geography of the benefits and the costs of operating those vehicles will be prepared. The analysis will show the relative benefits and costs of the various scenarios but will not constitute a comprehensive benefit-cost analysis of any individual scenario.

Subtask Schedule and Product: An evaluation of impacts of each scenario on economic productivity with different sectors of the economy will be developed by early March, 2014.

<u>1.3 Task Data Needs</u>

The methodology for the modal shift analysis establishes base case and scenario case modal freight activity using the ITI Model. The ITIC uses costing algorithms to estimate the total logistics costs of freight by alternative transportation modes. Data requirements for the model include:

- Comprehensive freight flow data: Annual commodity flow volumes between origins and destinations. The FAF3 database will be the source of commodity flow data. The Oak Ridge National Laboratory is disaggregating the data to provide county-level origin-destination data for the commodities and modes included in the FAF. The impact analyses to be conducted in the study require detailed origin and destination locations of the flows – *i.e.,* county-to-county flows. Disaggregate flows are necessary to properly assign scenario configurations to the highway networks to which they will be restricted. The **Appendix A: Mode Shift Example** illustrates how truck freight will shift across configurations, highway functional classes and gross vehicle weights from a base case analysis to a scenario analysis. The VMT distributions output from the mode shift analysis will provide the inputs for the Study's impact analyses on infrastructure, safety, traffic operations, energy, and the environment.

- Network route miles: Mileage by highway functional class for each scenario network analyzed. Highway networks include the National Truck Network as defined in 23 CFR Part 658 Appendix A, the Principal Arterial System and National Highway System Intermodal Freight Connectors, the National Highway System as designated and in use September 1, 2012, and the Interstate System as designated and in use September 1, 2012. GIS software (*e.g.*, TransCAD, ESRI) will be used to generate route miles between each origin-destination pair for each truck configuration being analyzed. Mileage between O-D pairs may differ by configuration if certain configurations are assumed to be prohibited on certain parts of the highway system.
- Commodity attributes: Density (pounds per cubic foot); Value (dollars per pound); Handling requirements (*e.g.*, refrigerated, hazardous). FHWA's existing values for commodity density will be reviewed using available sources – the National Motor Freight Classification if available - and industry contacts. Commodity values will be derived from 2007 Commodity Flow Survey (CFS) value and tonnage data. Commodity values calculated from the 2007 CFS will be mode-specific, that is the value of a commodity hauled by truck will be calculated as the total commodity value hauled by truck divided by the tonnage volume hauled by truck. Each mode hauling the given commodity will similarly have a mode specific commodity value calculated. The reason for calculation of mode specific commodity values is the lack of specificity in the CFS commodity groupings which allows for a broad range of commodities within a single CFS commodity group. Most CFS commodity groups have higher value per pound for what moves on truck than what moves on rail, for example, the value of "Articles of Base Metal" transported by truck in the 2007 CFS was $1.32/pound, while the value transported by rail was $0.41/pound. Commodity value affects inventory carrying costs, one component of the non-transportation logistics costs that will affect shipper mode choice in the diversion analysis.
- Freight rates: Truck rates from market rate database. Market-based truck rate data will be obtained either through purchase from a vendor, such as TransCore DAT, or updating the 2006 truck rate database FHWA obtained for the Strategic Multimodal Analysis project to analysis year price levels. Rail rates will be developed with Federal Railroad Administration (FRA) input based on rates in STB's railroad waybill sample. Waterway rates will be developed with MARAD input based on their rate development for 2006 report, "Four Corridor Case Studies of Short-sea Shipping Services".
- Equipment costs and operating characteristics from publicly available and industry sources. Information on new equipment prices will be collected from truck and trailer manufacturers, dealers and purchasers. Industry contacts will be used to solicit this

equipment pricing information. Price information for truck-tractors at horsepower ratings necessary to maintain speed for the configurations being analyzed and trailer prices for dry-van, flatbed, refrigerated, tanker, and dry-bulk cargo bodies will be collected. Empty/loaded ratios by equipment type will be estimated from the 2002 VIUS to develop rate differentials from dry-van rates for other equipment types.

