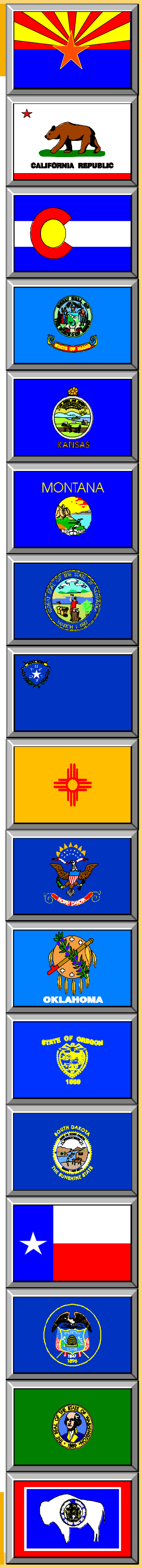
Final Report ..... Phase II

WESTERN TRANSPORTATION TRADE NETWORK - WTTN



1999

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Chapter 1
INTRODUCTION AND OVERVIEW

The Western Transportation Trade Network (WTTN) is a surface freight transportation concept which seeks to enhance the economic prosperity of the 17 western U.S. states. The WTTN concept was developed by the Western Association of State Highway and Transportation Officials (WASHTO) and, to date, has comprised a two-phase study:

- *Phase I* – Completed May 9, 1997, WTTN Phase I explained the WTTN concept, identified freight transportation systems and commodity movements throughout the WTTN states, identified and described the WTTN network (20 multimodal trade corridors), and identified trade corridor issues and needs. Phase I is a separately bound report volume dated 1997.
- *Phase II* – This second phase was completed in July 1999 and is summarized in this report document. The Phase II work builds upon the results of Phase I and focuses on the specific highways, rail lines, ports, waterways, airports, COFC/TOFC facilities and grain elevators within the 20 designated WTTN Trade Corridors. Freight transportation performance is evaluated, and deficiencies are identified from the freight transportation perspective.

WASHTO SUPPORT FOR WTTN

The WTTN concept was born in 1994, via the WASHTO Standing Committee on Planning, and as endorsed by the CAOs of the 17 states (Resolution 94-1).

In 1994, WASHTO established the WTTN mission, as follows:

WTTN Mission Statement

The purpose of WTTN is to promote economic growth and to maximize regional trade opportunities among Canada, the United States, and Mexico by defining and implementing a multimodal transportation and trade network.[1]

[1] "Western Transportation Trade Network Concept Paper," WASHTO Standing Committee on Planning, March 1994.

Within the context of that mission statement, WTTN was charged by WASHTO with four specific objectives:[2]

1. Develop a coalition of state DOTs and utilize the input of other interested parties, including private sector and non-profit organizations, to develop a multimodal transportation trade network in the western U.S.
2. Collect an adequate level of information on trade and its impact on the transportation system, in order to forecast and address network deficiencies and needs.
3. Develop a standardized database of information to support network investment decisions, which is compatible with GIS interface, related to transportation and trade in the western U.S.
4. Define performance objectives of the multimodal transportation and trade network and identify performance measures descriptive of the network.

The focus of WTTN is therefore trade, both domestic and international. Trade, as defined herein, refers to freight movement by surface transportation (trucking, railroads, waterways), and access to intermodal facilities such as ports, airports and intermodal container terminals.

TWO-PHASE WTTN STUDY

To attain the WTTN objectives, a two-phase WTTN study was designed.

WTTN Phase I – The Phase I study had three objectives:

1. Explore trade and freight transportation throughout the western U.S. and, based on these assessments, identify a multimodal transportation trade network for the western U.S. (the WTTN trade network);
2. Examine that defined WTTN trade network (rail lines, highways, intermodal facilities) and identify transportation infrastructure deficiencies that are adversely affecting trade and freight transportation; and

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[2] Resolution 94-1, Annual CAO Workshop, WASHTO, March 26, 1994.

3. Demonstrate that a regional (multi-state) approach to WTTN corridors, to freight transportation issues, and to WTTN trade network needs and opportunities, has merit.

The Phase I work was successfully completed in 1997. Based on that work, the WASHTO states decided to proceed with the Phase II work.

WTTN Phase II – The Phase II work was designed to address four subjects, comprising Tasks 1 through 4:

- *Task 1: WTTN Performance Objectives* – Identify performance objectives for each of the WTTN Trade Corridors. These are to be goals, from the freight industry's perspective, for suggestion to the individual states.
- *Task 2: Existing WTTN Corridor Performance* – Determine how well each WTTN trade network route is currently performing as compared with the Task 1 performance objectives. A comparison of goals and actual performance would yield a set of "deficiencies."
- *Task 3: General Nature of Benefits and Potential Solutions* – Identify a "menu of solutions" that could be considered to help achieve the goals and qualitatively explain the benefit types that might occur if the deficiencies were overcome.
- *Task 4: Identify Intermodal Facilities and Their Access* – Identify such intermodal facilities as water ports, railroad TOFC/COFC facilities, reload facilities, grain elevators and airports that are of significance to the WTTN corridors. Identify intermodal issues and deficiencies.

The WTTN states contracted with a consultant team[3] led by Wilbur Smith Associates to assist with the development of the WTTN Phase II study.

PHASE II STUDY SPONSORS

The WTTN Phase II study was sponsored by the western states and the U.S. Department of Transportation.

[3] Wilbur Smith Associates and Felsburg Holt & Ullevig.

Participating States – Thirteen states chose to sponsor the WTTN Phase II study, as represented by their state transportation agency:

- Arizona Department of Transportation
- California Department of Transportation
- Colorado Department of Transportation
- Idaho Department of Transportation
- Montana Department of Transportation
- New Mexico State Highway and Transportation Department
- North Dakota Department of Transportation
- Oregon Department of Transportation
- South Dakota Department of Transportation
- Texas Department of Transportation
- Utah Department of Transportation
- Washington State Department of Transportation
- Wyoming Department of Transportation

All participating states provided ideas, guidance, and data. The study's results reflect a general consensus of the states, but should not be assumed to reflect the specific positions or policies of any specific state. This is because some states might disagree with certain items contained in this report, and no state was asked to approve or adopt the report. Instead, the report as written reflects the consultant team's work, with certain data and guidance inputs provided by the states.

Lead State – One state was elected by the participating states to administer both phases of the study effort, and to serve as contract manager. This role was served by the Colorado Department of Transportation.

Federal Role – The study was supported in principle and supported financially by the U.S. Department of Transportation.

THE WTTN TRADE CORRIDOR NETWORK

A cornerstone of the WTTN program is the identification of the trade network itself. Phase I addressed that issue and identified a WTTN trade network. Phase II refined the Phase I findings and made a number of changes to that defined WTTN network.

Characteristics of a WTTN Trade Corridor

In identifying the WTTN trade corridor network, the participating states addressed such example issues as:

- What is a trade corridor?
- How is it defined?
- Are there many such trade corridors in the western states?
- What are the implications of one corridor being designated a trade corridor, and another corridor not being so designated?
- What is a trade network?

After considerable reflection and discussion among the states, the characteristics of a trade corridor became evident. It was determined that a trade corridor should:

- Be multi-state in nature
- Connect significant end points
- Be a wide, multimodal corridor
- Not be highway – or rail line-specific
- Carry regionally significant freight
- Serve intermodal facilities
- Serve international border crossings
- Serve important economic centers
- Include selected NHS highways

- Include selected railroad main lines
- Reflect future trade expectations
- Connect with out-of-region corridors, and
- Comprise all movement directions.

In discussions with the participating states, it was decided that, because the WTTN Mission Statement and Objectives called for a single trade network, a single WTTN network, together with a multimodal "supporting network," should be designated. In this way, all rail lines, and the entire National Highway System (NHS), would be included, at least in the supporting system. This WTTN network and its supporting system were defined as follows:

> Multimodal Transportation Trade Network (WTTN) – A system of broad geographic bands connecting major endpoints over which regionally-significant interstate freight is carried by one or more modes. These modes are confined to road, waterway and rail. Excluded are pipelines and air cargo.
>
> Supporting Transportation System – Comprises the remaining highway, rail, air, and other systems within the western region. The supporting system includes all other highways on the NHS, all rail lines, the region's intermodal facilities, ports, airports, and other freight transportation facilities.

These definitions were made to allow the identification of regional freight corridors throughout the WTTN region; they were not intended to concentrate only on the states with high volume freight corridors. The mode of transportation was also not identified in these definitions. Some corridors may have only one surface mode while others may have any combination of road, rail, and waterway routes within them.

Trade Corridor Identification Process

Based on the corridor characteristics and the network definitions, a six-step process was followed in Phase I whereby the trade corridors were identified. This process was as follows:

- States provided previous state-specific freight corridor designations, criteria used, and data that might be useful.
- The consultant reviewed that material, and submitted to the states a procedure, a set of criteria, and a set of definitions to be used to identify a preliminary set of trade corridors.
- The states used those procedures and criteria, plus other materials and/or criteria that the state believed important, and identified preliminary sets of freight corridors within the state's boundaries. These preliminary lists of corridors were sent to the consultant.
- The consultant reviewed each state's corridor designations, and identified contradictions and conflicts that may exist between states.
- The consultant depicted the rationalized results on suitable mapping and descriptive material.
- The participating states met to review the results and to finalize the WTTN Trade Corridor designations.

Several states desired additional corridors; however, to make certain the trade corridor criteria were consistently applied, only those agreed upon by the states were included.

The list of 20 WTTN Trade Corridors identified in Phase I was slightly modified by the states in Phase II. Two corridors (#17 and 18) were combined into one (Mexico – Canada/Midwest) and a new corridor was added along U.S. 59 (Laredo – Indianapolis). These changes were made to better reflect commodity flows between Mexico and the Upper Midwest and to recognize an important corridor (U.S. 59) that had been left off the list of WTTN corridors during Phase I pending results of a feasibility study.

The 20 WTTN Trade Corridors

The 20 trade corridors which now comprise the WTTN trade network are shown on Exhibit 1-1. These generalized corridor bands are typically multimodal, typically multi-state, and cover the entire 17-state region. Every state has two or more such corridors.

