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An Investigation of Truck Size and Weight Limits Technical Supplement Vol. 4

Truck Traffic Forecasts and TS&W Limit Scenario Analysis Methods

Joseph J. Mergel
Michael Nienhaus

Transportation Systems Center
Cambridge MA 02142

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. Abstract

This report documents the development of VMT data files which served as one input to the preparation of the Department of Transportation's report, An Investigation of Truck Size and Weight Limits. It describes the development of the 1985 base case truck traffic projection, and changes from this base that occur as a result of various postulated changes to existing limits. Each data file consists of a series of 15 x 15 matrices of truck VMT by gross combined weight group and truck axle configuration. There is a separate matrix for each of four highway types within each of the States. These files do not account for changes in truck traffic due to modal diversion, which are the subject of another volume in this series. These files do account for changes in VMT by each type of truck due to changes in truck payload, changes in the choice of equipment type, and changes in the route selected.

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Truck size and weight limits; Truck traffic forecasts; Truck productivity; Truck vehicle miles traveled

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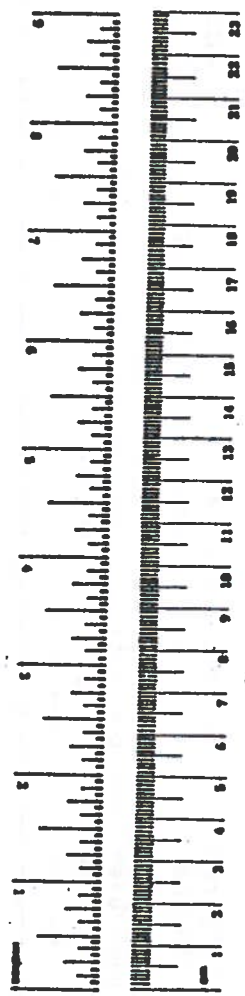
METRIC CONVERSION FACTORS

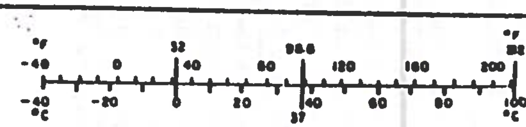
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This is one of several technical reports prepared in support of the Secretary of Transportation's response to Congress on the truck size and weight study mandated by Section 161 of the Surface Transportation Assistance Act of 1978.

This document, Volume 4 of a seven volume series, documents the development of the 1985 base case truck traffic activity projection, and changes from this base case that occur as a result of various postulated changes to existing truck size and weight limits. These scenario files do not account for the changes in truck activity attributable to modal diversion, which are the subject of another volume in this series. The basic premise of this study is that carrier and shipper responses to changes in truck size and weight limits, expressed in terms of changes in truck payload, changes in the choice of equipment type, and changes in the route selected, are economically motivated and can be estimated as changes in truck vehicle miles traveled by each type of truck. The Census Bureau's 1977 Truck Inventory and Use Survey Data was selected as the starting point for the development of the base case file since it provided most of the attributes of the required data base. A series of adjustments were made which transformed this data into the required form, that is, truck activity categorized by truck axle configuration, gross combined weight group, State, and highway class within a State for the study forecast year of 1985.

The data analyses and preparation of this report have been the responsibility of the authors under the technical direction of D.J. Maio, Manager of the TSC contribution to the DOT Truck Size and Weight Study. J.J. Mergel had primary responsibility for Sections 1,2,3 and Appendices A, E and F, while D.M. Nienhaus had responsibility for Section 4 and Appendices B, C and D. The extensive data processing efforts were the responsibility of Annette Tramontozzi and Subash Mahajan of System Development Corporation. System Design Concepts, Inc. provided extensive

assistance in this effort, in terms of the data inputs required for the adjustments and the development of certain methods needed to manipulate the data.

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1. INTRODUCTION

1.1 PURPOSE

This Technical Supplement, Vol. 4, documents, in part, the development of the 1985 Status Quo Base Case Truck Activity projections, and the truck traffic impacts of the alternative limit scenarios examined in the Department of Transportation's Truck Size and Weight Study. It describes the assumptions, data and procedures used in development of the aggregate level truck activity and the distributions of the activity among regions, highway classes and axle configurations. The output of this process became the input to a subsequent distribution of activity within these categories among vehicle gross weight groups. This subsequent "load shift" procedure is documented in Technical Supplement Vol. 6.

The intermediate activity data files developed by TSC and the load shifted truck activity produced by Sydec* together form the basis for all subsequent analyses by both organizations of the various impacts of truck size and weight limits. Changes in system performance measures such as transportation costs, fuel consumption, pavement costs, etc. are driven by changes in detailed truck activity expressed in vehicle miles traveled (VMT).

The status quo base case file consists of a series of 15 x 15 matrices of truck VMT by gross combined weight group and truck axle configuration. There is a separate matrix for each of four highway types within each of the States. Each of the 24 scenario files (12 including the effects of modal shifts, and 12 excluding

*Sydec (System Design Concepts, Inc.) is used in this report to refer to the study's team of consulting firms, of which Sydec is the prime contractor.

mode shift impacts)* consists of a set of matrices, corresponding to those of the base case, which reflect the changes in VMT from the base case that occur as a result of various postulated changes to existing truck size and weight limits.

Note that this report documents the creation of the base case file, and the scenario files in the absence of a modal shift. The methods used in creating the scenario VMT changes attributed to modal diversions are described in Technical Supplement, Vol. 5. The modification of these VMT files by Sydec to account for the effect of scenarios on the distribution of VMT by weight category and for truck activity over the postulated limits** is described in Technical Supplement, Vol. 6. The impact results of all scenarios analyzed, both those due to modal diversions and those due to shifts within the truck mode are presented and interpreted in Technical Supplement, Vol. 7.

This report has been structured to provide, at successive levels of detail, comprehensive coverage of the study methods and data used. Section 1.3 provides an overview of the entire process. Chapters 2, 3 and 4 describe the component steps of the analysis, while equations, input data, intermediate processes and products are presented in a series of appendices.

1.2 BACKGROUND

The Department of Transportation has conducted a comprehensive study of truck size and weight limits in response to Section 161 of the Surface Transportation Assistance Act of 1978. This study

*Note that only 9 scenarios are presented in the main TS&W Report, since the project schedule did not permit a complete analysis of all 12 scenarios in time for inclusion in the main report.

**This over-limit activity may be legitimately covered by State permit or tolerance policies, or it may be extra-legal activity. The intent of the Sydec adjustments is to segregate the effects attributable to limit changes from effects attributable to changes in the current level of State enforcement of limits.

was designed to provide estimates of the impacts of various alternatives for uniformity in truck size and weight limits throughout the United States. These impacts include changes in bridge and pavement costs; changes in transportation costs, and potential changes in modal competition; and changes in energy consumption, air quality and levels of highway safety.

TSC was assigned the task of estimating the impacts on transportation costs, intermodal competition and energy consumption, and of developing forecasts of total truck activity under the various size and weight limit scenarios. This last task, which is the subject of this report, is perhaps the most fundamental of all, since subsequent monetary and non-monetary impacts are determined as a function of changes in truck activity as measured in VMT. The basic premise of this study is that carrier and shipper responses to changes in truck size and weight limits, expressed in terms of changes in truck payloads, changes in the choice of equipment type, changes in the route selected and changes in the choice of mode, are economically motivated and can be adequately estimated as changes in the VMT of the various sizes and types of trucks.

1.3 ANALYTICAL APPROACH

The overall approach in this study to estimating impacts was to establish a base case in a future year which represents the current non-uniform size and weight limit environment; then to estimate the change from this "status quo" base case attributable to a specific set of alternative limits defined in each of several study scenarios. The forecast year 1985 was selected by the study team as representing the earliest date by which any change in limits resulting from this study would probably have full effect on the system. The twelve alternative scenarios defined for the study were designed to isolate the separate and sometimes countervailing effects of changes to axle limits, gross weight limits and configuration limits. The different combinations of limits and their application to the several classes of highways was intended to bound the range of alternatives proposed by various interest groups.

The study team is aware of the deficiency of the data available for this study, and that there remains a level of uncertainty about the accuracy of the final estimates. However, the data and methods used have yielded estimates of the impacts (or differences from the status quo) of sufficient accuracy to provide perspective on the direction and order of magnitude of the impacts.

Creating the required truck activity files involved two major efforts: the first was the construction of a 1985 status quo base case file; the second was the estimation of changes from the base case attributable to changes in truck size and weight limits hypothesized in each study scenario.

Required study outputs defined a need for a truck activity data base which did not exist in the required form. Subsequent impact analyses required inputs of total truck VMT (Vehicle Miles Traveled) broken down by truck axle configuration, gross combined weight group, State and highway system within each State for the study forecast year of 1985. Data from the Census Bureau's 1977 Truck Inventory and Use Survey Data (TI&U) was selected as the starting point for the development of a base case file since this provided most of the attributes of the required data base. Despite its deficiencies, it represented the only complete and comprehensive information available on truck activity relevant to this study.

Transforming the TI&U data into the 1985 Status Quo Base Case Truck Activity File involved four major steps. The first effort included clearing up some apparent discrepancies in the TI&U data dealing with missing, incomplete and misclassified data. The next phase involved deleting traffic not relevant to the study (e.g. light trucks and off-road vehicles); expanding the truck activity level to reflect anticipated traffic growth to the study year of 1985 (in the absence of truck size and weight limit changes); and the partitioning of the data set into two types of truck activity: a) that activity adequately defined by the TI&U data (e.g. local or non-freight in nature); and b) that activity representing inter-regional freight flows.* The third step involved the redistribution of this latter class of truck activity among the States by means of a network analysis which provided a more accurate distribution of long-haul truck vehicle-miles among the various States through which those trucks operated. The final step in the development of the base case file included various adjustments to the partitioned data set as well as merger of the two files. These adjustments included the distribution of truck activity by highway class within a State and the redistribution of vehicle miles across gross combined weight groups. The first adjustment (based on Federal Highway Administration (FHWA) data) was made because the highway class parameter was not included in the original TI&U data. The second adjustment (also based on FHWA data) was made since the FHWA data was felt to provide a better representation of the distribution of truck activity by gross combined weight than the TI&U data.

The development of the scenario VMT files proceeded along two parallel lines of effort, following along the lines of the partitioned data set indicated above. The first dealt with the predominantly local traffic defined adequately by the TI&U data (referred to as "type 2" traffic). The second dealt with the predominantly interregional traffic inadequately defined by the TI&U data (referred to as "type 3" traffic). The outputs of the separate efforts were then merged, scenario by scenario, to produce a complete scenario VMT file. These scenario VMT files were then further processed by Sydec to produce the final scenario VMT files for use in all subsequent analyses. This additional processing was performed because the TSC methodology assumed 100% compliance with proposed size and weight limits and that only truck VMT at or above the current limits would be affected by a change in limits. The Sydec "load shifting" procedure restored a

*It was felt that the origin-to-destination flow characteristics of this latter traffic could be more adequately defined by use of a network assignment model and commodity flow statistics of the Commodity Transportation Survey (CTS) of the Census of Transportation.

level of over-limit activity while adjusting the distribution of truck activity to insure that the payload ton-mile impacts were preserved.

For "type 2" traffic, two types of procedures were used to compute VMT changes due to weight limit changes. One type of change involved raising certain existing weight limits to some uniform higher level. The procedure used in this case involved identifying the portion of the VMT impacted within each truck-axle type and weight block cell of the base case VMT file for each affected State. VMT changes were then computed on the assumption that reduced tripmaking (in response to higher limits) would be proportional to the magnitude of the payload increases.

The other type of limit change involved the reduction of existing weight limits to some uniform lower level. The process used to compute VMT changes made in response to lowered weight limits involved (1) identifying the truck-axle type/weight group cells in the base case VMT file potentially impacted by the limit reductions; (2) dividing the impacted VMT among each of the possible responses permitted for the scenario, i.e. make increased trip shift to a truck type with more axles or shift to a highway class not affected by the lowered limits; and (3) transferring the impacted VMT's to an appropriate weight block, truck type or highway class.

For "type 3" traffic, three sources of VMT change, in the absence of mode shifts, were treated in the analysis. These were changes due to truck type shifts, route shifts, and shifts in payloads. These shifts were the assumed responses to increased or decreased weight limits and changes in restrictions on the movement of trucks of specific lengths or configurations (e.g., the 65' Western doubles). Within the context of the network model individual scenarios were represented as changes in the payload capacity of given truck types, changes in the subnetworks to which particular truck types were restricted, and/or through the introduction of new truck types. The various truck types were then allowed to "compete" for traffic (on the basis of cost) under the conditions specified for that scenario in order to determine the shifts in truck type, route and payload, and thus VMT, due to the size and weight and configuration restrictions defining the scenario.

2. DEVELOPMENT OF THE 1985 BASE CASE TRUCK ACTIVITY VMT FILE

2.1 INTRODUCTION

This chapter describes the steps followed in creating the 1985 Status Quo Base Case Truck Activity File for use in the Truck Size and Weight Study. The process consisted of the four phases outlined in Figure 2-1 and described in detail below.

The first phase consisted of validating the Census Bureau's 1977 Public Use Truck Inventory and Use Survey Data (TI&U). The primary effort here was aimed at clearing up some apparent discrepancies in the data, due to the misclassification of combination trucks as single unit trucks, an incomplete sample of combination truck registrations, and missing or incomplete data on the gross registered weight variable. This phase was conducted by the TSC Highway Cost Allocation Study Team under the direction of the FHWA.

In the second phase, adjustments were made to the validated TI&U data base to meet the specific needs of the TS&W study. First, truck activity not relevant to the study (off-road activity, and that involving trucks with a gross registered weight of less than 0,000 lbs.) was deleted from the file. Next, the truck activity evel was expanded to reflect anticipated traffic growth to the tudy year of 1985, assuming no change in the current system of ize and weight limits. Finally, the records of the data set were artitioned into two types of truck activity; that which is local, hort haul, or non-freight in nature and is adequately defined by he TI&U data, and that which is longer haul and represents interegional transportation of freight shipments. The origin-to-estination flow characteristics of this latter traffic could be dequately defined only by the CTS data.

In the third phase, this latter portion of the traffic was edistributed among the States. Since the TI&U data identifies ll truck activity for a particular truck with only one State

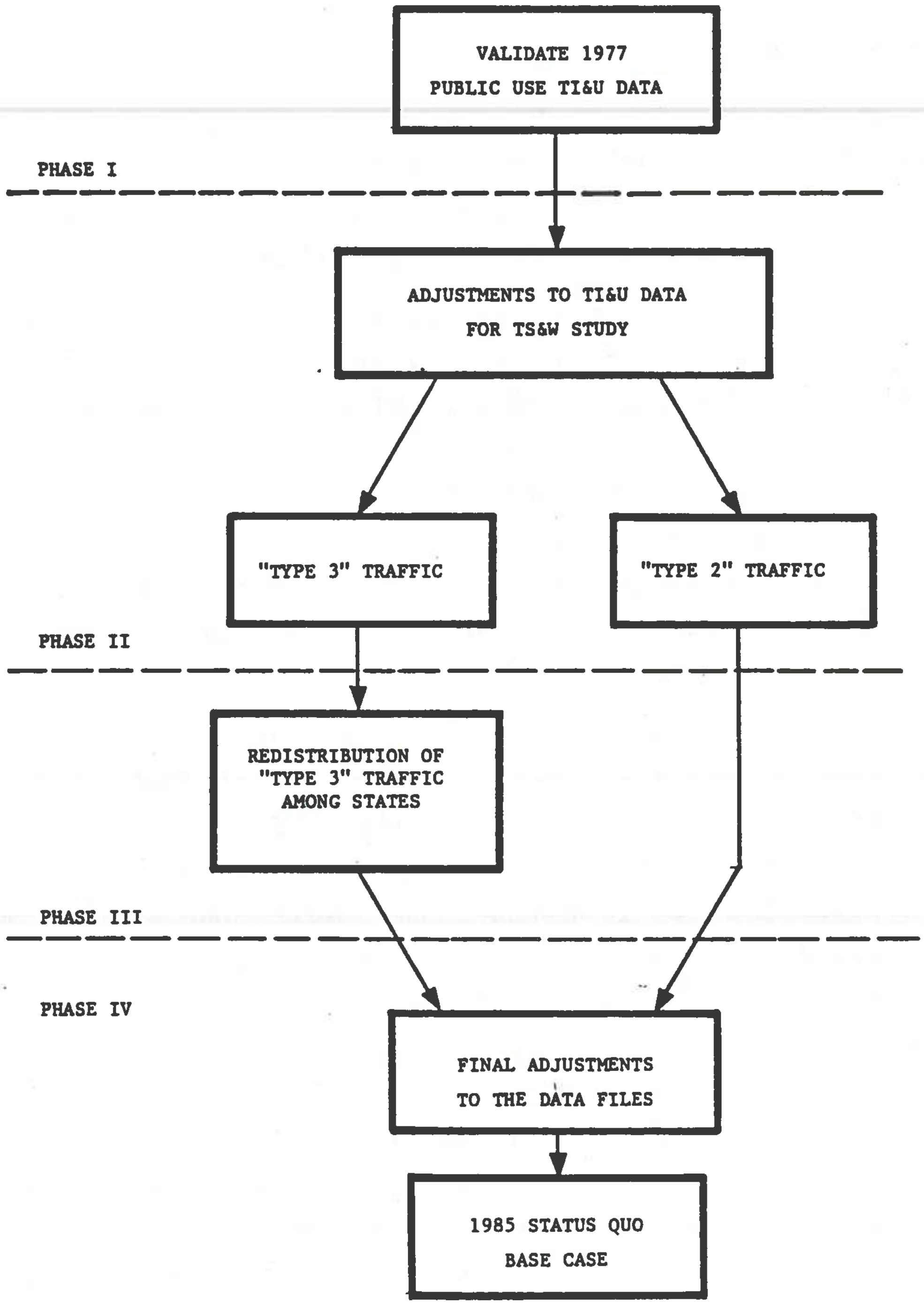

FIGURE 2-1. DEVELOPMENT OF THE 1985 STATUS QUO BASE CASE TRUCK ACTIVITY VMT FILE

(i.e., base of operations), it does not provide an accurate representation of the distribution of long haul truck vehicle miles among the various States through which the truck operated in the year. In order to redistribute the total long haul truck activity more realistically and to segregate that portion of this traffic actually affected by the "barrier State" limit changes, a network analysis was employed to assign truck VMT by category to States. Origin-destination flows of shipments were estimated from the 1972 Commodity Transportation Survey Data, converted to truck miles and then scaled to match the corresponding 1985 TI&U truck activity. The network analysis was then redone utilizing these inflated traffic flows and the VMT associated with these flows assigned to the various States through which the traffic passed.*

The final phase included various adjustments to the partitioned data file as well as the merger of the two files to form the 1985 Status Quo Base Case. First, the "truck type" categories used in the analysis of "type 3" traffic had to be disaggregated to match the level of detail required for that attribute in subsequent analysis. One additional attribute of the total State truck activity was required but was not provided by the Bureau of Census data, i.e., the distribution of truck activity among the several classes of highways within each State. Moreover, the distribution by weight group provided by the TI&U file was not adequate for TS&W study needs, since it attributed all vehicle miles reported by each vehicle to the maximum gross weight at which the truck operated in the survey year, and since it utilized weight blocks which were too broad in the weight ranges of interest to this study. Federal Highway Administration data was the basis for both the highway class distribution and an alternative weight block distribution by which the 1985 Status Quo Base Case truck VMT were distributed. Finally, since the 1977 base year data did

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*The data and the needs of the various subtasks of the entire TS&W study dictated State level disaggregation. However, the accuracy at this level is known to be suspect and all results of the study are reported at the more aggregate level of the 12 study regions.

not reflect the effects of post-1977 limit increases in several States, adjustments to the activity in those States were made so that the final Status Quo Base Case would reflect the probable situation in 1985 prior to any limit changes postulated by the various TS&W study scenarios.

2.2 VALIDATE THE BUREAU OF CENSUS 1977 PUBLIC USE TI&U DATA

2.2.1. Misclassified Combination Trucks

Processing of the TI&U* data by the TSC Highway Cost Allocation Study Team indicated a total of about 824,000 tractor-trailer combinations and only a few truck-trailer combination. This did not seem realistic to Department analysts or to analysts in the transportation industry consulted by the Cost Allocation Study Team. Other data on this subject suggested that the fleet size fo combinations of all types was well over a million, so an analysis was undertaken to determine the cause of this apparent undercount of combination trucks.

The first aspect of this problem dealt with the shortage of truck-trailer combinations in the data set. The TI&U contained 39,000 apparent truck-trailer combinations despite a questionnaire design flaw which instructed only tractor owners to complete the portion of the questionnaire dealing with trailers. Of these 39,000 vehicles, about 4,300 were pulling full trailers and the rest semi-trailers. The first group were assumed to be truck-trailer combinations and the remainder tractor-trailer combination In addition, about 55,800 tractor-trailer combinations were found to be miscoded (i.e., a tractor pulling a full trailer) and were reclassified as truck-trailer combinations. Finally, 83,700 singl unit trucks were apparently miscoded. These trucks (as coded) exceeded State size and weight limits and the physical capacity

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* For a brief description of the data gathered, survey method, reliability, etc. of the TI&U data see Truck Inventory and Use Survey, United States - 1977 Census of Transportation. Report TC77-T-52. U.S. Department of Commerce, Bureau of the Census. May, 1980.

limits for the axle type/body type assigned in the TI&U data. These were recoded by TSC as truck-trailer combinations and assigned appropriate trailer types based on the gross vehicle weight and the body type/axle type.

These adjustments resulted in a truck-trailer combination population of 143,882 and a tractor-trailer combination count of 804,621 for a total combination population of 948,503. While the truck-trailer combination population was now close to other estimates, the tractor-trailer combination and the total combination populations were still far below the previous estimates by FHWA and industry.

2.2.2 Combinations Missing From the Sample

Other sources (State vehicle registration data, various industry estimates, Chilton's Census of the Motor Fleet Market, extrapolation from earlier TI&U data, and analysis of diesel fuel tax revenues) indicate that the total combination population for 1977 should have been 1.2 to 1.4 million. Moreover, it was discovered that the sampling frame for the TI&U survey was incomplete. Many fleets tend to register their trucks late for cash flow and other reasons, and were not included in the sample. In addition, trucks of owners outside the State of registration (likely to be trucks owned by fleets) were deleted from the sample. It was felt that a disproportionate number of these missing trucks were tractors or heavy trucks used in combinations, thus contributing to the evidence that the TI&U combination truck population estimate was too low. While there is no available control total, all evidence indicates a shortfall in the TI&U estimated 1977 population of combination trucks.

Given the apparent sampling problems in the TI&U and the weight of other evidence, an adjustment was made by TSC to the TI&U data, rebenchmarking the combination totals by State to the 1977 FHWA published totals yielding a total combination truck population figure of 1.31 million.*

2.2.3 Missing Gross Registered Weight Data

It was necessary to impute values of gross registered weight (GRW) for trucks in the eleven States which do not use gross vehicle weight as their basis for registration. The inputed values o GRW were based on the other 40 States for which GRW was available The method was based on the matching of trucks with and without GRW values on the basis of other known characteristics of the trucks. The known GRW value was then assigned to the trucks without a GRW figure.

The matching procedure involved the construction of a series of tables for each sample type and gross vehicle weight. Data from the eleven States as well as records in the TI&U with registered weight = 0 were excluded. Within each table, data was categorized by body type (rows) and vehicle type (columns). Each table entry had the mean registered weight for all vehicles fallir into that category. In the final step, each vehicle in the excluded group was "looked up" in the tables and assigned the appropriate registered weight. GRW was the parameter used to screen light trucks from the data base in one of the adjustments required to create the TS&W Base Case.

2.3 ADJUSTMENTS TO THE VALIDATED TI&U DATA FOR THE TS&W BASE CASI

2.3.1 Activity Deleted From the File

Further modifications to the 1977 TI&U data file were require before it could be used to generate the TS&W Study's 1985 Status Quo Base Case. The first of these involved deleting that truck ac tivity which was for one reason or another not impacted by the pro posed scenario weight limit changes. The first group deleted was all trucks indicating their primary area of operation as "off-the-

*The mechanics of the adjustment process involved changing the population expansion factor in TI&U until the expanded TI&U population matched the FHWA combination truck population for that given State.

road." These trucks were assumed to be unaffected by limit changes implemented on either the Interstate, or Interstate and other Federal-aid-primary system. The second group deleted included "light trucks," i.e., those with a gross registered weight of less than 10,000 pounds. These trucks, which are predominantly 4-tire trucks, would also be unaffected by the proposed limit changes. Moreover, in subsequent pavement and bridge analyses light, 4-tire trucks were treated as passenger cars and their impacts were studied in a different fashion than heavy and medium duty trucks.

2.3.2 1977-1985 Growth Factor Applied to VMT

The 1985 Status Quo Base Case VMT were developed by applying a table of growth factors to the 1977 TI&U data. Table 2-1 is a matrix of growth factors (prepared by Jack Faucett Associates, a member of the TS&W Contractor Study Team) for each combination of 12 study regions and 23 TI&U commodity groups.

Ton-mile growth factors for all commodity groups at the national level were based on DOT's Long-Range Forecast Model. The values used here were based on a GNP projection about halfway between the low and medium growth scenarios projected by that model. Regional growth factors were obtained by multiplying the national growth factors by the ratio of the growth in regional earnings to national earnings for the industry groups producing the commodities within each TI&U commodity group.* The ton-mile growth factors were applied to the 1977 vehicle miles based on the location of the base of operations and the commodity carried by the trucks in the TI&U file. Implicit in this procedure was the assumption that for the 1985 Status Quo Base Case, the ton-mile per vehicle-mile ratio for each truck type remained unchanged.

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*"Truck-Usage Growth Factors" prepared for the Office of the Secretary, U.S. Department of Transportation, Jack Faucett Associates, Inc., Chevy Chase, Maryland, June 9, 1980.

TABLE 2-1. TON-MILE GROWTH FACTORS FOR TRUCK INVENTORY AND USE SURVEY COMMODITIES, BY REGION FOR THE PERIOD 1977 - 1985

		ORIGINAL TS&W STUDY REGION*											
TI&U Code	Commodity Description	1	2	3	4	5	6	7	8	9	10	11	12
01	Farm products	1.39	1.46	1.37	1.38	1.32	1.30	1.37	1.30	1.35	1.34	1.44	1.31
02	Live animals	1.25	1.31	1.23	1.24	1.19	1.17	1.23	1.17	1.22	1.21	1.29	1.17
03	Mining products	1.71	1.65	1.77	1.73	1.63	1.65	1.55	1.49	1.55	1.67	1.90	1.62
04	Logs and other forest products	1.40	1.49	1.38	1.20	1.33	1.29	1.29	1.17	1.40	1.26	1.27	1.38
05	Processed foods	1.23	1.26	1.34	1.29	1.35	1.25	1.24	1.26	1.28	1.27	1.17	1.26
06	Textile mill products	1.08	1.10	1.39	1.41	1.49	1.31	1.21	1.54	1.54	1.71	1.29	1.29
07	Building materials	1.23	1.22	1.31	1.27	1.28	1.24	1.25	1.17	1.24	1.17	1.20	1.11
08	Household goods (moving)	1.27	1.28	1.39	1.29	1.32	1.27	1.26	1.21	1.31	1.24	1.32	1.33
09	Furniture or hardware	1.18	1.37	1.43	1.28	1.45	1.34	1.34	1.46	1.36	1.33	1.66	1.75
10	Paper products	1.21	1.37	1.51	1.34	1.56	1.36	1.36	1.44	1.48	1.42	1.48	1.50
11	Chemicals or related products	1.42	1.46	1.57	1.47	1.55	1.60	1.60	1.48	1.65	1.42	1.79	1.50
12	Petroleum or petroleum products	1.35	1.29	1.67	1.45	1.51	1.30	1.50	1.35	1.36	1.29	1.26	1.75
13	Primary metal products	1.19	1.22	1.27	1.25	1.46	1.34	1.27	1.31	1.50	1.39	1.29	1.32
14	Fabricated metal products	1.24	1.24	1.57	1.24	1.41	1.30	1.31	1.49	1.21	1.35	1.66	1.45
15	Machinery, except electrical	1.29	1.34	1.80	1.31	1.58	1.34	1.39	1.49	1.58	1.69	1.76	1.23
16	Electrical machinery	1.07	1.22	1.60	1.35	1.71	1.29	1.24	1.63	1.35	1.55	1.29	1.29
17	Transportation equipment	1.19	1.31	1.46	1.35	1.60	1.37	1.40	1.26	1.28	1.38	1.34	1.49
18	Scrap, refuse, or garbage	1.21	1.24	1.44	1.30	1.56	1.38	1.38	1.51	1.44	1.41	1.57	1.47
19	Mixed cargoes	1.23	1.30	1.47	1.33	1.53	1.37	1.36	1.45	1.42	1.34	1.36	1.32
20	Craftsman's vehicle	1.28	1.31	1.35	1.33	1.33	1.29	1.31	1.23	1.28	1.27	1.32	1.29
21	Special equipment	1.26	1.23	1.35	1.31	1.33	1.27	1.28	1.17	1.26	1.23	1.18	1.10
22	Personal transportation	1.22	1.23	1.33	1.24	1.27	1.22	1.21	1.16	1.25	1.19	1.26	1.28
23	Other	1.25	1.27	1.34	1.27	1.33	1.25	1.27	1.19	1.28	1.24	1.23	1.27

*See Appendix C, Figure C-1 for the definition of regions 1 to 10. Region 11 is Alaska, and Region 12 is Hawaii.

Study regions were change after these growth factors were developed. Regions 1 and 2 were combined and Iowa was moved from region 6 to region 7.

2.3.3 Partition VMT Into "Type 2" and "Type 3" Truck Activity

The TI&U data was selected as the basic truck activity data source because it is the only comprehensive information available, covering all types of medium and heavy truck activity. The information available in the file, however does not include anything about the particular origins and destinations of shipments carried by the truck. For very short haul shipments, this does not matter. State-level VMT's are the desired final product, and the "State of operation" item in the file can be used to assign the reported VMT for each truck sampled. For trucks engaged in interstate traffic the "State of operation" is likely to be the State of origin for most shipments but not the State in which most of the vehicle miles are generated by that sampled truck. Insofar as States differ in the ratio of originated traffic to pass-through or terminated traffic, unadjusted use of "State of operation" would have introduced a serious bias.

The 1972 Census of Transportation, Commodity Transportation Survey (CTS) contains origin/destination information for part of the universe of truck activity. An augmented version of this file was constructed at TSC, as described in Appendix C.* The next section will describe how an analysis based on this data was used to re-allocate VMT among States. The use of this second data source, however, made it necessary to establish a relationship between them; that is, to indicate precisely what records in the TI&U were covered by the CTS and which were not.

The short vs. long length of haul distinction to be made corresponds to the distinction between "grandfather-clause" issues and "barrier-State" issues. The "grandfather-clause" issues involves, in general, a reduction of high axle and gross weight limits to the current federal standard, in those States where such limits are in effect.

*The modified CTS File contains BEA to BEA region flows of manufactured commodities and most agricultural commodities, excluding shipments of under 25 miles. The use of the file also excluded all intra-regional flows, so that the "average" haul minimum is about 50 miles.

The scenarios where this type of change was studied included 2, 2A, and 2B.* Scenarios 2 and 2A, which deal exclusively with this type of limit change, were referred to as the "grandfather" scenar (in reference to the "grandfather clause" in federal law which allowed States to retain limits higher than the federal standard, as well as tolerance and permit policies if they were in effect before the passage of the act regulating weight limits on the interstate highway system). The second group of limit changes involved elimination of limits which by their nature serve as "barriers" to interstate commerce, such as restrictions on the use of Western doubles, restrictive length limits, or weight limits below those of federal limits on the Interstate System. Also included within this group were scenarios that merely varied the level of the uniform federal standard. The scenarios where these types of changes were studied were referred to as "barrier State" scenarios and included scenarios 2B, 2C, 3, 4, 5, 6, 8, 9, 10 and 11. Note that the last three scenarios were not included in the final report.

The analysis using the CTS-based data was primarily intended for the barrier-State issue. The direct analysis of the TI&U data concentrated on the grandfather clause question. Thus the TI&U truck activity data was partitioned into segments, according to whether the activity was or was not covered by the CTS data. That portion of the traffic not so covered was referred to as "type 2" traffic, whereas that traffic which was covered by the CTS was referred to as "type 3" traffic.** "Type 2" traffic represents primarily short-haul, intrastate movements of vehicles engaged in retail/wholesale distribution, the various service industries or in the movement of certain bulk commodities. "Type 3" traffic represents longer, interstate movements of vehicles carrying various manufactured and agricultural commodities.

*See Appendix A, for definitions of the scenarios and the correspondence between the numbering scheme used during the study and that used in the final report.

**The lowered weight limits were analyzed under Task 2 of the TSC study and the barrier State limit changes were analyzed under Task 3. Thus, that portion of the data set used in each study task was labelled accordingly.

Specifically, a TI&U truck record was classified as "Type 2" if one or more of the following was true of it:

- o Item 6 (Major Use of Truck) = 3 mining or quarrying
  - 6 wholesale trade
  - 7 retail trade
  - 9 utilities
  - 10 services
  - 11 daily rental
  - 12 personal transportation
- o Item 7 (Products Carried) = 2 live animals
  - 3 mining products
  - 8 household goods*
  - 18 scrap, refuse, or garbage
  - 20 craftsman's vehicles
  - 21 special equipment
  - 22 personal transportation
- o Item 11 (Area of Operation) = 1 local
  - 4 off-road
- o Item 11 = 2 local to 200 miles <u>and</u> Item 23 (Vehicle Type) = 1, 2, or 3 (single-unit)
- o Item 21 (Body Type) = 1 Pickup truck
  - 2 panel truck
  - 3 multi-stop
  - 7 cattle rack
  - 14 utility
  - 15 winch or crane
  - 16 wrecker
  - 30 garbage
  - 70 concrete mixer
- o Item 9 (Base of Operations) = Alaska or Hawaii

All items not classified as "2" were classified as "3".

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*Household goods movement is partly local and short haul and partly long haul. However, because these movements were believed to be unaffected by the limit changes analyzed in the study, and since the revelant origin/destination data was not available, they were left in the Type 2 category.

2.4 REDISTRIBUTION OF 1985 "TYPE 3" ACTIVITY AMONG STATES

2.4.1 Assign Commodity Flows to Truck Types and Load Status

The accurate allocation of national VMT's associated with interstate commodity movements to individual States and regions was accomplished by a two-step procedure that first assigned particular commodity movements to particular truck types, and then assigned VMT by truck type to particular States. "Truck type" hei meant three representative axle configurations (i.e. - conventiona semi-trailer combinations, light single-axle doubles and triples a heavy tandem axle doubles). The semi-trailer combinations were fu ther distinguished by load status (i.e., loaded to 80,000 lb gross weight, loaded to 73,000 lb gross weight, and not fully loaded or limited by cubic volume). The allocation among truck types was made so as to minimize carrier costs, with certain exceptions. Th cost comparison was made at the origin/destination/commodity/ shipment size level (Details are given in Appendix D). The commodity flows assigned were from the 1972 CTS inter-BEA flow tap previously developed by the Bureau of the Census for TSC, as modified and augmented explicitly for this study.* Tons shipped, ton-miles, vehicle-miles, carrier revenues, shipment transit time in ton-days, and fuel consumption were computed for each commodity carrier-group/truck-type combination.

2.4.2 Scale 1972 CTS O/D Flows to Match 1985 TI&U "Type 3" Activi

The partitioning of the TI&U file into "type 2" and "type 3" VMT was based on knowledge of the gaps in the CTS, interpreted in terms of the TI&U questionaire as described earlier. No perfect match was expected between the "type 3" VMT and the CTS-based VMT produced by the methods described above.** Because the TI&U was

*Adjustments made to the CTS data and sources for agricultural and bulk flows are described in Appendix C.

**The CTS tonnages were expanded from 1972 to 1985 levels by means of growth factors also supplied by Jack Faucett Associates, showi in Table 2-2. Note that both the commodity grouping and the base year were different than in Table 2-1.