Table 3 summarizes data sources for the modal split analysis and methods for bring those data to the 2011 analysis year.

Table 3. Modal Shift Data Requirements and Sources

Data Need	Data Source	Method for Bringing Data to 2011 Analysis Year
Commodity Flow Data	2007 county-to-county FAF	Expand by factors applied to FAF3 database at FAF regional level
Network Route Miles	2011 National Highway Planning Network	No expansion necessary
Commodity Density	National Motor Freight Classification, other	No expansion necessary
Commodity Value	2007 CFS	Producer Price index
Truck Rates	TransCore DAT	No expansion necessary
Rail Rates	STB Confidential Waybill	No expansion necessary
Water Rates	2006 MARAD data	Consultation with MARAD
Equipment costs	Trucking industry	No expansion necessary
Empty-loaded ratios	2002 VIUS	Discussions with industry contacts

Page 1

APPENDIX A - MODE SHIFT VMT EXAMPLE

Functional Class (FC)	Weight (WGT) (in 1000s)	BASE CASE			SCENARIO CASE		
		CS5	CS6	DS8+	CS5	CS6	DS8+
Rural Interstate	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	136,025,499	0	0	110,835,634	246,745	0
	25	664,090,071	0	0	539,900,758	947,664	0
	30	1,783,791,037	17,004,337	154,442	1,454,485,453	209,686,111	170,765
	35	2,810,773,251	40,525,690	997,128	1,718,764,018	345,330,112	1,103,787
	40	2,935,578,578	63,009,768	3,672,479	1,796,151,509	383,095,796	4,068,487
	45	2,749,119,577	54,469,221	5,563,112	1,681,624,166	352,721,485	34,390,653
	50	2,732,486,208	46,916,957	5,764,381	1,668,322,504	340,756,913	144,689,401
	55	2,910,776,149	52,972,434	3,953,893	1,774,680,153	362,943,772	1,188,471,493
	60	3,032,946,503	52,305,739	2,528,481	1,847,582,613	373,946,106	714,240,544
	65	3,214,223,770	53,583,520	1,964,686	1,957,950,053	393,853,547	758,106,494
	70	3,273,934,712	53,750,708	2,067,228	1,995,633,757	400,523,134	706,566,939
	75	3,900,624,614	53,216,635	2,072,151	2,378,620,307	467,309,711	687,701,460
	80	3,472,074,595	51,964,401	2,687,817	2,118,092,379	420,887,346	720,855,832
	85	1,684,192,516	38,820,333	3,450,419	1,028,800,778	219,806,513	742,280,682
	90	769,598,631	30,657,018	4,329,377	470,885,895	114,786,091	786,415,808
	95	399,384,735	20,254,704	5,200,096	244,695,329	64,426,994	803,526,495
	100	201,750,186	12,964,463	5,726,080	123,862,216	35,934,442	957,049,264