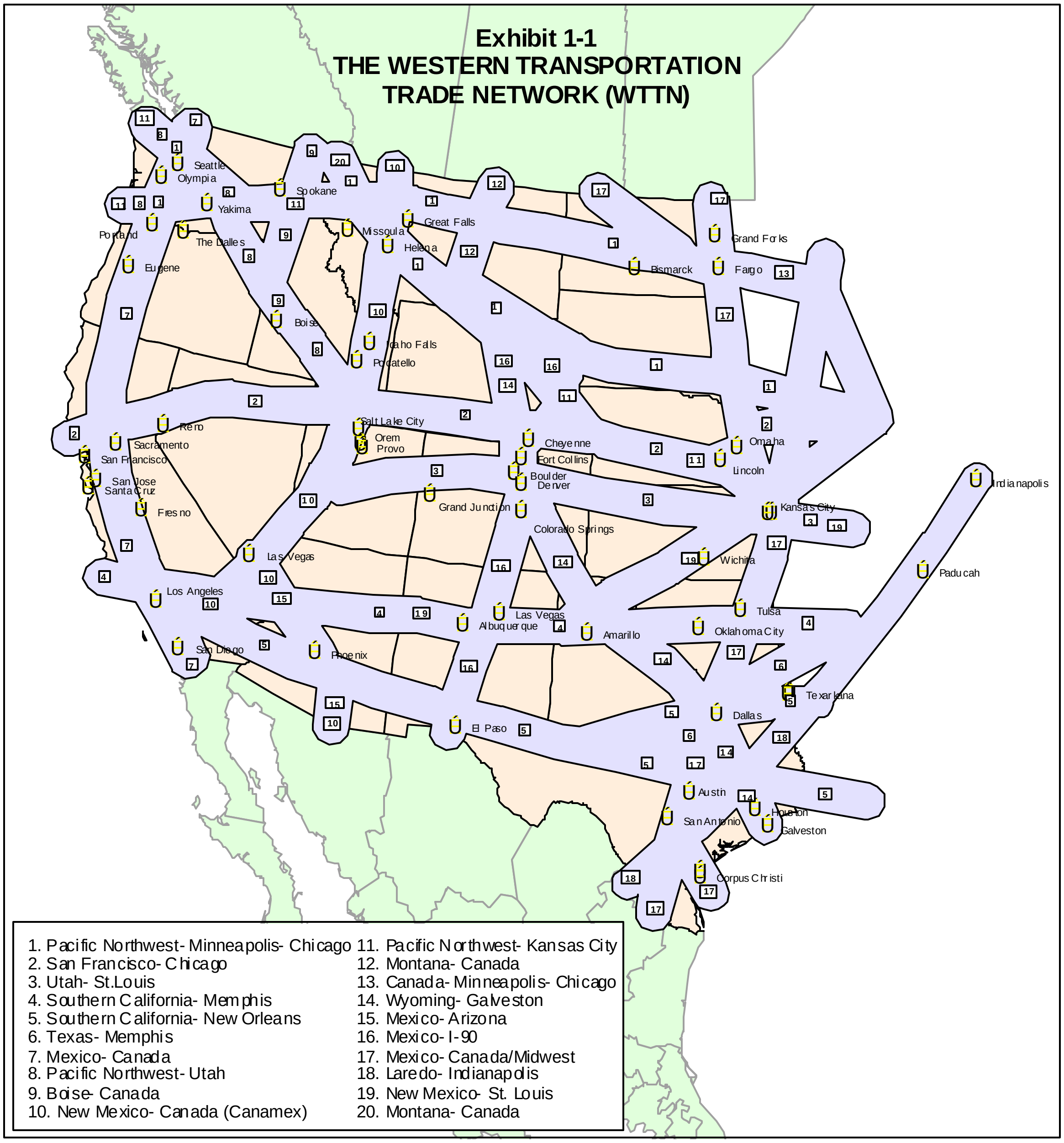


Exhibit 1-1
THE WESTERN TRANSPORTATION TRADE NETWORK (WTTN)

CONCLUSIONS FROM PHASE I

The Phase II effort builds upon the results of Phase I. The key conclusions from Phase I concerning the trade corridors are as follows.

WTTN Trade Corridor Conclusions from Phase I

Considerable effort was expended to identify the major trade corridors of the western U.S. This designation process yielded a number of trade corridor conclusions, including:

- The trade corridors are all multi-state and/or international in nature. Cooperative and coordinated multi-state approaches to the transportation corridors may therefore have merit and may in fact be essential.
- While some trade corridors dominate in terms of tonnage moved or value handled, everything is relative. On a proportionate basis, a less used corridor in a sparsely populated state could be relatively more economically significant to that state than is a heavily traveled route in a heavily populated state. Hence, there is a need for trade corridor designations throughout the western U.S.
- The interrelationships in trade movements suggest that it is too simplistic to regard trade as comprising a series of individual trade corridors. Instead, as is the case with passenger transportation, the WTTN is a true "trade network" – just as the name implies.
- Because so much freight moves between states, deficiencies or activities in one state can affect trade activities in another state. Therefore, regional (multi-state) approaches and sharing of information between states are important to the creation of an efficient regional freight system.
- Trade generally moves from origin to destination without regard for state and even international borders. The private sector makes its plans and carries its freight with little attention to such boundaries. States, however, tend to be constrained by such boundaries since their planning and funding is limited to their single state. Improved decisions regarding multi-state trade would be possible if the states were able to develop multi-state trade corridor planning and program approaches.
- Multi-state highway corridor coalitions (interest groups) are becoming increasingly prevalent. These groups are corridor specific and multi-state in nature. Multi-state corridor-specific coordination by the states might be a timely approach. To reflect

the multi-state nature of trade corridors, the U.S. should develop some type of legal mechanism whereby multi-state corridors can be cooperatively planned, programmed and funded by the states.

- If additional work is to be done relative to regional freight issues, it may be that the WTTN Trade Corridors should be grouped, with the states working together to deal with these trade corridor packages. WASHTO and the Western Governor's Association might seek such approaches.
- The technical advances offered by Commercial Vehicle Operations (CVO) and other Intelligent Transportation System (ITS) approaches to improving freight transportation efficiency especially lend themselves to multi-state approaches to corridor evaluation.
- The western states should put the trade corridor provisions of TEA-21 to good, productive use.

Next Step Recommendations from Phase I

The WTTN concept and study represents one of the first state-initiated (as opposed to federally initiated) attempts at regional (multi-state) voluntary investigation of freight transportation. In this sense, it was experimental. It caused the participating states to get together and deliberate and coordinate; it was a learning exercise; and, it defined and investigated certain elements of the western states' freight system.

As discussed in Phase I, this experimental study represented an initial step into the issues of regional freight, trade corridors, and voluntary coordination among the states. If it is to be effective, more elaboration, greater detail and additional work may be needed if the states are to benefit from this initial trade assessment. Following are several of the "next steps," as suggested in Phase I.

- "A next logical step would be to establish specific performance objectives in each trade corridor. These would be developed in close liaison with the private sector freight industry, and could provide the states with insights concerning where the freight industry would most be interested in projects and programs."

- "If performance objectives are established, a next step might then be to identify how well each corridor is performing relative to its objectives. Performance could be monitored, as could causes of performance deficiency."

- "Implicit in this study is the theory that if deficiencies in the WTTN corridors are dealt with, the freight industry, interstate and international trade, and the WTTN states' economies will benefit. Such benefits and which actions might cause the benefits to occur, remain to be demonstrated. That could be an element in any next step."

- "Intermodal facilities and services are an important element in the physical distribution process. This initial WTTN study (Phase I) was only able to identify intermodal facilities. A logical next step would be to assess these intermodal facilities, their performance, their deficiencies, and their needs."

These suggestions from Phase I were ultimately used by the states to define the WTTN Phase II work activities.

CONGRESSIONALLY IDENTIFIED "HIGH PRIORITY CORRIDORS"

The U.S. Congress has also been active in the identification of transportation corridors believed to merit special attention. Congress has identified 43 "High Priority Corridors" nationally. These were identified in three items of legislation:

- Intermodal Surface Transportation and Efficiency Act of 1991 (ISTEA) – Sec. 1105(c) – 21 corridors;
- NHS Designation Act of 1995 – 8 added corridors; and
- TEA-21 – Section 1118 – 14 added corridors.

The 43 High Priority Corridors are shown on Exhibit 1-2. The High Priority Corridors located in the 17 WTTN states are listed on Exhibit 1-3, together with their relevant WTTN Corridor number. Several observations are relevant:

- The 20 WTTN Trade Corridors include every Congressionally-identified High Priority Corridor located in the western states. This means that any federal funding or other programs associated with the High Priority Corridors may also fit the WTTN corridors.

- The WTTN work should help the WASHTO states in their use of these federal funds.

Exhibit 1-2
HIGH PRIORITY CORRIDORS

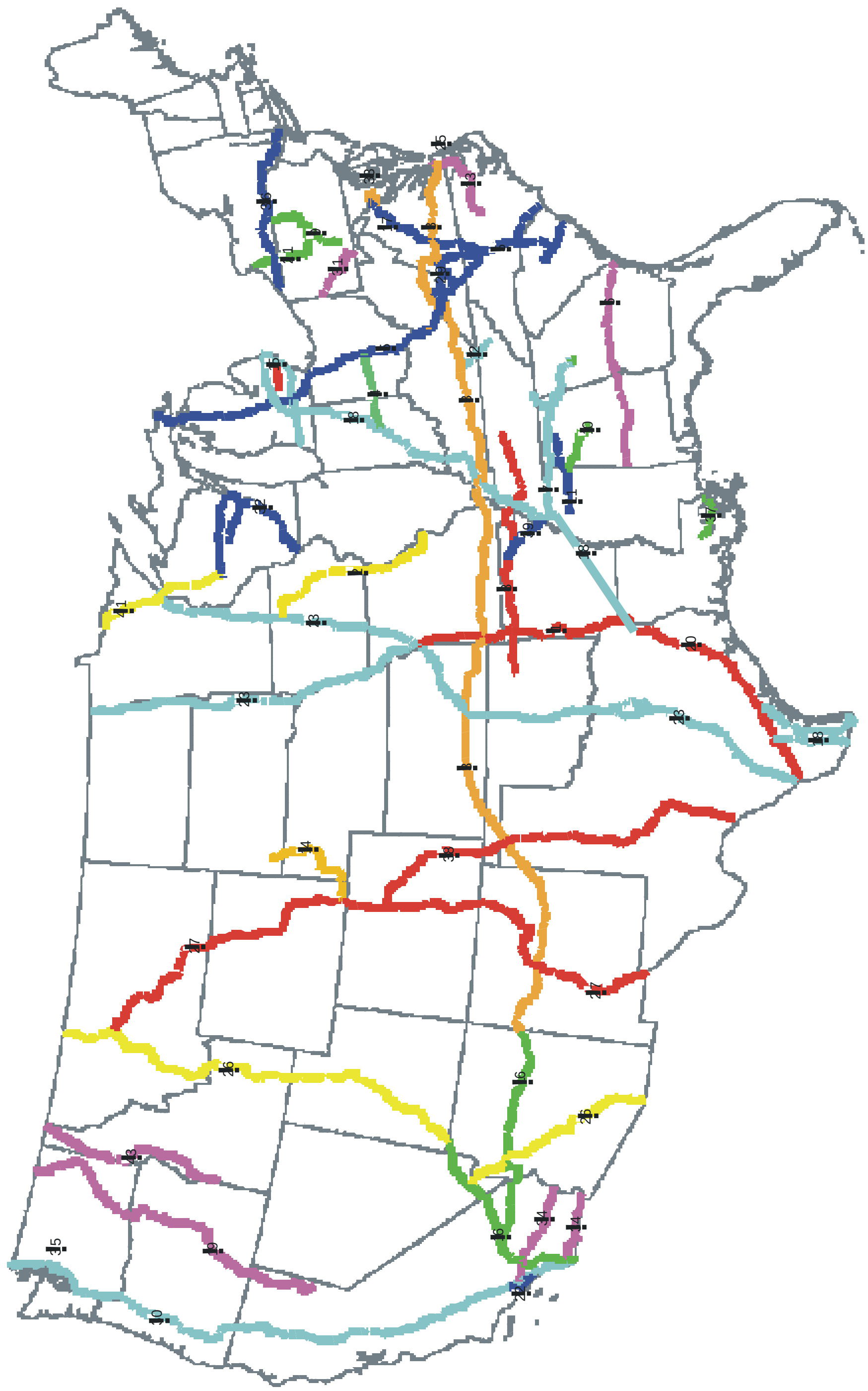


EXHIBIT 1-3
HIGH PRIORITY CORRIDORS IN THE 17 WESTERN STATES
Section 1105(c) of ISTEA (P.L. 102-240), as amended through P.L. 105-206