TABLE 2-2. GROWTH FACTORS FOR COMMODITY-FLOW DATA*

STCC CODE	TS&W STUDY REPORTING REGION 1	2	3	4	5	6	7	8	9	10
0113**	1.56	1.64	1.54	1.55	1.48	1.46	1.54	1.46	1.52	1.50
Other 01***	1.40	1.47	1.38	1.39	1.33	1.31	1.38	1.31	1.37	1.35
08 & 09**	2.37	2.53	2.33	2.03	2.25	2.18	2.18	1.98	2.37	2.13
20	1.42	1.45	1.54	1.48	1.56	1.44	1.42	1.45	1.47	1.46
21	1.31	1.33	1.76	1.39	1.69	1.49	1.52	1.69	1.65	1.61
22	1.21	1.14	1.59	1.49	1.74	1.72	1.44	1.54	1.78	1.65
23	1.28	1.47	1.85	1.70	1.76	1.49	1.41	1.85	1.79	2.09
24	1.37	1.59	1.66	1.49	1.69	1.56	1.56	1.69	1.58	1.55
25	1.42	1.65	1.72	1.54	1.75	1.62	1.62	1.76	1.64	1.60
26	1.48	1.61	1.77	1.56	1.90	1.66	1.66	1.85	1.74	1.67
27	1.46	1.70	1.94	1.68	1.89	1.65	1.64	1.73	1.82	1.81
28	1.92	1.96	2.12	1.99	2.09	2.15	2.16	1.99	2.22	1.91
29	1.56	1.49	1.93	1.68	1.74	1.50	1.73	1.56	1.57	1.49
30	1.78	1.80	2.39	1.88	2.29	1.97	2.06	2.30	2.24	2.19
31	1.34	1.36	1.80	1.42	1.72	1.48	1.55	1.73	1.68	1.64
32	1.29	1.31	1.73	1.36	1.66	1.42	1.49	1.66	1.62	1.58
33	1.38	1.42	1.47	1.46	1.69	1.56	1.48	1.52	1.74	1.62
34	1.44	1.44	1.82	1.44	1.64	1.51	1.52	1.72	1.40	1.56
35	1.59	1.65	2.22	1.62	1.95	1.65	1.71	1.84	1.95	2.08
36	1.24	1.41	1.86	1.57	1.98	1.50	1.44	1.90	1.57	1.80
371	1.47	1.47	1.75	1.59	1.98	1.66	1.57	1.75	1.59	1.78
Other 37	1.35	1.61	1.76	1.50	1.89	1.56	2.01	1.41	1.54	1.67
38	1.81	1.84	2.44	1.92	2.33	2.00	2.10	2.34	2.29	2.23
39	1.47	1.48	1.96	1.55	1.88	1.61	1.70	1.89	1.84	1.79

*Ton-mile growth factors for STCC commodities by region for the period 1972-1985.

**Growth factor for the period 1975-1985.

***Growth factor for the period 1977-1985.

For manufactured commodities, the base year of the data was 1972, while for field crops and fresh produce the years of the available data were 1975 and 1977, respectively.

Legend

Commodity	Description
0113	Grain
Other 01	Other Farm Products
08 & 09	Forest Products & Fresh Fish & Marine Products
20	Food & Kindred Products
21	Tobacco Products
22	Textile Mill Products
23	Apparel & Finished Textiles
24	Lumber & Wood Products
25	Furniture & Fixtures
26	Pulp, Paper & Allied Products
27	Printed Matter
28	Chemicals & Allied Prod.
29	Petroleum & Coal Products
30	Rubber & Misc. Plastics
31	Leather & Leather Prod.
32	Clay, Concrete, Glass & Stone Products
33	Primary Metal Products
34	Fabricted Metal Products
35	Machinery exc. Electrical
36	Electrical Machinery
371	Motor Vehicles & Equip.
Other 37	Other Trans. Equipment
38	Instruments, Photo & Optical Goods, Watches & Clocks
39	Misc. Prod. of Mfg.

the primary source of truck activity data, the CTS-based "results" were adjusted to agree with the TI&U . The level at which this equivalence was sought was at the commodity specific, national level. Adjustment at the State level would have defeated the purpose for which the CTS file was being used, which was to better allocate the VMT among States.

The adjustment procedure was as follows: first, calculate th "type 3" VMT by commodity group from the unadjusted CTS file; compare these numbers with those from the TI&U; introduce commodit specific adjustment factors that would produce agreement; and finally generate the "type 3" VMT again. A discussion of the source of the discrepancies and the rationale for the commodity match-ups is given in Appendix C.

2.4.3 Redistribute VMT Among States

The computer programs that assigned commodity flows to approx: mate truck types also produced a new file of O/D flows, showing vehicles of each type moving from BEA region to BEA region. The five types distinguished were 1) conventional semi trailers loaded to 73,000 lb, 2) conventional semi-trailers loaded to 80,000 lb, 3) cubed out or partially loaded conventional semitrailers, 4) light, short doubles (Western doubles) and triple combinations and 5) heavy, tandem-axle doubles.

A highway network was adapted from that developed by CACI, Inc for TSC for earlier projects.* Some links were added, others omitted, and new fields were introduced so that links representing Interstate Highways could be distinguished and 1980 TS&W limits could be represented.** Minimum-time paths were constructed for all O/D pairs for subnetworks of links permitting each of the

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*Freight Transportation Energy Use, Report No. DOT-TSC-OST-70-1 prepared for U.S. Department of Transportation, Transportation Systems Center. CACI Inc. October 1978. Transportation Flow Analysis: National Energy Transportation Study. Report No. DOT-OST-P-10-29, prepared for U.S. Department of Transportation, Office of the Secretary. CACI, Inc., January, 1980.

**The network is described in Appendix B.

vehicle types.* For each vehicle type, link loadings were made on the appropriate subnetwork. A subsidiary network file identified the States through which each link passed. This was used to aggregate the link loadings into State level VMTs.

2.4.4 Distribute Truck Activity Into Specified Gross Weight Groups and Truck Types

The VMT information generated by the preceding process was for more aggregate axle configuration and gross weight categories than those available in the TI&U data, and needed for subsequent pavement impact analyses by the contractor study team. Thus in order for the "type 3" VMTs to be merged with the "type 2" VMTs (in terms of truck axle configuration and weight block detail) the "type 3" VMTs had to be distributed to the more disaggregate matrix shown in Figure 2-2.

The "type 3" intermediate outputs consisted of 5 VMT data files for each State. The first (VMT 1) was the VMT for conventional semi's at 73,000 lb GCW; the second (VMT 2) was for conventional semi's at 80,000 lb GCW; the third (VMT 3) was for single unit trucks and conventional semis below 73,000 lb; the fourth (VMT 4) was for "light" doubles and triples combinations; the fifth (VMT 5) included the VMT for "heavy" doubles combinations. The distribution of the 1985 States Quo Base Case "type 3" traffic among the five truck types is shown in Table 2-3.

The first and second group of VMTs were distributed among 3S2, other 4 axle and 6 or more axle tractor semi-trailer combinations in the 70,000-80,000 lb weight blocks. The third group of VMTs was distributed among single unit trucks in the 10,000 lb -60,000 lb

*The time, distance, cost, and fuel consumption associated with these routes were also compiled, and were used in the assignment stage described in Section 2.4.1.

AXLE GROUP	GROSS WT GROUP*	1 < 10	2 10 20	3 20 30	4 30 40	5 40 50	6 50 60	7 60 70	8 70 73	9 73 80	10 80 90	11 90 100	12 100 110	13 110 120	14 120 130	15 > 130
1	2-Axle (6 Tire)	VMT 3 (Single Units)														
2	3-Axle Single Unit															
3	2S1															
4	2S2	VMT 3														
5	3S2															
6	Other 4A Semi	(Conventional Semitrailers)							VMT 1	VMT 2						
7	6 + Semi															
8	2-2															
9	2-3, 3-2	VMT 4 (Light Doubles Combinations)														
10	2S1-2															
11	3S1-2, 3+S1-2															
12	Other truck Trailer Double	VMT 5 (Heavy Doubles Combinations)														
13	All S1-2-2	VMT 4 (Light Triples Combinations)														
14	Truck + 2 Trailers															
15	All other Comb.	VMT 5 (Heavy Doubles Combinations)														

*Thousands of Pounds

FIGURE 2-2. DISTRIBUTION OF "TYPE 3" TRAFFIC FILES BY TRUCK CONFIGURATION AND WEIGHT GROUP

TABLE 2-3. 1985 TYPE 3 TRAFFIC DISTRIBUTION AMONG TRUCK TYPES

DATA FILE	10^6 VEHICLE-MILES
VMT 1	7,218
VMT 2	5,533
VMT 3	18,576
VMT 4	2,774
VMT 5	382
Total (loaded & partially loaded)	34,483
Total (including empty miles)*	45,517

*The five VMT files accounted for vehicle miles traveled by loaded or partially loaded trucks. Additional VMT (32% of loaded VMT) was added to account for empty truck miles. This was based on the ICC's Empty/Loaded Truck Mile Study. The following adjustments were made for each State:

VMT 3' = (1.32)(VMT 3) + (.32)(VMT 1) + (.32)(VMT 2)
VMT 4' = (1.32)(VMT 4)
VMT 5' = (1.32)(VMT 5)

weight blocks, and among all types of conventional semi-trailers : the 10,000-70,000 lb weight blocks. The VMT in the fourth file wa distributed among 2-2, 2-3/3-2 truck trailers, 2S1-2 and 3S1-2 doubles combinations and triples combinations among all "less thai 73,000 lb" weight blocks (110,000 lb for triples). The fifth VMT file was distributed between other truck trailer doubles and all other combinations across all weight blocks. The truck axle configuration distributions used in allocating VMTs were obtained from the TI&U data base. (This distribution was the national level distribution by axle configuration calculated on the basis of VMTs within each axle configuration). The distribution among weight groups was specific to highway classes as well as axle configurations, and used the Sydec* weight block data. This is described in Section 2.6. A regional distribution of "type 2" and "type 3" base case traffic for a few major truck types is indicated in Table 2-4.

2.5 DISTRIBUTE "TYPE 2" AND "TYPE 3" TRAFFIC BY HIGHWAY CLASS

Up to this point the intermediate truck activity files contained VMTs disaggregated by State, truck axle configuration and gross combined weight group. However, since the study's scenarios specify that limit changes apply only to specific types of highways, e.g., interstate only, the intermediate state level VMT had to be distinguished by administrative highway class. Since this parameter was not a part of the TI&U data set an outside source of information on the distribution of VMT by highway class and truck type was utilized.

The fraction of VMT for each truck axle type and State in eac of thirteen highway classes was developed by Sydec from FHWA data as part of the Highway Cost Allocation Study. These thirteen functional highway classes were consolidated by TSC into four administrative classes for use in the TS&W study as indicated in

*Sydec, System Design Concepts, Inc. is the prime contractor on the contractor study team supporting DOT on the TS&W Study.

TABLE 2-4. TYPE 2 AND TYPE 3 TRAFFIC DISTRIBUTION
1985 STATUS QUO BASE CASE

985 STATUS QUO BASE CASE (10^6 VMT)

:GION		SINGLE UNIT TRUCKS	CONVENTIONAL SEMI-TRAILERS COMBINATIONS	ALL OTHER COMBINATIONS	ALL TRUCKS
1	Type 2 traffic	10,312	4,096	1,253	15,661
	Type 3 traffic	195	7,600	319	8,114
	All traffic	10,507	11,696	1,572	23,775
3	Type 2	8,644	5,216	982	14,842
	Type 3	180	7,438	7	7,625
	All	8,824	12,654	989	22,467
4A	Type 2	3,054	1,829	501	5,384
H,KY)	Type 3	101	4,226	355	4,682
	All	3,155	6,055	856	10,066
4B	Type 2	1,583	759	634	2,976
ich.)	Type 3	25	1,039	201	1,265
	All	1,608	1,798	835	4,241
5	Type 2	900	945	163	2,008
	Type 3	47	1,991	3	2,041
	All	947	2,936	166	4,049
6	Type 2	8,311	3,305	596	12,212
	Type 3	147	6,450	1,000	7,597
	All	8,458	9,755	1,596	19,809
7	Type 2	4,991	1,307	416	6,714
	Type 3	33	1,595	318	1,946
	All	5,024	2,902	734	8,660
8	Type 2	4,889	1,922	322	7,133
	Type 3	39	2,130	552	2,721
	All	4,928	4,052	874	9,854
9	Type 2	7,810	6,434	2,232	16,476
	Type 3	120	6,185	1,017	7,322
	All	7,930	12,619	3,249	23,798
0	Type 2	2,224	988	500	3,712
	Type 3	30	1,667	395	2,092
	All	2,254	2,655	895	5,804
1	Type 2	61	41	15	117
aska	Type 3	0	0	0	0
	All	61	41	15	117
2	Type 2	83	30	10	123
waii	Type 3	0	0	0	0
	All	83	30	10	123
TIONAL	Type 2	52,862	26,873	7,625	87,360
TAL	Type 3	918	40,321	4,166	45,405
	All	53,780	67,194	11,791	132,765

Table 2-5. These percentages were applied to the Type 2 and Type VMT's to develop state and truck axle configuration level data by highway class.

The SYDEC distributions were based on 1977 FHWA data which provided State level VMTs for each of the 13 highway classes listed in Table 2-5 for each of the following vehicle types: (1) motorcycles; (2) small autos; (3) intermediate autos; (4) larg autos and "light" 4-tire trucks; (5) revenue buses; (6) nonrevenue buses; (7) single unit trucks under 26,000 lb; (8) single unit trucks over 26,000 lb; (9) combinations under 40,000 lb; (10) combinations over 40,000 lb.

The distribution of VMT by vehicle type within each highway class was based on classification count data collected by the individual State highway departments as part of the FHWA Truck Weight Study. For each highway class and State, VMT in the four truck categories of the FHWA data was distributed according to the more detailed truck axle configuration distributions available in the TI&U data. The regional distribution of base case traffic by highway class, for a few major truck types is indicated in Table 2-6.

2.6 REDISTRIBUTE "TYPE 2" AND "TYPE 3" TRAFFIC BY WEIGHT BLOCK

Since the basis for determining scenario impacts is the gross weight of trucks and whether or not trucks having specific gross weights are permitted under a certain scenario, an accurate description of the weight distribution of specific truck types was essential. The weight distribution provided in the TI&U data was deficient in two respects. First, the weights reported in TI&U represent maximum operating weights of the sampled trucks for the reporting year, and would thus tend to bias the weights distributic toward the high weight end. Secondly, the TI&U weight blocks were too aggregate in the gross weight ranges of interest, e.g., in the areas of the current gross weight limits of 73,280 pounds and 80,000 pounds. Thus, the study team felt that a more realistic weight distribution, and a more appropriate definition of weight

TABLE 2-5. HIGHWAY CLASSES

&W ADMINISTRATIVE HIGHWAY CLASS	FUNCTIONAL HIGHWAY CLASS
1. Interstate	Interstate (Rural) Interstate (Urban)
2. Other Federal Aid (Primary)	Other Primary Arterial (Rural) Other Primary Arterial (Urban)
3. Other Federal Aid (Non-Primary)	Urban System Arterials Urban System Collectors Secondary System Collectors
4. Non-Federal Aid	Non-Federal Aid Arterials (Rural) Non-Federal Aid Arterials (Urban) Non-Federal Aid Collectors (Rural) Non-Federal Aid Collectors (Urban) Non-Federal Aid Local Roads (Rural) Non-Federal Aid Local Roads (Urban)

TABLE 2-6. HIGHWAY CLASS TRAFFIC DISTRIBUTION

1985 STATUS QUO BASE CASE
(10^6 VMT)

REGION	ADMINISTRATIVE HIGHWAY CLASS	SINGLE UNIT TRUCKS	CONVENTIONAL SEMI-TRAILER COMBINATIONS	ALL OTHER COMBINATIONS	ALL TRUCKS
1	Interstate	1,764	4,113	557	6,434
	other primary	3,268	2,732	370	6,370
	other fed. aid	2,463	2,558	328	5,349
	non-fed. aid	3,012	2,293	317	5,622
3	Interstate	1,420	3,416	280	5,116
	other primary	3,031	3,404	259	6,694
	other fed. aid	2,369	3,345	264	5,978
	non-fed. aid	2,003	2,489	188	4,680
4A	Interstate	562	2,634	384	3,580
	other primary	841	1,452	214	2,507
	other fed. aid	926	1,296	177	2,399
	non-fed. aid	826	672	82	1,580
4B	Interstate	324	1,366	634	2,324
	other primary	408	144	67	619
	other fed. aid	465	122	57	644
	non-fed. aid	410	166	78	654
5	Interstate	173	911	52	1,136
	other primary	317	913	61	1,291
	other fed. aid	221	517	27	765
	non-fed. aid	235	594	27	856
6	Interstate	1,837	3,885	638	6,360
	other primary	2,094	3,485	574	6,153
	other fed. aid	2,652	1,749	274	4,675
	non-fed. aid	1,874	635	112	2,621
7	Interstate	600	841	212	1,653
	other primary	1,841	1,321	330	3,492
	other fed. aid	1,171	370	99	1,640
	non-fed. aid	1,411	370	95	1,876
8	Interstate	760	1,349	294	2,403
	other primary	1,635	1,468	318	3,421
	other fed. aid	1,379	773	164	2,316
	non-fed. aid	1,154	462	98	1,714
9	Interstate	1,531	4,620	817	6,968
	other primary	2,155	4,261	990	7,406
	other fed. aid	2,648	2,522	1,011	6,181
	non-fed. aid	1,596	1,308	339	3,243
10	Interstate	460	1,012	329	1,801
	other primary	662	833	286	1,781
	other fed. aid	591	452	154	1,197
	non-fed. aid	541	357	127	1,025
11	Interstate	0	0	0	0
	other primary	20	12	5	37
	other fed. aid	17	12	5	34
	non-fed. aid	24	16	7	47
12	Interstate	12	4	1	18
	other primary	34	13	3	50
	other fed. aid	14	4	2	20
	non-fed. aid	23	9	3	35
NATIONAL TOTAL	Interstate	9,445	24,152	4,195	37,792
	other primary	16,307	19,945	3,570	39,822
	other fed. aid	14,917	13,722	2,559	31,198
	non-fed. aid	13,111	9,651	1,190	23,952

locks were needed for use in the study.

The weight distribution data applied to the TI&U data files as developed by Sydec. It consisted of the fraction of VMT for ach of fifteen weight blocks for each State, highway type and ruck axle configuration used in the adjusted TI&U data files. ydec's weight blocks and those in the original TI&U file are ndicated in Table 2-7. Sydec's weight distributions were based n the FHWA 1977 Truck Weight Study Data. It was felt that this istribution would be more realistic since it is based on actual eight data collected in the field. While the FHWA weight data ay be biased toward the low side of the weight distribution (due o overweight trucks avoiding the weight stations), it was felt hat this distribution was superior to that reported in TI&U based n an analysis of total national ton-miles.

In developing the TSC data sets, the "type 3" VMT was distrib-ted into weight blocks first, for each State, highway type, and ruck axle configuration, and then "type 2" VMT was distributed. ue to maximum weight block limitations imposed on "type 3" VMT, ne final weight distribution found in the base case for any State, ighway type, and truck axle configuration category was not neces-arily equal to Sydec's weight distribution.

In processing the "type 3" traffic, the Sydec percentages for ne permitted "type 3" weight blocks (see Section 2.4.4) were ımmed and normalized to equal 100%. The "type 3" traffic was stributed among the allowed weight blocks according to the rmalized distribution. The resulting VMT distribution was mpared to the desired distribution of total ("type 2" plus "type) VMT to see if the "type 3" VMT assigned to specific weight ocks exceeded the total VMT as specified by Sydec's distribution. not, "type 2" VMT was assigned to each weight block as follows: ype 2" VMT assigned = total VMT desired - "Type 3" VMT assigned. "Type 3" VMT exceeded the desired total VMT for specific weight ocks, the "Type 2" VMT was assigned to the remaining weight ocks on the basis of the original Sydec weight distribution rmalized to 100% for those remaining weight blocks.

TABLE 2-7. WEIGHT BLOCK DEFINITION

TI&U GROSS VEHICLE WEIGHT GROUPS		TS&W STUDY GROSS WEIGHT BLOCKS	
1.	≤ 6,000 lbs	1.	≤ 10,000 lbs
2.	6,001 - 10,000 lbs	2.	10,001 - 20,000 lbs
3.	10,001 - 14,000 lbs	3.	20,001 - 30,000 lbs
4.	14,001 - 16,000 lbs	4.	30,001 - 40,000 lbs
5.	16,001 - 19,500 lbs	5.	40,001 - 50,000 lbs
6.	19,501 - 26,000 lbs	6.	50,001 - 60,000 lbs
7.	26,001 - 33,000 lbs	7.	60,001 - 70,000 lbs
8.	33,001 - 40,000 lbs	8.	70,001 - 73,280 lbs
9.	40,001 - 50,000 lbs	9.	73,281 - 80,000 lbs
10.	50,001 - 60,000 lbs	10.	80,001 - 90,000 lbs
11.	60,001 - 80,000 lbs	11.	90,001 - 100,000 lbs
12.	80,001 - 100,000 lbs	12.	100,001 - 110,000 lbs
13.	100,001 - 130,000 lbs	13.	110,001 - 120,000 lbs
14.	> 130,000 lbs	14.	120,001 - 130,000 lbs
		15.	> 130,000 lbs

2.7 ADJUSTMENTS TO "TYPE 2" TRAFFIC TO REFLECT THE EFFECT OF RECENT STATE TS&W LIMIT CHANGES

Due to recent (i.e., 1977 to 1980) changes in weight limits in several states, adjustments to the "type 2" VMT were required before the merger of the "type 2" and "type 3" files and creation of the base case file. (Note that these limit changes were concurrently incorporated in the redistribution of the "type 3" traffic). The limit changes in question involved an increase in GCW limits from 73,280 lb to 80,000 lb in Connecticut, Iowa, Maryland and Pennsylvania; and an increase in axle limits from 18,000/32,000 lb to 20,000/34,000 lb in Iowa and Illinois.* These limit changes were assumed to result in a reduction of VMT for the truck types impacted and a shift in their GCW distribution for the 1985 Status Quo Base Case.

For each State, the truck axle configuration/weight block cells impacted by the limit changes were identified (e.g., for a change from 73,280 lb to 80,000 lb only those trucks restricted by the 73,280 lb limit would be potentially impacted). The magnitude of the VMT reduction for the impacted trucks was assumed to be proportional to the magnitude of the potential payload increase. The portion of the VMT impacted within each cell was assumed to be that within 5% or 10% of the impacted limits.** Assuming a uniform distribution of GCWs and VMTs within each weight block, the required VMT adjustments were computed as follows:

(1) Where VMT did not shift weight blocks in the adjustment process, adjusted VMT were calculated as:

VMT' = (VMT x portion impacted x reduction factor) + (VMT x portion not impacted);

*The change in axle limits in Illinois involves a change in tolerance policy.

**The portion of the VMT impacted was assumed to be that within 5% of the GCW limit before the change for trucks impacted by the GCW limit change; and that within 10% of the axle limit before the change for trucks impacted by axle limit changes.

(2) Where VMT did shift weight blocks in the adjustment process, adjusted VMT was calculated as:

$$VMT'_{wt.\ block_i} = VMT_{wt.\ block_i}\ (1 - \text{portion impacted})$$

$$VMT'_{wt.\ block_j} = VMT_{wt.\ block_j} + (VMT_{wt.\ block_i} \times \text{portion impacted} \times \text{reduction factor}).$$

The actual equations used in the adjustment for each State/truck axle configuration/weight block are given in Appendix E.

3. ESTIMATING VMT CHANGES FOR "TYPE 2" TRAFFIC

3.1 INTRODUCTION

This chapter describes the procedure used to estimate the VMT changes, in the absence of mode shifts, for "type 2" truck traffic due to changes in weight limits. The VMT impacts on "type 3" traffic are discussed in another chapter. The mode shift effects of changed weight limits for both "type 2" and "type 3" traffic are considered in Technical Supplement, Vol. 5.

Note that this chapter describes the assumptions and procedures used by TSC in developing intermediate data files only. These files were subsequency modified by Sydec through the application of the SDHPT (Texas) load shift method and various other techniques of shifting VMT among weight blocks, to ensure a more realistic accounting of overloaded trucks and the conservation of payload ton-miles. TSC's output distribution of VMT by State, truck axle type and highway class was not altered by these modifications. The modified files, together with the intermediate files described here, formed the basis for the analysis and results indicated in the final report.

Two types of procedures were used to compute VMT changes due to two different types of weight limit changes. The first type of change involved the reduction of existing gross weight and axle load limits to some uniform lower level. This was the type of change involved in the "grandfather limits" scenarios (2, 2A and 2B), and in some of the "barrier limits" scenarios (5,8,10 and 11).* The second type of change involved the raising of existing gross weight and axle load limits to some uniform higher level as part of the "barrier limits" scenarios. Limit increases, aimed primarily at the "type 3", long-haul, interstate traffic, would also impact the short-haul, "type 2" traffic in some of the "barrier limit" scenarios (2B, 4, 6, 9 and 10).

*See Appendix A for the equivalence between the scenario numbers used in this volume and those used in the main volume of the Truck Size and Weight Report.

The procedure used to compute this second type of change is described in Section 3.2. It is essentially the same approach used to make adjustments to the base case "type 2" traffic to account for recent changes in TS&W limits in specific States, described in the previous chapter. The portion of the VMT impacted within each truck-axle type and weight block cell of the base case VMT file was identified for each affected State within each of the scenarios in question. VMT changes were computed assuming that reduced trip-making (in response to the higher limits) would be proportional to the magnitude of the potential payload increases.

Section 3.3 describes the procedure used to compute the VMT changes made in response to lowered weight limits. This method assumed that three possible responses were available to truck operators faced with reduced limits: a) make increased trips with reduced payloads; b) shift to a truck type with more axles so that the same payload could be carried in the same number of trips; or c) shift to a highway class not affected by the lower weight limits in order to carry the same payload in the same number of trips. The actual procedure involved (1) identifying the truck-axle type and weight block cells in the base case VMT file potentially impacted by the weight limit reductions called for in each scenario; (2) dividing the impacted VMT among each of the responses permitted for that scenario; and (3) transferring the VMTs to the appropriate weight block, truck type of highway class as called for in that scenario.

3.2 EFFECTS OF INCREASING WEIGHT LIMITS

3.2.1 Nature of the Problem

A distinction was made early in the study between that group of scenarios dealing with "barrier limit" problems in defining the scenarios for use in the Truck Size and Weight Study. However, it became apparent that the "type 2" traffic would also be impacted by the limit changes proposed in the "barrier limit" scenarios.

In general terms, the local and short-haul traffic impacts of the ten barrier limit scenarios fell into three categories:

1) No impact (scenario 2C and 3) - Limits would be raised on the Interstate System only. Local and short-haul traffic utilizing the Interstate would still be governed by lower limits off the Interstate;

2) Impact analogous to the "grandfather limit" scenarios (scenarios 5,8,10 and 11)* - Limits would be lowered on the Interstate and Primary systems to 18/32K per single/ tandem axle, and 73,280 pounds GCW in scenario 5, and a GCW determined by the bridge formula in scenario 8. These scenarios were analogous to the "grandfather limit" scenarios in that truck activity was forced to operate at some reduced weight limit level. In terms of the analysis, these scenarios were treated as "grandfather limit" scenarios and are described more fully in Section 3.3;

3) Impact due to <u>increased</u> limits on the Interstate and Primary system (scenarios 2B, 4,6,9 and 10)** - Limits would be raised on the Interstate and Primary systems in specified States in order to eliminate "barriers" and bring the limits up to some specified uniform level. This would result in reduced tripmaking in the impacted States for "type 2" traffic as well as "type 3" traffic. The treatment of the "type 2" traffic impact is described below.

3.2.2 <u>Method</u>

Except for the specific weight limits and States involved, the method used in determining the "type 2" traffic impacts of

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*In scenario 10 limits would be lowered in certain States on the Interstate and Primary systems to 20/34k per single/tandem axle with a GCW determined by the bridge formula.

**Note that scenarios 2B and 10 were subject to both "barrier limit" impacts and "grandfather limit" impacts since in some States, weight limits were raised while the "grandfather limits" were lowered in other States.

barrier limit changes was the same as that used in adjusting the base case "type 2" traffic to reflect the effect of recent State TS&W limit changes.

For each scenario, the affected States, and truck-axle type and weight block cells impacted by the limit changes were identified. The portion of the VMT impacted within each cell was assumed to be that within 5 percent of the GCW limit before the change, for trucks affected by a GCW limit change; and that within 10 percent of the axle limit before the change for trucks impacted by the axle limit change. The magnitude of the VMT reduction for the impacted trucks was assumed to be proportional to the magnitude of the potential payload increase.

Assuming a uniform distribution of GCWs and VMT within each weight block, the required VMT adjustments were computed as follows:

(1) Where VMT did not shift weight blocks in the adjustment process, adjusted VMT was calculated as

$$\text{VMT}' = (\text{VMT x portion impacted x reduction factor}) + (\text{VMT x portion not impacted});$$

(2) Where VMT did shift weight blocks in the adjustment process, adjusted VMT was calculated as

$$\text{VMT}'_{\text{wt.BLOCK i}} = \text{VMT}_{\text{wt.BLOCK i}} \text{ (1-portion impacted)}$$

$$\text{VMT}'_{\text{wt.BLCOK j}} = \text{VMT}_{\text{wt.BLOCK j}} + (\text{VMT}_{\text{wt.BLOCK i}} \text{ x portion impacted x reduction factor})$$

The actual equations used in the adjustments for each scenario, State, truck-axle type and weight block are indicated in Appendix F.

3.3 EFFECTS OF REDUCING WEIGHT LIMITS

3.3.1 Nature of the Problem

A number of study scenarios (2, 2A, and 2B*) were formulated specifically to study the effects of the elimination of weight limits, tolerance practices and permit policies which allowed the operation of trucks at gross weights or axle loads in excess of federal standards for the Interstate System. These were referred to as the "grandfather limit" scenarios. A basic assumption of the study was that only "type 2" traffic, i.e., primarily local and short-haul traffic would be impacted by a change in these "high" weight limits.

In addition, scenarios 5,8,10 and 11 which are primarily "barrier limit" scenarios, were also assumed to have an impact on "type 2" or local traffic, which would be analogous to the impact of the "grandfather limit" scenarios in certain States.

Scenario 2 calls for a reduction of all limits to a level of 80,000 pounds gross weight and 20,000/34,000 pounds per single/tandem axle on the Interstate System only. Scenarios 2A and 2B extend these same limits to the Primary System as well. Scenario 5 calls for a reduction of limits on the Interstate and Primary systems to 73,280 pounds gross weight and 18,000/32,000 pounds single/tandem axle (the pre-1974 federal limits) but allows retention of the grandfather limits. Scenarios 8 and 11 call for a reduction of axle limits to 18,000/32,000 pounds, but with the gross weight limit determined by a bridge formula (formula A). Scenario 10 calls for axle limits of 20,000/34,000 pounds with the gross weight limit determined by bridge formula B.

Three possible truck operator actions were postulated as responses to these proposed weight limit reductions. These included (a) increased trip making at the reduced weight levels; (b) a shift toward trucks with more axles, which could legally carry

*Scenario 2B studied the effects of the elimination of high weight limits and the removal of "barrier" type limits.

the same payload as carried by the operator's current trucks; and (c) a shift off the highway class (es) to which the more restrictive limits applied.

The method used for calculating the VMT changes due to these responses in each scenario is described below. It should be noted that implicit in this method is the assumption that the limits proposed in each scenario are strictly adhered to. This assumption carries with it the implication of a different enforcement policy than that in effect at present, since current limits are not strictly adhered to. Given a "business as usual" approach to weight limit enforcement, the results of this method would tend to overstate the impact of the proposed weight limit changes.

3.3.2 Method

The method for calculating the truck VMT changes due to a reduction of truck weight limits was developed by Sydec, who also supplied the data inputs needed to implement the procedure. This method assumed that three response options were available to truck users faced with reduced weight limits:

A. Use the same equipment and run more miles as a result of traveling lighter;

B. Use equipment with more axles so that the load carried and the VMT would remain constant;

C. Travel on the other Primary System instead of the Interstate System.

The third option was only available in scenario 2, since in the other scenarios, high limits were reduced on both the interstates and other primaries.

The Sydec method is shown in equation form below. The equations given for scenario 2A would be used on "type 2" traffic in scenarios 2B, 5,8,10 and 11 as well. For each truck axle group, in each state the change in VMT was to be calculated as follows:

Scenario 2 Interstate VMT

$$\Delta VMT_I = ISAVMT \times \left(\frac{\% A}{100}(AIF-1) - \frac{\% B}{100} - \frac{\% C}{100}\right) + \text{(Any VMT shifted from other truck types)*}$$

Scenario 2 Other Primary VMT

$$\Delta VMT_{OP} = \Delta VMT_I \times \left(\frac{100-\% IS}{\% IS}\right) + \frac{\% C}{\% IS} \times ISAVMT \times CCF$$

Scenario 2A Interstate VMT

$$\Delta VMT_I = ISAVMT \times \left(\frac{\% A}{100}(AIF-1) - \frac{\% B}{100}\right) \times \left(\frac{100}{100 - \% C}\right)^{**} + \text{(Any VMT shifted from other truck types)***}$$

Scenario 2A Other Primary VMT

$$\Delta VMT_{OP} = OPAVMT \times \left(\frac{\% A}{100}(AIF-1) - \frac{\% B}{100}\right) \times \left(\frac{100}{100 - \% C}\right)^{**} + \text{(Any VMT shifted from other truck types***}$$

Secondary and Non-Federal Aid VMT

$$\Delta VMT = VMT \left[\frac{(VMT_I + \Delta VMT_I) + (VMT_{op} + \Delta VMT_{op})}{VMT_I + VMT_{op}} - 1\right]$$

where

VMT_I = Interstate System VMT for this truck axle group and State,

ΔVMT_I = Change in the Interstate System VMT,

VMT_{op} = Other Primary System VMT for this truck axle group and State,

ΔVMT_{op} = Change in the other Primary System VMT,

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*As a result of their choosing to use equipment with more axles.

**Option C is not a real option with Scenario 2A. The last term normalizes %A and %B so that together they represent 100%.

***As a result of their choosing to see equipment with more axles.

%IS = Interstate VMT as a percentage of total VMT (this quantity was used to determine how the reduction of weight limits on Interstates affects other Primaries),

%A = Percentage of affected Interstate VMT choosing to run more miles with the same equipment (Option A),

AIF = VMT increase factor for VMT choosing Option A,

%B = Percentage of affected Interstate VMT choosing to shift to trucks or combinations with more axles (Option B),

%C = Percentage of affected Interstate VMT choosing to shift to other primaries from the Interstate System (Option C),

CCF = Circuity factor associated with Option C,

%ISAVMT = Percentage of Interstate System VMT which is affected under scenarios 2 and 2A,

ISAVMT = % ISAVMT * VMT_I,

%OPAVMT = Percentage of other Primary System VMT which is affected under scenario 2A,

OPAVMT = %OPAVMT * VMT_{op}.

The procedure represented by these equations was incomplete, because it did not deal with the distribution of VMT among weight blocks. The following decision rules, proposed by Sydec, were utilized as a guide in dealing with this deficiency:

1) For trucks choosing to travel lighter (Option A), the additional VMT was added to the weight block associated with the maximum permissable weight of that truck type under the new limits;

2) For affected trucks choosing to add an axle (Option B), the weight block to which the VMT was shifted was determined by comparing the tare weights of the two truck types and keeping the payload constant;

3) For trucks which changed highway system (Option C) the weight block remained the same.

The algorithm used for calculating VMT shifts is outlined below. It should be noted that in this procedure the maximum allowable weight block (MWB) was determined for each truck axle type along with the portion of the VMT in the MWB which was overweight, F (These values are shown in Table 3-1). The overweight VMT, and thus the VMT to be shifted as a result of the limit changes was taken as that portion of the VMT in the MWB which was overweight plus all VMT in the higher weight blocks. This amount of VMT superseded the %ISAVMT, and %OPAVMT (% overweight VMT) in all subsequent calculations except in the computation of additional VMT due to Option A.

Two sets of computations were performed. The first were those for VMT shifts in scenario 2, on the other primaries. The second, for scenario 2, Interstates, was also applied to both Interstates and other primaries in scenario 2A, 2B, 5,8,10 and 11. Most variables used, were defined previously. The subscript "i" refers to the weight block number (Table F-1 in Appendix F defines the weight block boundaries). F was the portion of the VMT which is overweight in a weight block (1 for all i>MWB). DIVPER was defined as the percent VMT which does not shift to rail in the mode shift scenarios (DIVPER=1 for the no mode shift scenarios).

VMT for other primaries in scenario 2 was computed in the following manner. First VMT shifting from the Interstates was added and the access to the Interstate, associated with this shifting VMT, was removed from the other primaries.

$$\Delta VMT_{\substack{op \\ i=MWB\rightarrow 15}} = [(VMT_{I_i} * CF)-(VMT_{I_i} * ISF)] * F_i$$

where $CF = \frac{\%C}{\%IS} * CCF * DIVPER$

$$ISF = \frac{(100 - \%IS)}{\%IS}$$

TABLE 3-1. MAXIMUM WEIGHT BLOCKS BY SCENARIO

TRUCK[1]	SCENARIO 2, 2A, 2B,10			SCENARIO 5			SCENARIO 8,11		
AXLE TYPE	Weight[2] Block Number	Maximum Allowable GCW	F[3]	Weight[2] Block Number	Maximum Allowable GCW	F[3]	Weight[2] Block Number	Maximum Allowable GCW	F[3]
1	4	32K	.8	3	30K	0	3	30K	0
2	5	46K	.4	5	44K	.6	5	44K	.6
3	6	52K	.8	5	48K	.2	5	48K	.2
4	7	66K	.4	7	62K	.8	7	62K	.8
5	9	80K	0	8	73K	0	8	73K	0
6	7	66K	.4	7	80K	.8	7	62K	.8
7	9	80K	0	8	73K	0	11	94K	.6
8	8	72K	.4	7	66K	.4	7	66K	.4
9	9	80K	0	8	73K	0	10	82K	.8
10	9	80K	0	8	73K	0	10	82K	.8
11	9	80K	0	8	73K	0	10	89K	.1
12	9	80K	0	8	73K	0	10	89K	.1
13	9	80K	0	8	73K	0	13	116K	.4
14	9	80K	0	8	73K	0	13	116K	.4
15	9	80K	0	8	73K	0	13	116K	.9

1. Truck axle type codes are defined in Appendix F, Table F-2.
2. Weight block codes are defined in Appendix F, Table F-1.
3. F is the portion of the VMT in the weight block which exceeds the maximum allowable GCW.