	105	127,763,900	9,783,957	7,106,854	78,370,335	24,484,911	856,287,827
	110	77,138,231	4,817,679	6,181,502	47,202,503	14,162,341	426,288,937
	115	48,175,878	4,186,952	3,347,721	24,519,569	10,396,387	200,936,477
	120	0	2,386,160	1,849,148	0	11,332,524	104,473,605
	125	0	1,466,144	1,117,073	0	8,893,739	53,568,066
	130	0	910,966	579,536	0	7,438,348	33,245,836
	135	0	579,007	330,985	0	6,079,639	19,659,567
	140	0	416,991	256,956	0	4,878,397	12,184,930
	145	0	0	156,573	0	0	1,894,962
	150	0	0	322,579	0	0	1,458,987
Rural Other Principal Arterial	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	95,002,057	0	0	78,016,880	246,745	0
	25	515,057,262	0	0	420,674,510	947,664	0
	30	1,606,035,583	20,010,478	72,181	1,312,281,091	194,616,093	220
	35	2,286,083,445	43,808,290	439,817	1,403,950,134	295,815,472	1,736
	40	1,949,057,973	50,903,353	1,415,013	1,204,239,146	273,547,962	7,187
	45	1,560,001,962	39,565,354	2,158,516	968,153,597	220,396,244	405,407
	50	1,406,889,920	31,659,243	2,235,544	872,964,731	194,465,341	1,525,988
	55	1,457,482,286	26,660,236	1,484,527	902,703,836	193,933,408	736,552,861
	60	1,432,446,475	27,039,648	922,252	887,282,595	191,156,622	531,886,793
	65	1,487,844,524	26,549,603	712,006	922,122,506	196,885,097	471,943,640
	70	1,486,109,061	27,215,025	717,121	922,938,367	197,858,454	387,565,847
	75	1,994,264,929	32,277,362	753,733	1,234,804,496	257,828,397	349,360,850
	80	1,841,069,738	31,179,982	1,018,018	1,139,489,465	239,080,882	358,278,401
	85	695,843,718	27,437,621	1,265,298	435,791,500	110,727,193	352,135,826
	90	300,624,669	21,700,790	1,692,015	189,501,517	59,828,089	367,210,835
	95	148,127,859	14,028,441	2,109,705	93,941,203	33,697,670	370,467,623
	100	68,068,349	8,861,262	2,236,882	43,653,114	18,873,377	486,997,436
	105	41,979,745	6,601,052	2,702,894	26,899,841	13,041,882	448,912,206
	110	24,907,677	4,976,745	2,296,127	15,864,171	9,082,445	182,941,766
	115	17,843,840	3,487,653	1,419,549	9,353,550	6,733,814	82,796,383
	120	0	3,740,542	719,104	0	12,686,907	41,793,460
	125	0	2,181,729	436,798	0	9,609,324	20,285,752
	130	0	1,983,618	236,954	0	8,510,999	12,355,860
	135	0	1,598,606	140,061	0	7,099,238	7,139,084
	140	0	1,472,936	119,429	0	5,934,341	4,848,889
	145	0	0	69,543	0	0	1,357,067
	150	0	0	171,864	0	0	971,680