No.	High Priority Corridors	WTTN States	WTTN Trade Corridor No.
(3)	East-West Transamerica Corridor	Kansas, Oklahoma, Texas, Colorado, New Mexico, Utah, Arizona, Nevada and California	19 (portions)
(14)	Heartland Expressway	Colorado, Nebraska and South Dakota	16
(16)	Economic Lifeline Corridor	California, Arizona, and Nevada	4, 10 (portions)
(18)	I-69 Corridor	Texas	18, 17 (portions)
(19)	United States Route 395 Corridor	Washington, Oregon, California and Nevada	9, 1 (portions)
(20)	United States Route 59 Corridor (I-69)	Texas	18
(22)	The Alameda Transportation Corridor	California	4, 5
(23)	The Interstate Route 35 Corridor	Texas, Oklahoma, Kansas, Nebraska, North Dakota, and South Dakota	17, 19 (portions)
(26)	The CANAMEX Corridor	Arizona, Nevada, Utah, Idaho, and Montana	10, 15 (portions)
(27)	The Camino Real Corridor	Texas, Colorado, New Mexico, Wyoming, and Montana	20, 16, 14 (portions) 11(portions), 1 (portions)
(30)	Interstate Route 5	California, Oregon, and Washington	7

EXHIBIT 1-3
HIGH PRIORITY CORRIDORS IN THE 17 WESTERN STATES
Section 1105(c) of ISTEA (P.L. 102-240), as amended through P.L. 105-206

No.	High Priority Corridors	WTTN States	WTTN Trade Corridor No.
(34)	The Alameda Corridor East and Southwest Passage	California	4, 5
(35)	Everett-Tacoma FAST Corridor	Washington	7
(38)	The Ports-to-Plains Corridor	Texas, Oklahoma and Colorado	14
(43)	The United States Route 95 Corridor	Idaho	9

NOTE: Some corridors are defined in detail, some more generally. The most inclusive corridor concept consistent with statutory language has been used for this listing.

- The west appears to have received a "fair share" of the Congressional High Priority Corridor designations.
- The High Priority Corridors are generally in a north-south orientation which, as presented in WTTN Phase I, makes sense due to NAFTA and due to the less developed north-south transportation systems of the WTTN states.
- The WTTN network contains more east-west corridors/routes than the Federal High Priority Corridors.

TRADE CORRIDOR AND BORDER CROSSING TEA-21 PROGRAM

Of immediate interest to the western states relative to trade corridors and border crossings, is Section 1118 of TEA-21.

TEA-21 Section 1118: National Corridor Planning and Border Infrastructure Programs

The WTTN Trade Corridors (and the transportation facilities within each corridor) have been shown to be of critical importance to the economies of the WTTN Region, the entire United States, and the world. Several special funding programs have been established by Congress that recognizes their importance by allocating federal financial assistance over and above regular formula apportionments.

Two of these special programs are the National Corridor Planning and Development Program (NCPD) and the Coordinated Border Infrastructure Program (CBI), which together provide up to $700 million over the final five years of TEA-21. The High Priority Corridor portions of each WTTN corridor are automatically eligible for the NCPD Program funding. The CBI Program focuses on border infrastructure and telecommunications at international crossings, which are key components of 12 WTTN Trade Corridors.

On May 27, 1999 Secretary Slater announced allocation of $123.6 million in Federal FY 1999 for these two programs. The WTTN states and WTTN Trade Corridors were well-represented in the FY 1999 allocation. Of the $123.6 million allocated in FFY 1999 for 55 projects nationwide, $64.7 million (52 percent) is targeted for 25 projects in WTTN corridors. This heavy emphasis from the U.S. DOT recognizes the importance of improving the WTTN infrastructure.

It is reported that the single TEA-21 program for which U.S. DOT has received the greatest public input and interest is the trade corridors program. When U.S. DOT asked for applicants for the initial $123.6 million for fiscal year 1999, it received applications totaling more than $2 billion. There appears to be great need, and great national interest, relative to trade, trade corridors, and border crossings.

After a process of selection, U.S. DOT has identified those projects which will participate in the initial trade corridor funding (for fiscal year 1999). Those projects located in the 17 western states, and the WTTN Trade Corridors within which they are located, are shown on Exhibit 1-4.

Exhibit 1-4
FFY 1999 NCPD & CBI ALLOCATIONS
WTTN STATES

Lead State	Project	$(M)	WTTN Corridor(s)
AZ	Canamex design	1.0	10, 15
AZ	Hoover Dam Bypass	2.0	10, 15
AZ	Commercial vehicle station @ Nogales	2.5	10, 15
AR	I-69 environmental studies	10.0	18
CA	S905 engineering, right of way	7.4	5
CA	Mexicali Border Crossing feasibility	0.3	7
ID	US 95 engineering, right of way	1.2	9
KS	US 54 engineering	0.6	19
MO	I-35 ITS	0.8	17
MT	Billings Bypass feasibility	0.2	1, 11
NM	S136 widening	4.0	16
ND	Border crossing improvements	0.2	17
OK	I-35 bridge	3.0	17
OR	I-5 multimodal corridor study	2.0	7
SD	S79/I-90 interchange	3.0	1, 16
TX	Laredo border crossing improvements	6.2	17, 18
TX	US 281 construction	1.8	17
TX	Hidalgo border crossing improvements	1.9	17
TX	International Bridge @ El Paso	2.4	16
TX	I-35 add lanes	1.7	17
WA	FAST grade separations, port access	10.0	7
WA	Whatcom County border coordination	0.8	7
WA	Whatcom O/D study	0.2	7
WA	Whatcom outreach & market program	0.2	7
WY	US 87 engineering	1.3	1, 11

THIS PHASE II STUDY REPORT

This second phase of the WTTN study is documented in two written reports:

- Executive Summary Report
- Final Study Report

The Final Study Report has six chapters (1-6) and six appendices (A-F).

Chapter 1: Introduction and Overview – This overview of the WTTN and the WTTN Phase II study.

Chapter 2: Transportation Facilities within Each WTTN Corridor – Identification of those specific highways, rail lines and other transportation facilities which comprise the WTTN network.

Chapter 3: Highways Analysis – The establishment of specific performance standards on each highway, identification of how each highway and highway link is performing, identification of resultant highway and bridge deficiencies, and types of solutions and benefits to be derived if the deficiencies were to be alleviated.

Chapter 4: Railroad Analysis – The identification of performance standards which the West's shippers of freight would appreciate, comparisons with how the railroads are actually performing, identification of deficiencies and shippers' ideas concerning those deficiencies, solution types, and ways deficiency alleviation might be of benefit to the WTTN states.

Chapter 5: Intermodal Facilities Analysis – The identification of important intermodal facilities (railroad TOFC/COFC, water ports, grain elevators, airports, and reload facilities) in the participating WTTN states, and the identification of issues and deficiencies regarding those intermodal facilities.

Chapter 6: Conclusions and Recommendations - A summary of the study's findings, including recommendations and opportunities available to the WTTN states.

Appendices – Six Appendices which contain detailed work that supports the study.

Chapter 2
TRANSPORTATION FACILITIES WITHIN EACH WTTN CORRIDOR

The 20 Western Transportation Trade Network (WTTN) Corridors of Exhibit 1-1 were identified in a generalized sense in the WTTN Phase I study. In Phase I, however the specific highways, rail lines, intermodal facilities and other facilities which make up each corridor were not specifically identified.

Because WTTN Phase II focuses on how well each corridor (and each highway, rail line, etc., within each corridor) is currently performing, their subsequent deficiencies and their potential "menu of solutions," it is necessary that the specific transportation facilities within each WTTN corridor be identified.

The entire Phase II study team (including each state) was involved in this identification process. The results, by mode, are presented on the following exhibits in chapters 2 and 5:

Exhibit	Facilities in Each WTTN Corridor
2-1 and 2-8	Highways
2-14	Rail Lines
5-20	Airports
5-23	Grain Elevators
5-26	TOFC/COFC Facilities
5-30	Cargo Ports

HIGHWAYS WITHIN EACH WTTN CORRIDOR

The specific highways determined to comprise a WTTN corridor usually, but not always, fall within the corridor boundaries shown on the maps. This is because the WTTN corridors really are intended to reflect alternative routes travelling from one place to another; the corridors are not intended to be limited in terms of width. The 20 WTTN corridors, and the specific highways included, are shown in Exhibit 2-1.

Highway Identification Process and Criteria

An important product of the WTTN Phase II study is to quantify corridor performance against baseline objectives. In order to quantify performance, measures of effectiveness were established and gauged against minimum tolerable standards on specific highways. This was accomplished through the identification of a facility-specific network of highways, gathering of data representing this network, and establishment of a process that identifies infrastructure deficiencies. Using these infrastructure deficiencies, assessments of facility performance and truck efficiencies were made. The highway identification process included input from each participating state.

Highway Criteria – The highway network identification process began with information developed during the WTTN Phase I Study (see Phase I, Chapters 3 and 4). Using the information developed by the states as a starting point, the consultant identified and listed highways determined to be important to WTTN truck operations. These important highways were linked with and assigned to a specific WTTN corridor(s) based on their location and termini served. The consultant then surveyed each state individually to determine which additional routes the states believed should be included in a WTTN Highway Network. Basic criteria indicated that, to be included, a highway:

- Should be higher-order facilities (probably part of the National Highway System); this is based on the assumption that higher-order state, U.S. and Interstate routes are more likely to be built to withstand truck weights and to accommodate large vehicles.
- Should be located within or serve termini in one of the 20 WTTN Trade Corridors. The purpose of the WTTN Phase II study is to continue the work from Phase I, as opposed to identifying different corridors.

Exhibit 2-1
HIGHWAYS IN EACH WTTN TRADE CORRIDOR

- Should serve multi-state long distance freight traffic within the corridor. The study recognized the importance of local truck movements, but the purpose of the study was to quantify the trucking operations that serve long distance operations (and termini) both within and outside the WTTN Region. A basic premise of the WTTN concept is that infrastructure within the Region is serving long distance freight traffic that ultimately benefits domestic and international markets within and outside the WTTN Region.