Next the access VMT for trucks choosing Option A was added to the maximum allowable weight block.

$$\Delta VMT_{op_{i=MWB}} = ISF* \left[(ISAVMT*TMP) + \sum_{i=MWB}^{15} (VMT_{I_i} * AN * F_i) \right]$$

where $TMP = \frac{\%A}{100} * (AIF-1) * DIVPER$

$$AN = \frac{\%A}{100} * DIVPER$$

Finally, the access VMT (if any) associated with trucks choosing Option B was calculated as

$$VMTB_{i=MWB \rightarrow 15} = VMT_{I_i} * BN * F_i * ISF$$

where $BN = \frac{\%B}{100} * DIVPER$

and added to the appropriate weight blocks of the new truck axle group.

$$\Delta VMT_{op_i} = VMTB_i * P_1$$

$$\Delta VMT_{op_{i+1,\ i \neq 15}} = VMTB_i * P_2$$

where $P_1 = 1 - DTARWT/10$

$$P_2 = DTARWT/10$$

DTARWT was the difference in tare weights of the original truck axle group and the new truck axle group (tare weights used in this analysis are shown in Table 3-2).

The procedure for calculating the VMT shifts on interstates and other primaries in scenarios 2A, 2B, 5,8,10 and 11 and interstates in scenario 2 as described below. First, the additional VMT (DVMT) associated with added trips under Option A was calculated.

TABLE 3-2. TRUCK TARE WEIGHTS

TRUCK AXLE GROUP [1]	TARE WEIGHT (1,000 lb) [2]
1	9.4
2	18.4
3	22.0
4	24.7
5	26.8
6	23.2
7	29.3
8	16.3
9	22.0
10	30.6
11	31.9
12	30.0
13	32.6
14	24.5
15	33.9

1. Truck axle configuration codes are defined in Appendix F, Table F-2.

2. Provided by the Sydec study team.

$$DVMT = ISAVMT * TMP \text{ for interstates}$$

$$DVMT = OPAVMT * TMP \text{ for other primaries}$$

where $TMP = \frac{\%A}{100} * (AIF-1) * DIVPER * OPCADJ$

$OPCADJ=1$, for scenario 2

$OPCADJ = \frac{100}{100-\%C}$, for other scenarios.

This VMT, along with the VMT choosing Option A was added to the maximum allowable weight block as

$$\Delta VMT_{MWB} = DVMT + \sum_{i=MWB}^{15} (VMT_i * AN * F_i)$$

where $AN = \frac{\%A}{100} * OPCADJ * DIVPER$

Next, the VMT shifting due to Option B, if any, was calculated as

$$VMTB_{i=MWB \rightarrow 15} = VMT_i * BN * F_i$$

where $BN = \frac{\%B}{100} * OPCADJ * DIVPER$

and added to the appropriate weight blocks of the new truck axle group as was done in the scenario 2, other primary case. Finally, the VMT associated with trucks in excess of the maximum allowable weight block was subtracted from the appropriate weight blocks,

$$\Delta VMT_{i=MWB \rightarrow 15} = VMT_i * F_i$$

where $F_i = 1$ for $i > MWB$

When all of the above computations were completed for a State, the VMT changes on the secondary and non-federal aid systems were computed for each truck axle configuration and weight block as indicated in Sydec's original memorandum* on the analysis of the grandfather scenarios.

*Incorporated into Technical Supplement Vol. 6 of this report.

4. ESTIMATING VMT CHANGES FOR "TYPE 3" TRAFFIC

4.1 INTRODUCTION

This chapter describes how the VMT changes for "type 3" truck traffic, attributable to changes in size and weight limits, were estimated. VMT changes due to mode shift, which needed additional assumptions to be computed, are discussed in technical supplement, Vol. 5.

A consistent method for deriving "type 3" VMTs was applied to all scenarios. In particular, since the "type 3" commodity flow data file (see Appendix C) contained only tonages, the method had to be applied to the base case itself. The basic process, therefore, has already been described in Section 2.4 and Appendix D. The same process was applied with only minor technical modifications to each of the alternative scenarios. The "no mode shift" VMT changes were generated by variations of the input assumptions, which in turn reflected the interpretation of the definitions of the various scenarios into special terms that were operational for the data files and program. Section 4.2 treats these interpretations.

The base case quantitative description rested on the assumption that historical (1977) mode shares at the level of O/D commodity markets would continue to prevail in 1985. The mode shift model was used only for the alternatives. The development of the model itself and of the parameters used in it are described in Technical Supplement, Volume 5. of this report.

4.2 INTERPRETATION OF THE SCENARIOS

As in the base case, the detailed analysis of "type 3" traffic used a few representative truck configurations, sizes, and weights for the sake of analytical economy. The results were translated to the level of the 15x15 configuration/weight-block matrices by variants of the base case disaggregation procedure explained in Section 2.4.4. The "interpretation" of the study scenario definitions into these representative terms will be explained here and the disaggregation in the next section.

There were only three system characteristics that could be changed to represent individual alternative scenarios. The first of these was the subnetworks of the unchanging highway study network to which particular truck types were restricted. All scenarios that involved a complete or partial movement to uniformity had such changes. The second was a change in the payload capacity of given truck types. The third and most drastic change was the introduction of new truck types, which, of course, also required the introduction of new cost and fuel consumption information.

Table 4-1 summarizes all of the system changes that were inputs to the various scenarios. All differences among "type 3" traffic results are consequences of these system input changes.

The payload capacity variations in Part 1 of the table mainly result from straightforward applications of the axle weight limits, gross weight limits, or bridge formulas to the vehicle of the type mentioned having the most use or most typical length and axle configuration. For example, a 55' 3S2 rig with 45' trailer is used for the conventional semi-trailer considerations in scenarios 1 through 6. The capacities for scenarios 8 through 11 are for slightly longer vehicles because the longer cab-behind-engine tractors are explicity encouraged. All payload capacities are for vans. Because vans are the dominant body type and because capacity variations among body types are within 5% of van capacities, body-type differences in capacity were not accounted for.

The second part of the table states which truck types are available in which scenarios, and where. Conventional semi-trailers are available always and everywhere, but at various payload capacities. In scenarios 1, 2C, and 3 there is at least some non-uniformity, with not all highways at the higher 80K GCW limit. There are thus two kinds of loaded-to-full-weight trucks in these scenarios, one at 73K and traveling anywhere, the other at 80K and restricted to the indicated subnetwork. In scenarios 2B and 4, 80K combinations are permitted everywhere, so the 73K full-load category is not used. In scenario 5 the heavier combinations are

TABLE 4-1. OPERATIONAL DEFINITIONS OF SCENARIOS

PART 1 - CUBIC AND PAYLOAD CAPACITIES

TRUCK TYPE	Cubic Capacity (ft^3)	Payload Capacity (Tons)						
		Scenario 1-5		Scenario 6	Scenario 8	Scenario 9	Scenario 10	Scenario 11
		18/32/73*	20/34/80*					
Conventional Semi	2911	22.70	25.06	25.95	22.30	24.31	24.31	22.30
Light Double[1]	3470	20.98	24.34	24.35	24.92	24.92	24.92	24.92
Tandem Axle[2] Double (Short)	3470	15.76	19.22	31.30	30.50	31.50	31.50	30.50
Turnpike Double[3]	5822	32.74	34.74	37.25	32.48	34.48	34.48	32.48
Light Triple[4]	5205	-	-	-	-	20.30	-	-
Tandem Axle[5] Triple	5205	-	-	-	-	43.95	-	-

*18/32/73 = 18,000 lbs/single axle, 32,000 lbs/tandem axle, 73,280 lbs GCW; 20/34/80 is analogous.

Source: Technical Supplement, Volume 1, Appendix C. (All data are for vans. Capacity differences among dominant body types are within ±5% of van capacities.)

1. Represents all versions of double combinations having mostly single axles, with an overall length of less than 65 feet.
2. Represents all versions of double combinations having mostly tandem axles, with an overall length of less than 70 feet.
3. Represents all versions of double combinations having mostly tandem axles, with an overall length of between 80 feet and 108 feet.
4. Three freight unit version of the light double.
5. Three freight unit version of the tandem axle double.

TABLE 4-1. OPERATIONAL DEFINITIONS OF SCENARIOS (CONT.)

PART 2 - NETWORK USE AND RESTRICTIVE EXCEPTIONS

Truck Type	Scenario										
	1	2B	2C	3	4	5	6	8	9	10	11
Conventional 73k	F	-	F	F	-	F	-	-	-	-	-
Semi-Trailer 80k	80	F	IU	IU	F	-	F	F	F	F	F
Light Double[1]	WD	65	65	WD	F	WD	WD	65	F	F	F
Tandem Axle Double (Short)[2]	4B/9	-	4B/9	4B/9	4B/9	4B/9	WD	65	F	F	F
Turnpike Double[2]	TD	-	TD	TD	TD	TD	TD	TD	-	TD	TD
Light Triple[3]	-	-	-	-	-	-	-	-	I	-	-
Tandem Axle Triple[3]	-	-	-	-	-	-	-	-	I	-	-

Subnetwork Codes:

F = All FAP Highways (Entire Network)

80 = States permitting 20/34/80 rigs in 1980

IU = All Interstates and all other highways permitting 20/34/80 rigs in 1980

WD = States permitting 65' doubles in 1980

65 = States permitting doubles of any length in 1980

4B/9= Region 4B (Michigan) and Region 9 (Southwest)

I = Interstate highways only.

TD = Turnpike corridor between Chicago and New York with spur to Boston

[1]Except in scenarios 4 and 9-11, western doubles are restricted to LTL and curtailed in regions 1, 3, 5.

[2]In scenarios 1-5, tandem axle doubles get only a fraction of the traffic in this region. The same is true for turnpike doubles in all scenarios.

[3]Triples are also restricted in scenario 9.

forbidden everywhere. The last five scenarios all have a uniform standard for conventional semi-trailer combinations which varies slightly from case to case, as Part 1 showed.

The light doubles are short enough to fit into a 65' length limit and thus in the base case can be used everywhere in region 4 and regions 6 to 10, and also along the turnpike routes in Region 1. This is the "WD" (Western Double) subnetwork. States that prohibit these doubles do so by either or both of two restrictions: an outright ban on double-trailer combinations per se or by an overall length limit significantly below 65 feet. It is possible that the federal regulations could adopt a length limit without addressing the 65-foot doubles question directly. This is explicit in scenario 2B and implicit in scenarios 2C and 8. Taking this literally, the "65" subnetwork was formed by appending to "WD" links in States that presently permit doubles, but not of 65 feet. (It is of course possible that some States which prohibit doubles are actually mostly concerned about length. If forced to accept greater length, they might permit doubles.) The remaining scenarios permit Western doubles everywhere.

The use of 65-foot doubles was subject to "exceptional" restrictions of one sort of another in all scenarios. On a strict cost basis 65-foot doubles are preferable vehicles for transporting all low-density shipments. Yet doubles are not in such overwhelming use today, even where legal. There are various reasons for this in the current non-uniform regulatory environment such as; the preference of carriers for using equipment that can be used over their entire route structure, and the preference of shippers for putting their large shipments in a single van. To realistically represent 65-foot doubles use in the base case, only regulated truck LTL shipments were permitted to use dobules.* Preliminary runs of the base case results incorporating this assumption were compared with the TI&U "type 3" traffic totals by truck type. It was found that the model predicted too much doubles use and in

*This was supported by the results of a contract study performed by FAY/TDS for TSC. See Technical Supplement, Vol. 7.

particular too much use in the East using the turnpike route. Clearly problems of cheap access and the fact that doubles are not customary in the East had to be accounted for. Denying doubles 50% of the traffic they would win on cost grounds alone if either or both trip end-points is in region 1, brought the total and regional distribution of doubles VMT in the base case much closer to that of the TI&U data.

In scenarios 2B, 2C and 8, in which the potential range of 65' doubles was extended only slightly, their penetration into regions 1, 3 and 5 was limited by the same restrictions used in region 1 in the base case. The justification was that the change was too small to change carrier and shipper attitudes or to make doubles dominant in the East. In scenarios 3, 5 and 6, the potential area of doubles use is not altered at all, and the base-case results for their actual usage are retained.

In the remaining cases (scenarios 4, 9, 10 and 11) 65-foot doubles are available on all primary highways in all States. The difference between scenario 4 and the others is that, since the 80K GCW limit is retained in scenario 4, 65-foot doubles are still practical only for low-density shipments. Thus, whereas in scenarios 9, 10 and 11, 65-foot doubles are the everywhere-dominant truck configuration in total, this is still not the case in scenario 4. Therefore, the restriction of doubles to LTL and the limit on their penetration of the East was once again applied. In contrast, in scenarios 9, 10, 11, 65-foot doubles were permitted to carry all LTL shipments. Other low-density shipments were not placed in doubles because it seemed unreasonable to have no traffic in conventional semi rigs, because of remaining shippers preferences, driver and carrier preferences and some maneuverability problems.

The next truck type, tandem-axle doubles, has a very different interpretation in the later scenarios (6-11) from that of the earlier ones. In the base case and scenarios 2 to 5, this type is really a book-balancing device introduced to account for the TI&U's report of activity for axle configurations 12 and 15 in

Michigan and the Southwest. Because the level of activity is small, the type is introduced as an "exception" to the minimum cost rule taking small percentages of high-density conventional semi-trailer traffic with appropriate origin and destination. No specfic capacity is introduced, so in effect it has the conventional semi-tailer capacity by default (as shown in Table 4-1). The rule for distributing this traffic type across weight blocks corrects for any distributional distortion caused by this, while the low level of activity guarantees no significant distortion in total vehicle-miles.

From scenario 6 on, short tandem-axle doubles are a serious contender for high-density traffic, representing a class of truck configuration and size that can be expected to evolve under the rules envisioned there. The key element common to these scenarios that is responsible for this is the reliance on the bridge formula to limit gross weights. This gives an advantage to combinations that are as long as possible and have more axles. In scenario 6 this means 65', and in scenarios 8, 70', vehicles in regions which currently permit doubles (4, and 6 through 10). Something like double 27' trailers with tandem axles would seem to be more versatile and manueverable than a single 54' trailer. In scenarios 9, 10 and 11 these doubles combinations could go anywhere. Apart from the network restrictions, no limit is placed on these "heavy doubles" in scenarios 6 and 8. In scenarios 9, 10 and 11 they are restricted somewhat to avoid the extreme consequence of the total disappearance of conventional semi trailer combinations.

The turnpike doubles, which are modeled as 3S2-4 twin 45' trailer combinations as the name implies, are restricted to the NY/Boston-Chicago turnpike corridor. Structly speaking, there should also be similar base case activity of long combinations in region 10, using 27 foot triples, but the TI&U data indicated it was too miniscule to bother with. The turnpike doubles are restricted even on the turnpike corridor to produce rough agreement with the TI&U data. They appear in every scenario but scenario 2B and 9 without variation in ton-miles. They disappear in scenario 9 because in that scenario, tandem-axle triples, which are very close in size and cost, are permitted. They disappear in scenario 2B because of the grandfather clause cancellation, which prohibits gross weights greater than 80,000 lb and effectively rules out turnpike doubles as an economic competitor.

Twenty seven foot triples are permitted on the interstate highways in scenario 9. Both light (i.e. single axle) and heavy (i.e. tandem axle triples) are allowed to become prominent vehicles. The use of triples, even when restricted to interstate highways, is highly speculative because supporting investments would be needed in many locations for assembly/disassembly areas,* access to these areas, and improvements in the highways themselves to assure that the vehicles could safely negotiate all curves. Thus, although this large capacity advantage would imply that triples be used as much as possible, it seems prudent to forecast a more modest rate of adoption. The impact of each scenario on the distribution of loaded and partially loaded "type 3" traffic among truck types is shown in Table 4-2.

The details of the standard cost-minimizing method for selectting truck-types, and of the exceptions to this principle, are the subject of Appendix D.

4.3 DISAGGREGATING TRUCK ACTIVITY INTO DETAILED AXLE CONFIGURATION/ GROSS WEIGHT GROUP MATRICES

In Section 2.4.4, it was shown how the code 3 base case results, in terms of "representative" truck types and payload weights, were disaggregated into the more detailed TS&W study format of 15 axle configurations and 15 gross weight blocks. The translation required two inputs. The first was a set of rules identifying the 5 representative truck type categories with specific groups of cells in the 15x15 matrix. This is most easily represented by Figure 2-2, which for convenience is reproduced here as Figure 4-1. The second is a set of rules for distributing each category within its assigned cells. In the base case, this was straightforward, as the TI&U type 3 data for those cells was used.

*The cost based rates postulated for carriers using these combinations included this investment.

TABLE 4-2. DISTRIBUTION OF LOADED (1) CODE 3 VMT AMONG TRUCK TYPES BY SCENARIO - NO MODE SHIFT

SCENARIO	CONV. SEMI TRAILER COMB. & SINGLE UNIT				LIGHT WEIGHT MULTIPLE TRAILERS		HEAVY DOUBLES COMB.			HEAVY TRIPLES COMB.		TOTAL
	WEIGHT LIMITED		NOT WEIGHT LIMITED		DOUBLE	TRIPLE	SHORT		LONG	FULL LOAD	PARTIAL LOAD	LOADED
	LOW LIMIT 18/22/73	HIGH LIMIT 20/34/80	PARTIAL LOAD HIGH DENSITY	LOW DENSITY			FULL LOAD	PARTIAL LOAD				VMT
1 BASE CASE	7,218	5,533	6,033	12,543	2,774		274		108			34,483
2B	0	12,592	6,033	12,274	3,028		0		0			33,927
2C	476	11,766	6,033	12,266	3,028		273		105			33,947
3	476	11,766	6,033	12,547	2,774		273		105			33,974
4	0	12,185	6,033	10,006	4,842		273		105			33,444
5	13,225	0	6,033	12,543	2,774		296		114			34,985
6	0*	6,087**	5,193	12,543	2,774		4,912	837	121			32,467
6A (2)	*	12,007**	6,033	12,543	2,774		273	0	105			33,735
8	5,712*	0	4,949	12,266	3,028		6,077	1,110	128			33,270
9		1,221*	1,951	1,087	5,163	1,902	6,710	3,505	0	2,004	611	30,155
10		1,221*	1,951	7,088	7,231		9,215	4,066	133			30,905
11		1,312*	1,951	7,088	7,231		9,522	4,066	141			31,311

(1) Empty mileage is estimated by application of 1.32 empty mileage factor to these values

(2) This alternative added here to illustrate the effect if tandem-axle doubles are not used for high-density traffic

* Bridge Formula Used in Place of Specific GCW Limit

** High Axle Limits (22.4K, 36K) and Bridge Formula Used

Figure 4-1 to 4-4 give the assignment matrices for scenarios 2 through 11. Figure 4-1, the base case assignment, also applies to scenarios 2 to 5. The definitions of the 5 VMT files and the truck types they represent are the same as the base case definitions presented in section 2.4.4. Note also that empty mileage in all scenarios is handled in a manner analogous to that of the base case. Figure 4-2 applies to scenarios 6 and 10. In this case VMT files 3,4 and 5 have the same meaning as in the base case. VMT 1 now applies to conventional semis at 80,000 lb GCW. VMT 2 applies to fully-loaded short heavy doubles (2-27', 3S2-3s) at 102,000 lb GCW while VMT 6 applies to short heavy doubles of GCWs of less than 100,000 lb. Figure 4-3 applies to scenarios 8 and 11. VMT files 1, 3, 4 and 5 have the same meaning here, as in the base case. VMT 2 applies to short heavy doubles (2-27', 3S2-3s) at 100,000 lb GCW, and VMT 6 applies to partially loaded short heavy doubles of less than 90,000 lb. Figure 4-4 indicates the distribution matrix for scenario 9. VMT files 3 and 4 are the same as in the base case, and VMT 1 applies to conventional semi's at 80,000 lb. VMT 2 and VMT 6 again apply to short heavy doubles, fully loaded at 103,000 lb and those partially loaded at less than 100,000 lb. VMT 7 is used for light triples, which are the same as those of the base case. VMT files 8 and 5 apply to heavy triples (3-27', 3S2-3-4s). VMT 8 includes fully loaded heavy triples at GCW of 140,000 lb., and VMT 5 includes partially loaded or cubed out heavy triples of less than 130,000 lb.

Several general points ought to be made about these assignments. First, all scenarios consistently rule out over-weight operations.* Secondly, the weight distributions within truck types are usually left to be determined by distribution rules. It should be noted that this section describes the assumptions and procedures used by TSC in developing <u>intermediate</u> data files only. These files were subsequently modified by Sydec through the application of the SDHPT (Texas) load shift method and various other techniques

*Subsequent application of a "load shifting" procedure by Sydec restores a realistic level of overweight activity in each scenario.

AXLE GROUP	GROSS WT GROUP*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		< 10	10 20	20 30	30 40	40 50	50 60	60 70	70 73	73 80	80 90	90 100	100 110	110 120	120 130	> 130
1	2-Axle (6 Tire)	VMT 3 (Single Units)														
2	3-Axle Single Unit															
3	2S1															
4	2S2	VMT 3														
5	3S2															
6	Other 4A Semi	(Conventional Semitrailers)							VMT 1	VMT 2						
7	6 + Semi															
8	2-2															
9	2-3, 3-2	VMT 4 (Light Doubles Combinations)														
10	2S1-2															
11	3S1-2, 3+S1-2															
12	Other truck Trailer Double	VMT 5 (Heavy Doubles Combinations)														
13	All S1-2-2	VMT 4 (Light Triples Combinations)														
14	Truck + 2 Trailers															
15	All other Comb.	VMT 5 (Heavy Doubles Combinations)														

*Thousands of Pounds

FIGURE 4-1. BASE- CASE ASSIGNMENT OF "TYPE 3" TRAFFIC FILES TO TRUCK CONFIGURATION AND WEIGHT GROUPS (ALSO APPLIES TO SCENARIOS 2-5)

AXLE GROUP \ GROSS WT GROUP*		1 < 10	2 10 20	3 20 30	4 30 40	5 40 50	6 50 60	7 60 70	8 70 73	9 73 80	10 80 90	11 90 100	12 100 110	13 110 120	14 120 130	15 > 130
1	2-Axle (6 Tire)		VMT 3 (Single Units)													
2	3-Axle Single Unit															
3	2S1															
4	2S2			VMT 3												
5	3S2															
6	Other 4A Semi	(Conventional Semitrailers)								VMT 1						
7	6 + Semi															
8	2-2															
9	2-3, 3-2		VMT 4 (Light Doubles Combinations)													
10	2S1-2															
11	3S1-2, 3+S1-2															
12	Other truck Trailer Double				VMT 5 (Long Heavy Doubles Combinations)											
13	All S1-2-2		VMT 4 (Light Triples Combinations)													
14	Truck + 2 Trailers															
15	All other Comb.			VMT 6 (Short Heavy Doubles Combinations)									VMT2			

*Thousands of Pounds

FIGURE 4-2. SCENARIO 6 ASSIGNMENT OF "TYPE 3" TRAFFIC FILES TO TRUCK CONFIGURATION

AXLE GROUP		GROSS WT GROUP * 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		< 10	10 20	20 30	30 40	40 50	50 60	60 70	70 73	73 80	80 90	90 100	100 110	110 120	120 130	> 130
1	2-Axle (6 Tire)		VMT 3 (Single Units)													
2	3-Axle Single Unit															
3	2S1															
4	2S2			VMT 3												
5	3S2															
6	Other 4A Semi	(Conventional Semitrailers)							VMT 1							
7	6 + Semi															
8	2-2															
9	2-3, 3-2		VMT 4 (Light Doubles Combinations)													
10	2S1-2															
11	3S1-2, 3+S1-2															
12	Other truck Trailer Double				VMT 5 (Long Heavy Doubles Combinations)											
13	All S1-2-2		VMT 4 (Light Triples Combinations)													
14	Truck + 2 Trailers															
15	All other Comb.			VMT 6 (Short Heavy Doubles Combinatio								VMT2				

*Thousands of Pounds

FIGURE 4-3. SCENARIO 8 ASSIGNMENT OF "TYPE 3" TRAFFIC FILES TO TRUCK CONFIGURATION AND WEIGHT GROUPS (ALSO APPLIES TO SCENARIO 11)

AXLE GROUP \ GROSS WT GROUP*		1 < 10	2 10–20	3 20–30	4 30–40	5 40–50	6 50–60	7 60–70	8 70–73	9 73–80	10 80–90	11 90–100	12 100–110	13 110–120	14 120–130	15 > 130
1	2-Axle (6 Tire)		VMT 3 (Single Units)													
2	3-Axle Single Unit															
3	2S1															
4	2S2			VMT 3												
5	3S2															
6	Other 4A Semi		(Conventional Semitrailers)							VMT 1						
7	6 + Semi															
8	2-2															
9	2-3, 3-2		VMT 4 (Light Doubles Combinations)													
10	2S1-2															
11	3S1-2, 3+S1-2															
12	Other truck Trailer Double					VMT 5 (Heavy Triples Combinations)										VMT8
13	All S1-2-2		VMT 7 (Light Triples Combinations)													
14	Truck + 2 Trailers															
15	All other Comb.			VMT 6 (Short Heavy Doubles Combinations)									VMT2			

*Thousands of Pounds

FIGURE 4-4. SCENARIO 9 ASSIGNMENT OF "TYPE 3" TRAFFIC FILES TO TRUCK CONFIGURATION of shifting VMT among weight blocks to ensure a more realistic accounting of overloaded trucks and the conservation of payload ton-miles. TSC's output distribution of VMT by State, truck axle type and highway class was not altered by these modifications. These modified files, together with the intermediate files described here, formed the basis for the analysis and results indicated in the final report. In each scenario, the dominant truck types for carrying weight-limited goods have separate full load and and partial load categories, and the full-load categories are always put in a single weight block. In scenarios 1 through 5, conventional trucks are dominant and there are two possible full-weight sizes, which are placed in the 70-73K lb and 73-80K lb blocks. In secenarios 6, 8, 10 and 11 conventional semis and tandem-axle doubles share dominance. In scenario 9 tandem-axle doubles and triples are considered the dominant vehicles for weight-limited traffic.

The rules governing the distribution of weights for each truck type in the alternative scenarios were difficult to design. Three issues had to be addressed. The first concerned truck types that are prominent in the base case and remain prominent, but for which the size of full load varies. Truck axle configuration #5 (3S2s), is the most important of these. The question was, does the effect at the upper weight limit have an "echo" effect at lower weights? The next issue was what distribution to apply to traffic that has switched truck types, to a type already prominent in the base case. The important example of this is the shift of LTL from semi trailers to light doubles. Each semi and double combination type has a well-defined weight distribution in the base case. The question is, which weight distribution should be applied to the shifted traffic. The thorniest issue of all concerns shifts, in scenarios 6 to 11, to truck types which were of negligible importance in the base case. Here there is no reliable weight distribution for the receiving truck type. The tandem-axle doubles hypothesized to become important in these cases are little used today, and what use there is, is presumably for unusual traffic that would not be aptly representative of the broad range to be attracted.

In the truck shift model, echo effects at low weights were postulated only for general freight carriers (see Appendix D). This "pull" effect of the weight limits on the weight of partially loaded trucks was too small at the envisioned weight limit changes to alter the distribution rules within a truck type. This consideration resolves the first two issues as follows. The base-case weight distributions were always used for traffic that has not changed truck types. For traffic that has shifted from singles to light doubles, the base-case distribution for the receiving doubles types was used. That traffic, which is entirely LTL up through scenario 8, is predominantly carried by general freight carriers. The existing distributions reflect the present experience of such carriers using doubles, which ought to be most applicable. General freight traffic tends to be operations-controlled, whereas other classes of traffic tend to be determined by the characteristics of available traffic.

The traffic that is attracted to tandem axle doubles and triples in scenarios 6 through 11 comes mainly from 3S2s. There is, however, a little bit of background tandem-axle double traffic in the early scenarios. The distribution applied to the arriving not-full-weight tandem-axle doubles is that derived from summing the VMTs of the 3S2s, which are contributing the traffic, and that of the tandem axle doubles (group 15), representing the pre-existing traffic. This approach is not entirely satisfactory, because of all the traffic that might shift from not-fully loaded singles to not-fully-loaded doubles, there is likely to be a bias in weight distribution for these that actually do. This bias may not be so large as might first be thought, however. The basic reason for using the heavier and more expensive rig at all, for less than full loads, is to obtain a backhaul.

APPENDIX A

TS&W STUDY SCENARIOS

For final reporting purposes, the scenario "numbering" system was changed from that used throughout most of the technical analysis. This accounts for the difference between scenario labels referred to in this volume and those in the final report of the TS&W study. The definitions of the scenarios were not changed. The correspondence between the two systems is indicated below.

Scenario Label Technical Supplement, Vol. 4	Scenario Label TS&W Final Report
2	B
2A	C
2B	G
2C	E
3	D
4	F
5	H
6	J
8	K
9, 10, 11	Not included in final report.

DEFINITION OF TS&W SCENARIOS
FIFTH REVISION, MAY 28, 1980
(Scenarios are listed in order of Priority for Analysis)

SCENARIO	GVW	BRIDGE FORMULA	AXLE LIMITS	LENGTH/CONFIGURATION LIMITS 1/	GRANDFATHER CLAUSE 2/	"BARRIER STATES" 3/	APPLICABLE HWY SYSTEM	COMMENTS
1. Base Case	80,000	Existing Federal Formula (B)	20/34k	N.A.	Retain	Permitted	Interstate	Status quo projected to 1985 and beyond.
2. Section 161(A) Uniform Max. TS&W Limits	"	"	"	"	Eliminate	"	"	Analysis required by Section 161(A)
2A. Extension of Section 161(A) Uniformity to Primary System	"	"	"	"	"	"	Interstate & Primary	Alternative interpretation of Congressional intent relating to reduction of highway impacts
2B. "Absolute" Uniformity; Interstate and Primary System	"	"	"	Minimum Limit of 65' Overall (Based on language of Melcher Amendment)	"	Prohibit	"	Alternative interpretation of Congressional intent emphasizing balanced elimination of both higher and lower limits
2C. Senator Melcher's Amendment to S.1390 4/	"	"	"	"	Retain	"	Interstate	Goes beyond scenario #3 by eliminating barriers to doubles and semis up to 65', although states may continue to prohibit doubles.
3. Uniformity for Interstate Shippers	"	"	"	N.A.	"	"	Interstate	Most important issue for truckers and shippers is elimination of barriers
4. Expand Federal Limit Applicability for Removal of Barriers	"	"	"	65' Doubles Must Be Permitted on Interstate and Primary	"	"	Interstate & Primary.	Further move toward uniformity by extending Fed. limits to Primary system and by eliminating states' power to prohibit Western Doubles

REVISED DRAFT DEFINITION OF TS&W SCENARIOS (5/28/80)
(Continued)

PAGE 2

SCENARIO	GVW	BRIDGE FORMULA	AXLE LIMITS	LENGTH/CONFIGURATION LIMITS 1/	GRANDFATHER CLAUSE 2/	"BARRIER STATES" 3/	APPLICABLE HWY SYSTEM	COMMENTS
5. Roll-back to Pre-1974 Limits	73,280	Pre-1974 Formula (Formula A)	18/32k	N.A.	Retain	Permitted	Interstate & Primary	Re-examination of justification for 1974 change in TS&W limits
6. Increase Axle Weight Limits, Remove GVW Limit and Rely on Bridge Formula	Eliminate GVW Limit	Bridge Formula C	22.4/36k	"	"	Prohibit	"	Examine warrant for extending higher existing state axle weight limits to entire Primary System and removing the arbitrariness of GVW limits
8. Eliminate GVW Limit, Rely on Bridge Formula, Roll-back Axle Limits and Establish Federal Length Limits	"	Bridge Formula A	18/32k	Minimum Limit of 65' Overall. No new prohibitions of doubles or triples. New length relationships to protect cab length and doubles length.	"	"	"	Reduce highway impacts while achieving economy for trucking and shipping industries. Prohibits overall length limits which encourage overly short cab designs.
9. Achieve Uniformity in Length Limits, Remove GVW Limits, Rely on Bridge Formula, and Standardize Permits and Exceptions	"	Existing Federal Formula (B)	20/34k	Singles 40' Tractor Cab 13' Trailers 45' Tractor-semi 60' Doubles & Triples: Interstate 108' Primary 70'	"	"	"	Examine warrant for high length limits on entire Interstate system and elimination of barriers to Western Doubles on the Primary System.

DEFINITION OF TS&W SCENARIOS (continued)

SCENARIO	GVW	BRIDGE FORMULA	AXLE LIMITS	LENGTH/CONFIGURATION LIMITS 1/	GRANDFATHER CLAUSE 2/	BARRIER STATES 3/	APPLICABLE HWY SYSTEM	COMMENTS
10. Eliminate GVW Limit, Rely on Bridge Formula, Achieve Uniformity in Length Limits, Achieve Uniformity in Axle Limits	Eliminate GVW Limit	Brige Formula (B)	20/34/K	Singles 40' Tractor Cab 13' Trailers 45' Tractor-Semi 60' Doubles 70' (Turnpike Doubles & Triples 108' on Designated hwys only)	Eliminate	Prohibit	Interstate & Primary	Achieve uniformity by eliminating both high and low axle limits. Eliminate arbitrary GCW limits and barriers to doubles on the primary system.
11. Eliminate GVW Limit, Rely on Bridge Formula, Roll-back Axle Limits and Establish Uniform Length Limits	" "	Bridge Formula (A)	18/32K	" "	" "	" "	" "	Eliminate arbitrary GCW limits and barriers to doubles on the primary system. Roll basic axle limits to a low, uniform level.

1/ Length limits for scenarios #1 through #6 are as presently exist (i.e., no federal control), except for scenarios #2B and #2C, which are based on the Melcher amendment (no state can set a limit of less than 65 feet overall for tractor and semi-trailer or other combinations, on the Interstate System). Scenario #8 involves Federal control of length limits on the Interstate System as defined in the trucking deregulation bill: (a) no state may have "a gross overall length limit of less than 65 feet for tractor, semitrailer and other motor vehicle combinations," (b) no state can have any new prohibitions of doubles or triples, (c) "the maximum allowable dimension of the trailer shall be 15 feet less than the maximum overall allowable length for the tractor-semitrailer combination," and (d) "the overall allowable length for a tractor-semitrailer-trailer combination shall be at least 10 feet longer than that for a tractor-semitrailer combination." Scenario #9 attempts to achieve two length objectives: (a) encouragement of CBE tractors, and (b) elimination of barriers to use of longer combinations. CBE tractors would be encouraged by prohibiting state limits on overall length which would have the combined effect of granting extra cubic cargo space for cab designs of less than 13 feet. The second objective would be achieved by providng for "turnpike doubles" and 27 foot triples on the Interstate system, and Western Doubles on the rest of the Primary System. Scenario #7 (which differed from scenario #9 only in that it involved no Federal controls on the Primary System) has been eliminate from this set of scenarios to keep the total number of scenarios to ten.

2/ Refers to authority for states to set limits above those specified in Section 127, Title 23, USC, if such higher limits were in force prior to passage of the Federal limits. "Grandfather Clause" covers higher permits and tolerances as well.

3/ Refers to authority for states to set limits below those specified in Section 127, Title 23, USC.

4/ The amendment says: "No State may enact or enforce any law denying reasonable access to and from the Interstate System on roads providing access between the Interstate System and terminals and facilities for food, fuel, repairs and rest." The following sentence goes on to prohibit limits below 20/34/80 and 65 feet on the Interstate System, but does not mention the Bridge Formula. In the analysis this provision will be interpretted no differently than the current law -- i.e., trucks allowed on the Interstate system must be allowed free access to all interchanges, but not necessarily permitted to operate beyond the immediate vicinity of interchanges. Widths may be increased to 102", under the Melcher amendment, but under restrictive conditions that would probably result in little or no effect on interstate shipping.

N.A. - Not Applicable

APPENDIX B

HIGHWAY AND RAIL NETWORKS FOR "TYPE 3" TRAFFIC ANALYSES

1. Introduction

The major reason for the special treatment of "type 3" traffic was the need for better estimates of the changes in VMT traveled within regions in response to the scenario changes. These "better" estimates were derived by substituting for part of the TI&U VMT file, a new VMT file which more accurately attributes VMTs to the region traveled, as opposed to the region that is the base of operations. The creation of these new files (one for each scenario) required two additional data files: the origin/destination commodity flow file, which will be described in Appendix C; and a highway network to be described here.

To produce the desired output, VMT by region traveled, it was necessary to have a highway network with sufficient link information to determine which types of trucks and payload weights could be used on which links, in each scenario. It was then necessary to have several programs to use this information: to extract the appropriate subnetwork that a given truck type could use in a given scenario; to find all the routes used over the subnetwork; and finally, to load the traffic attributed by the truck choice program to that truck type onto the links of the subnetwork, creating link VMTs that could be aggregated into regional VMTs.