APPENDIX A - MODE SHIFT VMT EXAMPLE

FC	WGT (in 1000s)	BASE CASE CS5	BASE CASE CS6	BASE CASE DS8+	SCENARIO CASE CS5	SCENARIO CASE CS6	SCENARIO CASE DS8+
Rural Minor Arterial	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	25,190,433	0	0	16,121,877	0	0
	25	107,858,758	0	0	69,029,605	0	0
	30	343,157,798	6,242,461	7,642	219,620,991	31,947,196	0
	35	538,334,453	15,176,386	54,537	258,400,538	53,993,755	0
	40	580,072,698	19,854,244	197,205	278,434,895	60,700,872	0
	45	535,873,658	14,681,995	275,436	257,219,356	53,440,929	0
	50	480,512,990	11,573,749	246,328	230,646,235	46,774,138	0
	55	470,241,063	10,269,322	157,583	225,715,710	45,013,197	39,603,305
	60	463,578,512	10,091,967	99,427	222,517,686	44,352,497	10,776,632
	65	490,263,186	9,325,445	68,764	235,326,329	45,935,375	11,608,330
	70	521,215,509	9,630,170	62,858	250,183,444	48,630,963	10,723,759
	75	637,425,647	11,351,364	69,545	305,964,311	59,167,034	9,617,214
	80	580,793,710	11,369,584	92,337	278,780,981	54,649,597	9,414,055
	85	304,754,477	10,561,760	120,744	146,282,149	31,984,825	9,283,645
	90	152,111,938	9,144,158	173,660	73,013,730	18,752,749	9,822,630
	95	84,408,130	6,729,814	240,771	40,515,903	11,598,117	10,448,387
	100	46,868,419	5,099,484	284,398	22,496,841	7,421,102	12,776,953
	105	28,533,242	4,058,549	335,019	13,695,956	5,204,814	11,649,376
	110	15,326,072	3,210,792	283,554	7,356,514	3,537,856	6,123,445
	115	8,632,604	3,069,949	209,844	3,453,042	2,900,972	3,063,223
	120	0	3,281,316	196,268	0	5,708,309	1,707,789
	125	0	2,181,184	140,458	0	4,442,796	951,414
	130	0	2,124,402	56,734	0	4,011,964	576,338
	135	0	1,885,191	23,874	0	3,435,188	308,909
	140	0	1,635,407	14,755	0	2,849,954	174,128
	145	0	0	8,170	0	0	66,443
	150	0	0	16,372	0	0	45,261
Rural Major Collector	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	15,689,317	0	0	12,551,454	0	0
	25	74,775,890	0	0	59,820,712	0	0
	30	237,457,318	5,091,802	4,581	189,965,854	14,164,177	0
	35	407,352,167	11,810,008	33,682	244,411,300	25,682,112	0
	40	489,867,250	16,510,388	124,228	293,920,350	31,923,037	0
	45	443,629,434	13,536,893	179,648	266,177,661	28,273,073	0
	50	398,674,924	11,271,072	164,271	239,204,954	25,005,729	0
	55	386,669,467	10,105,987	117,825	232,001,680	23,881,167	39,603
	60	368,314,823	10,003,195	94,092	220,988,894	22,917,179	8,156
	65	389,015,358	9,730,173	73,646	233,409,215	23,829,346	9,805
	70	393,833,146	9,737,443	66,586	236,299,888	24,073,507	8,879
	75	464,572,823	10,921,056	63,214	278,743,694	28,143,116	7,980
	80	420,587,560	10,686,845	78,246	252,352,536	25,838,458	7,741
	85	229,775,348	9,429,172	91,575	137,865,209	15,731,895	7,375
	90	123,272,981	7,785,056	126,629	73,963,789	9,666,924	7,793
	95	58,692,656	5,449,463	181,064	35,215,594	5,386,891	7,895
	100	28,919,868	3,943,723	198,625	17,351,921	3,220,669	9,311
	105	15,844,044	3,092,707	225,069	9,506,426	2,183,920	8,434
	110	8,014,839	2,379,551	188,043	4,808,904	1,471,540	4,614
	115	4,642,004	2,131,038	155,594	2,321,002	1,191,067	2,481
	120	0	2,258,962	149,980	0	3,056,516	1,189
	125	0	1,459,121	115,979	0	2,415,716	590
	130	0	1,410,933	51,391	0	2,150,743	322
	135	0	1,232,543	22,018	0	1,820,668	162
	140	0	1,052,999	18,231	0	1,490,017	95
	145	0	0	9,063	0	0	46
	150	0	0	17,519	0	0	31