Highway Links vs. Corridors – It is recognized that the process of identifying specific WTTN highways has both similarities and differences from the WTTN Trade Corridor concept. Following are some examples of these key similarities and differences:

- WTTN corridors are generally multi-state in nature; while many WTTN highways serve multiple states, others are wholly contained within a state.
- WTTN corridors connect significant freight endpoints (Chicago, San Francisco, Memphis, New Orleans, etc.), while WTTN highways typically serve just a portion of the corridor.
- Both WTTN corridors and highways serve regionally significant freight traffic, international crossings, movements in all directions, and important economic centers.
- Both WTTN corridors and highways must consider future trade expectations. While the tendency may be to focus on existing patterns and volumes, the states emphasized the need to consider future traffic volumes, new destinations, and anticipated growth.
- An example of this point is the inclusion of the Laredo – Indianapolis Corridor #18 in the WTTN. This corridor links Laredo, Houston and Texarkana on U.S. 59 with Memphis, Evansville, Indianapolis and Detroit. While no interstate-type facility exists in most of the corridor now, it has been the subject of considerable recent study to determine feasibility as a Congressionally-mandated High Priority Corridor. This corridor holds future promise as a freight route linking the Great Lakes Region with Mexico via Indianapolis and Memphis.
- Corridors serve external endpoints (Chicago, St. Louis, etc.), while WTTN highways terminate at the WTTN Region boundaries.

The states' suggestions for additional WTTN highways were presented to the WTTN Steering Committee, which reviewed every suggested highway in detail. The states did suggest some routes of marginal import regionally, but of significant import to local economies. The Steering Committee's role was one of ensuring that important freight highways serving regional travel were included in the Network. The Committee decided to exclude many suggested highways, while it added others determined by the Committee to meet the definition and criteria for the WTTN Highway Network. Each state was provided the opportunity to defend the nomination of an individual highway as a WTTN highway and question the inclusion of other highways.

Highways Selected for WTTN Inclusion

WTTN Highway Network – The resulting WTTN Highway Network comprises 26,346 miles of road, broken into 67 separate *highway links*. For presentation/summary purposes, some highway links are combined to connect logical termini. For example, a WTTN highway link from Interstate 94 at Billings, Montana to the Canadian border stretches over portions of three different marked routes (U.S. 87, U.S. 191 and Montana Route 19), but is represented as one WTTN highway. The WTTN highways and WTTN corridors are shown in Exhibit 2-2.

Exhibits 2-3 and 2-4 depict the composition of the WTTN highways by system and compare the average length of WTTN highways. Exhibit 2-5 depicts the WTTN Network composition as a subset of all WTTN Region highway mileage.

Interstate Highways – Of the 67 separate WTTN highway links, 32 are part of the interstate system, representing 16,992 miles (average length of 531 miles). Of the 18,041 miles of interstate highways in the 17 WTTN states, 94 percent are included in the WTTN Highway Network, which reflects the overall goal of including most higher-order facilities in the WTTN.

Exhibit 2-2
NATIONAL HIGHWAY SYSTEM AND WTTN HIGHWAYS

Exhibit 2-3
HIGHWAY SYSTEM TYPES COMPARISON
WTTN HIGHWAYS
Miles by System Type

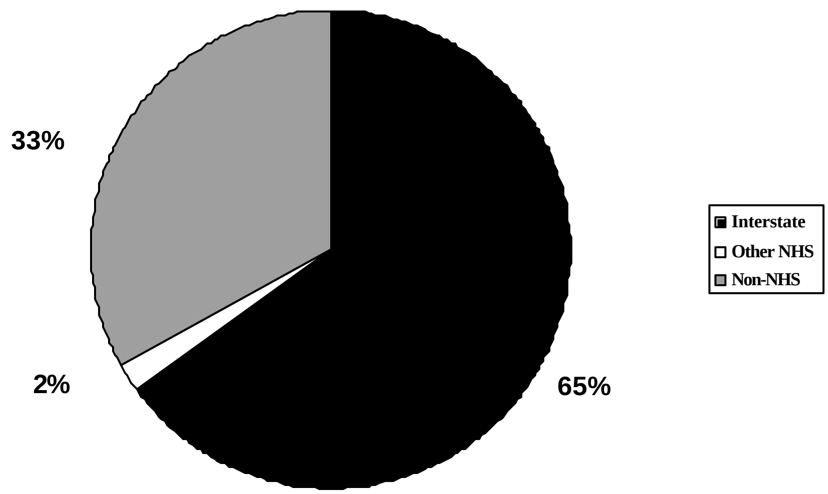


Exhibit 2-4
WTTN AVERAGE HIGHWAY LENGTH

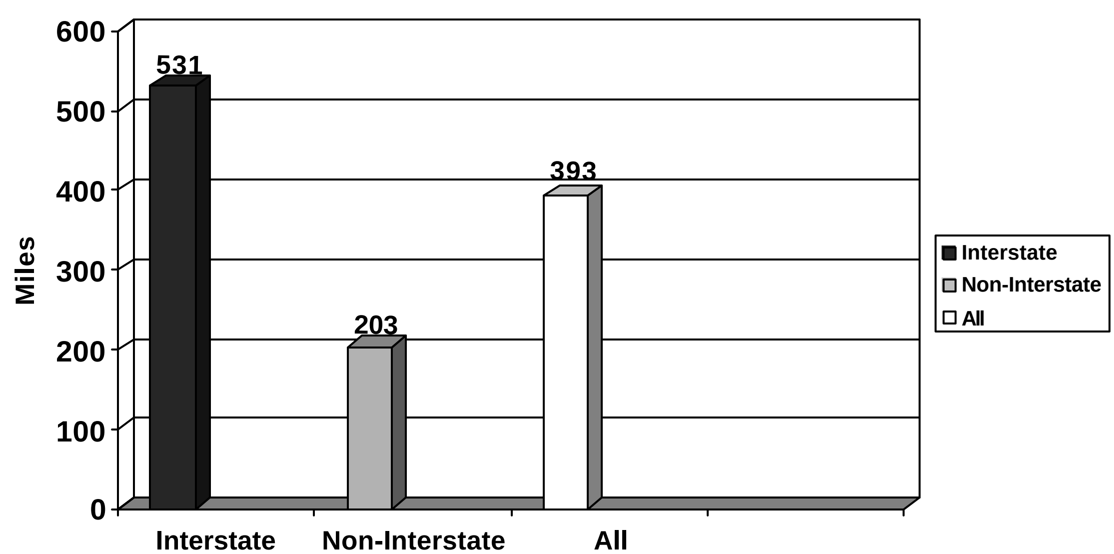
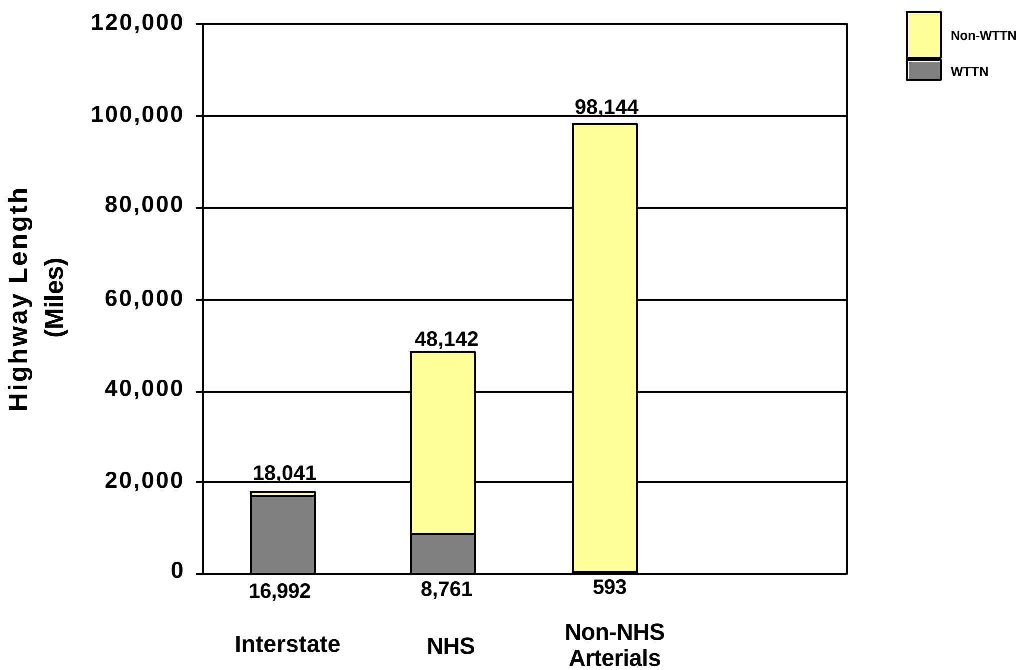


Exhibit 2-5
MILES OF WTTN HIGHWAYS IN THE WTTN REGION



Non-interstate NHS Routes – The 17 WTTN states have 48,142 non-interstate miles on their National Highway System (NHS). Of these, just over 18 percent (8,761 miles) are included in the WTTN Highway Network. The NHS is a system approved by Congress in 1995 as an outgrowth of the ISTEA legislation. NHS routes, like WTTN facilities, also serve long distance interregional traffic, intermodal facilities, and major freight generators. They are a higher-order subset of the principal arterial system.

Non-NHS Routes - Criteria for the WTTN Highway Network discouraged inclusion of highways that are not part of the NHS. Such highways are classified as lower order rural principal arterials, urban other principal arterials, rural/urban minor arterials, and rural/urban collectors. These facilities, as distinguished by their functional classification, tend to serve trips of shorter distances. Also, because the highway portion of the WTTN is a *truck* network, lower order facilities are usually excluded from state-designated truck systems (Class I, II, III designation). Therefore, these lower order highways were generally considered inappropriate for inclusion in the WTTN Highway Network.

However, the participating states agreed to include 593 miles of non-NHS highways in the WTTN Network, all of which are classified as principal or minor arterials. Inclusion of these routes in the WTTN Highway Network was approached on a case-by-case basis. Those non-NHS sections included in the Network are:

- U.S. 6, Loveland Pass (CO) – this 20-mile segment is an alternate route for hazardous materials which bypasses the I-70 Eisenhower Tunnel;
- U.S. 12, from U.S. 287 to I-94 at Forsyth (MT) – this 273-mile section serves heavy truck traffic as a bypass alternative to I-90 through Billings and Butte;
- U.S. 281, U.S. 14 to U.S. 20 (SD, NE) – a 121-mile section of U.S. 281 was excluded from NHS designation, but is included here for continuity between I-80 and I-94;
- New Mexico Route 136, St. Teresa Border Crossing (NM, TX) – an important border crossing that connects with I-10 north of El Paso (8 miles); and
- U.S. 287 from I-45 to U.S. 69 (TX) – the continuation of U.S. 287 from Colorado through Amarillo and Dallas-Ft. Worth to Port Arthur (171 miles).

The 17 WTTN states have 98,144 miles of non-NHS arterials, just 0.6 percent of which is included in the WTTN Network. The 46 non-interstate WTTN highways average about 203 miles in length, less than half the length of the average WTTN interstate highway.

The WTTN Region highway mileage by state and system is listed in Exhibit 2-6. Of the 164,327 highway miles classified arterial or higher in the 17 WTTN states, about 16 percent are included in the WTTN Highway Network. Texas has the largest amount of WTTN mileage (4,790), while Nevada has the least (566). A visual examination of the regional map (Exhibit 2-2) suggests the WTTN Highway Network is most dense in the northwestern part of the WTTN Region (Montana, Idaho, Washington) and Texas.