On the railroad side, the only network-related information that was absolutely necessary was the set of origin-to-destination distances. Because the network analysis machinery had been set up for the highway side, and a rail network compatible with the highway network was available, these distances were also obtained by our shortest-path program.

This appendix is a description of the network data used, the network analysis programs, and the outputs produced.

2. Network Data

The original source of both the highway and rail networks used is the collection of networks prepared by CACI Inc. for the Department of Transportation.* The CACI highway network contained 585 nodes and 1297 one-way links, while the railroad network had 895 nodes and 1752 links. (Both networks were based on even more detailed computerized networks originally compiled for FHWA and FRA respectively.) BEA zones were attached to the networks by means of one or more access links, which means that the actual network sizes were even larger. The highway network included information on the terrain (flat, hilly or mountainous) and type of highway (divided or undivided). The rail network did not have terrain codes, and neither network listed State or region for each link, although that information can be discovered by looking up the city names corresponding to the nodes and looking at maps.

The highway network was extensively over-hauled to obtain the network used in this task. In the first place, the original network was unnecessarily detailed for use with BEA flow data; the shortest paths between all pairs of BEA cities would use only a subset of the links. (This task did not use a link impedance function that increased when link flow increased.) Since quite a bit of path-building and path loading had to be done, it was decided to simplify the network at the beginning to include only those links that were needed. At the same time, nodes identified with each BEA region were placed within the network so that no access link structure was needed. Finally, each link had to be classified as to 1) whether it represented an interstate highway, 2) what base case size and weight limits applied to it, 3) what ICC cost region contained it, and 4) what states it passed through. The resulting TS&W study

*The preparation of the CACI Highway Network is described in Aggregation of the FHWA Highway Network, M. Bronzini and K. Wright, CACI Inc.-Federal, June 1977. The railroad network is described in Aggregation of the FRA Railroad Network, R. Kistler, M. Rahrer and M. Bronzini, CACI Inc.-Federal, November 1976.

highway network will be described shortly.

Much less work was done on the rail network, because less was to be done with it. Only two sets of rail path data were needed, and no rail link loadings were needed. Consequently, the original set of rail links was retained, with two items of information added for each link: the ICC cost region and the availability or non-availability of TOFC service.

3. The Highway Network

For historical reasons, the highway network data ended up in two separate files, called NETM.DAT and STATE.DAT. The first file lists, for each two-way link, the A-node number, the B-node number, the distance in miles, the highway class code, the ICC cost region, a terrain code, and a TS&W rule code. The second file contains the A-node number, B-node number, and four State codes, so that the link's distance can be divided among several states in fourths. (For example, 17, 17, 17, 17 means that all of the distance is attributed to State 17, whereas 17, 17, 19, 22 means that 50% is in State 17, 25% in 19 and 25% in 22.) Table B-1 defines the various codes. Table B-2 lists the cities corresponding to each network node number. Tables B-3 and B-4 list the files NETM.DAT and STATE.DAT respectively.

A few explanatory comments are in order. The TS&W rule codes ignore the high GCW limits due to the grandfather clause. Such traffic was analyzed as type 3 traffic only under the category "VMT 15", which included turnpike doubles in the East and certain activity within regions 4A and 9. As was explained in Chapter 4, the activity for this category was generated by applying percentages (estimated from the TI&U data) to the relevant O/D pairs, rather than by costs based on path data. Thus no special input path data file was needed by the truck choice program to generate this "heavy double" activity. It was, of course, necessary to produce state and regional VMT for this

TABLE B-1 NETWORK DATA CODES

HIGHWAY CLASS

CODE	DEFINITION
1	Interstate Highway
2	Other Limited Access Divided Highway
3	Other Highway

TERRAIN

CODE	DEFINITION
M	Mountainous
R	Rolling
L	Level

TS & W RULE CODE (AS OF 1980)

CODE	DEFINITION
1	80K GCW permitted/65' doubles permitted
2	73K GCW permitted/65' doubles permitted
3	80K GCW permitted/100' triples permitted
4	80K GCW permitted/65' doubles not permitted
5	73K GCW permitted/65' doubles not permitted

TABLE B-1 NETWORK DATA CODES (CONT.)

COST REGION CODE	NAME	TS&W COST REGION	STATES
1	New England	Northeast	ME, NH, VT, MA, RI, CT
2	Middle Atlantic	Northeast	NY, PA, NJ, DE, MD, WV
3	South	South	VA, NC, SC, GA, AL, MS, TN, KY, FL
4	Midwest	Central	OH, MI, IN, IL
5	North Central	Central	WI, MN, ND, SD
6	Central	Central	IA, MD, NE, KS
7	Southwest	Southwest	OK, TX, LA, AR
8	Mountain	Northwest	CO, NM, UT, WY, MT, ID
9	Pacific Coast	Southwest	CA, OR, WA, AZ, NV

TABLE B-2 NETWORK NODE NUMBERS AND NAMES

Node#	City Name	BEA#	Node#	City Name	BEA
1	Boston, MA	4	27	Toledo, OH	70
2	Hartford, CT	5	28	Detroit, MI	71
3	Albany, NY	6	29	Saginaw, MI	72
4	Syracuse, NY	7	30	Lansing, Mi	74
5	Rochester, NY	8	31	Grand Rapids, MI	73
6	Buffalo, NY	9	32	Fort Wayne, IN	75
7	New York, NY	14	33	South Bend, IN	76
8	Philadelphia, PA	15	34	Indianapolis IN	60
9	Harrisburg, PA	16	35	Chicago, IL	77
10	Pittsburgh, PA	66	36	Milwaukee, WI	84
11	Baltimore, MD	17	37	Minneapolis, MN	91
12	Durham, NC	23	38	St. Louis, MO	114
13	Greensboro, NC	25	39	Kansas City, MO	111
14	Charlotte, NC	26	40	New Orleans, LA	138
15	Spartanburg, SC	28	41	Youngstown, OH	67
16	Atlanta, GA	44	42	Houston, TX	141
17	Miami, Fl	36	43	Dallas, TX	127
18	Birmingham, AL	45	44	Denver, CO	148
19	Chattanooga, TN	48	45	Phoenix, AZ	162
20	Nashville, TN	49	46	Seattle, WA	155
21	Memphis, TN	46	47	Portland, OR	157
22	Louisville, KY	54	48	San Francisco, CA	171
23	Cincinnatti, OH	62	49	Los Angeles, CA	165
24	Columbus, OH	64	50	San Diego, CA	164
25	Cleveland, OH	68	51	Tulsa, OK	119
26	Dayton, OH	63	52	Mobile, AL	137

TABLE B-2 NETWORK NODE NUMBERS AND NAMES (CONT.)

de#	City Name	BEA#	Node#	City Name	BEA
3	Decatur, AL	47	79	Lexington, KY	53
4	Jackson, MS	135	80	Lima, OH	69
5	Springfield, Il	57	81	Anderson, IN	61
6	Oshkosh, WI	85	82	Evansville, IN	55
7	Davenport, IA	79	83	Milton, PA	11
8	Huntingotn, WV	52	84	Peoria, IL	78
9	Omaha, NE	107	85	Rockford, IL	82
0	Richmond, VA	21	86	Madison, WI	83
1	Norfolk, VA	22	87	Erie, PA	10
2	Little Rock, AR	117	88	Wausau, WI	86
	Beaumont, TX	140	89	Duluth, MN	87
	Salt Lake City, UT	151	90	Sioux Falls, SD	99
	Eugene, OR	158	91	Washington, DC	18
	Stockton, CA	167	92	Waterloo, IA	105
	Macon, GA	42	93	Des Moines, IA	106
	Fresno, CA	166	94	Sioux City, IA	103
	Jacksonville, FL	34	95	Springfield, MO	116
	Shreveport, LA	132	96	Staunton, VA	19
	Tampa, FL	37	97	Wichita, KS	110
	Burlington, VT	3	98	Lake Charles, LA	139
	Montgomery, AL	40	99	Monroe, LA	133
	Binghamton, NY	12	100	Roanoke, VA	20
	Scranton, PA	13	101	Portland, ME	2
	Greenville, MS	134	102	Oklahoma City, OK	120
	Knoxville, TN	50	103	Marshall, TX	130
	Paducah, KY	115	104	Kingsport, TN	51

TABLE B-2 NETWORK NODE NUMBERS AND NAMES (CONT.)

Node#	City Name	BEA#	Node#	City Name	BEA
105	Temple, TX	128	131	Terre Hautte, In	56
106	Austin, TX	129	132	Champaign, IL	58
107	San Antonio, TX	142	133	Eau Claire, WI	88
108	Amarillo, TX	122	134	La Crosse, WI	89
109	El Paso, TX	145	135	Rochester, MN	90
110	Albuquerque, NM	146	136	Fango, ND	97
111	Pueblo, CO	147	137	Grand Forks, ND	92
112	Ashville, NC	27	138	Bismarck, ND	96
113	Tucson, AZ	163	139	Minot, ND	93
114	Las Vegas, NV	161	140	Aberdeen, SD	98
115	Spokane, WA	154	141	Rapid City, SD	100
116	Columbia, SC	29	142	Dubuque, IA	81
117	Sacramento, CA	168	143	Iowa City, IA	80
118	Augusta, GA	32	144	Fort Dodge, IA	104
119	Columbus, GA	43	145	Quincy, IL	113
120	Bangor, ME	1	146	Columbia, MO	112
121	Clarksburg, WV	65	147	Lincoln, NE	108
122	Wilmington, NC	24	148	Grand Island, NE	102
123	Florence, SC	30	149	Scottsbluff, NE	101
124	Charleston, SC	31	150	Salina, KS	109
125	Savannah, GA	33	151	Orlando, FL	35
126	Tifton, GA	41	152	Texarkana, TX	131
127	Tallahassee, FL	38	153	Fort Smith, AK	118
128	Pensacola, FL	39	154	Wichita Falls, TX	121
129	Meridian, MS	136	155	Abilene, TX	125
130	LaFayette, IN	59	156	Ellensburg, WA	156

TABLE B-2 NETWORK NODE NUMBERS AND NAMES (CONT.)

de#	City Name	BEA#	Node#	City Name	BEA
7	Corpus Christi, TX	143	183	Charlestown, WV	-
8	Harlingen, TX	144	184	Winchester, VA	-
9	San Angelo, TX	126	185	Wyetheville, VA	-
0	Lubbock, TX	123	186	Rocky Mount, NC	-
1	Odessa, TX	124	187	Statesville, NC	-
2	Grand Junction, CO	149	188	Fayetteville, NC	-
3	Cheyenne, WY	150	189	Rockingham, NC	-
4	Billings, MT	95	190	Rosinville, SC	-
5	Great Falls, MT	94	191	Statesboro, GA	-
6	Butte, MT	153	192	Lake City, FL	-
	Pocatello, ID	152	193	Wildwood, FL	-
	Boise, ID	159	194	Tuscaloosa, AL	-
	Eureka, CA	169	195	Hattiesburg, MS	-
	Redding, CA	170	196	Tupelo, MS	-
	Reno, NV	180	197	Vicksburg, MS	-
	Concord, NH	-	198	Hopkinsville, KY	-
	Worcester, MA	-	199	Cambridge, OH	-
	Springfield, MA	-	200	Akron, OH	-
	Brewster, NY	-	201	Mansfield, OH	-
	Corning, NY	-	202	Ann Arbor, MI	-
	Newark, NJ	-	203	Battle Creek, MI	-
	Blakeslee, PA	-	204	Fremont, IN	-
	Allentown, PA	-	205	Peru, IN	-
	Breezewood, PA	-	206	Veedersburg, IN	-
	Mercer, PA	-	207	Effingham, IL	-
	Hagerstown, MD	-	208	Mount Vernon, IL	-

TABLE B-2 NETWORK NODE NUMBERS AND NAMES (CONT.)

Node#	City Name	BEA#	Node#	City Name	BEA#
209	Bloomington, IN	-			
210	Albert Lea, MN	-			
211	Worthington, MN	-			
212	Belfield, ND	-			
213	Watertown, SD	-			
214	Sikeston, MO	-			
215	Ogsllala, NE	-			
216	Perry, OK	-			
217	Denton, TX	-			
218	Dalhart, TX	-			
219	Raton, NM	-			
220	Limon, CO	-			
221	Orin, WY	-			
222	Little America, WY	-			
223	Missoula, MT	-			
224	Sulphurdale, UT	-			
225	Flagstaff, AZ	-			
226	Alexandria, LA	-			
227	Pendleton, OR	-			
228	Bakersfield, CA	-			
229	Barstow, CA	-			
230	San Bernardino, CA	-			

A	B	C	D	E	FG
1	101	108	1	1	R4
2	174	27	1	1	L4
3	174	86	1	1	M1
3	72	129	3	2	M4
5	176	80	3	2	R4
7	177	40	1	2	R4
8	177	88	1	2	L4
9	178	102	1	2	M4
10	41	71	1	2	R4
10	195	76	1	4	R4
12	60	141	1	3	L4
13	100	121	1	3	M4
14	116	93	1	3	L4
15	116	83	1	3	L4
16	118	140	1	3	L4
17	69	331	1	3	L1
18	73	78	1	3	L4
19	20	126	1	3	R5
20	21	186	1	3	R5
20	22	178	1	3	R5
21	76	133	3	3	L5
21	62	126	1	7	L2
22	82	100	1	4	L2
23	34	102	1	4	L2
24	26	64	1	4	R1
41	200	50	1	4	R1
25	200	32	1	4	R1
27	32	116	3	4	R2
27	201	88	1	4	R1
29	31	128	3	4	L1
30	203	39	1	4	L1
32	35	160	2	4	L2
33	203	101	1	4	L2
34	82	155	3	4	L2
34	206	64	1	4	L2
35	209	130	1	4	L2
36	86	68	1	5	R1
37	134	75	1	5	R1

A	B	C	D	E	FG
1	172	69	1	1	R4
2	173	79	1	1	L4
3	74	140	1	2	M4
4	176	102	3	2	R4
6	87	103	1	2	R1
8	9	127	1	2	M4
8	179	49	2	2	M4
9	179	82	1	2	M4
10	121	88	1	2	R4
11	91	35	1	2	L1
12	186	65	1	3	L4
13	187	61	1	3	R4
14	187	32	1	3	M4
15	118	104	3	3	L4
16	67	76	1	3	L4
17	151	223	2	3	L1
18	53	85	1	3	L4
19	112	164	3	3	R5
20	53	92	1	3	R5
20	198	83	1	3	R5
21	78	158	3	3	R5
22	23	95	1	3	R1
22	198	145	1	3	R1
23	79	75	1	3	R1
24	80	87	3	4	R1
41	181	28	1	2	R4
26	34	105	1	4	L2
27	80	65	1	4	R1
28	29	109	1	4	L1
29	202	116	2	4	L1
31	33	120	1	4	L2
32	204	43	1	4	L2
33	204	66	1	4	L2
34	81	35	1	4	L2
35	36	90	1	4	L2
35	206	159	3	4	L2
36	56	69	2	5	R1
37	135	80	2	5	L1

A	B	C	D	E	FG
1	173	44	1	1	R1
2	175	85	1	1	R4
3	4	118	1	2	R1
4	74	75	1	2	M4
6	176	130	3	2	R4
8	11	86	1	2	L4
9	11	67	1	2	L4
9	180	80	1	2	M4
10	180	114	1	2	R4
11	182	73	1	2	L1
12	189	93	3	3	R4
13	189	71	3	3	R4
14	189	72	2	3	R4
16	18	129	1	3	L4
16	119	96	1	3	L4
17	71	255	2	3	L1
18	194	40	1	3	L4
19	77	97	1	3	R5
20	77	160	1	3	R5
21	53	184	3	3	L5
21	214	150	1	7	L2
22	79	66	1	3	R1
23	24	92	1	4	R1
24	58	98	2	4	R1
24	201	42	1	4	R1
25	27	116	1	4	R1
26	80	65	1	4	R1
27	202	72	2	4	L1
28	202	37	1	4	L1
30	31	81	1	4	L1
31	203	89	1	4	L1
32	205	61	3	4	L2
33	205	66	2	4	L2
34	130	60	1	4	L2
35	132	127	1	4	L2
35	130	113	1	4	L2
37	89	138	1	5	L1
37	136	224	1	5	L1

A	B	C	D	E	FG
2	7	71	1	2	R4
3	175	100	1	2	M1
4	5	80	1	2	R1
5	6	67	1	2	R1
7	175	60	1	2	M1
8	61	247	2	2	L4
9	83	80	3	2	M4
9	182	68	1	2	M4
10	181	53	1	2	R4
12	13	53	1	3	R4
13	14	68	2	3	R4
14	15	79	1	3	L4
15	16	155	1	3	L4
16	19	104	1	3	L4
16	73	162	1	3	L4
18	19	143	1	3	L4
18	196	121	3	3	L5
19	53	132	2	3	R4
20	78	147	3	3	R5
21	54	201	1	3	L5
21	95	272	3	7	R2
22	34	109	1	4	L2
23	26	50	1	4	R1
24	195	79	1	4	R1
41	25	50	1	4	R1
25	87	95	1	4	R1
27	28	68	1	4	L1
27	204	70	1	4	L2
29	30	84	1	4	L1
30	202	61	1	4	L1
32	81	75	1	4	L2
33	35	100	1	4	L2
34	131	75	1	4	L2
34	205	62	2	4	L2
35	85	65	1	4	L2
36	85	71	1	5	L4
37	133	120	3	5	L4
37	210	82	1	5	L1

TABLE B-3, FILE NETM.DAT(continued)

A	B	C	D	E	FG	A	B	C	D	E	FG	A	B	C	D	E	FG	A	B	C	D	E	FG
37	211	145	3	5	L1	37	213	193	3	5	L1	38	55	86	1	4	L2	38	95	158	1	6	L2
38	146	126	1	6	L2	38	207	88	1	4	L2	38	208	60	1	4	L2	38	145	116	3	6	L2
38	214	198	1	6	L2	39	95	170	3	6	L2	39	59	195	1	6	L1	39	93	190	1	6	L2
39	97	183	1	6	L3	39	146	130	1	6	L2	39	150	186	1	6	L1	39	51	241	3	6	L1
40	54	122	1	3	L5	40	52	156	1	3	L5	40	98	156	1	7	L1	40	195	127	1	3	L5
40	197	183	3	3	L5	40	226	208	3	7	L1	43	42	229	1	7	L1	43	103	107	1	7	L1
43	105	81	1	7	L1	43	152	183	1	7	L1	43	154	143	2	7	L1	43	155	170	1	7	L1
43	217	76	1	7	L1	42	103	205	2	7	L1	42	63	70	1	7	L1	42	105	170	3	7	L1
42	106	142	3	7	L1	42	107	180	1	7	L1	42	157	220	3	7	L1	44	111	98	1	8	R1
44	162	221	1	8	M1	44	163	94	1	8	R1	44	220	78	1	8	R1	44	215	158	1	8	R1
45	113	99	1	9	R1	45	225	142	1	9	M1	45	114	280	3	9	M1	45	230	338	1	9	R1
46	47	151	1	9	R1	46	156	97	1	9	R1	47	65	105	1	9	R3	47	227	170	1	9	M3
48	49	406	2	9	M1	48	117	80	1	9	M1	48	66	72	1	9	M1	48	169	256	3	9	M1
49	50	135	1	9	M1	49	228	60	1	9	M1	49	230	74	1	9	M1	50	113	425	1	9	M1
50	230	100	1	9	M1	101	120	133	1	1	R4	101	72	218	3	1	M4	101	172	110	1	1	R4
101	173	132	1	1	R4	72	120	286	3	1	M4	72	172	148	1	1	M4	72	174	237	1	1	R4
74	75	55	1	2	M4	74	175	104	2	2	M4	74	176	105	2	2	M4	75	175	81	1	2	M4
75	178	36	1	2	M4	83	176	80	3	2	R4	83	178	66	1	2	M4	83	181	195	1	2	M4
87	176	182	2	2	R4	87	181	60	1	2	R4	91	182	62	1	2	L1	91	184	61	1	3	M4
91	60	104	1	3	L4	58	183	53	1	2	R4	58	104	171	3	3	M4	58	79	105	1	3	R1
58	23	150	3	4	R1	96	121	149	3	2	M4	96	183	194	1	2	M4	96	60	95	1	3	R4
96	100	82	1	3	M4	96	184	94	1	3	M4	60	61	86	1	3	L4	60	100	141	1	3	L4
60	186	65	1	3	L4	61	186	164	3	3	L4	61	122	288	3	3	L4	100	185	69	1	3	M4
104	185	84	1	3	M4	104	112	74	3	3	M4	104	77	94	1	3	R5	104	187	134	3	3	M4
112	187	94	1	3	M4	112	77	84	1	3	R5	112	15	56	1	3	L4	116	123	63	1	3	L4
116	189	118	3	3	L4	116	118	63	1	3	L4	116	190	60	1	3	L4	118	190	107	3	3	L4
118	191	80	3	3	L4	118	67	119	3	3	L4	67	191	118	1	3	L4	67	126	108	1	3	L4
67	119	76	3	3	L4	119	126	116	3	3	L4	119	127	167	3	3	L4	119	73	88	3	3	L4
69	125	138	1	3	L4	69	191	162	3	3	L4	69	192	68	1	3	L1	69	193	156	2	3	L1
69	151	145	1	3	L1	151	71	70	1	3	L1	151	153	45	2	3	L1	71	127	257	2	3	L1
71	193	60	1	3	L1	52	73	175	1	3	L4	52	128	65	1	3	L4	52	129	135	3	3	L5
52	195	81	3	3	L5	73	129	147	3	3	L5	73	127	198	2	3	L4	73	128	150	3	3	L4
73	194	100	3	3	L4	54	197	39	1	3	L5	54	129	80	1	3	L5	54	195	80	2	3	L5
76	197	70	3	3	L2	76	99	106	3	7	L2	76	62	155	3	7	L2	77	79	159	1	3	R5
78	198	75	1	3	R1	78	208	98	1	4	L2	78	214	60	3	3	L2	80	201	50	3	4	R1
80	32	61	3	4	R2	82	131	87	2	4	L2	82	208	76	1	4	L2	55	208	148	3	4	L2
55	132	75	1	4	L2	55	84	71	3	4	L2	55	145	115	3	4	L2	55	209	55	1	4	L2

A	B	C	D	E	FG	A	B	C	D	E	FG	A	B	C	D	E	FG	A	B	C	D	E	FG
84	209	33	1	4	L2	84	85	125	3	4	L2	84	57	87	1	4	L2	85	209	120	3	4	L2
85	86	65	1	5	L1	86	56	68	3	5	R4	86	88	101	3	5	R4	86	133	130	1	5	R1
86	134	162	1	5	R1	86	142	90	3	5	R4	56	88	60	3	5	R4	88	134	98	3	5	R4
89	134	156	3	5	R4	89	136	252	3	5	L1	89	137	260	3	5	L1	90	211	91	1	5	L1
90	213	90	1	5	L1	90	141	317	1	5	L1	90	94	85	1	5	L1	85	142	91	3	4	L2
57	142	61	3	6	L1	57	35	169	1	4	L2	57	143	50	1	6	L1	57	145	161	3	6	L2
92	143	87	3	6	L1	92	142	88	3	6	L1	92	144	75	3	6	L1	93	146	244	3	6	L2
93	144	60	1	6	L1	93	94	197	3	6	L1	93	59	125	1	6	L1	93	143	110	1	6	L1
94	59	103	1	6	L1	94	144	138	3	6	L1	94	211	113	3	5	L1	94	148	198	3	6	L1
95	146	160	3	6	L2	95	214	237	3	6	L2	95	62	204	3	7	M2	59	147	40	1	6	L2
39	147	198	3	6	L1	95	97	268	3	6	L2	97	111	429	3	6	L1	97	150	94	1	6	L1
97	218	390	3	6	L1	97	216	88	1	6	L1	98	226	88	3	7	L5	98	70	185	3	7	L5
98	63	72	1	7	L1	99	226	75	3	7	L5	99	70	103	1	7	L2	99	197	55	1	7	L1
62	152	140	1	7	L2	62	153	137	1	7	M2	51	102	95	1	7	L1	95	51	179	1	7	L2
51	153	128	1	7	L1	51	216	81	1	7	L1	51	217	230	3	7	L1	102	108	252	1	7	L1
102	154	128	1	7	L1	102	216	73	1	7	L1	102	217	127	1	7	L1	103	152	105	3	7	L1
103	63	210	3	7	L1	103	70	70	1	7	L1	105	106	88	1	7	L1	105	155	226	3	7	L1
105	159	233	3	7	L1	106	107	75	1	7	L1	106	155	210	3	7	L1	106	159	200	3	7	L1
107	155	260	3	7	L1	107	157	145	1	7	L1	107	159	193	3	7	L1	107	109	632	1	7	L1
108	154	212	2	7	R1	108	160	119	2	7	R1	108	109	412	3	8	M1	108	110	275	1	8	M1
108	218	81	3	7	R1	109	161	260	1	7	R1	109	110	265	1	8	M1	109	113	304	1	8	M1
110	225	302	1	8	M1	110	219	210	1	8	M1	111	220	108	3	8	R1	111	219	101	1	8	R1
64	171	485	1	8	M3	64	167	202	1	8	M3	64	222	130	1	8	M1	64	224	164	1	8	M3
114	224	233	1	8	M3	114	225	243	3	9	M1	114	171	420	3	9	M3	114	229	150	1	9	M1
115	168	315	3	8	M3	115	156	167	1	9	R1	115	223	173	1	8	M1	115	227	167	3	9	R1
65	168	335	3	9	M1	65	169	286	3	9	R1	65	170	268	1	9	R1	117	171	115	1	9	R1
117	170	158	1	9	M1	117	66	62	1	9	M1	66	68	136	2	9	R1	66	228	234	1	9	R1
68	228	104	2	9	R1	121	182	160	2	2	R4	121	183	90	1	2	R4	121	184	119	3	2	M4
122	186	159	3	3	L4	122	188	81	3	3	L4	122	123	112	3	3	L4	122	124	149	3	3	L4
123	188	79	1	3	L4	123	189	83	3	3	L4	123	124	105	3	3	L4	123	190	73	1	3	L4
124	125	85	3	3	L4	124	190	53	1	3	L4	125	190	79	1	3	L4	125	191	66	1	3	L4
126	127	116	3	3	L4	126	192	96	1	3	L4	127	128	190	1	3	L1	127	192	85	1	3	L1
129	194	107	1	3	L5	129	195	79	1	3	L5	129	196	145	3	3	L5	21	196	85	3	3	L5
82	198	74	1	3	R4	130	205	40	3	4	L2	130	206	35	3	4	L2	131	206	52	2	4	L2
131	207	68	1	4	L2	132	206	52	1	4	L2	132	207	65	1	4	L2	132	209	43	1	4	L2
133	134	80	3	5	R4	133	142	108	3	5	R4	133	135	61	1	5	L1	135	210	53	1	5	L1

TABLE B-3. FILE NETM.DAT(continued)

A	B	C	D	E	FG	A	B	C	D	E	FG	A	B	C	D	E	FG	A	B	C	D	E	FG
92	135	149	3	6	L1	92	210	108	3	6	L1	136	137	74	1	5	L1	136	136	188	1	5	L1
136	213	135	1	5	L1	137	139	209	3	5	L1	138	139	108	3	5	L1	138	140	185	3	5	L1
138	212	117	1	5	L1	140	213	101	3	5	L1	140	141	364	3	5	L1	141	149	194	3	5	L1
141	164	370	1	8	M1	141	212	233	3	5	L1	142	143	77	3	6	L1	143	145	162	3	6	L2
145	146	110	3	6	L2	147	148	88	1	6	L2	148	150	177	3	6	L1	148	215	184	1	6	L2
149	215	95	3	6	L1	149	221	186	3	8	M1	147	150	180	3	6	L1	150	220	340	1	6	L1
70	226	105	3	7	L1	70	152	70	3	7	L5	152	153	176	3	7	R2	152	217	187	3	7	L1
154	217	77	3	7	L1	154	155	133	3	7	L1	154	160	180	3	7	R1	155	159	89	3	7	L1
155	160	147	2	7	R1	155	161	158	1	7	R1	156	227	115	3	9	R1	157	158	108	2	7	L1
159	160	144	3	7	R1	160	161	167	2	7	R1	64	162	259	3	8	M1	162	224	232	1	8	M1
163	221	166	1	8	M1	163	222	270	1	8	M1	163	215	161	1	8	R2	164	165	228	3	8	R1
164	166	205	1	8	M1	164	212	371	1	8	R1	164	221	287	1	8	R1	165	166	140	1	8	M1
165	223	155	3	8	M1	165	212	409	3	8	R1	166	167	200	1	8	M1	166	223	118	1	8	M1
167	168	317	1	8	M3	167	222	233	3	8	M1	168	171	408	3	8	M3	168	227	170	1	9	M3
169	170	105	3	9	M1	170	171	179	1	9	M1	173	174	46	1	1	R1	177	178	69	1	2	F4
177	179	81	1	2	R4	178	179	34	2	2	M5	180	182	45	1	2	M4	182	184	49	1	3	R4
183	185	110	2	2	M4	183	199	158	1	4	R4	185	187	86	1	3	M4	186	188	83	1	3	L4
12	188	89	3	3	L4	188	189	61	3	3	R4	192	193	138	1	3	L1	76	154	202	3	3	L5
199	200	86	1	4	R1	200	201	120	1	4	R1	202	203	66	1	4	L1	203	204	43	1	4	L2
207	208	70	1	4	L2	208	214	115	1	4	L2	210	211	82	1	5	L1	144	210	61	1	6	L1
218	219	135	3	8	R1	225	229	349	1	9	M1	228	229	142	3	9	M1	171	229	370	3	9	M1
229	230	67	1	9	M1	78	82	124	3	3	R4	28	30	65	1	4	L1	175	177	55	3	2	R4
29	88	510	3	4	L1																		

A = A-node number
B = B-node number
C = distance in miles
D = highway class code
E = ICC cost region
F = terrain code
G = TS&W rule code

TABLE B-4. FILE STATE.DAT

1	101	1	1	2	4
1	172	4	4	2	2
1	173	4	4	4	4
2	7	6	6	6	7
2	173	6	6	4	4
2	174	6	6	6	4
2	175	6	6	6	7
3	4	7	7	7	7
3	72	3	3	3	7
3	74	7	7	7	7
3	174	4	4	7	7
3	175	7	7	7	7
4	3	7	7	7	7
4	5	7	7	7	7
4	74	7	7	7	7
4	176	7	7	7	7
5	4	7	7	7	7
5	6	7	7	7	7
5	176	7	7	7	7
6	5	7	7	7	7
6	87	7	7	7	9
6	176	7	7	7	7
7	2	6	6	6	7
7	175	7	7	7	7
7	177	8	8	8	8
8	9	9	9	9	9
8	11	8	9	10	11
8	61	8	10	10	11
8	177	8	8	8	8
8	179	9	9	9	9
9	8	9	9	9	9
9	11	9	9	9	11
9	83	9	9	9	9
9	178	9	9	9	9
9	179	9	9	9	9
9	180	9	9	9	9
9	182	9	9	9	11
10	41	9	9	9	9
10	121	9	9	12	12
10	180	9	9	9	9
10	181	9	9	9	9
10	199	9	12	19	19
11	8	8	9	10	11
11	9	9	9	9	11
11	91	11	11	11	11
11	182	11	11	11	11
12	13	14	14	14	14
12	60	13	13	14	14
12	186	14	14	14	14
12	188	14	14	14	14
12	189	14	14	14	14
13	12	14	14	14	14
13	14	14	14	14	14
13	100	13	13	14	14
13	187	14	14	14	14
13	189	14	14	14	14
14	13	14	14	14	14
14	15	14	14	15	15
14	116	15	15	15	15
14	187	14	14	14	14
14	189	14	14	14	14
15	14	14	14	15	15
15	16	15	16	16	16
15	112	14	14	15	15
15	116	15	15	15	15
15	118	15	15	15	15
16	15	15	16	16	16
16	18	16	16	18	18
16	19	16	16	16	16
16	67	16	16	16	16
16	73	16	16	18	18
16	118	16	16	16	16
16	119	16	16	16	16
17	69	17	17	17	17
17	71	17	17	17	17
17	151	17	17	17	17
18	16	16	16	18	18
18	19	16	18	18	18
18	53	18	18	18	18
18	73	18	18	18	18
18	194	18	18	18	18
18	196	18	18	18	22
19	16	16	16	16	16
19	18	16	18	18	18
19	20	23	23	23	23
19	53	18	18	18	23
19	77	23	23	23	23
19	112	14	14	14	23
20	19	23	23	23	23
20	21	23	23	23	23
20	22	20	20	20	23
20	53	18	23	23	23
20	77	23	23	23	23
20	78	20	20	20	23
20	198	20	20	23	23
21	20	23	23	23	23
21	53	18	18	22	22
21	54	22	22	22	22
21	62	28	28	28	28
21	76	22	22	22	22
21	78	20	23	23	23
21	95	27	27	28	28
21	196	22	22	22	22
21	214	27	27	28	28
22	20	20	20	20	23
22	23	20	20	20	20
22	34	24	24	24	24
22	79	20	20	20	20
22	82	24	24	24	24
22	198	20	20	20	20
23	22	20	20	20	20
23	24	19	19	19	19
23	26	19	19	19	19
23	34	19	24	24	24
23	58	19	19	19	19
23	79	20	20	20	20
24	23	19	19	19	19

TABLE B-4. FILE STATE.DAT(continued)

A	B	C1-C4				A	B	C1-C4				A	B	C1-C4			
24	26	19	19	19	19	32	35	24	24	24	24	37	213	30	30	30	32
24	58	19	19	19	19	32	80	19	19	19	24	38	55	25	25	25	25
24	80	19	19	19	19	32	81	24	24	24	24	38	95	27	27	27	27
24	199	19	19	19	19	32	204	24	24	24	24	38	145	27	27	27	27
24	201	19	19	19	19	32	205	24	24	24	24	38	146	27	27	27	27
25	27	19	19	19	19	33	31	21	21	21	21	38	207	25	25	25	25
25	41	19	19	19	19	33	35	24	24	24	25	38	208	25	25	25	25
25	87	9	19	19	19	33	203	21	21	21	21	38	214	27	27	27	27
25	200	19	19	19	19	33	204	24	24	24	24	39	51	34	34	34	35
26	23	19	19	19	19	33	205	24	24	24	24	39	59	27	27	27	33
26	24	19	19	19	19	34	22	24	24	24	24	39	93	26	26	27	27
26	34	19	24	24	24	34	23	19	24	24	24	39	95	27	27	27	27
26	80	19	19	19	19	34	26	19	24	24	24	39	97	34	34	34	34
27	25	19	19	19	19	34	81	24	24	24	24	39	146	27	27	27	27
27	28	21	21	21	21	34	82	24	24	24	24	39	147	33	33	34	34
27	32	19	19	19	24	34	130	24	24	24	24	39	150	34	34	34	34
27	80	19	19	19	19	34	131	24	24	24	24	40	52	22	22	22	36
27	201	19	19	19	19	34	205	24	24	24	24	40	54	22	22	36	36
27	202	21	21	21	21	34	206	24	24	24	24	40	98	36	36	36	36
27	204	19	19	19	24	35	32	24	24	24	24	40	195	22	22	36	36
28	27	21	21	21	21	35	33	24	24	24	25	40	197	22	22	36	36
28	29	21	21	21	21	35	36	25	25	29	29	40	226	36	36	36	36
28	30	21	21	21	21	35	57	25	25	25	25	41	10	9	9	9	9
28	202	21	21	21	21	35	85	25	25	25	25	41	25	19	19	19	19
29	28	21	21	21	21	35	130	24	24	24	25	41	181	9	9	19	19
29	30	21	21	21	21	35	132	25	25	25	25	41	200	19	19	19	19
29	31	21	21	21	21	35	206	24	24	24	25	42	43	37	37	37	37
29	88	21	21	21	29	35	209	25	25	25	25	42	63	37	37	37	37
29	202	21	21	21	21	36	35	25	25	29	29	42	103	37	37	37	37
30	28	21	21	21	21	36	56	29	29	29	29	42	105	37	37	37	37
30	29	21	21	21	21	36	85	25	29	29	29	42	106	37	37	37	37
30	31	21	21	21	21	36	86	29	29	29	29	42	107	37	37	37	37
30	202	21	21	21	21	37	89	30	30	30	30	42	157	37	37	37	37
30	203	21	21	21	21	37	133	30	30	30	30	43	42	37	37	37	37
31	29	21	21	21	21	37	134	29	29	29	29	43	103	37	37	37	37
31	30	21	21	21	21	37	135	30	30	30	30	43	105	37	37	37	37
31	33	21	21	21	21	37	136	30	30	30	30	43	152	37	37	37	37
31	203	21	21	21	21	37	210	30	30	30	30	43	154	37	37	37	37
32	27	19	19	19	24	37	211	30	30	30	30						

TABLE B-4. FILE STATE.DAT(continued)