Page 3

APPENDIX A - MODE SHIFT VMT EXAMPLE

FC	WGT (in 1000s)	BASE CASE CS5	BASE CASE CS6	BASE CASE DS8+	SCENARIO CASE CS5	SCENARIO CASE CS6	SCENARIO CASE DS8+
Rural Minor Collector	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	6,279,312	0	0	5,023,449	0	0
	25	23,286,370	0	0	18,629,096	0	0
	30	51,049,996	1,083,922	353	40,839,997	3,040,265	0
	35	73,848,075	2,268,118	3,182	44,308,845	4,713,057	0
	40	79,844,327	3,148,236	12,835	47,906,596	5,408,922	0
	45	72,912,648	2,754,025	15,938	43,747,589	4,884,944	0
	50	65,458,708	2,360,325	14,255	39,275,225	4,335,081	0
	55	64,858,811	2,116,952	10,319	38,915,287	4,195,569	39,603
	60	63,503,915	2,092,929	8,030	38,102,349	4,117,014	1,478
	65	64,560,740	2,030,148	5,240	38,736,444	4,141,604	1,597
	70	64,056,082	1,997,729	4,815	38,433,649	4,101,782	1,459
	75	73,554,191	2,246,266	4,769	44,132,515	4,688,529	1,310
	80	64,963,389	2,154,733	5,930	38,978,034	4,217,799	1,298
	85	36,416,739	1,865,174	7,049	21,850,043	2,660,165	1,271
	90	21,034,536	1,563,713	9,510	12,620,721	1,755,398	1,292
	95	12,217,324	1,159,343	12,992	7,330,394	1,132,571	1,282
	100	6,972,191	898,237	14,554	4,183,314	752,816	1,473
	105	4,515,045	705,612	18,339	2,709,027	543,278	1,301
	110	2,769,839	565,858	17,053	1,661,903	393,128	730
	115	1,753,062	500,667	12,949	876,531	312,953	422
	120	0	538,711	9,769	0	2,196,391	245
	125	0	350,017	6,231	0	1,861,164	140
	130	0	340,931	2,983	0	1,615,742	91
	135	0	292,054	1,552	0	1,350,424	56
	140	0	244,459	1,324	0	1,085,747	35
	145	0	0	838	0	0	11
	150	0	0	1,321	0	0	7
Rural Local	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	9,869,816	0	0	7,895,853	493,491	0
	25	37,906,578	0	0	30,325,262	1,895,329	0
	30	99,151,317	4,127,557	1,098	79,321,054	6,814,967	0
	35	149,815,490	9,277,667	8,683	89,889,294	11,665,725	1
	40	159,739,957	11,475,820	35,950	95,843,974	13,151,117	4
	45	148,139,557	8,109,402	54,088	88,883,734	11,056,209	203
	50	134,537,718	6,232,958	52,442	80,722,631	9,531,717	763
	55	133,260,777	5,308,577	34,283	79,956,466	9,051,898	1,986
	60	132,974,175	5,292,347	22,945	79,784,505	9,030,265	2,999
	65	139,587,956	4,395,139	16,563	83,752,774	8,957,210	3,196
	70	144,197,887	4,366,946	15,872	86,518,732	9,175,020	2,964
	75	171,217,662	5,600,597	16,001	102,730,597	11,081,152	2,692
	80	152,586,925	5,501,883	19,936	91,552,155	10,105,193	2,667
	85	80,721,851	5,496,811	23,496	48,433,111	6,509,657	2,662
	90	41,432,733	5,083,727	30,854	24,859,640	4,359,314	2,795
	95	22,262,884	4,414,309	40,663	13,357,730	3,099,583	2,888
	100	12,247,740	3,870,368	45,353	7,348,644	2,354,053	3,429
	105	7,569,858	3,108,946	58,844	4,541,915	1,777,519	3,058
	110	4,767,924	2,750,412	53,903	2,860,755	1,476,081	1,620
	115	2,921,118	2,768,366	39,065	1,460,559	1,391,821	833
	120	0	3,155,137	33,751	0	3,504,604	449
	125	0	2,073,664	24,320	0	2,722,988	247
	130	0	2,117,810	9,833	0	2,504,181	152
	135	0	1,898,778	4,468	0	2,153,786	96
	140	0	1,633,940	3,738	0	1,780,488	59
	145	0	0	2,240	0	0	63
	150	0	0	3,981	0	0	42