Table 2-6
WTTN REGION ARTERIAL HIGHWAY MILEAGE (1996)

State	Interstate Total	Interstate WTTN	Other NHS Total	Other NHS WTTN	Other Arterials Total	Other Arterials WTTN	All Arterials Total	All Arterials WTTN
Arizona	1,167	1,167	1,645	231	3,193	0	6,005	1,398
California	2,428	2,103	5,149	679	22,918	0	30,495	2,782
Colorado	954	749	2,476	238	5,861	20	9,291	1,007
Idaho	611	608	1,760	778	1,918	0	4,289	1,386
Kansas	872	821	2,927	299	6,393	0	10,192	1,120
Montana	1,204	1,204	2,669	1,782	3,333	273	7,206	3,259
Nebraska	480	456	2,526	643	5,375	40	8,381	1,139
Nevada	571	554	1,581	12	1,409	0	3,561	566
New Mexico	1,000	996	1,972	370	2,544	6	5,516	1,372
North Dakota	569	569	2,152	669	3,720	0	6,441	1,238
Oklahoma	930	891	2,381	98	5,592	0	8,903	989
Oregon	728	723	2,999	183	3,540	0	7,267	906
South Dakota	678	664	2,253	386	4,033	81	6,964	1,131
Texas	3,234	2,948	10,103	1,669	19,252	173	32,589	4,790
Utah	940	910	1,244	0	2,088	0	4,272	910
Washington	763	717	2,635	644	4,979	0	8,377	1,361
Wyoming	912	912	1,670	80	1,996	0	4,578	992
Total	**18,041**	**16,992**	**48,142**	**8,761**	**98,144**	**593**	**164,327**	**26,346**

Exhibit 2-7 summarizes WTTN Highway mileage by WTTN Trade Corridor, and Exhibit 2-8 lists the highway links within each corridor. It is important to recognize that a highway can be listed in more than one WTTN Trade Corridor. For example, Interstate 82 serves Corridor 1 (Pacific Northwest – Minneapolis - Chicago) and Corridor 11 (Pacific Northwest - Kansas City). Thus, the 81 highways listed in Exhibit 2-7 include some duplication/double-counting. This duplication is not intended to suggest that highways in more than one WTTN corridor are more important than others, but instead demonstrates that specific highways serve destinations in more than one WTTN corridor.

Exhibit 2-7
MILEAGE BY WTTN TRADE CORRIDOR

	WTTN Trade Corridor	Number of Highways	WTTN Mileage
1	Pacific NW-Minneapolis-Chicago	10	4,781
2	San Francisco-Chicago	3	1,754
3	Utah-St. Louis	2	1,126
4	Southern California-Memphis	2	1,546
5	Southern California-New Orleans	5	2,746
6	Texas-Memphis	2	857
7	Mexico-Canada	10	2,162
8	Pacific NW-Utah	1	734
9	Boise-Canada	3	672
10	Mexico-Canada (Canamex)	4	2,155
11	Pacific NW-Kansas Ciity	7	2,369
12	Montana-Canada	1	260
13	Canada-Minneapolis-Chicago	2	442
14	Wyoming-Galveston	4	1,738
15	Mexico-Arizona	1	337
16	Mexico-I-90	4	1,380
17	Mexico-Canada/Midwest	9	3,472
18	Laredo-Indianapolis	3	1,013
19	Mexico-St. Louis	6	2,087
20	Montana-Canada	2	854
Total		81	32,485

Exhibit 2-8
WTTN HIGHWAYS IN EACH WTTN CORRIDOR

Route[1]	Termini	States
Corridor 1	**Pacific NW-Minneapolis-Chicago**	
I-90	I-5 @ Seattle to Sioux Falls, SD	WA, ID, MT, WY, SD
I-94	I-90 @ Billings to Fargo, ND	MT,ND
I-84	I-5 @ Portland to I-82	OR
I-82	I-90 to I-84	WA, OR
U.S. 2	I-5 N. Seattle to Grand Forks, ND	WA, ID, MT, ND
U.S. 12	U.S. 95 @ Lewiston to I-90 @ Missoula, MT	ID, MT
U.S. 12	I-90 NW of Butte to I-94 @ Forsyth, MT	MT
U.S. 87/S 200	I-90 @ Missoula to U.S. 2 @ Havre, MT	MT
S 18	I-5 in Seattle to I-90 E. Seattle	WA
U.S. 395	I-82 to I-90	WA
Corridor 2	**San Francisco-Chicago**	
I-80/U.S. 101	I-280 in San Francisco to Omaha	CA, NV, UT, WY, NE
I-238/580/880	I-80 in Oakland to I-5 E. of San Francisco	CA
I-205	I-580 to I-5 E. of San Francisco	CA
Corridor 3	**Utah-St. Louis**	
I-70	I-15 to Kansas City	UT, CO, KS
U.S. 6	Loveland Pass	CO
Corridor 4	**Southern California-Memphis**	
I-40	I-15 to Ft. Smith, AR	CA, AZ, NM, TX, OK
S 58	S 99 to Barstow	CA
Corridor 5	**Southern California-New Orleans**	
I-8	I-5 in San Diego to I-10 S. Phoenix	CA, AZ
S 94/125	San Diego (I-5 to I-8)	CA
I-10	I-5 in Los Angeles to E. Beaumont, TX	CA, AZ, NM, TX
I-20	I-10 to W. Shreveport, LA	TX
S 60	I-10 in Los Angeles to I-10 near Beaumont, CA	CA
Corridor 6	**Texas-Memphis**	
I-20	I-10 to W. Shreveport, LA	TX
I-30	Dallas (I-20) to Texarkana	TX

Route[1]	Termini	States
Corridor 7	**Mexico-Canada**	
I-5	Mexico (S. of San Diego) to Canada	CA, OR, WA
I-205	Around Portland	OR, WA
I-405	In Portland	OR
I-405	I-5 in Los Angeles to I-5 @ Irvine	CA
I-710	Long Beach to I-5	CA
I-805	I-5 to I-15 in San Diego	CA
U.S. 97/S 58	I-5 @ Weed, CA to I-5 @ Eugene	CA, OR
S 7/86/78	Mexico to I-10	CA
S 905	I-5 in San Diego to Mexico	CA
S 99	I-5 S. Bakersfield to I-5 @ Sacramento	CA
Corridor 8	**Pacific NW-Utah**	
I-84	I-5 in Portland to I-80 E. of Salt Lake City	OR, ID, UT
Corridor 9	**Boise-Canada**	
U.S. 95	I-84 W. Boise to Canada	ID
U.S. 195	U.S. 95 (Idaho SL) to I-90 @ Spokane	WA
U.S. 395	Spokane to Canada	WA
Corridor 10	**Mexico to Canada (Canamex)**	
I-19/I-10/ U.S. 93/60	Mexico to I-15 @ Las Vegas	AZ, NV
I-15	I-5 @ San Diego to Canada	CA, NV, AZ, UT, ID, MT
I-215	I-15 @ Temecula to I-15 N. San Bernadino	CA
U.S. 20/191	I-15 @ Idaho Falls to I-90 W. Bozeman, MT	ID, MT
Corridor 11	**Pacific NW-Kansas City**	
I-82	I-90 to I-84	OR, WA
I-84	I-5 @ Portland to I-82	OR
I-86	I-84 to I-15 @ Pocatello, ID	ID
I-90	I-5 in Seattle to I-25	WA, ID, MT, WY
I-25	I-90 to I-80 @ Cheyenne	WY
I-80	I-25 @ Cheyenne to Omaha	WY, NE
U.S. 26	I-25 to I-80	WY, NE
Corridor 12	**Montana-Canada**	
U.S. 87/S 19/U.S. 191	I-94 @ Billings to Canada	MT

Route[1]	Termini	States
Corridor 13	**Canada-Minneapolis-Chicago**	
U.S. 52	Canada to I-94 @ Jamestown, ND	ND
I-94	U.S. 52 to I-29	ND
Corridor 14	**Wyoming-Galveston**	
I-25	I-90 to I-70 @ Denver	WY, CO
I-70	I-25 @ Denver to U.S. 40/287 @ Limon	CO
U.S. 287	I-70 @ Limon to Port Arthur	CO, OK, TX
I-45	I-30 @ Dallas to Galveston	TX
Corridor 15	**Mexico-Arizona**	
I-10/17/19	Mexico to I-40 @ Flagstaff, AZ	AZ
Corridor 16	**Mexico-I-90**	
I-25	I-10 @ Las Cruces to I-90 N. Casper, WY	NM, CO, WY
U.S. 287/S 14	I-25 @ Ft. Collins to I-80 @ Laramie, WY	CO, WY
S 79/U.S. 385	I-90 to I-80 @ Sidney, NE	SD, NE
S 136	St. Teresa Border to I-10	NM, TX
Corridor 17	**Mexico-Canada/Midwest**	
I-35	Laredo, TX to Kansas City	TX, OK, KS
I-37	I-35 in San Antonio to Corpus Christi (U.S. 181)	TX
I-44/U.S. 287	I-35 N. Dallas/Ft. Worth to Joplin	TX, OK
I-45	I-30 in Dallas to Galveston	TX
I-135	I-35 to I-70 @ Salina, KS	KS
I-29	Sioux City to Canada	SD, ND
U.S. 81	I-70 @ Salina, KS to I-29 @ Watertown, SD	KS, NE, SD
U.S. 281	I-80 @ Grand Island, NE to I-94 @ Jamestown, ND	NE, SD, ND
I-335	I-35 to I-70 @ Topeka, KS	KS
Corridor 18	**Laredo-Indianapolis**	
U.S. 59	Laredo to I-30 @ Texarkana	TX
U.S. 77	Brownsville to U.S. 59	TX
U.S. 281	Mexico to I-37	TX
Corridor 19	**New Mexico-St. Louis**	
I-40	Albuquerque to Ft. Smith, AR	NM, TX, OK
I-44	I-35 N. Oklahoma City to Joplin	OK
I-35	I-40 in Oklahoma City to Kansas City	OK, KS
I-235	I-135 N. to I-135 S. of Wichita	KS

Route[1]	Termini	States
U.S. 54	I-10 in El Paso to I-235 @ Wichita	TX, NM, OK, KS
U.S. 70	I-25 to U.S. 54	NM
Corridor 20	**Montana-Canada**	
I-15/S 3	I-94 @ Billings to Canada	MT
I-90/U.S. 93	Billings to Canada	MT

(1) See Exhibit 2-2 for map which depicts each WTTN corridor.

HIGHWAY SEGMENTATION

In order to conduct detailed deficiency and performance analyses on the individual highways in the WTTN Highway Network, it was necessary to subdivide each highway into logical sections. This was done so that each section could be individually analyzed for deficiencies and performance characteristics, then combined with other sections to provide summary information for different termini within the WTTN Region.