A	B	C1-C4			
43	155	37	37	37	37
43	217	37	37	37	37
44	111	39	39	39	39
44	162	39	39	39	39
44	163	39	39	39	39
44	215	39	39	39	39
44	220	39	39	39	39
45	113	42	42	42	42
45	114	42	42	42	42
45	225	42	42	42	42
45	230	42	42	48	48
46	47	46	46	46	46
46	156	46	46	46	46
47	46	46	46	46	46
47	65	47	47	47	47
47	227	47	47	47	47
48	49	48	48	48	48
48	66	48	48	48	48
48	117	48	48	48	48
48	169	48	48	48	48
49	48	48	48	48	48
49	50	48	48	48	48
49	228	48	48	48	48
49	230	48	48	48	48
50	49	48	48	48	48
50	113	42	42	42	48
50	230	48	48	48	48
51	39	34	34	34	35
51	95	27	27	35	35
51	102	35	35	35	35
51	153	35	35	35	35
51	216	35	35	35	35
51	217	35	35	35	35
52	40	22	22	22	36
52	73	18	18	18	18
52	128	17	17	18	18
52	129	18	18	22	22
52	195	18	22	22	22
53	18	18	18	18	18
53	19	18	18	18	23
53	20	18	23	23	23
53	21	18	18	22	22
54	21	22	22	22	22
54	40	22	22	36	36
54	129	22	22	22	22
54	195	22	22	22	22
54	197	22	22	22	22
55	38	25	25	25	25
55	84	25	25	25	25
55	132	25	25	25	25
55	145	25	25	25	25
55	208	25	25	25	25
55	209	25	25	25	25
56	36	29	29	29	29
56	86	29	29	29	29
56	88	29	29	29	29
57	35	25	25	25	25
57	84	25	25	25	25
57	142	26	26	26	26
57	143	26	26	26	26
57	145	26	26	26	27
58	23	19	19	19	19
58	24	19	19	19	19
58	79	20	20	20	20
58	104	13	20	20	20
58	183	12	12	12	12
59	39	27	27	27	33
59	93	26	26	26	26
59	94	26	26	26	26
59	147	33	33	33	33
60	12	13	13	14	14
60	61	13	13	13	13
60	91	13	13	13	13
60	96	13	13	13	13
60	100	13	13	13	13
60	186	13	13	14	14
61	8	8	10	10	11
61	60	13	13	13	13
61	122	14	14	14	14
61	186	13	14	14	14
62	21	28	28	28	28
62	76	28	28	28	28
62	95	27	28	28	28
62	152	28	28	28	28
62	153	28	28	28	28
63	42	37	37	37	37
63	98	36	36	37	37
63	103	37	37	37	37
64	162	43	43	43	43
64	167	43	43	45	45
64	171	43	44	44	44
64	222	40	40	43	43
64	224	43	43	43	43
65	47	47	47	47	47
65	168	45	47	47	47
65	169	47	47	47	48
65	170	47	47	48	48
66	48	48	48	48	48
66	68	48	48	48	48
66	117	48	48	48	48
66	228	48	48	48	48
67	16	16	16	16	16
67	118	16	16	16	16
67	119	16	16	16	16
67	126	16	16	16	16
67	191	16	16	16	16
68	66	48	48	48	48
68	228	48	48	48	48
69	17	17	17	17	17
69	125	16	16	16	17
69	151	17	17	17	17
69	191	16	16	16	17
69	192	17	17	17	17
69	193	17	17	17	17
70	98	36	36	36	36
70	99	36	36	36	36

TABLE B-4. FILE STATE.DAT(continued)

A	B	C1-C4			
70	103	37	37	37	37
70	152	28	28	36	36
70	226	36	36	36	36
71	17	17	17	17	17
71	127	17	17	17	17
71	151	17	17	17	17
71	193	17	17	17	17
72	3	3	3	3	7
72	101	1	2	2	3
72	120	1	1	3	3
72	172	2	2	3	3
72	174	3	3	3	4
73	16	16	16	18	18
73	18	18	18	18	18
73	52	18	18	18	18
73	119	18	18	18	18
73	127	17	17	18	18
73	128	17	18	18	18
73	129	18	18	18	22
73	194	18	18	18	18
74	3	7	7	7	7
74	4	7	7	7	7
74	75	7	9	9	9
74	175	7	7	7	7
74	176	7	7	7	7
75	74	7	9	9	9
75	175	7	7	9	9
75	178	9	9	9	9
76	21	22	22	22	22
76	62	28	28	28	28
76	99	28	28	36	36
76	194	18	22	22	22
76	197	28	36	36	36
77	19	23	23	23	23
77	20	23	23	23	23
77	79	20	20	20	23
77	104	23	23	23	23
77	112	14	14	23	23
78	20	20	20	20	23

A	B	C1-C4			
78	21	20	23	23	23
78	82	20	20	20	20
78	198	20	20	20	20
78	208	25	25	25	25
78	214	20	20	27	27
79	22	20	20	20	20
79	23	20	20	20	20
79	58	20	20	20	20
79	77	20	20	20	23
80	24	19	19	19	19
80	26	19	19	19	19
80	27	19	19	19	19
80	32	19	19	19	24
80	201	19	19	19	19
81	32	24	24	24	24
81	34	24	24	24	24
82	22	24	24	24	24
82	34	24	24	24	24
82	78	20	20	20	20
82	131	24	24	24	24
82	198	20	20	20	20
82	208	24	24	25	25
83	9	9	9	9	9
83	176	9	9	9	9
83	178	9	9	9	9
83	181	9	9	9	9
84	55	25	25	25	25
84	57	25	25	25	25
84	85	25	25	25	25
84	209	25	25	25	25
85	35	25	25	25	25
85	36	25	29	29	29
85	84	25	25	25	25
85	86	25	29	29	29
85	142	25	25	25	25
85	209	25	25	25	25
86	36	29	29	29	29
86	56	29	29	29	29
86	85	25	29	29	29

A	B	C1-C4			
86	88	29	29	29	29
86	133	29	29	29	29
86	134	29	29	29	29
86	142	29	29	29	29
87	6	7	7	7	9
87	25	9	19	19	19
87	176	7	7	7	7
87	181	9	9	9	9
88	29	21	21	21	29
88	56	29	29	29	29
88	86	29	29	29	29
88	134	29	29	29	29
89	37	30	30	30	30
89	134	29	29	29	29
89	136	30	30	30	30
89	137	30	30	30	30
90	94	32	32	32	32
90	141	32	32	32	32
90	211	30	30	30	32
90	213	32	32	32	32
91	11	11	11	11	11
91	60	13	13	13	13
91	182	11	11	11	11
91	184	13	13	13	13
92	135	26	26	26	30
92	142	26	26	26	26
92	143	26	26	26	26
92	144	26	26	26	26
92	210	26	26	26	26
93	39	26	26	27	27
93	59	26	26	26	26
93	94	26	26	26	26
93	143	26	26	26	26
93	144	26	26	26	26
93	146	26	27	27	27
94	59	26	26	26	26
94	90	32	32	32	32
94	93	26	26	26	26

TABLE B-4. FILE STATE.DAT(continued)

A	B	C1-C4			
94	144	26	26	26	26
94	148	33	33	33	33
94	211	26	26	26	26
95	21	27	27	28	28
95	38	27	27	27	27
95	39	27	27	27	27
95	51	27	27	35	35
95	62	27	28	28	28
95	97	27	27	34	34
95	146	27	27	27	27
95	214	27	27	27	27
96	60	13	13	13	13
96	100	13	13	13	13
96	121	12	12	13	13
96	183	12	12	13	13
96	184	13	13	13	13
97	39	34	34	34	34
97	95	27	27	34	34
97	111	34	34	34	39
97	150	34	34	34	34
97	216	34	34	35	35
97	218	34	34	35	37
98	40	36	36	36	36
98	63	36	36	37	37
98	70	36	36	36	36
98	226	36	36	36	36
99	70	36	36	36	36
99	76	28	28	36	36
99	197	36	36	36	36
99	226	36	36	36	36
100	13	13	13	14	14
100	60	13	13	13	13
100	96	13	13	13	13
100	185	13	13	13	13
101	1	1	1	2	4
101	72	1	2	2	3
101	120	1	1	1	1
101	172	1	1	2	2
101	173	1	1	4	4

A	B	C1-C4			
102	51	35	35	35	35
102	108	35	35	37	37
102	154	35	35	35	35
102	216	35	35	35	35
102	217	35	35	35	35
103	42	37	37	37	37
103	43	37	37	37	37
103	63	37	37	37	37
103	70	37	37	37	37
103	152	37	37	37	37
104	58	13	20	20	20
104	77	23	23	23	23
104	112	14	14	23	23
104	185	13	13	13	13
104	187	14	14	14	23
105	42	37	37	37	37
105	43	37	37	37	37
105	106	37	37	37	37
105	155	37	37	37	37
105	159	37	37	37	37
106	42	37	37	37	37
106	105	37	37	37	37
106	107	37	37	37	37
106	155	37	37	37	37
106	159	37	37	37	37
107	42	37	37	37	37
107	106	37	37	37	37
107	109	37	37	37	37
107	155	37	37	37	37
107	157	37	37	37	37
107	159	37	37	37	37
108	102	35	35	37	37
108	109	37	38	38	38
108	110	37	38	38	38
108	154	37	37	37	37
108	160	37	37	37	37
108	218	37	37	37	37
109	107	37	37	37	37
109	108	37	38	38	38
109	110	37	37	37	37

A	B	C1-C4			
109	113	38	38	42	42
109	161	37	37	37	37
110	108	37	38	38	38
110	109	37	37	37	37
110	219	38	38	38	38
110	225	38	38	38	38
111	44	39	39	39	39
111	97	34	34	34	39
111	219	39	39	39	39
111	220	39	39	39	39
112	15	14	14	15	15
112	19	14	14	14	23
112	77	14	14	23	23
112	104	14	14	23	23
112	187	14	14	14	14
113	45	42	42	42	42
113	50	42	42	42	48
113	109	38	38	42	42
114	45	42	42	42	42
114	171	44	44	44	44
114	224	43	43	44	44
114	225	42	42	42	42
114	229	44	48	48	48
115	156	46	46	46	46
115	168	45	45	45	46
115	223	41	41	41	45
115	227	46	46	46	46
116	14	15	15	15	15
116	15	15	15	15	15
116	118	15	15	15	15
116	123	15	15	15	15
116	189	15	15	15	15
116	190	15	15	15	15
117	48	48	48	48	48
117	66	48	48	48	48
117	170	48	48	48	48
117	171	44	48	48	48
118	15	15	15	15	15
118	16	16	16	16	16

TABLE B-4. FILE STATE.DAT(continued)

A	B	C1-C4			
118	67	16	16	16	16
118	116	15	15	15	15
118	190	15	15	15	15
118	191	16	16	16	16
119	16	16	16	16	16
119	67	16	16	16	16
119	73	18	18	18	18
119	126	16	16	16	16
119	127	16	16	16	17
120	72	1	1	3	3
120	101	1	1	1	1
121	10	9	9	12	12
121	96	12	12	13	13
121	182	12	12	12	12
121	183	12	12	12	12
121	184	12	12	12	12
122	61	14	14	14	14
122	123	14	14	15	15
122	124	14	15	15	15
122	186	14	14	14	14
122	188	14	14	14	14
123	116	15	15	15	15
123	122	14	14	15	15
123	124	15	15	15	15
123	188	14	15	15	15
123	189	14	15	15	15
123	190	15	15	15	15
124	122	14	15	15	15
124	123	15	15	15	15
124	125	15	15	15	16
124	190	15	15	15	15
125	69	16	16	16	17
125	124	15	15	15	16
125	190	15	15	15	16
125	191	16	16	16	16
126	67	16	16	16	16
126	119	16	16	16	16

A	B	C1-C4			
126	127	16	16	16	17
126	192	16	16	17	17
127	71	17	17	17	17
127	73	17	17	18	18
127	119	16	16	16	17
127	126	16	16	16	17
127	128	17	17	17	17
127	192	17	17	17	17
128	52	17	17	18	18
128	73	17	18	18	18
128	127	17	17	17	17
129	52	18	18	22	22
129	54	22	22	22	22
129	73	18	18	18	22
129	194	18	18	18	22
129	195	22	22	22	22
129	196	22	22	22	22
130	34	24	24	24	24
130	35	24	24	24	25
130	205	24	24	24	24
130	206	24	24	24	24
131	34	24	24	24	24
131	82	24	24	24	24
131	206	24	24	24	24
131	207	25	25	25	25
132	35	25	25	25	25
132	55	25	25	25	25
132	206	24	25	25	25
132	207	25	25	25	25
132	209	25	25	25	25
133	37	30	30	30	30
133	86	29	29	29	29
133	134	29	29	29	29
133	135	30	30	30	30
133	142	29	29	29	29
134	37	29	29	29	29

A	B	C1-C4			
134	86	29	29	29	29
134	88	29	29	29	29
134	89	29	29	29	29
134	133	29	29	29	29
135	37	30	30	30	30
135	92	26	26	26	30
135	133	30	30	30	30
135	210	30	30	30	30
136	37	30	30	30	30
136	89	30	30	30	30
136	137	31	31	31	31
136	138	31	31	31	31
136	213	31	31	32	32
137	89	30	30	30	30
137	136	31	31	31	31
137	139	31	31	31	31
138	136	31	31	31	31
138	139	31	31	31	31
138	140	31	31	31	32
138	212	31	31	31	31
139	137	31	31	31	31
139	138	31	31	31	31
140	138	31	31	31	32
140	141	32	32	32	32
140	213	32	32	32	32
141	90	32	32	32	32
141	140	32	32	32	32
141	149	32	32	33	33
141	164	32	40	40	41
141	212	31	31	32	32
142	57	26	26	26	26
142	85	25	25	25	25
142	86	29	29	29	29
142	92	26	26	26	26
142	133	29	29	29	29
142	143	26	26	26	26
143	57	26	26	26	26

TABLE B-4. FILE STATE.DAT(continued)

A	B	C1-C4			
143	92	26	26	26	26
143	93	26	26	26	26
143	142	26	26	26	26
143	145	26	26	26	27
144	92	26	26	26	26
144	93	26	26	26	26
144	94	26	26	26	26
144	210	26	26	26	26
145	38	27	27	27	27
145	55	25	25	25	25
145	57	26	26	26	27
145	143	26	26	26	27
145	146	27	27	27	27
146	38	27	27	27	27
146	39	27	27	27	27
146	93	26	27	27	27
146	95	27	27	27	27
146	145	27	27	27	27
147	39	33	33	34	34
147	59	33	33	33	33
147	148	33	33	33	33
147	150	33	33	34	34
148	94	33	33	33	33
148	147	33	33	33	33
148	150	33	33	34	34
148	215	33	33	33	33
149	141	32	32	33	33
149	215	33	33	33	33
149	221	33	33	40	40
150	39	34	34	34	34
150	97	34	34	34	34
150	147	33	33	34	34
150	148	33	33	34	34
150	220	34	34	34	39
151	17	17	17	17	17
151	69	17	17	17	17
151	71	17	17	17	17
151	193	17	17	17	17
152	43	37	37	37	37
152	62	28	28	28	28
152	70	28	28	36	36
152	103	37	37	37	37
152	153	28	28	28	28
152	217	37	37	37	37
153	51	35	35	35	35
153	62	28	28	28	28
153	152	28	28	28	28
154	43	37	37	37	37
154	102	35	35	35	35
154	108	37	37	37	37
154	155	37	37	37	37
154	160	37	37	37	37
154	217	37	37	37	37
155	43	37	37	37	37
155	105	37	37	37	37
155	106	37	37	37	37
155	107	37	37	37	37
155	154	37	37	37	37
155	159	37	37	37	37
155	160	37	37	37	37
155	161	37	37	37	37
156	46	46	46	46	46
156	115	46	46	46	46
156	227	46	46	46	47
157	42	37	37	37	37
157	107	37	37	37	37
157	158	37	37	37	37
158	157	37	37	37	37
159	105	37	37	37	37
159	106	37	37	37	37
159	107	37	37	37	37
159	155	37	37	37	37
159	160	37	37	37	37
160	108	37	37	37	37
160	154	37	37	37	37
160	155	37	37	37	37
160	159	37	37	37	37
160	161	37	37	37	37
161	109	37	37	37	37
161	155	37	37	37	37
161	160	37	37	37	37
162	44	39	39	39	39
162	64	43	43	43	43
162	224	43	43	43	43
163	44	39	39	39	39
163	215	33	33	33	40
163	221	40	40	40	40
163	222	40	40	40	40
164	141	32	40	40	41
164	165	41	41	41	41
164	166	41	41	41	41
164	212	41	41	41	41
164	221	40	40	40	41
165	164	41	41	41	41
165	166	41	41	41	41
165	212	41	41	41	41
165	223	41	41	41	41
166	164	41	41	41	41
166	165	41	41	41	41
166	167	41	41	45	45
166	223	41	41	41	41
167	64	43	43	45	45
167	166	41	41	45	45
167	168	45	45	45	45
167	222	40	40	45	45
168	65	45	47	47	47
168	115	45	45	45	46
168	167	45	45	45	45

TABLE B-4. FILE STATE.DAT(continued)

A	B	C1-C4			
168	171	44	44	45	47
168	227	45	47	47	47
169	48	48	48	48	48
169	65	47	47	47	48
169	170	48	48	48	48
170	65	47	47	48	48
170	117	48	48	48	48
170	169	48	48	48	48
170	171	48	48	48	48
171	64	43	44	44	44
171	114	44	44	44	44
171	117	44	48	48	48
171	168	44	44	45	47
171	170	48	48	48	48
171	229	44	48	48	48
172	1	4	4	2	2
172	72	2	2	3	3
172	101	1	1	2	2
173	1	4	4	4	4
173	2	6	6	4	4
173	101	1	1	4	4
173	174	4	4	4	4
174	2	6	6	6	4
174	3	4	4	7	7
174	72	3	3	3	4
174	173	4	4	4	4
175	2	6	6	6	7
175	3	7	7	7	7
175	7	7	7	7	7
175	74	7	7	7	7
175	75	7	7	9	9
175	177	7	7	8	8
176	4	7	7	7	7
176	5	7	7	7	7
176	6	7	7	7	7
176	74	7	7	7	7
176	83	9	9	9	9
176	87	7	7	7	7

A	B	C1-C4			
177	7	8	8	8	8
177	8	8	8	8	8
177	175	7	7	8	8
177	178	8	8	8	8
177	179	8	8	8	8
178	9	9	9	9	9
178	75	9	9	9	9
178	83	9	9	9	9
178	177	8	8	8	8
178	179	9	9	9	9
179	8	9	9	9	9
179	9	9	9	9	9
179	177	8	8	8	8
179	178	9	9	9	9
180	9	9	9	9	9
180	10	9	9	9	9
180	182	9	9	11	11
181	10	9	9	9	9
181	41	9	9	19	19
181	83	9	9	9	9
181	87	9	9	9	9
182	9	9	9	9	11
182	11	11	11	11	11
182	91	11	11	11	11
182	121	12	12	12	12
182	180	9	9	11	11
182	184	12	12	13	13
183	58	12	12	12	12
183	96	12	12	13	13
183	121	12	12	12	12
183	185	12	12	12	12
183	199	12	12	19	19
184	91	13	13	13	13
184	96	13	13	13	13
184	121	12	12	12	12
184	182	12	12	13	13
185	100	13	13	13	13

A	B	C1-C4			
185	104	13	13	13	13
185	183	12	12	12	12
185	187	13	14	14	14
186	12	14	14	14	14
186	60	13	13	14	14
186	61	13	14	14	14
186	122	14	14	14	14
186	188	14	14	14	14
187	13	14	14	14	14
187	14	14	14	14	14
187	104	14	14	14	23
187	112	14	14	14	14
187	185	13	14	14	14
188	12	14	14	14	14
188	122	14	14	14	14
188	123	14	15	15	15
188	186	14	14	14	14
188	189	14	14	14	14
189	12	14	14	14	14
189	13	14	14	14	14
189	14	14	14	14	14
189	116	15	15	15	15
189	123	14	15	15	15
189	188	14	14	14	14
190	116	15	15	15	15
190	118	15	15	15	15
190	123	15	15	15	15
190	124	15	15	15	15
190	125	15	15	15	16
191	67	16	16	16	16
191	69	16	16	16	17
191	118	16	16	16	16
191	125	16	16	16	16
192	69	17	17	17	17
192	126	16	16	17	17
192	127	17	17	17	17
192	193	17	17	17	17

TABLE B-4. FILE STATE.DAT(continued)

A	B	C1-C4			
193	69	17	17	17	17
193	71	17	17	17	17
193	151	17	17	17	17
193	192	17	17	17	17
194	18	18	18	18	18
194	73	18	18	18	18
194	76	18	22	22	22
194	129	18	18	18	22
195	40	22	22	36	36
195	52	18	22	22	22
195	54	22	22	22	22
195	129	22	22	22	22
196	18	18	18	18	22
196	21	22	22	22	22
196	129	22	22	22	22
197	40	22	22	36	36
197	54	22	22	22	22
197	76	28	36	36	36
197	99	36	36	36	36
198	20	20	20	23	23
198	22	20	20	20	20
198	78	20	20	20	20
198	82	20	20	20	20
199	10	9	12	19	19
199	24	19	19	19	19
199	183	12	12	19	19
199	200	19	19	19	19
200	25	19	19	19	19
200	41	19	19	19	19
200	199	19	19	19	19
200	201	19	19	19	19
201	24	19	19	19	19
201	27	19	19	19	19
201	80	19	19	19	19
201	200	19	19	19	19
202	27	21	21	21	21

A	B	C1-C4			
202	28	21	21	21	21
202	29	21	21	21	21
202	30	21	21	21	21
202	203	21	21	21	21
203	30	21	21	21	21
203	31	21	21	21	21
203	33	21	21	21	21
203	202	21	21	21	21
203	204	21	21	21	21
204	27	19	19	19	24
204	32	24	24	24	24
204	33	24	24	24	24
204	203	21	21	21	21
205	32	24	24	24	24
205	33	24	24	24	24
205	34	24	24	24	24
205	130	24	24	24	24
206	34	24	24	24	24
206	35	24	24	24	25
206	130	24	24	24	24
206	131	24	24	24	24
206	132	24	25	25	25
207	38	25	25	25	25
207	131	25	25	25	25
207	132	25	25	25	25
207	208	25	25	25	25
208	38	25	25	25	25
208	55	25	25	25	25
208	78	25	25	25	25
208	82	24	24	25	25
208	207	25	25	25	25
208	214	25	25	25	27
209	35	25	25	25	25
209	55	25	25	25	25
209	84	25	25	25	25
209	85	25	25	25	25
209	132	25	25	25	25

A	B	C1-C4			
210	37	30	30	30	30
210	92	26	26	26	26
210	135	30	30	30	30
210	144	26	26	26	26
210	211	30	30	30	30
211	37	30	30	30	30
211	90	30	30	30	32
211	94	26	26	26	26
211	210	30	30	30	30
212	138	31	31	31	31
212	141	31	31	32	32
212	164	41	41	41	41
212	165	41	41	41	41
213	37	30	30	30	32
213	90	32	32	32	32
213	136	31	31	32	32
213	140	32	32	32	32
214	21	27	27	28	28
214	38	27	27	27	27
214	78	20	20	27	27
214	95	27	27	27	27
214	208	25	25	25	27
215	44	39	39	39	39
215	148	33	33	33	33
215	149	33	33	33	33
215	163	33	33	33	40
216	51	35	35	35	35
216	97	34	34	35	35
216	102	35	35	35	35
217	43	37	37	37	37
217	51	35	35	35	35
217	102	35	35	35	35
217	152	37	37	37	37
217	154	37	37	37	37
218	97	34	34	35	37
218	108	37	37	37	37

TABLE B-4. FILE STATE.DAT(continued)

A	B	C1-C4			
218	219	37	38	38	38
219	110	38	38	38	38
219	111	39	39	39	39
219	218	37	38	38	38
220	44	39	39	39	39
220	111	39	39	39	39
220	150	34	34	34	39
221	149	33	33	40	40
221	163	40	40	40	40
221	164	40	40	40	41
222	64	40	40	43	43
222	163	40	40	40	40
222	167	40	40	45	45
223	115	41	41	41	45
223	165	41	41	41	41
223	166	41	41	41	41
224	64	43	43	43	43
224	114	43	43	44	44
224	162	43	43	43	43
225	45	42	42	42	42
225	110	38	38	38	38
225	114	42	42	42	42
225	229	42	42	48	48
226	40	36	36	36	36
226	70	36	36	36	36
226	98	36	36	36	36
226	99	36	36	36	36
227	47	47	47	47	47
227	115	46	46	46	46
227	156	46	46	46	47
227	168	45	47	47	47
228	49	48	48	48	48
228	66	48	48	48	48
228	68	48	48	48	48
228	229	48	48	48	48
229	114	44	48	48	48
229	171	44	48	48	48
229	225	42	42	48	48
229	228	48	48	48	48
229	230	48	48	48	48
230	45	42	42	48	48
230	49	48	48	48	48
230	50	48	48	48	48
230	229	48	48	48	48

A = A-node number

B = B-node number

C1 to C4 = state code numbers

category, and this required a suitable subnetwork. This was produced manually.

The TS&W codes also ignored high single or tandem axle weight limits, which are also grandfather-clause issues. It was assumed that such high limits, when not accompanied by a high GCW limit, were for special very-short but heavy types of equipment used in short-haul movements, for example construction. (These were considered in the analysis of type 2 traffic.)

In certain States, the present rules permit doubles combinations but with overall length limits of less than 65 feet. These were coded forbiden Western doubles. Certain scenarios (2C, 3 and 8) assume a uniform 65' length limit but do not mandate the legalization of doubles. In those cases 65' doubles must be allowed in those States which permitted the shorter doubles, making the basic coding system inadequate. For these scenarios, a variant of the basic network data file was used, which coded the links in question as permitting doubles.

Along the "turnpike route" between Chicago and Albany, NY, with extensions to Boston and New York City, Western doubles are permitted except on the stretch through Pennsylvania. This gap is small enough that some carriers find it profitable to use Western doubles across it by breaking them up and hauling the trailers across one at a time. This is permitted with our model, and is accomplished by adding twice the length of the gap to the doubles trip distance when the trip crosses the gap. The penalty comes to 96 miles. Whether or not doubles are chosen for such a trip depends on whether it is long enough so that the inherent advantage of doubles outweighs this distance penalty.

4. <u>The Railroad Network</u>

The reader is referred to CACI's reports for detailed information about the railroad network. As was mentioned earlier, a cost region code and TOFC availability code were added to the data for each link. The cost regions were official, South and West, as these are defined in ICC publications. (The borders are rather imprecise but accurate enough for the purpose.) A list of scheduled TOFC service was obtained from FRA, Office of Freight Systems, and links considered to be part of one or more such routes were coded as having TOFC service. Preliminary analysis of TOFC traffic sugested that traffic diversion from TOFC would be a minor issue and that this method would be adequate for the study's purposes. A more serious study of TOFC competition would require defining availability of service at the O/D pair level.

5. Path-Finding Procedures

It was necessary to calculate highway path data for each of the subnetworks listed below. All of these are made from NETM by the programs NETMOD and ONEWAY except NET65 which is made from the variant NETN described earlier and NETHD which was made by hand. The list of the subnetworks is as follows:

NETF - the complete network, always available for conventional semi use at less than 80K GCW and for conventional semis at 80K or slightly higher in scenarios 2B, 4, 6, 8, 9, 10 and 11 and for 65' doubles in scenarios 4, 9, 10 and 11;

NET80 - the subnetwork of links permitting conventional semis at 80K GCW in the base case;

NETWD - the subnetwork of links permitting 65' doubles in the base case;

NET65 - the subnetwork of links permitting doubles in the base case (generated from the variant network data file);

NETIU - the subnetwork of all links that either permit 80K semis in the base case or are interstate highway links;

NETI - the subnetwork of all interstate highway links;

NETHD - the subnetwork for "unusual" trucks in the base case (the turnpike doubles route plus regions 4A and 9).

The path data files list the total time, distance, fuel consumption and "corrected distance" between each pair of BEA cities for the subnetwork in question. Each subnetwork generates its own path data file, from the program BLDPTH. The paths are minimum-time paths. The "corrected distance" is distance weighted by a region-specific cost factor that accounts for the part of inter-regional cost variation that is considered to be caused by the route rather than by the area of operations. Path data is compiled only for 71x120 O/D pairs, using nodes numbered 1 through 71 as origins and 1 through 120 as destinations. They are afterwards re-numbered to use BEA numbering as opposed to network numbering.

6. Compiling the State and Regional VMT's

The truck choice programs generate vehicle trip tables for each type of truck, showing total vehicle flow between each of the 71x120 BEA city pairs. There are usually 5 or 6 truck types in the sense meant here, but 8 types in scenario 9 where triples are important. Each type is associated with one of the subnetworks. It is loaded onto the links of its subnetwork by the program LOAD, which then computes total VMT for each link, for a given truck type. These link loadings are then aggregated to the State and regional levels, using the identification of states with links contained in STATE.DAT.

7. Railroad Path Data

Slightly modified versions of the highway path-finding programs were used to build two 71x120 sets of railroad path data: for NETR1, the entire rail network was used; and for NETR2, the TOFC rail network. No link loading was done for the rail network.

APPENDIX C

COMMODITY FLOW DATA SOURCES

FOR "TYPE 3" TRAFFIC

1. Basic Data Sources

The development of the type 3 traffic data was a process of combining disparate sources, in order to have full, consistent coverage of the inter-regional truck traffic. Table C-1 lists these sources and summarizes their limitations. The major source for origin-to-destination flow was the 1972 Census of Transportation, Commodity Transportation Survey. More specifically, the TSC BEA region-to BEA region 2- digit commodity flows tape, hereafter referred to as the CTS/BEA tape, was used. The CTS/BEA data excludes local shipments (of less than 25 miles) and all shipments not originating in manufacturing establishments. The latter exclusion includes imports, movements from distribution centers, non-manufactured commodities and some specific commodities within such manufactured STCC groups as 24 (lumber products) and 32 (stone, clay and glass products), which are not shipped by establishments of the sort surveyed.

Since the project relied on the TI&U survey as its comprehensive data source on national aggregate truck activity, the type 3 file did not have to be comprehensive. Its rationale, however, was that it would permit a better assignment of truck activity to states and study regions for inter-state traffic, since trips from origins to destinations could be correctly distributed among the States along the way. Most of the traffic excluded from the CTS fortunately is not of this long distance sort, and can be safely omitted. This is certainly true of the local movements, and is in great part true of the non-manufacturing movements. Some corrections were needed however, to make the file adequate even for long-distance traffic.

Three corrections were made. The National Transportation Policy Study Commission's (NTPSC) version of the Jack Faucett Associates bulk commodity flows was obtained, and the agricultural products flows from this tape were

TABLE C-1. COMMODITY FLOW DATA SOURCES

Source	Coverage	Base Year	Limitations
Census of Transportation Commodity Transportation Survey	Most Manufactured Commodities	1972	Excludes Movements not Originating at Manufacturing Establishments, i.e. - Imports - Movements from warehouses - Some primary lumber products Excludes Local Movements (< 25 miles) Excludes Movements from Small Establishments Excludes Movements of Printed Matter
National Transportation Policy Study Commission Commodity Flow Data Tape	All Commodities	1975	Information about Truck Movements of Bulk Commodities is Sketchy Perishable Agricultural Commodities Excluded
U.S. Department of Agriculture Fresh Fruits & Vegetables Unloads Reports	Fresh Fruits & Vegetables, Including Potatoes	All Years	Not all destinations Covered Point of Entry of Imports Difficult to Identify

extracted. The other commodity groups on this tape either duplicated the CTS data, or contained no significant truck flows. The "agriculatural products" flows are apparently all field crops - corn, wheat and soybeans. These are, of course, important overall; but fresh fruits and vegetables (including potatoes) are also quite significant for the truck transport industry. Flows of fresh produce are reported by the U.S. Department of Agriculture (USDA) on an annual basis, as state-to-state flows for each individual fruit and vegetable type. This data, as an average of 1977 and 1978 flows, was transcribed into machine-readable form using a crude State/BEA correspondence as shown in Table C-2.

The last correction was to account for some of the most egregious omissions of import and non-manufacturing flows. These were identified by searching for commodity groups and study regions for which the CTS truck originations are far short of the reported TI&U activity, and for which there is a reasonable explanation in terms of generally-acknowledged import or production activity. Flows for such commodity/region pairs were adjusted towards parity with the TI&U by increasing the growth rate applied. (This was simply a convenient way of making the adjustment, since the growth factors were applied at just the right level, the commodity/origin-region pair.) The corrections made in this manner and their relationships are listed in Table C-3.

2. Commodity Re-Classification

The CTS data was also re-classified and disaggregated to put it in a more convenient form. Two things were done: flows whose commodity composition was not disclosed in the original file were assigned to specific commodities, and twelve groups of low-density commodities were extracted. All O/D tonnage flows were unchanged by either of these operations, which were

TABLE C-2. ASSIGNMENT OF STATES TO BEA REGIONS FOR FRESH PRODUCE FLOWS

STATE	BEA NUMBER	STATE	BEA NUMBER
ALABAMA	137	NEW HAMPSHIRE	3
ARIZONA	162	NEW JERSEY	15
ARKANSAS	46	NEW MEXICO	146
CALIFORNIA	166	NEW YORK	12,14
COLORADO	147	NORTH CAROLINA	26
CONNECTICUT	5	NORTH DAKOTA	96
DELAWARE	17	OHIO	62
FLORIDA	36,37	OKLAHOMA	120
GEORGIA	41	OREGON	158
HAWAII	165	PENNSYLVANIA	15
IDAHO	152	RHODE ISLAND	4
ILLINOIS	114	SOUTH CAROLINA	31
INDIANA	60	SOUTH DAKOTA	99
IOWA	79	TENNESSEE	50
KANSAS	109	TEXAS	143
KENTUCKY	54	UTAH	151
LOUISIANA	139	VERMONT	3
MAINE	1	VIRGINIA	21
MARYLAND	17	WASHINGTON	156
MASSACHUSETTS	4	WEST VIRGINIA	19
MICHIGAN	72,85	WISCONSIN	83
MINNESOTA	90	WYOMING	150
MISSISSIPPI	135	MEXICO	142,145,164
MISSOURI	116	CANADA	3,92,555
MONTANA	95	OTHER (IMPORT)	14,22,36
NEBRASKA	102		37,77,138
NEVADA	161		141,157
			165,171

TABLE C-3. CORRECTIONS TO COMMODITY/ORIGIN REGION GROWTH RATES

COMMODITY GROUP	REGION	ORIGINAL GROWTH FACTOR	ADJUSTED GROWTH FACTOR	BASIS
H-22	9	1.78	17.80	Missing Imports
H-23	9	1.79	17.90	Missing Imports
H-24	10	1.55	3.10	Missing Lumber Flows
H-28	8	1.99	9.95	Missing Petroleum Flows
H-33	9	1.74	3.48	Missing Imports

simply re-classifications. The data to support these procedures were production/consumption data by BEA region for 1972, prepared for TSC by Data Resources, Inc. (DRI) for a prior project.

This file contains estimates of tons produced, used, exported, and imported during 1972, in each BEA region, for each of 330 manufactured groups. Since the commodities can be aggregated, the only difficulty with this data was that the shipments measure included local shipments, excluded from the CTS. This is serious, since the percentage of shipments that are local is likely to vary by commodity. Unfortunately it was not possible to judge this difficulty quantitatively.

The steps of the procedure for reallocating the non-disclosed flows were as follows:

1. For each BEA region, identify commodity groups for which the CTS/BEA file reports no commodity shipments to any destination.
2. For each of the CTS/BEA commodity groups, identify the commodities in the DRI/BEA file that constitute it.
3. From the DRI/BEA file, compute the total shipped from each BEA region, of each CTS commodity group, by summing over all of the DRI commodities that correspond to that commodity group.
4. For each BEA region, sum the shipment totals computed in step 3 over all the "empty" commodity groups identified in step one. Form percentages for each of these empty groups, by taking the shipment totals for that group divided by the just-computed sum.
5. Divide the nondisclosed flow from any BEA region to any other BEA region by applying the percentages computed in step 4, for the BEA region of origin.

Symbolically, if:

g_{ijk} = unadjusted flow of commodity k from i to j,

f_{ijk} = corrected flow of commodity k from i to j,

V_{ik} = total shipments of k from i (from DRI),

s_{ik} = percentages of nondisclosed flow from i to be attributed to commodity k,

then,

$$s_{ik} = V_{ik} / \left(\sum_{m} V_{im} \right) \left(\text{summed over m such that } \sum_{j} g_{ijm} = \emptyset \right),$$

and

$$f_{ijk} = s_{ik}\, g_{ij\emptyset}, \text{ where commodity } \emptyset \text{ is the nondisclosed.}$$

There are two notable facts about this re-allocation procedure. First, the re-allocation is origin-specific but not O/D pair-specific. Secondly, although an outside data source (the DRI/BEA file) is used to form the correction percentages, the flows being corrected are always CTS/BEA flows. Nothing is added or subtracted to these flows in the process.

The same data source, the DRI/BEA file, that was used to re-allocate the nondisclosed flows was also used to obtain some additional commodity details, thus allowing a more isolated glimpse at the low-density commodities.