APPENDIX A - MODE SHIFT VMT EXAMPLE

FC	WGT (in 1000s)	BASE CASE			SCENARIO CASE		
		CS5	CS6	DS8+	CS5	CS6	DS8+
Urban Interstate	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	114,886,968	0	0	91,909,575	0	0
	25	482,681,698	0	0	386,145,358	0	0
	30	1,350,884,837	10,744,462	47,612	1,080,707,870	144,758,499	0
	35	2,118,326,636	23,382,899	380,126	1,270,995,982	232,877,273	0
	40	2,208,563,795	29,132,943	1,349,595	1,325,138,277	247,076,028	0
	45	1,930,791,612	25,740,507	2,118,497	1,158,474,967	216,245,618	0
	50	1,756,388,303	22,527,656	2,163,602	1,053,832,982	195,913,721	0
	55	1,738,547,077	20,783,950	1,403,140	1,043,128,246	192,560,262	1,524,727,248
	60	1,692,200,390	21,017,357	881,109	1,015,320,234	188,135,661	618,884,888
	65	1,752,092,762	21,563,394	730,673	1,051,255,657	194,616,331	623,337,835
	70	1,816,602,399	22,651,750	751,328	1,089,961,440	202,046,815	538,648,950
	75	2,193,830,990	27,440,276	804,074	1,316,298,594	244,079,348	489,113,020
	80	1,922,561,398	28,276,166	1,011,216	1,153,536,839	217,704,689	477,843,536
	85	972,190,064	24,508,615	1,226,029	583,314,038	119,276,760	460,975,911
	90	499,776,190	18,089,380	1,679,371	299,865,714	66,258,061	474,820,532
	95	265,151,144	11,411,924	2,253,187	159,090,686	36,785,846	503,411,185
	100	142,783,396	7,632,211	2,460,573	85,670,038	21,147,329	617,804,415
	105	92,246,242	5,618,998	2,811,407	55,347,745	14,281,722	541,321,189
	110	57,806,061	3,924,928	2,288,170	34,683,637	9,313,042	270,409,465
	115	37,067,756	2,865,740	1,501,376	18,533,878	6,285,941	139,247,885
	120	0	2,560,366	966,450	0	6,414,436	75,314,292
	125	0	1,992,622	666,740	0	5,364,933	41,229,574
	130	0	1,709,862	323,355	0	4,600,415	26,809,362
	135	0	1,098,573	147,963	0	3,507,367	17,279,282
	140	0	873,781	117,447	0	2,800,816	11,050,014
	145	0	0	52,438	0	0	857,911
	150	0	0	112,738	0	0	741,500
Urban Freeways & Express-ways	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	18,515,401	0	0	14,812,321	0	0
	25	117,659,877	0	0	94,127,902	0	0
	30	486,895,429	2,433,484	15,889	389,516,343	50,879,679	0
	35	979,136,978	7,300,213	61,536	587,482,187	104,483,890	0
	40	856,625,582	8,575,471	231,510	513,975,349	93,380,482	0
	45	666,512,991	7,314,250	289,963	399,907,795	73,234,124	0
	50	625,876,681	5,946,988	264,928	375,526,008	67,939,957	0
	55	618,820,693	5,134,817	216,152	371,292,416	66,503,405	811,748,946
	60	576,912,450	4,417,409	187,618	346,147,470	61,666,913	330,844,157
	65	586,061,716	4,423,465	141,468	351,637,030	62,587,290	284,694,898
	70	691,395,571	4,637,402	116,170	414,837,343	73,313,219	226,881,135
	75	1,061,435,286	5,817,111	102,944	636,861,172	111,378,928	211,625,887
	80	1,059,549,984	6,206,971	122,927	635,729,991	111,541,272	206,523,160
	85	417,391,873	4,859,479	125,194	250,435,124	46,112,718	194,512,805
	90	147,313,326	3,495,097	162,004	88,387,996	17,876,920	198,717,490
	95	67,325,847	2,154,336	244,842	40,395,508	8,671,487	234,615,998
	100	33,771,311	1,391,273	270,173	20,262,786	4,629,277	340,925,956
	105	17,552,727	1,003,894	317,414	10,531,636	2,658,777	323,177,048
	110	9,003,709	705,021	292,968	5,402,225	1,534,890	133,474,918
	115	4,965,077	547,033	287,952	2,482,538	988,837	54,309,348
	120	0	467,341	328,222	0	4,321,411	28,334,431
	125	0	318,598	273,273	0	3,690,910	15,076,617
	130	0	269,448	109,509	0	3,160,000	9,344,697
	135	0	182,965	44,340	0	2,591,759	6,038,196
	140	0	144,331	42,963	0	2,071,366	3,681,672
	145	0	0	16,096	0	0	262,952
	150	0	0	34,895	0	0	217,739