Segmentation Process

For purposes of analyzing deficiencies and performance, the 67 WTTN highway links were divided into 206 *supersegments*. The division of WTTN highways into supersegments allows for easier analysis and the ability to calculate performance attributes between city pairs or other termini. A "break" was made in a WTTN highway to create a new supersegment for the following general instances:

- Route passes through an urbanized area with significant congestion, speed reduction, and/or change in operating conditions. Separate breaks were made for the following urbanized areas:

  - Los Angeles
  - San Diego
  - San Francisco
  - Sacramento
  - Portland
  - Seattle/Tacoma
  - Spokane
  - Salt Lake City
  - Las Vegas
  - Reno
  - Cheyenne
  - Denver

- Colorado Springs
- Phoenix
- El Paso
- San Antonio
- Houston
- Dallas/Ft. Worth
- Amarillo
- Corpus Christi
- Oklahoma City
- Tulsa
- Topeka
- Wichita

- Intersection of WTTN highways that comprise major routing decision points. For example, I-90 was broken at the I-94 intersection at Billings, Montana because eastbound trucks must make a travel choice. Other examples of routing breaks include:

  - I-15/I-40 in California
  - I-40/U.S. 93 and I-17 in Arizona
  - I-10/I-19 in Arizona
  - I-70/U.S. 40 in Colorado
  - U.S. 2/U.S. 95 in Idaho
  - I-84/I-86 in Idaho
  - I-15/I-86 in Idaho
  - I-90/U.S. 95 in Idaho
  - U.S. 95/U.S. 12 in Idaho
  - I-15/U.S. 20 in Idaho
  - I-90/U.S. 93 in Montana
  - I-40/U.S. 54 in New Mexico
  - I-84/I-82 in Oregon
  - I-5/S 58 in Oregon
  - I-90/U.S. 281 and U.S. 81 in South Dakota
  - I-29/I-94 in North Dakota
  - I-10/I-20 in Texas
  - I-15/I-70 in Utah
  - I-5/I-90 in Washington
  - I-25/U.S. 26 in Wyoming
  - I-29/I-90 in South Dakota

Supersegments were also defined in order to connect logical city pairs, including:

- Butte/Great Falls (I-15)
- Butte/Missoula (I-90)
- Reno/Salt Lake City (I-80)
- Las Vegas/Salt Lake City (I-15)
- Las Cruces/Albuquerque (I-25)
- Albuquerque/Amarillo (I-40)
- Denver/Cheyenne (I-25)
- San Francisco/Portland (I-5)
- Billings/Bismarck (I-94)
- Minot/Grand Forks (U.S. 2)
- Oklahoma City/Kansas City (I-44)
- Rapid City/Sioux Falls (I-90)
- El Paso/San Antonio/Houston (I-10)
- Phoenix/El Paso (I-10)
- Ft. Worth/Houston (I-45)
- Seattle/Spokane (U.S. 2)
- Cheyenne/Omaha (I-80)

The states decided that supersegments should cover similar roadway stretches regardless of state boundaries. Therefore, WTTN highways were not broken into supersegments at state lines. For example, Supersegment Number 160 on Interstate 70 stretches from Interstate 15 in Utah to the western urban limit of Denver. The Utah and

Colorado portions of that supersegment were analyzed separately and later combined because of separate state data submittals.

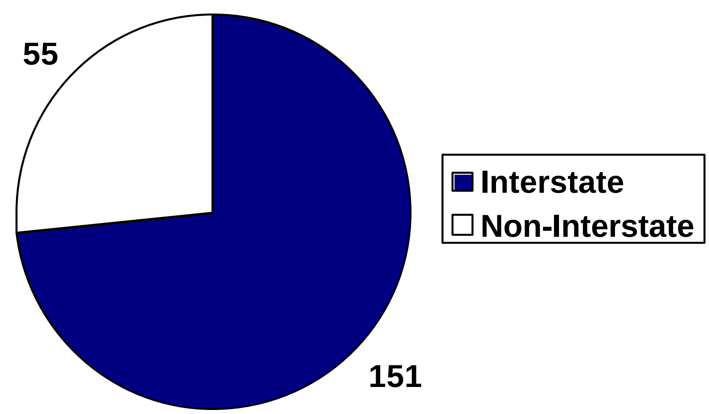
Resulting Supersegments – Exhibit 2-9 lists the WTTN corridors, number of WTTN highways and mileage in each, and the number of supersegments by corridor. The exhibit adds to 81 corridor highways, 32,485 WTTN highway miles, and 261 supersegments due to duplication.

Exhibit 2-9
SUPERSEGMENTS BY WTTN CORRIDOR

WTTN Corridor	Termini	No. of WTTN Highways	WTTN Miles	No. of WTTN Supersegments
1	Pacific NW-Minneapolis-Chicago	10	4,781	28
2	San Francisco-Chicago	3	1,754	19
3	Utah-St. Louis	2	1,126	7
4	Southern California-Memphis	2	1,546	11
5	Southern California-New Orleans	5	2,746	20
6	Texas-Memphis	2	857	5
7	Mexico-Canada	10	2,162	23
8	Pacific NW-Utah	1	734	6
9	Boise-Canada	3	672	5
10	Mexico-Canada (Canamex)	4	2,155	22
11	Pacific NW-Kansas Ciity	7	2,369	21
12	Montana-Canada	1	260	1
13	Canada-Minneapolis-Chicago	2	442	2
14	Wyoming-Galveston	4	1,738	13
15	Mexico-Arizona	1	337	4
16	Mexico-I-90	4	1,380	13
17	Mexico-Canada/Midwest	9	3,472	33
18	Laredo-Indianapolis	3	1,013	5
19	Mexico-St. Louis	6	2,087	18
20	Montana-Canada	2	854	5
Total		81	32,485	261

Overall, the 206 WTTN supersegments average about 128 miles in length. Of these, 151 are on interstate routes, averaging 112 miles in length, compared with the 55 non-interstate supersegments averaging 170 miles in length.

Exhibit 2-10
WTTN HIGHWAY SUPERSEGMENTS



A detailed list of supersegments is provided in Appendix B as well as individual state and urbanized area maps with the supersegments number shown in red (Appendix A).

RAILROADS WITHIN EACH WTTN CORRIDOR

The railroad lines comprising the WTTN Rail System were defined in WTTN Phase I. This rail system is shown in Exhibit 2-11. The lines depicted on this map are main lines, most of which are owned by either the Burlington Northern and Santa Fe Railway (BNSF) or the Union Pacific Railroad (UP).

Rail System – The WTTN Phase I rail lines were selected from the 1994 Western rail system. At that time, railroads operating in the WTTN states had approximately 58,000 miles of track as shown in Exhibit 2-12. Not surprisingly, Texas had the most mileage with nearly 11,000 miles. As can be seen from the map, the system is more dense in the eastern part of the region because of the many lines built in the Midwest to capture grain traffic, and the convergence of competing railroads on the east-west gateways such as New Orleans, Memphis, Kansas City, St. Louis, and Chicago.

Exhibit 2-11
MAJOR WTTN RAILROADS

Exhibit 2-12
RAILROAD MILEAGE IN WESTERN STATES
1994

State	Mileage	Class I Railroads (1)
Arizona	2,126	ATSF, SP
California	6,672	ATSF, BN, SP, UP
Colorado	3,035	ATSF, BN, SP, UP
Idaho	2,317	BN, UP
Kansas	5,730	ATSF, BN, KCS, NS, SOO, SP, UP
Montana	3,301	BN, UP
Nebraska	3,463	ATSF, BN, CNW, UP
New Mexico	1,999	ATSF, BN, SP
North Dakota	4,161	BN, SOO
Nevada	1,200	SP, UP
Oklahoma	3,474	ATSF, BN, KCS, SP, UP
Oregon	2,082	BN, SP, UP
South Dakota	1,939	BN, CNW, SOO
Texas	10,681	ATSF, BN, KCS, SP, UP
Utah	1,467	SP, UP
Washington	2,917	BN, UP
Wyoming	1,737	BN, CNW, UP
Total	**58,301**	

(1)

ATSF	Atchison, Topeka and Santa Fe	NS	Norfolk Southern
BN	Burlington Northern	SOO	Soo Line
CNW	Chicago and NorthWestern	SP	Southern Pacific
KCS	Kansas City Southern	UP	Union Pacific

Note: Several railroads have merged since 1994. Following are the current railroads serving these states:

BNSF	Burlington Northern and Sante Fe	CP	Soo Line now part of CP
KCS	Kansas City Southern	UP	Southern Pacific, Chicago and North/ Western, and Union Pacific
NS	Norfolk Southern		

SOURCE: Association of American Railroads (AAR)

Rail Carriers – As shown in Exhibit 2-12, there were eight large Class I railroads in the region in 1994. The class distinction denotes the level of operating revenue earned by a railroad[1]. Class I railroads earn the highest levels. Dominant railroads were the Burlington Northern (BN), the Atchison, Topeka and Santa Fe (ATSF), the Southern Pacific (SP), and the UP. Since 1994, two mergers have occurred which have reduced the number of major railroads serving the Region.

As a result of recent railroad consolidations, two rail carriers dominate the West: the BNSF and UP. BNSF was created by the 1995 merger of the BN and the ATSF. Union Pacific, which had been acquiring a number of other railroads through the 1980s and 1990s, bought SP and began combined operations in 1996.

Of the two railroad systems, UP has more miles of track. As of 1995, UP and SP operated on a combined trackage of 51,677 miles[2] in that year, BN and ATSF operated on a combined trackage of 44,462 miles. BNSF, however, serves more Western states: In 1998, the merged UP system had operations in 16 of the 17 states in the WTTN area. BNSF had operations in all 17. Exhibit 2-13 lists the states served by each railroad.

An “x” indicates that a railroad has operations in a particular state. Operations can be over rail lines which the railroad owns outright, or over rail lines on which the railroad possesses trackage or haulage rights. These rights allow the railroad to operate trains over the lines of another railroad. An example of trackage rights would be the BNSF rights to run trains on UP’s central corridor route (WTTN Corridor 2) between Denver and Northern California.

There are other Class I railroads operating in the WTTN area. These include the Kansas City Southern Railroad (KCS) and the Canadian Pacific Railway (CP). However, the numbers of states served by these carriers are far fewer, as can be seen in the exhibit.

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[1] The U.S. Surface Transportation Board classifies railroads on the basis of their annual revenue. For 1996, a Class I railroad was one having $255 million in revenue for the year. This level may vary from year to year.
[2] *Analysis of Class I Railroads 1995*, published by the American Association of Railroads.

Exhibit 2-13
MAJOR RAILROADS IN WTTN STATES

State	BNSF	UP	KCS	CP	MRL	DME
1 Arizona	x	x				
2 California	x	x				
3 Colorado	x	x				
4 Idaho	x	x			x	
5 Kansas	x	x	x			
6 Montana	x	x			x	
7 Nebraska	x	x	x			x
8 Nevada	x	x				
9 New Mexico	x	x				
10 North Dakota	x			x		
11 Oklahoma	x	x	x			
12 Oregon	x	x				
13 South Dakota	x	x		x		x
14 Texas	x	x	x			
15 Utah	x	x				
16 Washington	x	x				
17 Wyoming	x	x				x

In addition to the Class I railroads, there are numerous short line railways in the WTTN states. The short line terminology refers to a railroad's relative length of haul. As these railroads generally originate and terminate traffic, carrying the traffic to and from main line railroads, their hauls typically are short compared to those of the main line hauls. Of these various short lines, the two largest are Montana Rail Link (MRL) and the Dakota, Minnesota & Eastern Railroad Corporation (DME). MRL operates from northern Idaho to south central Montana. DME operates in South Dakota, Nebraska, Wyoming, Minnesota and Iowa.[3] Both of these railroads were created from the spin-off of lines belonging to major Class I railroads.