Since this disaggregation used the same data as the reallocation procedure, it has the same two properties mentioned above -- it was origin-specific but not O/D-specific, and it neither added nor subtracted flows from the original CTS/BEA file.

The disaggregation was accomplished by the following steps:

1. Several low-density groups were defined, using density as the primary grouping criterion and value per pound as a secondary

criterion. Each new group was specified both as a set of 5-digit STCC numbers and as a set of DRI commodity numbers.

2. Using the DRI/BEA file, the total shipments from each region, of each of the 12 original CTS commodity groups, were computed. Using the same file, the total shipments from each region, of the portion of each new low-density commodity group previously located within each of the 12 old groups, were computed.

3. The existing CTS/BEA commodity flows were then divided between the old and new commodity groups using the origin-specific shipment totals computed in the previous steps as weights. One additional refinement, however, was made. Published CTS reports contain some national-level ton and ton-mile data at the 5- digit commodity level. For each two-digit group, this gave us fairly accurate estimates of the percentage of that group which is accounted for, nationally, by each low-density subset. Using these percentages as scale factors, permitted the construction of new disaggregate flows that better approximate the (unknown) disaggregate CTS flows.

Symbolically, using the same symbols as before,

V_{ilk} = total shipments of low-density group 1, coming from 2-digit group k, from region i (from DRI)

r_{lk} = percentages of U.S. total tonnage of k attributable to 1 (from CTS)

f_{ikl} = flow of disaggregate commodity 1 from i to j.

f_{ij} = total flow of tons from i to j

then

$$W_{lk} = \left(r_{lk} / \left(\sum_i V_{ilk} / \sum_i V_{ik}\right)\right)$$

and

$$\tilde{f}_{ijl} = \sum_k \left((V_{ilk}/V_{ik}) \cdot W_{lk} \cdot f_{ijk} \right).$$

$$f_{ijl} = \left(f_{ij} / \sum_{\ell} \tilde{f}_{ijl} \right) \cdot \tilde{f}_{ijl}$$

Table C-4 shows the type of non-disclosed tonnage for each important BEA region, and shows the commodity groups to which these were re-allocated.

Table C-5 lists the final set of commodity groups in our flow data files, with their STCC coverage and names of prominent members.

3. Projection to 1985

Having augmented and re-classified the 1972 flow data, it was then necessary to project it to 1985. The growth factors for this were supplied by Jack Faucett Associates.* Tables C-6 and C-7 give the factors as they were applied. They are specific to mode, commodity group, and region. (Figure C-1 shows the study regions used in this analysis). Note that the regional breakdown shown here is slightly different from what was ultimately used in the final results. Here there were two separate regions: 1) (MA, ME, NH, VT, NY, NH and DE, and 2) CT, PA and MD, which are combined into "1" in the final results. In addition, Iowa, which is in Region 7 in the final results, is here in Region 6. All other states stayed in the same places. (The reason for these changes was a burst of TSW& law changes in 1980, after the original study regions has been defined.)

The JFA growth factors had to be combined in proportions determined by truck ton-miles to produce growth factors for the low-density manufactured groups. As was stated earlier, a few growth factors were inflated to accomplish some corrections for missing flows. This was all that was done to produce the truck growth factors (Table C-6).

*A subcontractor on the Sydec study team.

TABLE C-4. COMMODITIES NOT DISCLOSED IN MAJOR ORIGIN BEA REGIONS

BEA Region		2-Digit STCC's Not Disclosed
Number	Name	
4	Boston	36,37
5	Hartford	24,37
6	Albany	29,33,36,50
7	Syracuse	28,29,32,45,50
8	Rochester	26,29,33,37,50,55
9	Buffalo	29,37
14	New York	35,37
15	Philadelphia	
16	Harrisburg	29,36
17	Baltimore	33,37
21	Richmond	28,29,32,33,34,35,36,37
22	Norfolk	26,28,29,32,33,34,35,36,37
23	Raleigh-Durham	26,28,29,32,33
25	Greensboro-Winston Salem	20,28,29,33,34,37
26	Charlotte	26,28,29,33,34,35,37,50
28	Greenville, SC	20,26,29,32,33,34,36,37,50
34	Jacksonville	29,32,33,35,36,37,45,50
36	Miami	26,28,29,32,33,34,35,36,37,50,55
37	Tampa	26,29,33,35,37,45,55
42	Macon	20,28,29,33,34,35,36,37,45,50,55
44	Atlanta	29,32,35,37,50
45	Birmingham	26,29,36,37
46	Memphis	29,37
47	Huntsville, AL	20,26,29,32,35,37,50
48	Chattanoga	20,26,29,35,37
49	Nashville	20,26,29,32,45

TABLE C-4. COMMODITIES NOT DISCLOSED IN MAJOR ORIGIN BEA REGIONS (CONTINUED)

BEA Region		2-Digit STCC's Not Disclosed
Number	Name	
52	Huntington - Ashland	20,26,29,34,35,36,37,45,50
54	Louisville	26,29,32,33,36,37,45
57	Springfield, IL	26,29,33,34,37,45,50,55
60	Indianapolis	28,29,45
62	Cincinatti	32,33,37
63	Dayton	29,32,34,36,45,50
64	Columbus, OH	26,29,45,50
66	Pittsburgh	36,45
67	Youngstown	20,26,28,29,37,45,50
68	Cleveland	29,45
70	Toledo	28,29,36,45,50
71	Detroit	37,45
72	Saginaw	20,26,29,32,33,45
73	Grand Rapids	26,29,32,37,45
74	Lansing	28,29,34,37,45,50
75	Fort Wayne	26,28,29,32,36,45,50
76	South Bend	26,28,29,32,45,50
77	Chicago	45,50
79	Davenport	28,29,32,36,45,50
84	Milwaukee	29,32,45
85	Oshkosh - Appleton	28,29,32,36,45
91	Minneapolis	28,37
107	Omaha	26,28,29,32,36,45,50
111	Kansas City	29,33,37,50
114	St. Louis	29,34
117	Little Rock	28,29,32,33,34,35,36,37

TABLE C-4. COMMODITIES NOT DISCLOSED IN MAJOR ORIGIN BEA REGIONS (CONTINUED)

BEA Region		2-Digit STCC's Not Disclosed
Number	Name	
119	Tulsa	26,28,33,34,45,50
127	Dallas	26,29,33,37
132	Sherveport	20,26,28,29,32,33,35,36,37,45,50,55
135	Jackson, MS	26,28,29,32,33,34,35,36,37,45,50,55
137	Mobile	20,29,32,33,35,36,37,45,55
138	New Orleans	33,35,36,37,45
140	Beumont, TX	20,26,32,33,34,35,36,37,45
141	Houston	32,33,45
148	Denver	26,29,32,33,36,37,55
151	Salt Lake City	20,26,28,29,32,33,34,36,37,45,50,55
155	Seattle	28,36,37,45,55
157	Portland, OR	28,29,35, 36,45,55
158	Eugene	20,28,29,32,33,34,35,36,37,45,55
162	Phoenix	20,26,28,29,32,34,35,36,45,50,55
164	San Diego	20,26,28,29,32,33,34,45,50
165	Los Angeles	33,45
166	Fresno	26, 28,29,32,33,36,45,50,55
167	Stockton	26,28,29,33,35,36,37,45,55
171	San Francisco	37,45,55

Note: STCC 45 = 22 and 23 combined.
STCC 50 = 24 and 25 combined.
STCC 55 = 21,30,31,38, and 39 combined.

TABLE C-5. COMMODITY GROUP DEFINITIONS

Commodity Number	STCC Included	Descriptive Name(s)
B-1	01132,01137,01144	Field Crops
B-2	01195,012,013	Fresh Fruits and Vegetables
L-1	3711,3712,3715,373	Motor Vehicles
L-2	2293,2513,2515,2646, 316,341	Metal Cans; Upholstered Furniture
L-3	3142,364,3671,3942, 3952,3953,3961,3991, 3994	Lighting Fixtures
L-4	3573,3674,3693,3842 3951,3962	Computers
L-5	2043,2051,2291,2292,2511, 2512,2514,2516,25171,25174, 25179,2518,2647,375,376,379	Furniture; Miscellaneous Transportation
L-6	25173,2519,302,306,307, 3582,3631,3632,3633, 3679,3963	Other Rubber & Plastic Products Major Appliances
L-7	3141,3636,3822,393,3964	Shoes
L-8	2052,227,2296,265, 301,3296,3491,3635	Paperboard Containers; Tires & Tubes
L-9	3581,3694,381	Electrical Equipment for Engines
L-10	2294,253,2644,3261, 3262,3431,3634,3943	Small Appliances
L-11	315,365,3723,3729,3841 385,3955	Aircraft Parts; TV's & Radios
H-12	224,2297,2431,2434,244 2541,2591,2642,3589, 3639,3941	Millwork; Service Industry Machines

TABLE C-5. COMMODITY GROUP DEFINITIONS (CONTINUED)

Commodity Number	STCC Included	Descriptive Name(s)
H-20	201,202,203,2041,2042,2044, 2045,2046,206,207,208,209	Food Products
H-21	21	Tobacco Products
H-22	221,222,223,225,228,2295, 2298,2299	Textiles
H-23	23	Apparel
H-24	241,242,2432,2433,249,2542, 2599	Lumber Products
H-26	261,262,263,2643,2645,266	Paper Products
H-28	28	Chemicals
H-29	29	Petroleum Products
H-32	321,322,324,325,3264,3269 327,328,3291,3292,3293, 3295,3299	Stone, Clay & Glass Products
H-33	33	Primary Metals
H-34	342,3432,3433,344,345,346 348,3492,3493,3494,3499	Fabricated Metal Products
H-35	351,352,353,354,355,356 3572,3574,3576,3579,3585 359	Machinery
H-36	361,362,366,3691,3692,3699	Electrical Equipment
L-37	3714,3721,3722,374	Motor Vehicle Parts
H-65	303,311,312,313,319,3821, 383,386,387,391,3949,3992, 3993,3996,3997,3999	Miscellaneous Manufacturers

TABLE C-6. TRUCK GROWTH FACTORS, 1972, TO 1985

OMMODITY	ORIGINAL TS&W STUDY REPORTING REGION									
	1	2	3	4	5	6	7	8	9	10
B-1*	1.56	1.64	1.54	1.55	1.48	1.46	1.54	1.46	1.52	1.50
B-2**	1.40	1.47	1.38	1.39	1.33	1.31	1.38	1.31	1.37	1.35
L-1	1.47	1.49	1.75	1.59	1.98	1.66	1.57	1.75	1.59	1.78
L-2	1.45	1.57	1.77	1.51	1.76	1.60	1.60	1.78	1.59	1.61
L-3	1.24	1.41	1.86	1.57	1.98	1.50	1.44	1.90	1.57	1.80
L-4	1.66	1.71	2.29	1.72	2.08	1.77	1.84	2.01	2.06	2.13
L-5	1.45	1.63	1.75	1.65	1.83	1.64	1.64	1.80	1.69	1.64
L-6	1.51	1.61	1.13	1.73	2.14	1.74	1.75	2.10	1.91	2.00
L-7	1.34	1.36	1.80	1.42	1.72	1.48	1.55	1.73	1.68	1.64
L-8	1.49	1.52	1.92	1.64	1.98	1.78	1.72	1.90	1.92	1.84
L-9	1.81	1.84	2.44	1.92	2.33	2.00	2.10	2.34	2.29	2.23
L-10	1.37	1.38	1.78	1.40	1.65	1.47	1.51	1.69	1.51	1.57
L-11	1.30	1.51	1.81	1.54	1.94	1.53	1.73	1.66	1.56	1.74
H-12	1.40	1.55	1.77	1.51	1.75	1.58	1.61	1.76	1.67	1.63
H-20	1.42	1.45	1.54	1.48	1.56	1.44	1.42	1.45	1.47	1.46
H-21	1.31	1.33	1.76	1.39	1.69	1.49	1.52	1.69	1.65	1.61
H-22	1.21	1.14	1.59	1.49	1.74	1.72	1.44	1.54	17.80	1.65
H-23	1.28	1.47	1.85	1.70	1.76	1.49	1.41	1.85	17.90	2.09
H-24	1.37	1.59	1.66	1.49	1.69	1.56	1.56	1.69	1.58	3.10
H-26	1.48	1.61	1.77	1.56	1.90	1.66	1.66	1.85	1.74	1.67
H-28	1.92	1.96	2.12	1.99	2.09	2.15	2.16	9.95	2.22	1.91
H-29	1.56	1.49	1.93	1.68	1.74	1.50	1.73	1.56	1.57	1.59
H-32	1.29	1.31	1.73	1.36	1.66	1.42	1.49	1.66	1.62	1.58
-33	1.38	1.42	1.47	1.46	1.69	1.56	1.48	1.52	3.48	1.62
-34	1.44	1.44	1.82	1.44	1.64	1.51	1.52	1.72	1.40	1.56
-35	1.59	1.65	2.22	1.62	1.95	1.65	1.71	1.84	1.95	2.08
-36	1.24	1.41	1.86	1.57	1.98	1.50	1.44	1.90	1.57	1.80
-37	1.35	1.61	1.76	1.50	1.89	1.56	2.01	1.41	1.54	1.67
-65	1.47	1.48	1.96	1.55	1.88	1.61	1.70	1.89	1.84	1.79

All commodities, base = 1972 except

*Base = 1975

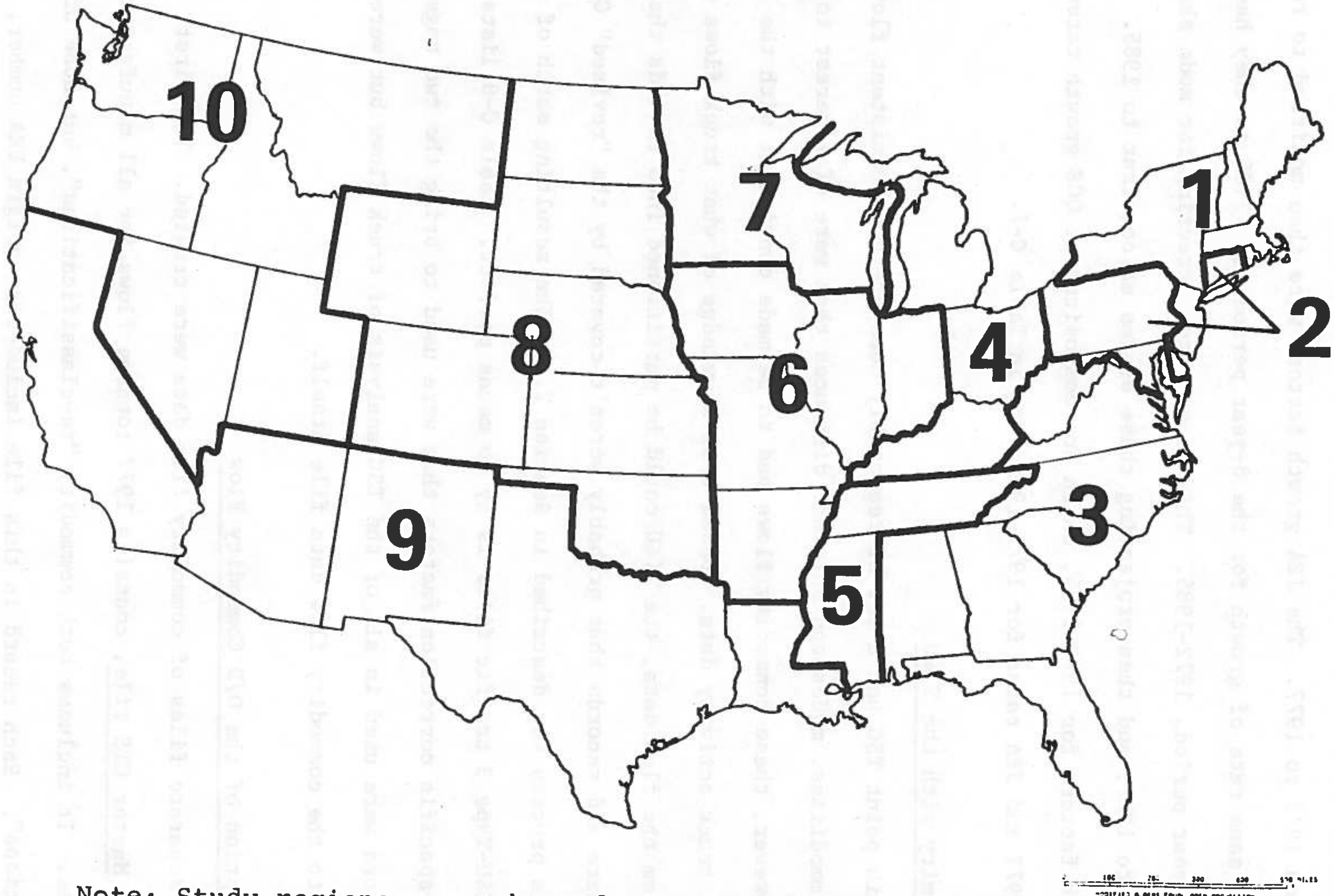
**Base = 1977

TABLE C-7. RAIL GROWTH FACTORS 1972-1985

COMMODITY	ORIGINAL TS&W STUDY REPORTING REGION									
	1	2	3	4	5	6	7	8	9	10
B-1*	1.56	1.64	1.54	1.55	1.48	1.46	1.54	1.46	1.52	1.50
B-2**	1.40	1.47	1.38	1.39	1.33	1.31	1.38	1.31	1.37	1.35
L-1	1.19	1.31	1.46	1.35	1.60	1.37	1.40	1.26	1.28	1.38
L-2	1.22	1.30	1.54	1.29	1.49	1.33	1.33	1.46	1.34	1.38
L-3	1.07	1.22	1.60	1.35	1.71	1.29	1.24	1.63	1.35	1.55
L-4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L-5	1.21	1.37	1.51	1.34	1.56	1.36	1.36	1.44	1.48	1.42
L-6	1.07	1.22	1.60	1.35	1.71	1.29	1.24	1.63	1.35	1.55
L-7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L-8	1.22	1.30	1.41	1.30	1.42	1.30	1.31	1.31	1.36	1.30
L-9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L-10	1.18	1.37	1.43	1.28	1.45	1.34	1.34	1.46	1.36	1.33
L-11	1.07	1.22	1.60	1.35	1.71	1.29	1.24	1.63	1.35	1.55
H-12	1.23	1.22	1.31	1.27	1.28	1.24	1.25	1.17	1.24	1.17
H-20	1.23	1.26	1.34	1.29	1.35	1.25	1.24	1.26	1.28	1.27
H-21	1.23	1.26	1.34	1.29	1.35	1.25	1.24	1.26	1.28	1.27
H-22	1.08	1.10	1.38	1.41	1.49	1.31	1.21	1.54	1.54	1.71
H-23	1.08	1.10	1.39	1.41	1.49	1.31	1.21	1.54	1.54	1.71
H-24	1.40	1.49	1.38	1.20	1.33	1.29	1.29	1.17	1.40	1.26
H-26	1.21	1.37	1.51	1.34	1.56	1.36	1.36	1.44	1.48	1.42
H-28	1.42	1.46	1.57	1.47	1.55	1.60	1.60	1.48	1.65	1.42
H-29	1.35	1.29	1.67	1.45	1.51	1.30	1.50	1.35	1.36	1.29
H-32	1.23	1.22	1.31	1.27	1.28	1.24	1.25	1.17	1.24	1.17
H-33	1.19	1.22	1.27	1.25	1.46	1.34	1.27	1.31	1.50	1.39
H-34	1.24	1.24	1.57	1.24	1.41	1.30	1.31	1.49	1.21	1.35
H-35	1.29	1.34	1.80	1.31	1.58	1.34	1.39	1.49	1.58	1.69
H-36	1.07	1.22	1.60	1.35	1.71	1.29	1.24	1.63	1.35	1.55
L-37	1.19	1.31	1.46	1.35	1.60	1.37	1.40	1.26	1.28	1.38
H-65	1.23	1.30	1.47	1.33	1.53	1.37	1.36	1.45	1.42	1.34

All commodities, base = 1972 except

*Base = 1975
**Base = 1977



Note: Study regions were changed after growth factors were developed.
Final regions combined 1 and 2 and moved Iowa from 6 to 7.

FIGURE C-1. ORIGINAL TS&W STUDY REPORTING REGIONS

An additional correction was made to the rail flows. The 1972 and 1977 Quarterly Commodity Statistics were consulted to see how rail shares had changed from 1972 to 1977. The JFA growth factors were then modified to represent the same rate of growth for the 8-year period 1977-1985 as they had for the 13-year period, 1972-1985. This amounts to correcting for mode share changes up to 1977, and then projecting these shares as constant to 1985. The rail growth factors for 1972-1985, which are composites of QCS growth rates for 1972-1977 and JFA rates for 1977-1985, are in Table C-7.

4. Conformity with the TI&U

At this point TSC had a set of reasonably complete and consistent flows for the commodities, modes and shipment distances that were of interest to the study. However, these commodity flows had to be made consistent with the TI&U total truck activity data. Based upon knowledge of what truck flows were missing from the flow data, the TI&U could be partitioned into records that probably were and records that probably weren't covered by the "revised" CTS file. This process was described in Section 2.3. The resulting match of the CTS and TI&U-Type 3 traffic files is by no means perfect. Table C-8 lists commodity-specific correction factors that were used to bring the two together. These factors were used in all of the TSC analysis of truck flows but were not blended into the commodity flow data file itself.

5. Description of the O/D Commodity Flow

Four separate files of commodity flow data were created. The first, called the Master CTS file, contains 1972 tonnage flows for all manufactured commodities. It includes both commodity "re-classifications", but none of the "augmentations". Each record in this file includes an origin BEA number, a

TABLE C-8. CTS/TI&U VMT ADJUSTMENT FACTORS

TI&U COMMODITY GROUP	CTS COMMODITY GROUP	TI&U "TYPE 3" VMT	1.32 * CTS VMT	ADJUSTMENT FACTOR
1	B1, B2	4,844	2,266	2.14
4,7	12, 24, 32	6,180	3,244	1.90
6,9	5, 7, 22, 23	1,890	1,089	1.73
11,12	28, 29	4,322	3,791	1.14
13,14	2, 33, 34	3,578	3,180	1.13
10	10, 26	1,234	953	1.29
5	20	3,905	4,097	0.95
15	4, 35	875	712	1.23
16	3, 9, 11, 36	473	402	1.18
17	1, 37	1,684	1,389	1.21
19,23	6, 8, 21, 65, LTC	15,873	12,657	1.26
ALL	ALL	44,858	33,760	1.33

destination BEA number, a mode code, a commodity code, a shipment size code, and a tonnage, in the form:

O-region, D-region, commodity, mode, shipment size, tons in the format (2I3, I2, I1, I2, F15.0).

There are 171 BEA regions, listed in Table C-9; 27 commodities listed in Table C-5, 5 modes and 8 shipment sizes listed in Table C-10. The file is sorted by origin-region destination-region and commodity. It contains more than 2 million records.

The <u>sample CTS File</u> is a random selection from the Master File, selecting all records for which the second last digit of "tonnage" is 9. When this sample was extracted, totals were computed for both the master file and the sample file of tons by each commodity group, each origin region, each destination region, and shipment size and each mode. The composition and format of the records in this file is the same as in the master file. It has about 200,000 records.

The <u>expanded sample CTS file</u> is the sample file with the truck and rail growth factors applied to it. This was the file used in all of the type 3 traffic analysis.

The <u>bulk commodity file</u>, which is much smaller than the others, has the field crop and fruits and vegetables data, plus two irrelevant commodities that were not used. It is sorted by origin-region, destination-region and commodity. Each record has O-region, D-region, commodity, mode, tons in the format (1X, 2I3, I2, I1, I11). The flows are for 1985.

TABLE C-9. BEA ECONOMIC AREAS

1. Bangor, ME
2. Portland-South Portland, ME
3. Burlington, VT
4. Boston, MA
5. Hartford, CT
6. Albany, Schnectady-Troy, NY
7. Syracuse, NY
8. Rochester, NY
9. Buffalo, NY
10. Erie, PA
11. Williamsport, PA
12. Binghamton, NY-PA
13. Wilkes-Barre-Hazelton, PA
14. New York, NY
15. Philadelphia, PA-NJ
16. Harrisburg, PA
17. Baltimore, MD
18. Washington, DC, MD-VA
19. Staunton, VA
20. Roanoke, VA
21. Richmond, VA
22. Norfolk-Portsmouth, VA
23. Raleigh, NC
24. Wilmington, NC
25. Greensboro-Winston-Salem, NC
26. Charlotte, NC
27. Asheville, NC
28. Greenville, SC
29. Columbia, SC
30. Florence, SC
31. Charleston, SC
32. Augusta, GA
33. Savannah, GA
34. Jacksonville, FL
35. Orlando, FL
36. Miami, FL
37. Tampa-St. Petersburg, FL
38. Tallahassee, FL
39. Pensacola, FL
40. Montgomery, AL
41. Albany, GA
42. Macon, GA
43. Columbus, GA-AL
44. Atlanta, GA
45. Birmingham, AL
46. Memphis, TN-AR
47. Huntsville, AL
48. Chattanooga, TN-GA
49. Nashville, TN
50. Knoxville, TN
51. Bristol, VA-TN
52. Huntington-Ashland, WV-KY-OH
53. Lexington, KY
54. Louisville, KY-IN
55. Evansville, IN-KY
56. Terre Haute, IN
57. Springfield, IL
58. Champaign-Urbana, IL
59. Lafayette-West Lafayette, IN
60. Indianapolis, IN
61. Anderson, IN
62. Cincinnati, OH-KY-IN
63. Dayton, OH
64. Columbus, OH
65. Clarksburg, WV
66. Pittsburgh, PA

TABLE C-9. BEA ECONOMIC AREAS (CONT.)

67. Youngstown-Warren, OH
68. Cleveland, OH
69. Lima, OH
70. Toledo, OH
71. Detroit, MI
72. Saginaw, MI
73. Grand Rapids, MI
74. Lansing, MI
75. Fort Wayne, IN
76. South Bend, IN
77. Chicago, IL
78. Peoria, IL
79. Davenport-Rock Island-Moline, IA
80. Cedar Rapids, IA
81. Dubuque, IA
82. Rockford, IL
83. Madison, WI
84. Milwaukee, WI
85. Appleton-Oshkosh, WI
86. Wausau, WI
87. Duluth-Superior, MN-WI
88. Eau Claire, WI
89. LaCrosse, WI
90. Rochester, MN
91. Minneapolis-St. Paul, MN
92. Grand Forks, ND
93. Minot, ND
94. Great Falls, MT
95. Billings, MT
96. Bismarck, ND
97. Fargo-Moorhead, ND-MN
98. Aberdeen, SD
99. Sioux Falls, SD
100. Rapid City, SD
101. Scottsbluff, NE
102. Grand Island, NE
103. Sioux City, IA-NE
104. Fort Dodge, IA
105. Waterloo, IA
106. DesMonies, IA
107. Omaha, NE-IA
108. Lincoln, NE
109. Salina, KS
110. Wichita, KS
111. Kansas City, MD-KS
112. Columbia, MO
113. Quincy, IL
114. St. Louis, MO-IL
115. Paducah, KY
116. Springfield, MO
117. Little Rock-North Little Rock, AR
118. Fort Smith, AR-OK
119. Tulsa, OK
120. Oklahoma City, OK
121. Wichita Falls, TX
122. Amarillo, TX
123. Lubbock, TX
124. Odessa, TX
125. Abilene, TX
126. San Angelo, TX
127. Dallas, TX
128. Kileen-Temple, TX
129. Austin, TX
130. Tyler, TX
131. Texarkana, TX-AK
132. Shreveport, LA

TABLE C-9. BEA ECONOMIC AREAS (CONT.)

133. Monroe, LA
134. Greenville, MS
135. Jackson, MS
136. Meridan, MS
137. Mobile, AL
138. New Orleans, LA
139. Lake Charles, LA
140. Beaumont-Port Arthur-Orange, TX
141. Houston, TX
142. San Antonio, TX
143. Corpus Christi, TX
144. McAllen-Pharr-Edinburg, TX
145. El Paso, TX
146. Albuquerque, NM
147. Colorado Springs, CO
148. Denver, CO
149. Grand Junction, CO
150. Cheyenne, WY
151. Salt Lake City, UT
152. Idaho Falls, ID
153. Butte, MT
154. Spokane, WA
155. Seattle-Everett, WA
156. Yakima, WA
157. Portland, OR-WA
158. Eugene, OR
159. Boise City, ID
160 Reno, NV
161. Las Vegas, NV
162. Phoenix, AZ
163. Tulson, AZ
164. San Diego, CA
165. Los Angeles-Long Beach, CA
166. Fresno, CA
167. Stockton, CA
160. Sacramento, CA
161. Redding, CA
170. Eureka, CA
171. San Francisco-Oakland, CA

TABLE C-10. CODES FOR MODE AND SHIPMENT SIZE

Mode	Code Number
Rail	1
Regulated Truck	2
Private Truck (Manufactured Commodities)	3
All Truck (Bulk Commodities)	3
Water	4
All Other Modes	5

Shipment Size	Code Number
<5,000 lbs	8
5,000 - 10,000 lbs	11
10,000 - 20,000 lbs	21
20,000 - 30,000 lbs	22
30,000 - 40,000 lbs	31
40,000 - 50,000 lbs	32
50,000 - 60,000 lbs	33
>60,000 lbs	40

APPENDIX D: ASSIGNING COMMODITY SHIPMENTS TO PARTICULAR TRUCK TYPES AND CARRIER CLASSES FOR "TYPE 3" TRAFFIC

1. Introduction

The purpose of this appendix is to present the details of the methods and data used to convert the commodity flow data described in Appendix C into the type 3 VMT files. The conversion process is rather complicated, having seven major steps: 1) dividing the "regulated truck" tonnages into the general commodity and special commodity service categories; 2) extracting the LTL shipments from each commodity group; 3) assigning each shipment to a truck type; 4) converting ton-miles into vehicle-miles; 5) accumulating national statistics by carrier service and industry; 6) loading O/D accumulations of vehicle flow by truck type on to appropriate networks and aggregating to get state-level VMTs; 7) and finally, dissaggregating these VMTs to the 15 x 15 level of detail (15 axle configurations, 15 weight blocks). This process is indicated in Figure D-1 and is discussed below.

2. Original Datum

The commodity flow data file, whose construction was described in Appendix C, lists tons by origin BEA zone, destination BEA zone, commodity group, mode and shipment size. (The bulk commodity flow file does not have shipment size. Each record is assigned the largest shipment size, "greater-than-truck load" ($\geq$ 60,000 lb) by the program.) The tonnages read from these files had to be expanded to match the hypothetical U.S. total tonnages. There were three reasons for this expansion, two of which were discussed in Appendix C. Those were the use of a random subset from the full manufactured commodity flow data tape, and the adjustment of the totals to match the TI&U totals. The last adjustment was to account for the fact that not all origin and destination zones were explicitly analyzed. Table D-1 lists the 71 regions which were analyzed as both origins and destinations, the 49 regions analyzed as destinations only, and the 53 regions that were never analyzed. To say this another

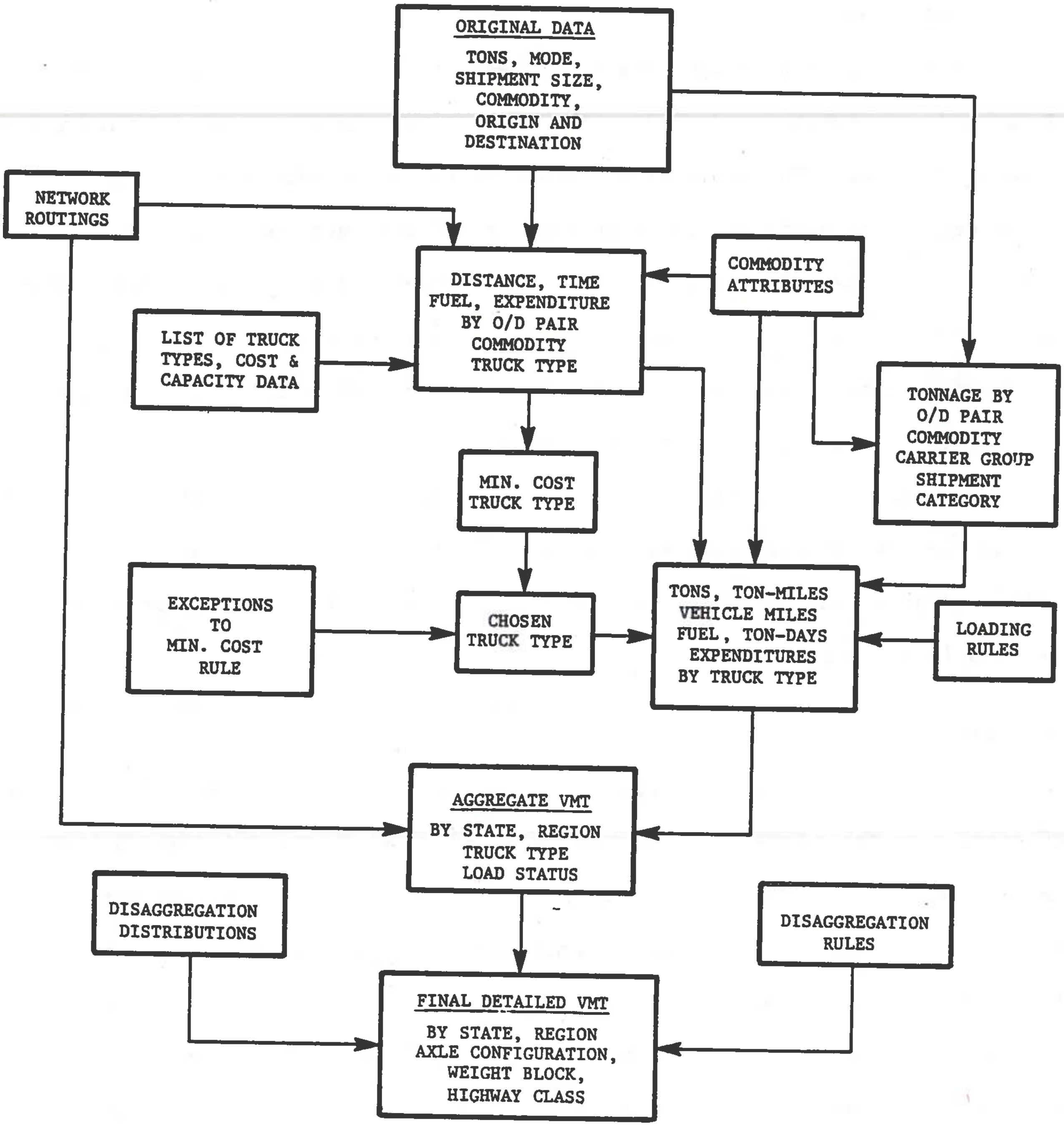


FIGURE D-1. HOW A TON BECOMES A VEHICLE-MILE

TABLE D-1. ORIGIN AND DESTINATION REGIONS USED IN THE ANALYSIS

A. REGIONS USED AS ORIGINS AND DESTINATIONS

Number	Name	Number	Name
4	Boston, MA	76	South Bend, IN
5	Hartford, CT	77	Chicago, IL
6	Albany, NY	79	Davenport, IA
7	Syracuse, NY	84	Milwaukee, WI
8	Rochester, NY	85	Oshkosh, WI
9	Buffalo, NY	91	Minneapolis, MN
14	New York, NY	107	Omaha, NE
15	Philadelphia, PA	111	Kansas City, MO
16	Harrisburg, PA	114	St. Louis, MO
17	Baltimore, MD	117	Little Rock, AR
23	Raleigh, NC	119	Tulsa, OK
25	Greensboro, NC	127	Dallas, TX
26	Charlotte, NC	132	Shreveport, LA
28	Greenville, SC	135	Jackson, MS
34	Jacksonville, FL	137	Mobile, AL
36	Miami, FL	138	New Orlenas, LA
37	Tampa, FL	140	Beaumont, TX
42	Macon, GA	141	Houston, TX
44	Atlanta, GA	148	Denver, CO
45	Birmingham, AL	151	Salt Lake City, UT
46	Memphis, TN	155	Seattle, WA
47	Huntsville, AL	157	Portland, OR
48	Chattenoga, TN	158	Eugene, OR
49	Nashville, TN	162	Phoenix, AZ
52	Huntington, WV	164	San Diego, CA
54	Louisville, KY	165	Los Angeles, CA
57	Springfield, IL	166	Fresno, CA
60	Indianapolis, IN	167	Stockton, CA
62	Cincinnatti, OH	171	San Francisco, CA
63	Dayton, OH	21	Richmond, VA
64	Columbus, OH	22	Norfolk, VA
66	Pittsburgh, PA		
67	Youngstown, OH		
68	Cleveland, OH		
70	Toledo, OH		
71	Detroit, MI		
72	Saginaw, MI		
73	Grand Rapids, MI		
74	Lansing, MI		
75	Fort Wayne, IN		

TABLE D-1. ORIGIN AND DESTINATION REGIONS USED IN THE ANALYSIS (Cont.)