APPENDIX A - MODE SHIFT VMT EXAMPLE

FC	WGT (in 1000s)	BASE CASE			SCENARIO CASE		
		CS5	CS6	DS8+	CS5	CS6	DS8+
Urban Other Principal Arterial	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	54,270,549	0	0	43,416,440	0	0
	25	303,551,049	0	0	242,840,839	0	0
	30	979,188,103	5,315,673	8,603	783,350,483	102,702,916	0
	35	1,277,328,475	12,525,901	59,087	766,397,085	139,006,159	0
	40	1,007,281,182	17,428,073	198,887	604,368,709	116,413,384	0
	45	822,454,434	15,851,613	278,191	493,472,660	96,511,895	0
	50	771,460,929	13,011,705	262,324	462,876,557	88,856,627	0
	55	745,650,400	11,699,431	170,990	447,390,240	85,094,528	39,603,305
	60	720,640,019	11,007,431	103,037	432,384,011	81,970,690	25,556,873
	65	749,746,068	10,669,311	72,620	449,847,641	84,576,986	20,152,886
	70	911,858,033	11,090,157	63,937	547,114,820	101,166,944	16,455,482
	75	1,246,321,853	12,684,577	72,944	747,793,112	136,048,304	15,436,513
	80	1,071,680,178	12,438,017	93,962	643,008,107	118,362,233	14,922,404
	85	462,030,885	9,866,074	123,017	277,218,531	55,082,555	14,425,102
	90	222,814,021	7,906,302	182,301	133,688,413	29,397,074	15,013,151
	95	135,708,355	5,394,919	264,301	81,425,013	18,426,263	18,263,591
	100	74,265,541	3,652,261	312,957	44,559,324	10,713,589	24,957,733
	105	54,794,537	2,891,404	352,661	32,876,722	8,081,717	21,468,870
	110	41,368,307	1,797,561	295,308	24,820,984	5,754,636	9,270,148
	115	26,077,047	1,417,444	216,806	13,038,524	3,883,404	4,477,961
	120	0	1,141,143	155,413	0	4,995,213	2,729,708
	125	0	811,465	104,530	0	4,183,777	1,495,764
	130	0	604,613	50,982	0	3,495,166	1,100,989
	135	0	460,061	25,055	0	2,868,855	829,872
	140	0	404,352	17,434	0	2,331,387	523,284
	145	0	0	8,989	0	0	23,722
	150	0	0	20,174	0	0	18,247
Urban Minor Arterial	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	27,504,078	0	0	22,003,263	0	0
	25	103,180,165	0	0	82,544,132	0	0
	30	256,305,854	2,777,106	7,858	205,044,683	28,129,981	0
	35	409,981,709	5,822,603	51,485	245,989,025	46,238,514	0
	40	469,273,659	7,025,985	200,427	281,564,196	53,250,752	0
	45	396,521,320	5,898,150	443,940	237,912,792	44,960,467	0
	50	342,522,576	5,056,419	530,878	205,513,546	38,803,034	0
	55	310,137,281	4,748,116	296,269	186,082,369	35,287,032	39,603
	60	276,733,869	4,499,759	153,994	166,040,321	31,723,170	8,215
	65	265,946,355	4,576,742	117,188	159,567,813	30,713,703	9,397
	70	265,298,171	4,965,718	115,309	159,178,902	30,998,963	7,942
	75	301,587,937	6,125,152	116,249	180,952,762	35,671,430	6,862
	80	268,766,405	6,413,824	143,826	161,259,843	32,649,082	6,217
	85	149,403,408	5,683,758	163,220	89,642,045	20,055,723	5,551
	90	81,680,453	4,778,971	206,545	49,008,272	12,469,119	5,340
	95	40,659,719	3,200,987	274,177	24,395,831	6,946,860	5,333
	100	24,713,522	2,201,167	307,733	14,828,113	4,452,402	6,063
	105	14,565,872	1,643,030	427,469	8,739,523	2,935,314	5,418
	110	8,897,580	1,200,478	392,223	5,338,548	1,970,188	3,027
	115	5,680,285	911,975	252,099	2,840,142	1,388,806	1,659
	120	0	861,645	132,720	0	4,715,715	826
	125	0	614,642	91,195	0	3,986,953	503
	130	0	517,124	42,542	0	3,407,677	296
	135	0	388,278	21,775	0	2,797,072	180
	140	0	296,910	21,542	0	2,223,945	116
	145	0	0	9,599	0	0	18
	150	0	0	24,375	0	0	15