Rail Lines Selected for WTTN Inclusion

Having the higher freight traffic densities and larger networks, BNSF and UP were the principal focus of the WTTN Phase I rail analysis. Rail deficiencies in the WTTN corridors were identified only for BNSF and UP lines, with one exception[4]. Lighter density lines and most short lines were not viewed as WTTN corridor lines other than in the context of handling traffic to and from the main lines. An exception was MRL, which was included as a major segment of WTTN Corridor 11 (Pacific Northwest - Kansas City).

Exhibit 2-14 identifies the set of trade corridors relative to the railroad lines of the Western U.S. Most lines within these corridors are owned by BNSF and UP. As in Phase I, the primary focus of analysis in Phase II was on the BNSF and UP main lines.

As can be seen, these rail lines run in four principal east - west corridors, and comprise the western end of the transcontinental rail routes (WTTN Corridors 1, 2, 4 and 5). Lines also run in two principal north - south corridors (WTTN Corridors 7, and 17). Several other major routes crisscross between the east - west and north - south corridors.

The corridors on the western end of the WTTN area terminate at the major West Coast metropolitan areas and seaports of Seattle/Portland, San Francisco/Oakland, and Los Angeles. Eastern termini include the major mid-continent gateways of Chicago, Kansas City, St. Louis, Memphis, and New Orleans. North - south routes run from the Canadian to the Mexican borders of the U.S., and from the Midwest to the Gulf of Mexico.

[3] The DME has plans for a new rail line running to the Powder River Basin coal mines in Wyoming.
[4] Capacity, congestion, safety, environment, and community impact deficiencies were cited for the CP line between Fairmont and Portal, North Dakota in Corridor 13.

Exhibit 2-14
WTTN RAIL LINES

OTHER TRANSPORTATION FACILITIES WITHIN EACH WTTN CORRIDOR

While highways and rail lines comprise the principal surface transportation routes, the intermodal facilities within the corridors are of equal importance. These "other" intermodal transportation facilities (airports, grain elevators, rail TOFC/COFC and reload facilities, and water ports), are the initiators and/or receptors of much of the freight served by the highways and rail lines. A total of 335 WTTN intermodal facilities were identified in the study. The transportation facility analysis, which examines ground access issues by category type, is included in Chapter 5 of this report. Each type of facility is mapped and listed separately, along with the general criteria applied regionwide to designate such facilities.

- The WTTN states designated 18 **airports**, including one proposed facility (see Exhibit 5-20).
- Of the 234 **grain elevators** included in the WTTN analysis, all but nine are located in five states (see Exhibit 5-23).
- The states identified 55 **rail intermodal** facilities (TOFC and COFC operations) and **rail reload** handling a wide variety of commodities (see Exhibit 5-26).
- The four WTTN states with ocean access designated 27 public **ports** for inclusion, plus Lewiston, Idaho (see Exhibit 5-30).

Please refer to Chapter 5 for a discussion of these intermodal facilities.

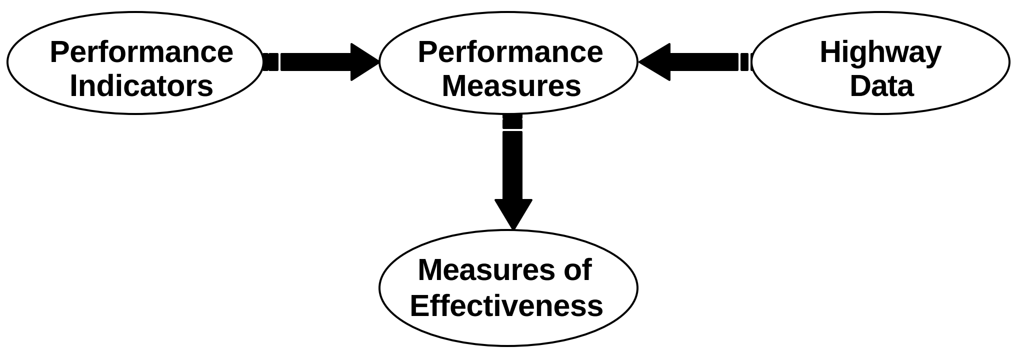
Chapter 3
HIGHWAYS ANALYSIS

The consultant worked closely with the WTTN Steering Committee to develop a process through which the performance of truck traffic on WTTN highways could be determined.

PERFORMANCE STANDARDS

Process

Exhibit 3-1
WTTN ANALYSIS PROCESS



The performance analysis process is based on the ability to quantify the following four basic *indicators of truck performance*:

- *Operating cost* – price per mile of driving a vehicle, including fuel, oil, tires, depreciation, and repairs.
- *Operating speed* – average speed (mph) to traverse a defined roadway section, usually expressed in peak and off-peak hours, under favorable weather conditions without exceeding the prevailing safe speed.
- *Safety* – use of accident and fatality data to identify roadway sections with geometric deficiencies.
- *Reliability* – on-time delivery.

Studies by the Federal Highway Administration and other consultants have yielded a much longer list of potential truck performance indicators. However, this consultant's work in other studies and this WTTN Steering Committee determined that these four performance indicators best represent those factors over which the roadway system itself, and its capacity and physical features, have a bearing.

These indicators of truck performance are not readily measurable, nor can they be determined directly. However, the establishment of quantifiable *performance measures,* as surrogates of the performance indicators, can be used to identify and quantify the causes of truck performance problems by identifying infrastructure deficiencies that affect truck performance. The performance measures (deficiencies) can be translated into *measures of effectiveness* that allow truck performance to be expressed in concise, consistent terminology.

Performance Measures - The consultant recommended focusing on the *outcome* side of highway planning characteristics to quantify truck performance on WTTN highways. The following performance measures were recommended to the Committee for consideration:

- *Pavement/Bridge Condition* – assess current WTTN highway pavement conditions using the International Roughness Index (IRI) or Pavement Serviceability Rating (PSR) as consistent reporting devices. Assess bridge conditions using National Bridge Inventory (NBI) data. Pavement and bridge conditions affect truck cost through higher maintenance/repair bills and detour routings. Poor pavement/bridge conditions slow trucks down, affecting travel speed, and make travel less safe. Poor pavement and bridge conditions directly impact truck reliability.

- *Pavement Geometry* – measure how geometric restrictions (lane width, shoulder width, bridge underclearance) affect truck performance. Narrow lanes are less safe, especially for large vehicles, and frequent speed reductions due to lane width directly impact speed and reliability. Narrow lanes and bridges lead to frequent speed cycling, which increases operating cost.

- *Roadway Alignment* – determine the impact of horizontal and vertical alignment on truck performance. Steep vertical alignment (grades) and radical horizontal alignment (curves) directly contribute to speed cycling, safety risks, and increased costs due to speed recovery. Alignment problems are among the most costly to address, and greatly affect the cost and reliability of freight traffic.

- *Congestion* – examine the effects of congestion, both existing and at future traffic levels, on truck performance using level-of-service (LOS) and volume/capacity measures. Congestion has the most direct effect on operating speed and the cost of trucks. Frequent speed changes due to congestion increases the safety risk and hampers reliability. Many trucks attempt to traverse congested urbanized areas during off-peak hours to avoid delays. Therefore, it was determined that the consultant would examine congestion during both peak and average daily intervals. "Peak" is defined as the busiest hour during the day.

  In many studies, the peak travel time (both time and duration) is established so that congestion effects can be quantified for an individual city or route. The broad extent of the WTTN Region and significant disparity between peak hours (the peak hour is decidedly different in Cheyenne than in Los Angeles) makes individualized congestion determinations expensive and of questionable value. The more important determination is how truck traffic performs in peak conditions, regardless of when the peak exists.

Certainly, it is possible to select other measures to estimate truck performance; however, these four outcomes/measures were selected because each impacts all four performance indicators. Further, it was determined that each can be readily measured using data normally available through state DOTs.

MINIMUM TOLERABLE CONDITIONS

The evaluation process involves establishing *minimum tolerable conditions (MTCs)* for truck performance on WTTN highways. Minimum tolerable conditions represent the lowest acceptable threshold for truck performance and facility condition/geometry in specific, measurable areas. MTCs are very different from *design standards*, which are the parameters to which a new, reconstructed, or rehabilitated roadway is brought. For example, the shoulder width design standard for a rural interstate-type facility might be 12 feet, whereas the WTTN truck minimum tolerable condition for the same facility is eight feet.

Each state establishes different design standards and establishes its own minimum tolerable conditions. MTCs are frequently used in the transportation capital programming process to signal the need for an improvement once a measure falls below the minimum. For this study, it was desirable to establish a set of minimum tolerable conditions that are consistent across the WTTN Region. Therefore, the minimum tolerable conditions established for this study represent a consensus of the WTTN Steering Committee for trucking operations across the entire WTTN Region. The states represented in the WTTN Region establish unique minimum tolerable conditions to quantify highway needs and set capital improvement priorities in their states. The WTTN Minimum Tolerable Conditions are in no way intended to replicate or replace these individual state criteria.

HPMS - The consultant and Steering Committee agreed to use terminology and definitions consistent with the FHWA's Highway Performance Monitoring System (HPMS). The HPMS is the nation's highway database, maintained by the FHWA using data supplied by the states, and updated on a regular basis. The HPMS is supported by a suite of computer software that uses HPMS data to calculate performance characteristics, estimate capital needs by functional classification and category, model traffic growth and pavement deterioration, calculate capacity and congestion, and other factors over time. Information produced by the HPMS is used by transportation agencies, the FHWA, USEPA, and Congress. In fact, HPMS output is used to compute the apportionment of some federal highway funding authorized by TEA-21. Because both the states and consultant are familiar with this system, the WTTN performance evaluation is based upon data and processes from the HPMS, modified for use in the WTTN Region.

The HPMS was developed to replace a series of random needs studies requested by the FHWA. The new system is based upon a statistically valid sample of roadway sections by functional classification, volume group, and geographic area. The sample remains constant over time so the FHWA can model items like pavement deterioration and traffic growth using real field data. In addition, the FHWA asks the states to update the HPMS data on a regular basis. Some items which can change quickly, like traffic volume and pavement condition, are updated more frequently than other data items.

Higher-order routes, like interstates, typically have 40 to 60 percent of their mileage sampled by the HPMS. The sample rate decreases as the functional classification drops in importance. Not every route in a state is necessarily sampled for the HPMS; the random nature of selecting sample sections ensures representation of like routes with like traffic volumes, but there is no requirement that every route be sampled. That said, many states sample their routes at rates higher than the FHWA minimum, especially on interstates on the NHS. The number of states with 100 percent representation on higher-order functional classes in the HPMS is growing. This is because more states have come to appreciate and use some of the supporting analytical software provided by the FHWA to help quantify investment needs over time.

The states also must report certain information for the highway *universe*, which is part of the HPMS database. For example, the states must report mileage, ADT, route number, ownership, and pavement condition for the *universe* of principal arterials (all mileage, whether sampled or not). HPMS sample sections on principal arterials have other additional data requirements, including detailed pavement/improvement information, geometrics data, traffic/capacity data, and environmental data. The universe reporting requirements lessen as functional classification drops to other arterials and collectors.