B. REGIONS USED AS DESTINATIONS ONLY

Number	Name	Number	Name
1	Bangor, ME	99	Sioux Falls, SD
2	Portland, ME	103	Sioux City, IA
3	Burlington, VT	105	Waterloo, IA
10	Erie, PA	106	Des Moines, IA
11	Williamsport, PA	110	Wichita, KS
12	Binghamton, NY	115	Paducah, KY
13	Scranton, PA	116	Springfield, MO
18	Washington, DC	120	Oklahoma City, OK
19	Staunton, VA	122	Amarillo, TX
20	Roanoke, VA	128	Temple, TX
27	Asheville, NC	129	Austin, TX
29	Columbia, SC	130	Tyler, TX
32	Augusta, GA	133	Monroe, LA
43	Columbus, GA	134	Greenville, MS
50	Knoxville, TN	139	Lake Charles, LA
51	Bristol, VA	142	San Antonio, TX
53	Lexington, KY	145	El Paso, TX
55	Evansville, IN	146	Albuquerque, NM
61	Anderson, IN	147	Colorado Springs, CO
69	Lima, OH	154	Spokane, WA
78	Peoria, IL	161	Las Vegas, NV
82	Rockford, IL	163	Tueson, AZ
83	Madison, WI	168	Sacramento, CA
86	Wausau, WI	40	Montogomery, AL
87	Duluth, MN		

TABLE D-1. ORIGIN AND DESTINATION REGIONS USED IN THE ANALYSIS (Cont.)

C. REGIONS NOT USED

Number	Name	Number	Name
24	Wilmington, NC	102	Grand Island, NE
30	Florence, SC	104	Fort Dodge, IA
31	Charleston, SC	108	Lincoln, NE
33	Savannah, GA	109	Salina, KS
35	Orlando, FL	112	Columbia, MD
38	Tallahassee, FL	113	Quincy, IL
39	Pensacola, FL	118	Fort Smith, AR
41	Albany, GA	121	Wichita Falls, TX
56	Terre Haute, IN	123	Lubbock, TX
58	Champaign, IL	124	Odessa, TX
59	Lafayette, IN	125	Abilene, TX
65	Clarksburg, WV	126	San Angelo, TX
80	Cedar Rapids, IA	131	Texarkana, TX
81	Dubuque, IA	136	Meridian, MS
88	EauClaire, WI	143	Corpus Christi, TX
89	LaCrosse, WI	144	Harlingen, TX
90	Rochester, MN	149	Grand Junction, CO
92	Grand Forks, ND	150	Cheyenne, WY
93	Minot, ND	152	Idaho Falls, ID
94	Great Falls, MT	153	Butte, MT
95	Billings, MT	156	Yakima, WA
96	Bismarck, ND	159	Boise, ID
97	Fargo, ND	160	Reno, NV
98	Abendeen, SD	169	Eureka, CA
100	Rapid City, SD	170	Redding, CA
101	Scottsbluff, NE		

way, only commodity flow records whose O/D numbers fit within the indicated 71 x 120 set of O/D pairs were analyzed. The reason for O/D sampling was to conserve computer space, since path data files containing information on each O/D pair to be analyzed had to be built for each subnetwork (six in all) to which a type of truck might be restricted. These files were stored and used several at a time in doing the truck choice analysis. The origin and destination regions were selected so that they accounted for the majority of tons, and so that coverage by region was roughly even. All three adjustments to tonnages were made with factors that were commodity-specific but national. These factors are listed in Table D-2.

3. Tonnage by Carrier Service and Shipment Category

The next step was to get more information at the O/D tonnage level. The CTS file did not separate regulated truck shipments by type of authority (special commodity or general commodity) under which the goods moved. The operations and hence the costs associated with the two types are quite different. The former is dock-to-dock truckload business, while the latter is predominantly (but by no means exclusively) less-than-truckload shipments, using a network of terminals and traveling in vans. Two outside sources of information were used to split the regulated tonnage: a breakdown by commodity of tons carried by regular route, irregular route, and contract carrier services; and a breakdown by commodity of tons carried in trucks of each of several body types (see Technical Supplement, Vol. I). Regular route carriers have primarily general commodity authorities, and irregular route and contract carriers have mostly special commodity authorities. The complication is that the large regular route firms often have what are in effect irregular-route subsidiaries, with special commodity authorities and operating dock-to-dock just like the irregular-route only firms. One indication that this is not a negligible category of activity

TABLE D-2. EXPANSION FACTORS FOR ALL COMMODITIES

COMMODITY	A	B	RAIL EXFAC	C	TRUCK EXFAC
B-1	1.00	2.80	2.80	2.14	5.99
B-3	1.00	1.53	1.53	2.14	3.27
1	7.35	1.22	8.97	1.21	10.85
2	11.14	1.37	15.26	1.13	17.24
3	12.66	1.44	18.23	1.18	21.51
4	14.47	1.52	21.99	1.23	27.05
5	11.45	1.56	17.86	1.73	30.90
6	7.86	1.30	10.22	1.26	12.88
7	16.26	1.37	22.27	1.73	38.53
8	11.25	1.41	15.86	1.26	19.98
9	11.52	2.06	23.73	1.18	28.00
10	9.63	1.74	16.75	1.29	21.61
11	10.62	1.38	14.65	1.18	17.29
37	9.08	1.14	10.35	1.21	12.52
20	11.04	1.61	17.77	0.95	16.88
21	8.11	1.51	12.25	1.26	15.44
22	9.11	1.80	16.40	1.73	28.37
23	11.99	1.71	20.50	1.73	35.46
26	8.75	1.59	13.91	1.29	17.94
28	10.40	1.27	13.21	1.14	15.06
29	10.00	1.00	10.00	1.00	10.00
32	12.09	1.62	19.59	1.90	37.22
33	11.48	1.21	13.89	1.13	15.70
34	9.20	1.22	11.22	1.13	12.68
35	9.13	1.48	13.51	1.23	16.62
36	10.79	1.34	14.46	1.18	17.06
12	10.59	1.73	18.32	1.90	34.81
50	10.60	1.90	20.14	1.90	38.27
65	9.07	1.53	13.87	1.26	17.48

A = Correction for commodity flow sampling
B = Correction for O/D sampling
Rail EXFAC = AxB = expansion factor for rail
C = Correction to Match TI&U
Truck EXFAC = Rail EXFAC x C = Expansion factor for truck

is that for several commodity groups the percentage of traffic carried by regular-route carriers is far higher than the percentage carried in vans. It was decided that for cost purposes this "special commodity via regular route firm" operation would be most similar to the other "special commodity" operation. (What we call special-commodity costs were derived from a sample of irregular-route firms. The one discrepancy here might be that the "special commodity via regular route firm" is more likely to be unionized.)

The division was carried out as follows. All regulated truck shipments of less-than-truckload size were classified as "general commodity." The remaining regulated truck shipments were divided between the two types according to a commodity specific percentage, which was the smaller of the regular-route percentage and the van percentage. (Both sets of percentages are listed in Table D-3.) No distortion was introduced by applying the percentage to non-LTL shipments (i.e., those greater than 10,000 lbs) only, because the commodity statistics from which the percentages were derived included mixed cargoes as a separate commodity category.

The second refinement made on the raw tonnage data was to classify each record as LTL (less than truckload), PTL (partial truckload) and TL (full truckload). Tons were classified as LTL if they were carried by regulated truck and if the indicated shipment weight was less than 10,000 lbs. LTL was treated as a separate commodity. Tons were classified as PTL if the shipment weight was more than 10,000 lbs and less than an upper limit that depended on commodity density. The upper limit was 30,000 lbs if density was greater than 17 lbs/ft^3, 20,000 lbs if the density was less than 12 lbs/ft^3, and 20,000 + 2,000 x (density -12) for densities between 12 and 17. Tonnage classified PTL <u>and</u> classified as carried in general commodity service was considered as a separate commodity, essentially large LTL shipments. All other special-

TABLE D-3. PERCENTAGE SHARES OF VANS, REGULAR ROUTE CARRIERS AND GENERAL COMMODITY FREIGHT BY MANUFACTURED COMMODITY GROUP

COMMODITY		% Carried in Vans	% Carried by RRCC Firms	% Classified as General Freight
L-1	Motor Vehicles	0	0	0
L-2	Metal Cans, etc.	100	50	50
L-3	Lighting Fixtures	85	80	80
L-4	Computers	100	85	85
L-5	Furniture, etc.	90	70	70
L-6	Appliances, etc.	80	80	80
L-7	Shoes	100	85	85
L-8	Tires, etc.	90	75	75
L-9	Engine Equipment	90	75	75
L-10	Small Appliances	85	80	80
L-11	TV Sets, etc.	100	55	55
L-37	Motor Vehicle Parts	100	90	90
H-20	Food Products	37	43	37
H-21	Tobacco Products	100	58	58
H-22	Textiles	100	62	62
H-23	Apparel	100	83	83
H-24	Lumber Products	15	28	15
H-12	Millwork, etc.	60	55	55
H-26	Paper Products	90	63	63
H-28	Chemicals	50	35	35
H-29	Petroleum Products	8	5	5
H-32	Stone, Clay & Glass	35	16	16
H-33	Primary Metals	20	63	20
H-34	Fabricated Metals	40	61	40
H-35	Machinery	37	51	37
H-36	Electrical Equipment	75	70	70
H-65	Misc. Manufactures	90	80	80
B-1	Field Crops	22	0	0
B-2	Fruit & Vegetables	22	0	0
	LTL	100	100	100

commodity shipments were classified as TL. The other general-commodity shipments were also classified as truckload. (See the section on average loads for an interpretative comment on this.) For private truck shipments, the actual shipment sizes were ignored and national commodity specific divisions between full and partially loaded trucks were used. Table D-4 lists the commodity densities and percent trucks that are loaded that were used.

There is some evidence that the ratio of LTL tons to total tons within the trucking mode has been diminishing. In part this may be due to growing truck shares of commodity groups such as chemicals that have always generated fewer LTL shipments. It could also be due in part to increased traffic volumes or to improved logistics practices such as the use of warehouses. Insofar as the second set of reasons is important, the LTL share for a given commodity and a given O/D corridor might be decreasing. There was no way to verify that this trend exists or to quantify it. Therefore it was assumed that no significant change would occur between 1972 and 1985. As a consequence, the reported LTL volumes may be somewhat high. The method used to predict use of light doubles will thus produce somewhat more doubles activity. This distortion is likely to be small, and is concentrated by the fact that doubles have been excluded from the larger low-density shipment markets.

Another major issue concerning shipment size trends concerns the relationship between shipment size and mode choice. This issue is internal to the large range of shipment sizes here labeled as "truckload". The treatment of mode choice and shipment size is explained in Technical Supplement, Volume 5.

4. Network Routings

The development of the highway network file, and the data contained in it, was described in Appendix B. From the various link codes it was easy to identify subnetworks that were available to each type and size of truck in each

TABLE D-4. COMMODITY DENSITY AND PERCENT LOADED

COMMODITY		Density (Lbs/Ft^3)	% of Trucks That are Fully Loaded*
L-1	Motor Vehicles	6	40
L-2	Metal Cans, etc.	7	40
L-3	Lighting Fixtures	8	40
L-4	Computers	9	40
L-5	Furniture, etc.	10	40
L-6	Appliances, etc.	11	40
L-7	Shoes	12	40
L-8	Tires, etc.	13	40
L-9	Engine Equipment	14	40
L-10	Small Appliances	15	40
L-11	TV Sets, etc.	16	40
L-37	Motor Vehicle Parts	14	40
H-20	Food Products	37	34
H-21	Tobacco Products	18	25
H-22	Textiles	22	25
H-23	Apparel	18	25
H-24	Lumber Products	29	38
H-12	Millwork, etc.	18	31
H-26	Paper Products	36	25
H-28	Chemicals	47	37
H-29	Petroleum Products	48	56
H-32	Stone, Clay & Glass	57	41
H-33	Primary Metals	150	37
H-34	Fabricated Metals	60	34
H-35	Machinery	28	33
H-36	Electrical Equipment	66	28
H-65	Misc. Manufactures	28	26
B-1	Field Crops	45	100
B-2	Fruit & Vegetables	30	100
	LTL	12	40

*Remaining trucks are partially loaded. See Table D-12 for the maximum payloads and partial payloads under various weight limits.

scenario. Appendix B lists these subnetworks. Table D-5 shows which trucks were restricted to which subnetworks in each scenario. For each subnetwork, a path data file was assembled showing for each of the 71 x 120 O/D combinations that were to be analyzed, the origin node number, the destination node number, the distance, the transit time, the "corrected distance" and the fuel consumption. These path data files were used in computing ton-miles, line-haul cost and line-haul fuel consumption for each of the one or two truck types that might be used to move a particular commodity flow. The paths are minimum-time paths over the relevant subnetwork. The transit times are line-haul only, assuming continuous travel at the speeds associated with each class of link. Assumed line-haul speeds, including estimated typical delays in route, are indicated in Table D-6. Terminal delays and in-transit rest delays for private trucks are added in a later step. The fuel consumption is for line-haul travel in an empty 45' van semitrailer rig. Various corrections and additions to account for payloads, circuity and empty backhaul are made to this later on.

The treatment of cost needs close attention. The costs developed by TSC are specific to carrier groups, regions and truck types (both configuration and body type). "Region specific" means specific to a sample of carriers operating principally in that region. Such cost differences are in part due to differences in terrain, fuel prices, congestion, wages and salaries, capital costs of facilities, etc. Among regions, the first three factors are affected by the route traveled, while the latter two are more a function of the base of operations. If route specific factors were dominant, one would expect the same general relationship among regions to hold for all carrier groups and truck types. Table D-7 shows that this is not so. On the other hand, there are well-known terrain and congestion differences among regions, so that the opposite assumption, that cost differences arise from the differences in base

TABLE D-5. TRUCK TYPES, SUBNETWORKS AND SCENARIOS

Truck Type	Scenario										
	1	2B	2C	3	4	5	6	8	9	10	11
Conventional Semi 73	F	–	F	F	–	F					
Conventional Semi 80	80	F	IU	IU	F	–	F	F	F	F	F
Light Double[1]	WD	65	65	WD	F	WD	WD	65	F	F	F
Tandem Axle Double (Short)[2]	4B/9	–	4B/9	4B/9	4B/9	4B/9	WD	65	F	F	F
Turnpike Double[2]	TD	–	TD	TD	TD	TD	TD	TD	–	TD	TD
Light Triple[3]	–	–	–	–	–	–	–	–	I	–	
Tandem Axle Triple[3]	–	–	–	–	–	–	–	–	I	–	

Subnetwork Codes:

F = All FAP Highways (Entire Network)

80 = States permitting 20/34/80 rigs in 1980

IU = All Interstates and all other highways permitting 20/34/80 rigs in 1980

WD = States permitting 65' doubles in 1980

65 = States permitting doubles in 1980

4B/9= Region 4B (Michigan) and Region 9 (Southwest)

I = All Interstate highways.

TD = Turnpike corridor between Chicago and New York with spur to Boston

[1]Except in scenarios 4 and 9-11, western doubles are restricted to LTL and curtailed in regions 1, 3, 5.

[2]In scenarios 1-5, tandem axle doubles get only a fraction of the traffic in this region. The same is true for turnpike doubles in all scenarios.

[3]Triples are also restricted in scenario 9.

TABLE D-6. LINE-HAUL SPEEDS

TERRAIN TYPE	CLASS OF ROAD	
	LIMITED ACCESS DIVIDED	OTHER
Level	42 mph	37 mph
Rolling	36 mph	31 mph
Mountainous	27 mph	24 mph

TABLE D-7. TOTAL LINE-HAUL VAN COSTS, REGIONAL FACTORS, AND RESIDUAL LINE-HAUL VAN COSTS

	Northeast	Middle West	South	West
1. Actual Costs ($ per vehicle mile)*				
General Freight	1.413	1.096	0.934	1.194
Special Commodity	1.222	1.441	0.939	1.302
Private Truck	0.981	0.848	0.881	1.088
2. Average Van Cost	1.136	1.058	0.842	1.084
3. Cost Factor	1.35	1.25	1.00	1.28
4. Residual Line-Haul Costs (Line 1 divided by Line 3)				
General Freight	1.05	0.88	0.93	0.93
Special Commodity	0.84	1.05	0.82	0.86
Private Truck	0.64	0.62	0.77	0.74

*Technical Supplement, Vol. 2.

of operations is also not satisfactory. An intermediate method was necessary. The basic idea of the approach adopted was to identify a systematic component of inter-regional differences, based on averaging the differences over the three carrier groups. This systematic component is then used as a set of correction factors for each region, intended to represent the terrain and congestion effects on cost. These factors were derived from van costs only, since that is by far the most important body type and the only body type for regular route carriers. Each original cost element was then divided by the appropriate regional factor to obtain what are called "residual" costs. This insures that none of the cost variation in the original data has been lost. Table D-7 shows the original van cost data, the derivation of the regional cost factors, and the resulting table of residual van costs. Table D-8 contains the original and residual costs for all body types.

The cost factors were applied at the network level. On each link, something called "corrected distance" was calculated as the product of distance and the relevant cost factor. The path data files created by the network analysis show the total corrected distance for each O/D pair. The truck choice model calculates the cost for a given truck and a given O/D pair by multiplying the appropriate residual cost per vehicle mile by this corrected distance, to get the full line-haul cost per vehicle.

5. Choice of Truck Type

Two additional pieces of data were introduced to complete the set needed to make the selection of the least-cost truck: detailed costs by commodity; and loads per vehicle by truck type, carrier group, commodity and shipment size cateogry. Table D-8 gives the costs in terms of body types, both before and after correction for the regional factors. Table D-9 shows the body type composition of each commodity group. Table D-10 shows the commodity line-haul

TABLE D-8. LINE-HAUL COSTS BY BODY TYPE

1. Original Costs ($/vehicle-mile)

	Region				
Body Type	Northeast	Midwest	South	Southwest	Northwest
Van - Gen. Freight	1.413	1.096	0.934	1.194	1.194
Van - Special Commodity	1.222	1.441	0.939	1.302	1.302
Van - Private	0.981	0.898	0.881	1.088	1.088
Reefer	1.230	1.273	0.912	1.182	0.845
Flat	1.189	1.046	1.013	1.176	1.176
Auto	1.698	1.741	2.237	2.494	2.494
Tank	1.522	1.518	1.789	1.526	1.603
Dump	1.237	1.237	1.842	1.842	1.842

2. "Residual Costs" = Original Costs ÷ Regional Cost Factors

Body Type	Northeast	Midwest	South	Southwest	Northwest
Van - Gen. Freight	1.05	0.88	0.93	0.93	0.93
Van - Special Commodity	0.84	1.05	0.82	0.86	0.86
Van - Private	0.64	0.62	0.77	0.74	0.74
Reefer	0.91	1.02	0.91	0.92	0.66
Flat	0.88	0.84	1.01	0.92	0.92
Auto	1.26	1.39	2.24	1.95	1.95
Tank	1.13	1.21	1.79	1.19	1.25
Dump	0.92	0.99	1.84	1.44	1.44

TABLE D-9. BODY TYPE DISTRIBUTIONS

Commodity	Percent Carried by Body Type						
	Van	Reefer	Flat	Tank	Dump	Auto	Other
B-1, Grain	22	15	10				53
9, Forest & Fish	25	75					
10, Ores					100		
11, Coal					100		
13, Oil & Gas				100			
14, Minerals	11		12	6	66		5
B-2, Fruit & Vegetables	22	78					
20, Food Products	37	53	1	6			3
21, Tobacco	84	12		4			
22, Textiles	96	4					
23, Apparel	91	7	2				
24, Lumber	14	1	85				
26, Paper	82	7	11				
28, Chemicals	49	10	6	35			
29, Petroleum Products	8	4	12	76			
32, Stone, Clay & Glass	30	4	41	4	4		17
33, Primary Metals	21	2	75		2		
34, Fabricated Metals	36	4	60				
35, Machinery	36	1	63				
36, Electrical	71	6	23				
37, Motor Vehicle Parts	100						
C-40, Miscellaneous	86	6	8				
L-1, Motor Vehicles			15			80	5
L-2, Cans	88	8	4				
L-3, Lighting Fixtures	80	5	15				
L-4, Computers	93	4	3				
L-5, Furniture	85	5	10				
L-6, Misc. Rubber Prod.	74	8	18				
L-7, Shoes	86	14					
L-8, Boxes & Tires	76	15	9				
L-9, Ignition Motors	84	5	11				
L-10, Appliances	77	7	16				
L-11, TV Sets	83	13	4				
L-12, Millwork	58	5	37				
LTL, LTL	93	5	2				

TABLE D-10. RESIDUAL LINE-HAUL COSTS BY COMMODITY ($ PER VEHICLE-MILE) (CONTINUED)

1. Conventional Semis

Commodity Code	Private Truck				Special Commodity			
	Northeast	South	Midwest	West	Northeast	South	Midwest	West
L-1	1.26	2.24	1.34	1.95	1.26	2.24	1.39	1.95
L-2	0.64	0.77	0.62	0.74	0.84	0.82	1.05	0.86
L-3	0.68	0.81	0.65	0.77	0.87	0.96	0.89	0.90
L-4	0.64	0.77	0.62	0.74	0.84	0.82	1.05	0.86
L-5	0.66	0.79	0.64	0.76	0.85	0.89	0.98	0.88
L-6	0.69	0.82	0.66	0.78	0.88	1.01	0.84	0.92
L-7	0.64	0.77	0.62	0.74	0.84	0.82	1.05	0.86
L-8	0.66	0.79	0.64	0.76	0.86	0.90	0.97	0.88
L-9	0.66	0.79	0.64	0.76	0.86	0.90	0.97	0.88
L-10	0.68	0.81	0.65	0.77	0.87	0.96	0.89	0.90
L-11	0.65	0.78	0.63	0.75	0.84	0.84	1.03	0.87
L-37	0.64	0.77	0.62	0.74	0.84	0.82	1.05	0.86
H-20	0.83	0.94	0.89	0.85	0.94	1.05	1.05	0.93
H-21	0.64	0.77	0.62	0.74	0.84	0.82	1.05	0.86
H-22	0.64	0.77	0.62	0.74	0.84	0.82	1.05	0.86
H-23	0.64	0.77	0.62	0.74	0.84	0.82	1.05	0.86
H-26	0.68	0.81	0.65	0.77	0.86	0.90	0.97	0.88
H-28	0.82	1.14	0.84	0.91	1.00	1.36	1.12	1.01
H-29	1.08	1.63	1.14	1.15	1.08	1.63	1.14	1.15
H-32	0.81	1.13	0.82	0.98	0.89	1.20	0.94	1.04
H-33	0.83	0.96	0.80	0.88	0.88	1.01	0.84	0.92
H-34	0.78	0.91	0.75	0.85	0.88	1.01	0.84	0.92
H-35	0.79	0.92	0.76	0.85	0.88	1.01	0.84	0.92
H-36	0.70	0.83	0.66	0.78	0.87	0.97	0.88	0.91
H-12	0.73	0.86	0.70	0.81	0.87	0.98	0.88	0.91
H-24	0.84	0.97	0.81	0.89	0.88	1.01	0.84	0.92
H-65	0.66	0.74	0.64	0.76	0.86	0.90	0.97	0.88
B-1	0.87	0.95	0.91	0.90	0.87	0.95	0.91	0.90
B-2	0.89	0.89	1.03	0.87	0.89	0.89	1.03	0.87
ALL General Freight Carriers					·1.05	0.93	0.88	0.93

TABLE D-10. RESIDUAL LINE-HAUL COSTS BY COMMODITY ($ PER VEHICLE-MILE) (CONTINUED)

2. Western Doubles

	Northeast	South	Midwest	West
General Freight/LTL	1.06	0.94	0.89	0.94

3. Light Triples

	Northeast	South	Midwest	West
General Freight/LTL	1.45	1.19	1.14	1.15

4. Turnpike Doubles

Commodity Code	Private Truck				Special Commodity			
	Northeast	South	Midwest	West	Northeast	South	Midwest	West
B-1	1.03	1.19	0.99	1.10	1.03	1.19	0.99	1.10
B-2	1.10	1.17	1.14	1.07	1.10	1.17	1.14	1.07
L-1	1.51	2.54	1.72	2.39	1.51	2.54	1.72	2.39
L-2,-4,-7,-11-37	0.91	1.13	0.88	1.05	1.09	1.19	1.35	1.21
H-21,-22,-23,-37	0.91	1.13	0.88	1.05	1.09	1.19	1.35	1.21
L-3,L-10	0.93	1.14	0.90	1.06	1.05	1.20	1.08	1.14
L-5	0.92	1.14	0.89	1.06	1.07	1.20	1.23	1.18
L-6	0.93	1.15	0.90	1.07	1.04	1.21	0.98	1.12
L-8,L-9	0.92	1.14	0.89	1.06	1.07	1.20	1.19	1.18
H-20	1.07	1.26	1.11	1.12	1.18	1.38	1.26	1.15
H-26	0.93	1.14	0.89	1.06	1.07	1.20	1.19	1.18
H-28	1.09	1.53	1.12	1.26	1.25	1.76	1.43	1.43
H-29	1.35	2.15	1.50	1.60	1.35	2.15	1.50	1.60
H-32	1.03	1.40	1.10	1.21	1.07	1.41	1.20	1.24
H-33	1.01	1.20	0.96	1.10	1.04	1.21	0.98	1.12
H-34,H-35	1.00	1.18	0.95	1.09	1.04	1.21	0.98	1.12
H-36	0.95	1.15	0.91	1.07	1.06	1.20	1.11	1.15
H-12	0.96	1.15	0.91	1.07	1.05	1.20	1.09	1.14
H-24	1.02	1.20	0.96	1.11	1.04	1.21	0.98	1.12
All General Freight Carriers					1.33	1.08	1.06	1.08

TABLE D-10. RESIDUAL LINE-HAUL COSTS BY COMMODITY ($ PER VEHICLE-MILE) (CONTINUED)

5. Short Heavy Doubles

*Multiply all costs for conventional semis by the following factors to get short heavy doubles costs. This yields costs that are roughly halfway between conventional semi costs and turnpike double costs.

Commodity Code	Northeast	South	Midwest	West
H-28	1.140	1.131	1.128	1.120
All Others	1.138	1.129	1.126	1.118

6. Heavy Triples

Use turnpike double costs.

costs, corrected for regional factors, which are the appropriately-weighted mixtures of the body type costs.* Part one pertains to conventional semis, part two to the Western doubles, part three to the short heavy doubles and part four to turnpike doubles and heavy triples.

Table D-11 shows the terminal area costs. Finally, Table D-12 shows the payload weights for each size of truck in each scenario, for full loads and partial loads. On the basis of all this data it was possible to compute the cost per ton for moving any commodity between any pair of cities in any size of truck, taking into account differences in route miles, operating costs and payloads. Thus the minimum-cost truck type for each O/D pair, commodity and shipment size could be identified.

The actual truck choices involved some modification of these strictly calculated minimum-cost truck choices. This mainly involved restricting the use of doubles to account for unmeasured costs associated with their use. The exact nature of these exceptions to the minimum cost rule and their rationalization were explained in section 4.2.

6. Converting Ton-Miles Into Vehicle Miles

The conversion of ton-miles into vehicle miles was the most important step in the analysis. The method was implied in sections 3 and 5 of this Appendix, but it requires more explanation.

To go from tons to vehicles, the tons carried per vehicle for both fully or partially loaded trucks must be known. Table D-12 summarizes the payload weights used. The process for dividing the flows according to truck load status is

*Perhaps the appropriate weights are not completely self-evident. All general freight traffic goes by van, so only van costs are used for general freight. To be consistent, an amended body type distribution for special commodity traffic had to be assembled, omitting the general freight van share, so that "regulated truck" as a whole gets the right distribution. Private truck uses the unadjusted distribution.

TABLE D-11. TERMINAL AREA COSTS & DELAYS

1. COSTS (dollars per vehicle)

	CONVENTIONAL SEMIS				LIGHT DOUBLES				LIGHT TRIPLES			
	NORTHEAST	SOUTH	MIDWEST	WEST	NORTHEAST	SOUTH	MIDWEST	WEST	NORTHEAST	SOUTH	MIDWEST	WEST
LOW DENSITY												
General Freight												
LTL	95.68	143.44	112.62	137.64	95.68	143.44	112.62	137.64	98.35	146.11	115.29	140.31
PTL	15.36	23.27	17.79	21.77	15.36	23.27	17.79	21.77	18.03	25.44	20.46	24.44
TL	9.66	11.00	14.30	13.33	9.66	11.00	14.30	13.33	12.33	13.67	16.97	16.00

	CONVENTIONAL SEMIS				SHORT HEAVY DOUBLES				TURNPIKE DOUBLES/HEAVY TRIPLES			
HIGH DENSITY	NORTHEAST	SOUTH	MIDWEST	WEST	NORTHEAST	SOUTH	MIDWEST	WEST	NORTHEAST	SOUTH	MIDWEST	WEST
General Freight	9.66	11.00	14.30	13.33	9.66	11.00	14.30	13.33	11.62	12.96	16.26	15.29
Private Truck	2.42	2.32	2.83	2.21	2.42	2.32	2.83	2.21	4.38	4.28	4.79	4.17
Exempt Carriers	2.42	2.32	2.83	2.21	2.42	2.32	2.83	2.21	3.85	3.75	4.26	2.21

* Special Commodity terminal costs are absorbed in line-haul costs.

2. DELAYS (hours)

		CONVENTIONAL SEMIS	LIGHT DOUBLES	HEAVY DOUBLES	TRIPLES
General Freight Carriers	LTL	52	28	-	30
	PTL	28	-	16	18
	TL	8	-	10	12
Exempt, Private and Special Commodity Carriers		2	-	4	6

TABLE D-12. PAYLOAD WEIGHTS (TONS)

TRUCK TYPE	FULL TRUCKLOAD AT INDICATED SINGLE AXLE/TANDEM AXLE/GCW LIMITS					PARTIAL TRUCKLOAD
	18/32/73	20/34/80	22/36/B	18/32/B	20/34/B	
Conventional Semi	22.70	25.06	25.95	22.30	24.31	13.25
Short Tandem Axle Double	22.70	25.06	31.30	30.50	31.50	13.25
Long Tandem Axle Double	32.74	34.74	37.25	32.48	34.48	13.25
Tandem Axle Triple	-	-	-	-	43.95	13.25

For low density commodities the full truckload payload equals:

(.9 x 2911 x Density)/2000 for conventional semis;

(.9 x 3470 x Density)/2000 for light doubles; and

(.9 x 5205 x Density)/2000 for light triples.

The partial truckload weight for low density commodities equals 40% of the full truckload weight.

The Single Axle/Tandem Axle/GCW limits are expressed in kips (thousand pounds). The presence of "B" in the expression indicates the use of a GCW limit determined by the application of a bridge formula, rather than the use of an arbritrary GCW limit.

complex. One reason for this is that there were two possible information sources, which were not entirely consistent. The first was the data on "percent loaded" by commodity listed in Table D-4. The second is the shipment size code listed for each non-agricultural shipment in the commodity flow data file. The first source pertains to trucks while the second pertains to shipments. These two do not have to be the same, especially for general freight carriers.

However, there was a second and even more perplexing difficulty. For simplicity it was assumed that there was one size of conventional semi, and one size of each of the other trucks. This is of course not true. There are other trailer lengths besides 45' and 27'. Similarly, within our commodity groups there is a range of densities rather than the single density used. Now suppose each record in the commodity flow data file showed the actual truck payload weight. Having decided what truck type carried the shipment in the base case, one could judge whether the truck was fully loaded by glancing at Table D-12. Such a procedure, however, would underestimate the number of fully loaded trucks because it would not take into account the occurrences of smaller truck capacities and/or high shipment densities that occur in the real world as compared to the study assumptions. Consequently this procedure would underestimate the effect of size and weight limit changes.

The way that these difficulties were met was as follows:

1) General Freight Carriage - Three shipment sizes, LTL, PTL and TL, whose boundaries were defined earlier, in Section 3, were used with the classification based on the CTS information. Forty percent of LTL and PTL shipments travel in full trucks, the rest in partially loaded trucks (40% is the "percent loaded" for LTL from Table D-4). The truckload shipments were also divided into two payload weight groups, based on the appropriate commodity's "percent loaded" figure. The

partial truckload weight, however, has to be higher than the figure in Table D-12, because it has to be at least as large as the shipment weight. A figure of 75% of the fully loaded payload weight was used.

2) Special Commodity Carriage - This was classified as PTL or TL according to the CTS data. PTL shipments were placed in partially loaded trucks and TL shipments in fully loaded trucks.

3) Private Truck - Here the CTS shipment weights were ignored completely and the "percent loaded" figures were used.

4) Exempt Carriage - All exempt carriers were assumed to use fully loaded trucks.

It was thought that private truckers were most likely to use nonstandard equipment sizes, tailored to their own requirements and that the CTS shipment weights could not be trusted for predicting which shipments were fully loaded. On the whole the procedure used here probably overstates the number of fully-loaded full-size trucks, but this is probably cancelled out by the unrepresented category of fully-loaded undersized trucks, so that the VMT changes in any alternative scenario are not biased.

7. Accumulating National Statistics by Carrier Group and Commodity

As a useful side-product, output statistics were produced at the national level retaining carrier group, commodity and some truck type detail. Tons, ton-miles, vehicle-miles, costs, ton-days and fuel consumption totals were produced for each scenario. The first four of these have already been discussed.

The ton-days are based on path-specific times, which are in turn based on the speeds of Table D-6, and on terminal area delays (Table D-11) that are specific to carrier group, shipment size and truck type. The line-haul time for private truck is slowed down to account for a lack of relief drivers, and is based on the assumption of 10 hours of driving time per day.

Fuel consumption was calculated as follows:

Total Fuel Consumption = FFxDISTxTYPExEBHxMODExBODY +

VFxTPVxDIST + TERMFC + REEF

These terms have the definition and parameter values indicated below:

FF - gallons of fuel consumed per empty vehicle mile for a conventional van semitrailer. This is the source of the "fuel consumption" contained in the path data file.

= .147 on level terrain

= .148 on hilly terrain

= .150 on mountainous terrain

DIST - distance

TYPE - factor for type of truck

= 1.00 for singles

= 1.05 for light doubles

= 1.09 for tandem axle double,

= 1.21 for light triples

= 1.45 for tandem axle triples

EBH - empty backhaul factor

= 1.12

MODE - carrier group factor

= 1.0 for general freight carriers

= 1.134 for all other carriers

BODY - body type factor

= 1.00 for vans

= 0.92 for flats

= 1.18 for auto carriers

VF - variable (with net tons) fuel consumption factor

= .0023 gallons per mile

TPV - tons per vehicle

TERMFC - terminal area fuel consumption

= 2 gal for special commodity, exempt and private carriers

= 8 gal for TL general freight

= 16 gal for PTL general freight

= 66 gal for LTL general freight

REEF - refrigeration unit fuel consumption

= 16.8 gallons per day

APPENDIX E: EQUATIONS FOR "TYPE 2" BASE CASE TRAFFIC ADJUSTMENTS TO ACCOUNT FOR RECENT STATE LIMIT CHANGES

Adjustments were made to the base case, type 2 traffic for the states, axle configurations, and weight blocks indicated for all highway types as follows:

Connecticut

Truck Type 5*

$$VMT'_9 = VMT_9 + VMT_8\ (.87)$$

$$VMT'_8 = 0$$

Truck Type 7

$$VMT'_9 = VMT_9 + VMT_8\ (.86)$$

$$VMT'_8 = 0$$

Truck Type 8

$$VMT'_9 = VMT_9 + VMT_8\ (.92)$$

$$VMT'_8 = 0$$

Truck Type 9

$$VMT'_9 = VMT_9 + VMT_8\ (.88)$$

$$VMT'_8 = 0$$

Truck Type 12

$$VMT'_9 = VMT_9 + VMT_8\ (.86)$$

$$VMT'_8 = 0$$

Truck Type 15

$$VMT'_9 = VMT_9 + VMT_8\ (.85)$$

$$VMT'_8 = 0$$

Maryland

Truck Type 5

$$VMT'_9 = VMT_9 + VMT_8\ (.87)$$

$$VMT'_8 = 0$$

Truck Type 7

$$VMT'_9 = VMT_9 + VMT_8\ (.86)$$

$$VMT'_8 = 0$$

---

*VMT_i = VMT in the ith weight block for a given truck and State before adjustment

VMT'_i = VMT in the ith weight block for given truck and State after adjustment

Weight block codes appear in Table F-1.

Truck axle type codes appear in Table F-2.

Maryland (Cont.)

Truck Type 9

$$VMT'_9 = VMT_9 + VMT_8 \, (.88)$$

$$VMT'_8 = 0$$

Truck Type 12

$$VMT'_9 = VMT_9 + VMT_8 \, (.86)$$

$$VMT'_8 = 0$$

Truck Type 15

$$VMT'_9 = VMT_9 + VMT_8 \, (.85)$$

$$VMT'_8 = 0$$

Pennsylvania

Truck Type 5

$$VMT'_9 = VMT_9 + VMT_8 \, (.87)$$

$$VMT'_8 = 0$$

Truck Type 7

$$VMT'_9 = VMT_9 + VMT_8 \, (.86)$$

$$VMT'_8 = 0$$

Truck Type 8

$$VMT'_9 = VMT_9 + VMT_8 \, (.92)$$

$$VMT'_8 = 0$$

Truck Type 9

$$VMT'_9 = VMT_9 + VMT_8 \, (.88)$$

$$VMT'_8 = 0$$

Truck Type 11

$$VMT'_9 = VMT_9 + VMT_8 \, (.85)$$

$$VMT'_8 = 0$$

Pennsylvania (Cont.)