Page 6

APPENDIX A - MODE SHIFT VMT EXAMPLE

FC	WGT (in 1000s)	BASE CASE CS5	BASE CASE CS6	BASE CASE DS8+	SCENARIO CASE CS5	SCENARIO CASE CS6	SCENARIO CASE DS8+
Urban Collector	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	2,806,944	0	0	2,245,556	0	0
	25	12,783,809	0	0	10,227,048	0	0
	30	33,501,885	420,022	508	26,801,508	3,728,208	0
	35	53,125,063	938,598	3,848	31,875,038	6,157,245	0
	40	59,358,904	1,240,761	14,780	35,615,343	7,052,576	0
	45	57,504,857	1,062,084	23,405	34,502,914	6,706,361	0
	50	51,347,307	886,210	24,558	30,808,384	5,932,320	0
	55	48,780,835	804,689	18,323	29,268,501	5,602,304	39,603
	60	47,485,253	787,024	15,052	28,491,152	5,456,847	1,064
	65	48,790,064	772,383	12,406	29,274,039	5,574,151	1,188
	70	51,523,220	794,452	11,832	30,913,932	5,867,329	1,151
	75	64,705,423	967,221	10,910	38,823,254	7,341,041	1,028
	80	59,717,330	983,433	13,008	35,830,398	6,856,823	977
	85	33,390,643	848,953	14,107	20,034,386	4,103,122	951
	90	19,236,082	675,937	18,126	11,541,649	2,531,952	978
	95	10,795,133	468,225	24,848	6,477,080	1,500,916	1,033
	100	5,511,443	338,008	25,101	3,306,866	855,352	1,297
	105	3,075,582	258,452	29,174	1,845,349	540,165	1,197
	110	1,635,378	194,064	25,220	981,227	338,196	670
	115	954,052	166,746	19,499	477,026	245,477	387
	120	0	170,832	13,604	0	4,024,902	217
	125	0	114,329	10,513	0	3,486,640	111
	130	0	106,879	5,554	0	2,997,432	62
	135	0	89,731	2,736	0	2,498,524	33
	140	0	74,882	2,888	0	2,001,917	19
	145	0	0	1,421	0	0	4
	150	0	0	2,719	0	0	3
Urban Local	5	0	0	0	0	0	0
	10	0	0	0	0	0	0
	15	0	0	0	0	0	0
	20	1,835,054	0	0	1,468,043	0	0
	25	7,794,949	0	0	6,235,959	0	0
	30	20,920,248	271,708	692	16,736,198	2,336,562	0
	35	31,785,807	582,186	5,049	19,071,484	3,702,548	0
	40	34,437,325	829,566	19,525	20,662,395	4,190,342	0
	45	30,829,425	770,210	34,032	18,497,655	3,776,132	0
	50	27,723,269	666,194	37,091	16,633,961	3,371,902	0
	55	27,545,167	609,030	24,957	16,527,100	3,302,644	39,603
	60	27,288,606	595,019	18,091	16,373,164	3,264,378	6,375
	65	28,801,045	614,360	14,449	17,280,627	3,433,029	6,902
	70	29,352,910	627,952	13,775	17,611,746	3,500,448	6,180
	75	33,558,584	702,866	12,932	20,135,151	3,988,438	5,558
	80	27,712,599	675,041	15,615	16,627,559	3,378,797	5,525
	85	14,745,846	563,555	17,184	8,847,508	1,981,784	5,475
	90	7,851,654	442,375	22,119	4,710,993	1,183,303	5,782
	95	4,191,626	295,229	30,314	2,514,975	684,869	5,901
	100	2,173,635	196,317	31,586	1,304,181	394,049	6,743
	105	1,350,367	147,902	38,576	810,220	268,149	5,581
	110	801,566	101,389	34,094	480,940	171,407	2,983
	115	503,379	75,374	25,323	251,690	118,175	1,596
	120	0	70,888	16,788	0	3,924,958	855
	125	0	45,230	12,594	0	3,417,542	447
	130	0	38,555	6,425	0	2,929,108	276
	135	0	29,912	3,189	0	2,438,706	164
	140	0	24,105	3,323	0	1,951,140	104
	145	0	0	1,622	0	0	16
	150	0	0	3,226	0	0	12
Totals		120,265,894,135	2,292,533,161	147,162,257	74,184,983,133	13,978,668,642	26,652,177,084
		98.0%	1.9%	0.1%	64.6%	12.2%	23.2%