Truck Type 12

$$VMT'_9 = VMT_9 + VMT_8\ (.86)$$

$$VMT'_8 = 0$$

Truck Type 15

$$VMT'_9 = VMT_9 + VMT_8\ (.85)$$

$$VMT'_8 = 0$$

Illinois

Truck Type 1

$$VMT'_4 = VMT'_4 + VMT_3\ (.91)\ (.18)$$

$$VMT'_3 = VMT_3\ (.82)$$

Truck Type 2

$$VMT'_5 = VMT_5\ (.68) + VMT_5\ (.93)\ (.32)$$

Truck Type 3

$$VMT'_6 = VMT_6 + VMT_5\ (.87)\ (.18)$$

$$VMT'_5 = VMT_5\ (.82)$$

Truck Type 4

$$VMT'_7 = VMT_7\ (.80) + VMT_7\ (.90)\ (.20)$$

Truck Type 5

$$VMT'_9 = VMT_9\ (.68) + VMT_9\ (.92)\ (.32)$$

Truck Type 6

$$VMT'_7 = VMT_7\ (.80) + VMT_7\ (.91)\ (.20)$$

Truck Type 7

$$VMT'_{11} = VMT_{11}\ (.68) + VMT_{11}\ (.92)\ (.32)$$

Truck Type 8

$$VMT'_8 = VMT_8 + VMT_7\ (.89)\ (.18)$$

$$VMT'_7 = VMT_7\ (.82)$$

Illinois (Cont.)

Truck Type 9

$$VMT'_{10} = VMT_{10} + VMT_9\ (.91)\ (.25)$$

$$VMT'_9 = VMT_9\ (.75)$$

Iowa

Truck Type 1

$$VMT'_4 = VMT_4 + VMT_3\ (.91)\ (.18)$$

$$VMT'_3 = VMT_3\ (.82)$$

Truck Type 2

$$VMT'_5 = VMT_5\ (.68) + VMT_5\ (.93)\ (.32)$$

Truck Type 3

$$VMT'_6 = VMT_6 + VMT_5\ (.87)\ (.18)$$

$$VMT'_5\ VMT_5\ (.82)$$

Truck Type 4

$$VMT'_7 = VMT_7\ (.80) + VMT_7\ (.90)\ (.20)$$

Truck Type 5

$$VMT'_9 = VMT_9 + VMT_8\ (.92)$$

$$VMT'_8 = 0$$

Truck Type 6

$$VMT'_7 = VMT_7\ (.80) + VMT_7\ (.91)\ (.20)$$

Truck Type 8

$$VMT'_8 = VMT_8 + VMT_7\ (.84)\ (.18)$$

$$VMT'_7 = VMT_7\ (.82)$$

Truck Type 12

$$VMT'_9 = VMT_9 + VMT_8\ (.86)$$

$$VMT'_8 = 0$$

Iowa (Cont.)

Truck Type 15

$$VMT'_9 = VMT_9 + VMT_8 (.85)$$

$$VMT'_8 = 0$$

APPENDIX F: EQUATIONS FOR "TYPE 2" BASE CASE TRAFFIC ADJUSTMENTS TO ACCOUNT FOR THE IMPACT OF BARRIER LIMIT SCENARIO CHANGES

Adjustments were made to the base case, type 2 traffic for the states, highway types, axle configurations and weight blocks indicated as follows:

Scenario - 2B, 4

Limit change from 18/32/73 to 20/34/80

Arkansas, Indiana, Mississippi, Missouri, Tennessee (All highway types)

Nebraska (Interstates only)

Truck Type 1*

$$VMT_4' = VMT_4 + VMT_3\ (.91)(.18)$$

$$VMT_3' = VMT_3\ (.82)$$

Truck Type 2

$$VMT_5' = VMT_5\ (.68) + VMT_5\ (.93)(.32)$$

Truck Type 3

$$VMT_6' = VMT_6 + VMT_5\ (.87)(.18)$$

$$VMT_5' = VMT_5\ (.82)$$

Truck Type 4

$$VMT_7' = VMT_7\ (.80) + VMT_7\ (.90)(.20)$$

Truck Type 5

$$VMT_9' = VMT_9 + VMT_8\ (.87)$$

$$VMT_8' = 0$$

---

*VMT_i = VMT in the ith weight block for a given truck and State before adjustment

VMT_i' = VMT in the ith weight block for a given truck and State after adjustment

Weight block codes appear in Table F-1

Truck axle type codes appear in Table F-2

Truck Type 6

$$VMT_7' = VMT_7\ (.80) + VMT_7(.91)(.20)$$

Truck Type 7

$$VMT_9' = VMT_9 + VMT_8\ (.86)$$

$$VMT_8' = 0$$

Truck Type 8

$$VMT_8' = VMT_8 + VMT_7\ (.89)(.18)$$

$$VMT_7' = VMT_7\ (.82)$$

Truck Type 9

$$VMT_9' = VMT_9 + VMT_8\ (.88)$$

$$VMT_8' = 0$$

Truck Type 10

$$VMT_9' = VMT_9 + VMT_8\ (.86)$$

$$VMT_8' = 0$$

Truck Type 11

$$VMT_9' = VMT_9 + VMT_8\ (.85)$$

$$VMT_8' = 0$$

Truck Type 12

$$VMT_9' = VMT_9 + VMT_8\ (.86)$$

$$VMT_8' = 0$$

Truck Type 13

$$VMT_9' = VMT_9 + VMT_8\ (.85)$$

$$VMT_8' = 0$$

Truck Type 14

$$VMT_9' = VMT_9 + VMT_8\ (.88)$$

$$VMT_8' = 0$$

Truck Type 15

$$VMT_9' = VMT_9 + VMT_8\ (.85)$$

$$VMT_8' = 0$$

Limit change from 20/34/73 to 20/34/80

Illinois (All highway types)

Truck Type 5

$$VMT_9' = VMT_9 + VMT_8\ (.87)$$

$$VMT_8' = 0$$

Truck Type 7

$$VMT_9' = VMT_9 + VMT_8\ (.86)$$

$$VMT_8' = 0$$

Truck Type 9

$$VMT_9' = VMT_9 + VMT_8\ (.88)$$

$$VMT_8' = 0$$

Truck Type 10

$$VMT_9' = VMT_9 + VMT_8\ (.86)$$

$$VMT_8' = 0$$

Truck Type 11

$$VMT_9' = VMT_9 + VMT_8\ (.85)$$

$$VMT_8' = 0$$

Truck Type 12

$$VMT'_9 = VMT_9 + VMT_8 \ (.86)$$

$$VMT'_8 = 0$$

Truck Type 13

$$VMT'_9 = VMT_9 + VMT_8 \ (.85)$$

$$VMT'_8 = 0$$

Truck Type 14

$$VMT'_9 = VMT_9 + VMT_8 \ (.88)$$

$$VMT'_8 = 0$$

Truck Type 15

$$VMT'_9 = VMT_9 + VMT_8 \ (.85)$$

$$VMT'_8 = 0$$

Limit change from 18/32/77 to 20/34/80

Montana (All highway types)

Truck Type 1

$$VMT'_4 = VMT_4 + VMT_3 \ (.91)(.18)$$

$$VMT'_3 = VMT_3 \ (.82)$$

Truck Type 2

$$VMT'_5 = VMT_5 \ (.68) + VMT_5 \ (.93)(.32)$$

Truck Type 3

$$VMT'_6 = VMT_6 + VMT_5 \ (.87)(.18)$$

$$VMT'_5 = VMT_5(.82)$$

Truck Type 4

$$VMT_7' = VMT_7\ (.80) + VMT_7\ (.90)(.20)$$

Truck Type 5

$$VMT_9' = VMT_9\ (.46) + VMT_9\ (.94)(.54)$$

Truck Type 6

$$VMT_7' = VMT_7(.80) + VMT_7(.91)(.20)$$

Truck Type 7

$$VMT_9' = VMT_9\ (.46) + VMT_9\ (.94)(.54)$$

Truck Type 8

$$VMT_8' = VMT_8 + VMT_7\ (.89)(.18)$$

$$VMT_7' = VMT_7\ (.82)$$

Truck Type 9

$$VMT_9' = VMT_9\ (.46) + VMT_9\ (.95)(.54)$$

Truck Type 10

$$VMT_9' = VMT_9\ (.46) + VMT_9\ (.94)(.54)$$

Truck Type 11

$$VMT_9' = VMT_9\ (.46) + VMT_9\ (.94)(.54)$$

Truck Type 12

$$VMT_9' = VMT_9\ (.46) + VMT_9\ (.94)(.54)$$

Truck Type 13

$$VMT_9' = VMT_9\ (.46) + VMT_9\ (.94)(.54)$$

Truck Type 14

$$VMT_9' = VMT_9\ (.46) + VMT_9\ (.95)(.54)$$

Truck Type 15

$$VMT_9' = VMT_9\ (.46) + VMT_9\ (.93)(.54)$$

Limit change from 18/32/bridge to 20/34/80

Michigan (Other primary, secondary, non-federal aid)

Truck Type 1

$$VMT_4' = VMT_4 + VMT_3\ (.91)(.18)$$

$$VMT_3' = VMT_3\ (.82)$$

Truck Type 2

$$VMT_5' = VMT_5\ (.68) + VMT_5\ (.93)(.32)$$

Truck Type 3

$$VMT_6' = VMT_6 + VMT_5\ (.87)(.18)$$

$$VMT_5' = VMT_5\ (.82)$$

Truck Type 4

$$VMT_7' = VMT_7\ (.80) + VMT_7\ (.90)(.20)$$

Truck Type 5

$$VMT_9' = VMT_9 + VMT_8\ (.87)$$

$$VMT_8' = 0$$

Truck Type 6

$$VMT_7' = VMT_7\ (.80) + VMT_7\ (.91)(.20)$$

Truck Type 8

$$VMT_8' = VMT_8 + VMT_7\ (.89)(.18)$$

$$VMT_7' = VMT_7\ (.82)$$

Scenario 6

Limit change from 18/32/73 to 22.4/36/bridge

Arkansas, Indiana, Mississippi, Missouri, Tennessee (All highway types)

Nebraska (Interstate only)

Truck Type 1

$$VMT_4' = VMT_4 + VMT_3\ (.83)(.18)$$

$$VMT_3' = VMT_3\ (.82)$$

Truck Type 2

$$VMT_5' = VMT_5\ (.68) + VMT_5\ (.87)(.32)$$

Truck Type 3

$$VMT_6' = VMT_6 + VMT_5\ (.75)(.18)$$

$$VMT_5' = VMT_5\ (.82)$$

Truck Type 4

$$VMT_8' = VMT_8 + VMT_7\ (.81)(.20)$$

$$VMT_7' = VMT_7\ (.80)$$

Truck Type 5

$$VMT_{10}' = VMT_{10} + VMT_8\ (.84)$$

$$VMT_8' = 0$$

Truck Type 6

$$VMT_8' = VMT_8 + VMT_7\ (.82)(.20)$$

$$VMT_7' = VMT_7\ (.80)$$

Truck Type 7

$$VMT_{12}' = VMT_{12} + VMT_8\ (.57)$$

$$VMT_8' = 0$$

Truck Type 8

$$VMT'_9 = VMT_9 + VMT_7\ (.79)(.18)$$

$$VMT'_7 = VMT_7\ (.82)$$

Truck Type 9

$$VMT'_{10} = VMT_{10} + VMT_8\ (.77)$$

$$VMT'_8 = 0$$

Truck Type 10

$$VMT'_{10} = VMT_{10} + VMT_8\ (.74)$$

$$VMT'_8 = 0$$

Truck Type 11

$$VMT'_{11} = VMT_{11} + VMT_8\ (.67)$$

$$VMT'_8 = 0$$

Truck Type 12

$$VMT'_{11} = VMT_{11} + VMT_8\ (.68)$$

$$VMT'_8 = 0$$

Truck Type 13

$$VMT'_{13} = VMT_{13} + VMT_8\ (.46)$$

$$VMT'_8 = 0$$

Truck Type 14

$$VMT'_{13} = VMT_{13} + VMT_8\ (.51)$$

$$VMT'_8 = 0$$

Truck Type 15

$$VMT'_{13} = VMT_{13} + VMT_8\ (.45)$$

$$VMT'_8 = 0$$

Limit change from 20/34/73 to 22.4/36/bridge

Illinois (All highway types)

Truck Type 1

$$VMT_4' = VMT_4\ (.80) + VMT_4\ (.90)(.20)$$

Truck Type 2

$$VMT_5' = VMT_5\ (.66) + VMT_5\ (.93)(.34)$$

Truck Type 3

$$VMT_6' = VMT_6\ (.80) + VMT_6\ (.86)(.20)$$

Truck Type 4

$$VMT_8' = VMT_8 + VMT_7\ (.90)(.27)$$

$$VMT_7' = VMT_7\ (.73)$$

Truck Type 5

$$VMT_{10}' = VMT_{10} + VMT_8\ (.84)$$

$$VMT_8' = 0$$

Truck Type 6

$$VMT_8' = VMT_8 + VMT_7\ (.91)(.27)$$

$$VMT_7' = VMT_7\ (.73)$$

Truck Type 7

$$VMT_{12}' = VMT_{12} + VMT_8\ (.57)$$

$$VMT_8' = 0$$

Truck Type 8

$$VMT_9' = VMT_9 + VMT_8\ (.89)(.67)$$

$$VMT_8' = VMT_8\ (.33)$$

Truck Type 9

$$VMT'_{10} = VMT_{10} + VMT_8\ (.77)$$

$$VMT'_8 = 0$$

Truck Type 10

$$VMT'_{10} = VMT_{10} + VMT_8\ (.74)$$

$$VMT'_8 = 0$$

Truck Type 11

$$VMT'_{11} = VMT_{11} + VMT_8\ (.67)$$

$$VMT'_8 = 0$$

Truck Type 12

$$VMT'_{11} = VMT_{11} + VMT_8\ (.68)$$

$$VMT'_8 = 0$$

Truck Type 13

$$VMT'_{13} = VMT_{13} + VMT_8\ (.46)$$

$$VMT'_8 = 0$$

Truck Type 14

$$VMT'_{13} = VMT_{13} + VMT_8\ (.51)$$

$$VMT'_8 = 0$$

Truck Type 15

$$VMT'_{13} = VMT_{13} + VMT_8\ (.45)$$

$$VMT'_8 = 0$$

Limit change from 18/32/77 to 22.4/36/bridge

Montana (All highway types)

Truck Type 1

$$VMT_4' = VMT_4 + VMT_3\ (.83)(.18)$$

$$VMT_3' = VMT_3\ (.82)$$

Truck Type 2

$$VMT_5' = VMT_5\ (.68) + VMT_5\ (.87)(.32)$$

Truck Type 3

$$VMT_6' = VMT_6 + VMT_5\ (.74)(.18)$$

$$VMT_5' = VMT_5\ (.82)$$

Truck Type 4

$$VMT_8' = VMT_8 + VMT_7\ (.81)(.20)$$

$$VMT_7' = VMT_7\ (.80)$$

Truck Type 5

$$VMT_{10}' = VMT_{10} + VMT_9\ (.91)(.54)$$

$$VMT_9' = VMT_9\ (.46)$$

Truck Type 6

$$VMT_8' = VMT_8 + VMT_7\ (.82)(.20)$$

$$VMT_7' = VMT_7\ (.80)$$

Truck Type 7

$$VMT_{12}' = VMT_{12} + VMT_9\ (.62)(.54)$$

$$VMT_9' = VMT_9\ (.46)$$

Truck Type 8

$$VMT_9' = VMT_9 + VMT_7\ (.79)(.18)$$

$$VMT_7' = VMT_7\ (.82)$$

Truck Type 9

$$VMT_{10}' = VMT_{10} + MVT_9\ (.83)(.54)$$

$$VMT_9' = VMT_9\ (.46)$$

Truck Type 10

$$VMT_{10}' = VMT_{10} + VMT_9\ (.81)(.54)$$

$$VMT_9' = VMT_9\ (.46)$$

Truck Type 11

$$VMT_{11}' = VMT_{11} + VMT_9\ (.74)(.54)$$

$$VMT_9' = VMT_9\ (.46)$$

Truck Type 12

$$VMT_{11}' = VMT_{11} + VMT_9\ (.74)(.54)$$

$$VMT_9' = VMT_9\ (.46)$$

Truck Type 13

$$VMT_{13}' = VMT_{13} + VMT_9\ (.50)(.54)$$

$$VMT_9' = VMT_9\ (.46)$$

Truck Type 14

$$VMT_{13}' = VMT_{13} + VMT_9\ (.55)(.54)$$

$$VMT_9' = VMT_9\ (.46)$$

Truck Type 15

$$VMT'_{13} = VMT_{13} + VMT_9\ (.50)(.54)$$

$$VMT'_9 = VMT_9\ (.46)$$

<u>Limit Change from 18/32/bridge to 22.4/36/bridge</u>

<u>Michigan (Other primary, secondary, non-federal aid)</u>

Truck Type 1

$$VMT'_4 = VMT_4 + VMT_3\ (.83)(.18)$$

$$VMT'_3 = VMT_3\ (.82)$$

Truck Type 2

$$VMT'_5 = VMT_5\ (.68) + VMT_5\ (.87)(.32)$$

Truck Type 3

$$VMT'_6 = VMT_6 + VMT_5\ (.74)(.18)$$

$$VMT'_5 = VMT_5\ (.82)$$

Truck Type 4

$$VMT'_8 = VMT_8 + VMT_7\ (.81)(.20)$$

$$VMT'_7 = VMT_7\ (.80)$$

Truck Type 5

$$VMT'_{10} = VMT_{10} + VMT_8\ (.84)$$

$$VMT'_8 = 0$$

Truck Type 6

$$VMT'_8 = VMT_8 + VMT_7\ (.82)(.20)$$

$$VMT'_7 = VMT_7\ (.80)$$

Truck Type 7

$$VMT'_{12} = VMT_{12} + VMT_{11}\ (.84)(.40)$$

$$VMT'_{11} = VMT_{11}\ (.60)$$

Truck Type 8

$$VMT_9' = VMT_9 + VMT_7 (.79)(.18)$$

$$VMT_7' = VMT_7 (.82)$$

Truck Type 9

$$VMT_{10}' = VMT_{10} (.80) + VMT_{10} (.91)(.20)$$

Truck Type 10

$$VMT_{10}' = VMT_{10} (.80) + VMT_{10} (.89)(.20)$$

Truck Type 11

$$VMT_{11}' = VMT_{11} + VMT_{10} (.93)(.44)$$

$$VMT_{10}' = VMT_{10} (.56)$$

Truck Type 12

$$VMT_{11}' = VMT_{11} + VMT_{10} (.94)(.44)$$

$$VMT_{10}' = VMT_{10} (.56)$$

Truck Type 13

$$VMT_{13}' = VMT_{13} (.42) + VMT_{13} (.95)(.58)$$

Truck Type 14

$$VMT_{13}' = VMT_{13} (.42) + VMT_{13} (.96)(.58)$$

Truck Type 15

$$VMT_{13}' = VMT_{13} (.90) + VMT_{13} (.90)(.10)$$

<u>Limit change from 20/34/bridge to 22.4/36/bridge</u>

<u>Michigan (Interstate only)</u>

Truck Type 1

$$VMT_4' = VMT_4 (.80) + VMT_4 (.90)(.20)$$

Truck Type 2

$$VMT_5' = VMT_5 (.66) + VMT_5 (.93)(.34)$$

Truck Type 3

$$VMT'_6 = VMT_6\ (.80) + VMT_6\ (.86)(.20)$$

Truck Type 4

$$VMT'_7 = VMT_7 + VMT_6\ (.90)(.27)$$

$$VMT'_6 = VMT_6\ (.73)$$

Truck Type 5

$$VMT'_{10} = VMT_{10} + VMT_9\ (.96)(.57)$$

$$VMT'_9 = VMT_9\ (.43)$$

Truck Type 6

$$VMT'_7 = VMT_7 + VMT_6\ (.91)(.27)$$

$$VMT'_6 = VMT_6\ (.73)$$

Truck Type 7

$$VMT'_{12} = VMT_{12} + VMT_{11}\ (.92)(.50)$$

$$VMT'_{11} = VMT_{11}\ (.50)$$

Truck Type 8

$$VMT'_9 = VMT_9 + VMT_8\ (.89)(.67)$$

$$VMT'_8 = VMT_8\ (.33)$$

Truck Type 9

$$VMT'_{10} = VMT_{10}\ (.57) + VMT_{10}\ (.97)(.43)$$

Truck Type 10

$$VMT'_{10} = VMT_{10}\ (.57) + VMT_{10}\ (.96)(.43)$$

Truck Type 11

$$VMT'_{11} = VMT_{11}\ (.90) + VMT_{11}\ (.97)(.10)$$

Truck Type 12

$$VMT'_{11} = VMT_{11}\ (.90) + VMT_{11}\ (.97)(.10)$$

Truck Type 13

$$VMT'_{13} = VMT_{13}\ (.41) + VMT_{13}\ (.98)(.59)$$

Truck Type 14

$$VMT'_{13} = VMT^{1}_{13}\ (.41) + VMT_{13}\ (.98)(.59)$$

Truck Type 15

$$VMT'_{15} = VMT_{15}\ (.50) + VMT_{13}\ (.94)(.50)$$

<u>Limit change from 20/34/80 to 22.4/36/bridge</u>

<u>Arizona, California, Idaho, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Nevada, N. Dakota, Ohio, Oklahoma, Oregon, S. Dakota, Texas, Utah, Washington, W. Virginia, Wisconsin, (All highway types)</u>

<u>Nebraska (Other primary, secondary, non-federal aid)</u>

Truck Type 1

$$VMT'_{4} = VMT_{4}\ (.80) + VMT_{4}\ (.90)(.20)$$

Truck Type 2

$$VMT'_{5} = VMT_{5}\ (.66) + VMT_{5}\ (.93)(.34)$$

Truck Type 3

$$VMT'_{6} = VMT_{6}\ (.80) + VMT_{6}\ (.86)(.20)$$

Truck Type 4

$$VMT'_{8} = VMT_{8} + VMT_{7}\ (.90)(.27)$$

$$VMT'_{7} = VMT_{7}\ (.73)$$

Truck Type 5

$$VMT'_{10} = VMT_{10} + VMT_{9}\ (.96)(.57)$$

$$VMT'_{9} = VMT_{9}\ (.43)$$

Truck Type 6

$$VMT_8' = VMT_8 + VMT_7\ (.91)(.27)$$

$$VMT_7' = VMT_7\ (.73)$$

Truck Type 7

$$VMT_{12}' = VMT_{12} + VMT_9\ (.66)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 8

$$VMT_9' = VMT_9 + VMT_8\ (.89)(.67)$$

$$VMT_8' = VMT_8\ (.33)$$

Truck Type 9

$$VMT_{10}' = VMT_{10} + VMT_9\ (.88)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 10

$$VMT_{10}' = VMT_{10} + VMT_9\ (.86)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 11

$$VMT_{11}' = VMT_{11} = VMT_9\ (.79)(.57)$$

$$VMT_9' = VMT_9 = (.43)$$

Truck Type 12

$$VMT_{11}' = VMT_{11} + VMT_9\ (.79)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 13

$$VMT_{13}' = VMT_{13} + VMT_9\ (.54)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 14

$$VMT'_{13} = VMT_{13} + VMT_9\ (.58)(.57)$$

$$VMT'_9 = VMT_9\ (.43)$$

Truck Type 15

$$VMT'_{13} = VMT_{13} + VMT_9\ (.53)(.57)$$

$$VMT'_9 = VMT_9\ (.43)$$

<u>Limit change from 20/36/80 to 22.4/36/bridge</u>

<u>Colorado, Wyoming (All highway types)</u>

Truck Type 1

$$VMT'_4 = VMT_4\ (.80) + VMT_4\ (.90)(.20)$$

Truck Type 3

$$VMT'_6 = VMT_6\ (.80) + VMT_6\ (.86)(.20)$$

Truck Type 4

$$VMT'_8 = VMT_8 + VMT_7\ (.95)(.20)$$

$$VMT'_7 = VMT_7\ (.80)$$

Truck Type 5

$$VMT'_{10} = VMT_{10} + VMT_9\ (.96)(.57)$$

$$VMT'_9 = VMT_9\ (.43)$$

Truck Type 6

$$VMT'_8 = VMT_8 + VMT_7\ (.78)(.20)$$

$$VMT'_7 = VMT_7\ (.80)$$

Truck Type 7

$$VMT'_{12} = VMT_{12} + VMT_9\ (.66)(.57)$$

$$VMT'_9 = VMT_9\ (.43)$$

Truck Type 8

$$VMT_9' = VMT_9 + VMT_8\ (.89)(.57)$$

$$VMT_8' = VMT_8\ (.43)$$

Truck Type 9

$$VMT_{10}' = VMT_{10} + VMT_9\ (.88)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 10

$$VMT_{10}' = VMT_{10} + VMT_9\ (.86)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 11

$$VMT_{11}' = VMT_{11} + VMT_9\ (.79)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 12

$$VMT_{11}' = VMT_{11} + VMT_9\ (.79)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 13

$$VMT_{13}' = VMT_{13} + VMT_9\ (.54)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 14

$$VMT_{13}' = VMT_{13} + VMT_9\ (.58)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 15

$$VMT_{13}' = VMT_{13} + VMT_9\ (.53)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Limit change from 21.6/34/86 to 22.4/36/bridge

New Mexico (All highway types)

Truck Type 1

$$VMT_4' = VMT_4\ (.78) + VMT_4\ (.97)(.22)$$

Truck Type 2

$$VMT_5' = VMT_5\ (.66) + VMT_5\ (.93)(.34)$$

Truck Type 3

$$VMT_6' = VMT_6\ (.78) + VMT_6\ (.95)(.22)$$

Truck Type 4

$$VMT_7' = VMT_7 + VMT_6\ (.94)(.28)$$

$$VMT_6' = VMT_6\ (.72)$$

Truck Type 5

$$VMT_{10}' = VMT_{10} + VMT_9\ (.96)(.57)$$

$$VMT_9' = VMT_9\ (.43)$$

Truck Type 6

$$VMT_7' = VMT_7 + VMT_6\ (.94)(.28)$$

$$VMT_6' = VMT_6\ (.72)$$

Truck Type 7

$$VMT_{12}' = VMT_{12} + VMT_{10}\ (.74)(.43)$$

$$VMT_{10}' = VMT_{10}\ (.57)$$

Truck Type 8

$$VMT_{10}' = VMT_{10} + VMT_9\ (.96)(.31)$$

$$VMT_9' = VMT_9\ (.69)$$

Truck Type 9

$$VMT'_{10} = VMT_{10}\ (.57) + VMT_{10}\ (.97)(.43)$$

Truck Type 10

$$VMT'_{10} = VMT_{10}\ (.57) + VMT_{10}\ (.96)(.43)$$

Truck Type 11

$$VMT'_{11} = VMT_{11} + VMT_{10}\ (.88)(.43)$$

$$VMT'_{10} = VMT_{10}\ (.57)$$

Truck Type 12

$$VMT'_{11} = VMT_{11} + VMT_{10}\ (.89)(.43)$$

$$VMT'_{10} = VMT_{10}\ (.57)$$

Truck Type 13

$$VMT'_{13} = VMT_{13} + VMT_{10}\ (.61)(.43)$$

$$VMT'_{10} = VMT_{10}\ (.57)$$

Truck Type 14

$$VMT'_{13} = VMT_{13} + VMT_{10}\ (.64)(.43)$$

$$VMT'_{10} = VMT_{10}\ (.57)$$

Truck Type 15

$$VMT'_{13} = VMT_{13} + VMT_{10}\ (.60)(.43)$$

$$VMT'_{10} = VMT_{10}\ (.57)$$

Scenario 9,10

Limit change from 18/32/73 to 20/34/bridge

Arkansas, Indiana, Mississippi, Missouri, Tennessee (All highway types)

Nebraska (Interstate only)

Truck Type 1

$$VMT_4' = VMT_4 + VMT_3 (.91)(.18)$$

$$VMT_3' = VMT_3 (.82)$$

Truck Type 2

$$VMT_5' = VMT_5 (.68) + VMT_5 (.93)(.32)$$

Truck Type 3

$$VMT_6' = VMT_6 + VMT_5 (.87)(.18)$$

$$VMT_5' = VMT_5 (.82)$$

Truck Type 4

$$VMT_7' = VMT_7 (.80) + VMT_7 (.90)(.20)$$

Truck Type 5

$$VMT_9' = VMT_9 + VMT_8 (.87)$$

$$VMT_8' = 0$$

Truck Type 6

$$VMT_7' = VMT_7 (.80) + VMT_7 (.91)(.20)$$

Truck Type 7

$$VMT_{11}' = VMT_{11} + VMT_8 (.62)$$

$$VMT_8' = 0$$

Truck Type 8

$$VMT_8' = VMT_8 + VMT_7\ (.89)(.18)$$

$$VMT_7' = VMT_7\ (.82)$$

Truck Type 9

$$VMT_{10}' = VMT_{10} + VMT_8\ (.80)$$

$$VMT_8' = 0$$

Truck Type 10

$$VMT_{10}' = VMT_{10} + VMT_8\ (.76)$$

$$VMT_8' = 0$$

Truck Type 11

$$VMT_{11}' = VMT_{11} + VMT_8\ (.69)$$

$$VMT_8' = 0$$

Truck Type 12

$$VMT_{11}' = VMT_{11} + VMT_8\ (.70)$$

$$VMT_8' = 0$$

Truck Type 13

$$VMT_{13}' = VMT_{13} + VMT_8\ (.47)$$

$$VMT_8' = 0$$

Truck Type 14

$$VMT_{13}' = VMT_{13} + VMT_8\ (.52)$$

$$VMT_8' = 0$$

Truck Type 15

$$VMT_{13}' = VMT_{13} + VMT_8\ (.40)$$

$$VMT_8' = 0$$

Limit change from 20/34/73 to 20/34/bridge

Illinois (All highway types)

Truck Type 5

$$VMT'_9 = VMT_9 + VMT_8\ (.87)$$

$$VMT'_8 = 0$$

Truck Type 7

$$VMT'_{11} = VMT_{11} + VMT_8\ (.78)$$

$$VMT'_8 = 0$$

Truck Type 9

$$VMT'_{10} = VMT_{10} + VMT_8\ (.80)$$

$$VMT'_8 = 0$$

Truck Type 10

$$VMT'_{10} = VMT_{10} + VMT_8\ (.76)$$

$$VMT'_8 = 0$$

Truck Type 11

$$VMT'_{11} = VMT_{11} + VMT_8\ (.69)$$

$$VMT'_8 = 0$$

Truck Type 12

$$VMT'_{11} = VMT_{11} + VMT_8\ (.70)$$

$$VMT'_8 = 0$$

Truck Type 13

$$VMT'_{13} = VMT_{13} + VMT_8\ (.47)$$

$$VMT'_8 = 0$$

Truck Type 14

$$VMT'_{13} = VMT_{13} + VMT_8\ (.52)$$

$$VMT'_8 = 0$$

Truck Type 15

$$VMT'_{13} = VMT_{13} + VMT_8\ (.48)$$

$$VMT'_8 = 0$$

Limit change from 18/32/77 to 20/34/bridge

Montana (All highway types)

Truck Type 1

$$VMT'_4 = VMT_4 + VMT_3\ (.91)(.18)$$

$$VMT'_3 = VMT_3\ (.82)$$

Truck Type 2

$$VMT'_5 = VMT_5\ (.68) + VMT_5\ (.93)(.32)$$

Truck Type 3

$$VMT'_7 = VMT_7 + VMT_6\ (.87)(.18)$$

$$VMT'_6 = VMT_6\ (.82)$$

Truck Type 4

$$VMT'_7 = VMT_7\ (.80) + VMT_7\ (.90)(.20)$$

Truck Type 5

$$VMT'_9 = VMT_9\ (.46) + VMT_9\ (.94)(.54)$$

Truck Type 6

$$VMT'_7 = VMT_7\ (.80) + VMT_7\ (.91)(.20)$$

Truck Type 7

$$VMT'_{11} = VMT_{11} + VMT_9\ (.68)(.54)$$

$$VMT'_9 = VMT_9\ (.46)$$

Truck Type 8

$$VMT_8' = VMT_8 + VMT_7 (.89)(.18)$$

$$VMT_7' = VMT_7 (.82)$$

Truck Type 9

$$VMT_{10}' = VMT_{10} + VMT_9 (.86)(.54)$$

$$VMT_9' = VMT_9 (.46)$$

Truck Type 10

$$VMT_{10}' = VMT_{10} + VMT_9 (.84)(.54)$$

$$VMT_9' = VMT_9 (.46)$$

Truck Type 11

$$VMT_{11}' = VMT_{11} + VMT_9 (.76)(.54)$$

$$VMT_9' = VMT_9 (.46)$$

Truck Type 12

$$VMT_{11}' = VMT_{11} + VMT_9 (.77)(.54)$$

$$VMT_9' = VMT_9 (.46)$$

Truck Type 13

$$VMT_{13}' = VMT_{13} + VMT_9 (.52)(.54)$$

$$VMT_9' = VMT_9 (.46)$$

Truck Type 14

$$VMT_{13}' = VMT_{13} + VMT_9 (.56)(.54)$$

$$VMT_9' = VMT_9 (.46)$$

Truck Type 15

$$VMT_{13}' = VMT_{13} + VMT_9 (.53)(.54)$$

$$VMT_9' = VMT_9 (.46)$$

Limit change from 18/32/bridge to 20/34/bridge

Michigan (Other primary, secondary, non-federal aid)

Truck Type 1

$$VMT_4' = VMT_4 + VMT_3\ (.91)(.18)$$

$$VMT_3' = VMT_3\ (.82)$$

Truck Type 2

$$VMT_5' = VMT_5\ (.68) + VMT_5\ (.93)(.32)$$

Truck Type 3

$$VMT_6' = VMT_6 + VMT_5\ (.87)(.18)$$

$$VMT_5' = VMT_5\ (.82)$$

Truck Type 4

$$VMT_7' = VMT_7\ (.80) + VMT_7\ (.90)(.20)$$

Truck Type 5

$$VMT_9' = VMT_9 + VMT_8\ (.87)$$

$$VMT_8' = 0$$

Truck Type 6

$$VMT_7' = VMT_7\ (.80) + VMT_7\ (.91)(.20)$$

Truck Type 7

$$VMT_{12}' = VMT_{12} + VMT_{11}\ (.92)(.40)$$

$$VMT_{11}' = VMT_{11}\ (.60)$$

Truck Type 8

$$VMT_8' = VMT_8 + VMT_7\ (.89)(.18)$$

$$VMT_7' = VMT_7\ (.82)$$

Truck Type 9

$$VMT'_{10} = VMT_{10}\ (.80) + VMT_{10}\ (.94)(.20)$$

Truck Type 10

$$VMT'_{10} = VMT_{10}\ (.80) + VMT_{10}\ (.93)(.20)$$

Truck Type 11

$$VMT'_{11} = VMT_{11} + VMT_{10}\ (.97)(.44)$$

$$VMT'_{10} = VMT_{10}\ (.56)$$

Truck Type 12

$$VMT'_{11} = VMT_{11} + VMT_{10}\ (.97)(.44)$$

$$VMT'_{10} = VMT_{10}\ (.56)$$

Truck Type 13

$$VMT'_{13} = VMT_{13}\ (.42) + VMT_{13}\ (.98)(.58)$$

Truck Type 14

$$VMT'_{13} = VMT_{13}\ (.42) + VMT_{13}\ (.98)(.58)$$

Truck Type 15

$$VMT'_{13} = VMT_{13}\ (.90) + VMT_{13}\ (.95)(.10)$$

TABLE F-1. WEIGHT BLOCK CODES

WEIGHT BLOCK NUMBER	WEIGHT INTERVAL (POUNDS)
1	≤ 10,000
2	10,001 - 20,000
3	20,001 - 30,000
4	30,001 - 40,000
5	40,001 - 50,000
6	50,001 - 60,000
7	60,001 - 70,000
8	70,001 - 73,280
9	73,281 - 80,000
10	80,001 - 90,000
11	90,001 - 100,000
12	100,001 - 110,000
13	110,001 - 120,000
14	120,001 - 130,000
15	> 130,000

TABLE F-2. TRUCK AXLE CODES

TRUCK AXLE CODE NUMBER	TRUCK AXLE CONFIGURATION
1	2 Axle, 6 Tired Single Unit
2	3 Axle Single Unit
3	2S1
4	2S2
5	3S2
6	Other 4 Axle Semi Trailer
7	6^+ Axle Semi Trailer
8	2-2
9	2-3, 3-2
10	2S1-2
11	3S1-2, 3+S1-2
12	Other Truck Trailer Doubles
13	All S1-2-2
14	Truck and Two Trailers
15	All Other Combinations

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