The nature and extent of data reported routinely to support the HPMS become important as the consultant and WTTN Steering Committee considered data collection requests to support the WTTN deficiency analysis.

Specific MTCs - The WTTN Highway Corridors Truck Minimum Tolerable Conditions (MTCs) are listed in Exhibit 3-2. Each Minimum Tolerable Condition category corresponds with one of the performance measures listed earlier. The column headings in Exhibit 3-2 help differentiate the MTCs for various facility types (interstate-type vs. non-interstate-type) in various operating environments (flat/rolling/mountainous terrain and urban). MTCs for each of the facilities studied in this effort (interstate vs. non-interstate) in various operating environments (flat/rolling, mountainous as well as urban) are described in Exhibit 3-2. The goal is to minimize the number of categories of MTCs needed to accurately assess the highway system.

Exhibit 3-2
WTTN HIGHWAY CORRIDORS
TRUCK MINIMUM TOLERABLE CONDITIONS

	INTERSTATE-TYPE[1]			NON-INTERSTATE-TYPE[2]		
	Flat/ Rolling	Moun-tainous	Urban	Flat/ Rolling	Moun-tainous	Urban
Roadway						
Pavement Condition						
- IRI (Roughness)	120	120	120	170	170	170
- PSR (Condition)	3.0	3.0	3.0	2.5	2.5	2.5
Lane Width	12	12	12	12	12	12
Shoulder Width	8	8	8	4	4	4
Vertical/Horizontal Alignment Adequacy	2	2	--	2	2	--
Speed Limit	65	60	55	55	55	55
Weighted Design Speed (WDS)	70	70	70	60	60	60
Bridges						
Deck Condition	4	4	4	4	4	4
Superstructure, Substructure	4	4	4	4	4	4
Operating Rating (tons)	28	28	28	28	28	28
Posted Load Limit	5	5	5	5	5	5
Underclearance	4	4	4	4	4	4
Deck Geometry	4	4	4	4	4	4
Approach Rdwy Alignment	4	4	4	4	4	4
Operation						
Volume/Capacity Ratio[3]	0.75	0.75	0.92	0.80	0.80	0.52
Level-of-Service (LOS)	C	C	D	C	C	D
Measure of Effectiveness Truck Operating Speed	65	50	40	55	45	35

1. 4 or more lanes, divided, full control of access.
2. Undivided or divided, <full access control.
3. Indicator only, as the V/C ratio is dictated by the facility type and LOS.

Interstate-type highways are distinct from other highways in the WTTN network. Interstate-type highways have four or more lanes, are divided by a median, and have full control of access. These facilities perform at a much higher level than *non-interstate-type highways*, which are generally two-lane facilities in rural areas and signalized two and four-lane arterials in urban areas and smaller towns. Non-interstate-type facilities are generally built to lower design standards than interstate-type highways. That is, they may have steeper grades, more curves, restricted passing opportunities, narrower shoulders, lower speed limits, etc. These lower standards mean that the operating speeds of all vehicles, especially trucks, are much lower than interstate-type highways. It is for this reason that the MTCs are distinctly different for these two general types of facilities. It follows that performance expectations and minimum acceptable conditions are lower also.

Each facility type is divided into three environments: flat/rolling, mountainous, and urban. Once again, as-built conditions vary significantly for a highway in mountainous terrain versus comparable facilities in flat, open terrain and with urban settings. It follows that performance expectations and acceptable conditions will vary also. For example, alignment variations in mountainous terrain reduce vehicle-operating speeds below the speed that the same vehicle would operate at on flat terrain. Therefore, the minimum tolerable truck operating speed is 50 mph in mountainous terrain for interstate-type highways and 65 mph in flat and rolling terrain.

Information on each of the individual MTCs is provided in the following subparagraphs. Both an overall definition and explanation of minimum values is provided.

- *Pavement Condition*. The measure of pavement condition is crucial in assessing highway performance. Pavement conditions contribute to overall operating cost because of speed cycling and the additional vehicle repairs necessitated by rough road conditions (especially tires and shocks). Poor pavement conditions also contribute to a variety of safety problems (weaving, loss of skid-resistance, unpredictable speed changes, etc.).

  The most widely accepted expression of pavement roughness is the International Roughness Index (IRI). For the HPMS, the IRI is a required value for all rural minor arterial HPMS samples, and all universe and sample sections classified as principal arterial or on the National Highway System. The IRI, as the name implies, is a measure of pavement roughness, not condition. It is expressed as inches/mile as a three-digit number (maximum 632). The minimum tolerable IRI for interstate-type facilities is 120, which corresponds to the high end of the “fair” range as defined by the FHWA. For non-interstate-type facilities, the WTTN minimum tolerable IRI is 170, which is mid-range of the “fair” category.

The PSR is a 0 to 5 value reported to the nearest tenth. PSR is a value derived from the Pavement Serviceability Index and other sufficiency ratings, and is designed to assess pavement condition, not roughness alone (like IRI). The PSR is somewhat subjective in nature and there is no universal/standard PSR measuring equipment, so it is a less-preferred measure for the FHWA in the HPMS (it is required for paved roadways only when the IRI is not available). The consultant and Steering Committee have defined a minimum tolerable PSR for interstate-type facilities as 3.0 and 2.5 for non-interstates, which correspond to the mid- to high range of the fair condition rating.

The consultant values the condition-rating assessment aspect of the PSR and prefers it to the IRI for the purposes of the WTTN performance analysis. The PSR provides a more inclusive evaluation of pavement condition. The IRI is less useful since it can provide deceptively high (deficient) ratings for rough, yet sound, concrete and deceptively low (adequate) ratings for structurally poor bituminous pavements that ride smoothly. The WSA deficiency model checks first for the availability of the PSR and uses it alone if available. If a PSR value is not available, the WSA deficiency model uses the IRI. The following exhibit taken from the HPMS Field Manual depicts pavement condition definitions for different PSR ratings.

- *Lane Width & Shoulder Width*. The minimum tolerable truck lane width for WTTN highways is 12 feet, regardless of facility type. The Steering Committee and consultant agreed that the 12-foot lane width was a key safety component that would impact non-interstate highways only, but was very important to safety considerations. The minimum tolerable shoulder width of eight feet on interstate-type highways is less than the interstate design standard, while the four-foot minimum for non-interstates is hardly adequate to allow a truck pull-off. Shoulder deficiencies are recognized as contributors to safety problems, but most states do not program capital funds for projects to improve only shoulders. Shoulder improvements are typically scheduled as part of a larger rehabilitation improvement; therefore shoulders-only improvements will not be identified as part of the WTTN analysis.

- *Alignment Adequacy*. Alignment adequacy is an expression that defines the extent of vertical and horizontal alignment deficiencies (curves and grades). The HPMS requires curve and grade data to be reported for all paved rural arterials and urban principal arterials. However, this data is very difficult to collect and report in the detail requested by the FHWA. The states have expressed considerable frustration with this data item. In fact, the FHWA is currently reducing the required data for curves and grades in response to the states concerns.

Exhibit 3-3
PAVEMENT CONDITION RATING

PSR	Description
4.0 – 5.0	Only new (or nearly new) superior pavements are likely to be smooth enough and distress free (sufficiently free of cracks and patches) to qualify for this category. Most pavements constructed or resurfaced during the data year would normally be rated in this category.
3.0 – 4.0	Pavements in this category, although not quite as smooth as those described above, give a first class ride and exhibit few, if any, visible signs of surface deterioration. Flexible pavements may be beginning to show evidence of rutting and fine random cracks. Rigid pavements may be beginning to show evidence of slight surface deterioration, such as minor cracks and spalling.
2.0 – 3.0	The riding qualities of pavements in this category are noticeably inferior to those of new pavements, and may be barely tolerable for high-speed traffic. Surface defects of flexible pavements may include rutting, map cracking, and extensive patching. Rigid pavements in this group may have a few joint failures, faulting and/or cracking, and some pumping.
1.0 – 2.0	Pavements in this category have deteriorated to such an extent that they affect the speed of free-flow traffic. Flexible pavement may have large potholes and deep cracks. Distress includes raveling, cracking, rutting and occurs over 50 percent of the surface. Rigid pavement distress includes joint spalling, patching, cracking, scaling and may include pumping and faulting.
0.0 – 1.0	Pavements in this category are in an extremely deteriorated condition. The facility is passable only at reduced speeds, and with considerable ride discomfort. Large potholes and deep cracks exist. Distress occurs over 75 percent or more of the surface.

Source: HPMS Field Manual, 1998.

Nonetheless, alignment problems are key contributors to reduced truck performance. Steep grades slow loaded truck speeds to a crawl, and sharp curves also reduce truck speeds. Poor alignment affects safety, cost, speed and congestion for trucks. Therefore, the consultant team is very interested in obtaining accurate alignment data without asking for additional data to be collected. For the purposes of the WTTN deficiency analysis, the consultant prefers to use raw HPMS curve and grade data, which is translated into an expression of adequacy by the HPMS software programs (0 to 4 scale). For both curves and grades, an expression of adequacy of "2" is the minimum tolerable (see Exhibit 3-4 from the HPMS Field Manual). This rating of adequacy is defined as "all curves can be safely and comfortably negotiated at the prevailing speed limit" for horizontal alignment. For grades, a "2" rating means the vertical alignment provides "sufficient sight distance for safe travel and does not substantially affect the speed of trucks." The Steering Committee and consultant agreed that conditions worse than a "2" rating were unacceptable for the WTTN Highway Network.

Exhibit 3-4
HPMS ALIGNMENT DEFINITIONS

Code	Description
Item 60 – Vertical Alignment Adequacy (Rural Date Item) (Length = 1)	
This item is required for paved rural major collectors unless Grades by Class (Item 61) is reported for the section. (See Table IV-4). If Item 61 is not reported for the required systems (paved rural arterials and paved urban principal arterials) this item should be appropriately coded. The following codes will be used:	
0	Item 61 (Grades) is reported (the HPMS calculation software will insert an appropriate code based on the grade data), or this item is not required for the section.
1	All grades (rates and length) and vertical curves meet minimum design standards appropriate for the terrain. Reduction in rate or length of grade would be unnecessary even if reconstruction were required to meet other deficiencies (i.e., capacity, horizontal alignment, etc.).
2	Although some grades (rate and/or length) and vertical curves are below appropriate design standards for new construction, all grades and vertical curves provide sufficient sight distance for safe travel and do not substantially affect the speed of trucks.
3	Infrequent grades and vertical curves that impair sight distance and/or affect the speed of trucks (when truck-climbing lanes are not provided).
4	Frequent grades and vertical curves that impair sight distance and/or severely affect the speed of trucks; truck-climbing lanes are not provided.
Item 57 – Horizontal Alignment Adequacy	
0	Item 58 (Curves) is reported (the HPMS calculation software will insert the appropriate code based on the curve data), or this item is not required for the section.
1	All curves meet appropriate design standards for the type of roadway. Reduction of curvature would be unnecessary even if reconstruction were required to meet other deficiencies (i.e., capacity, vertical alignment, etc.).
2	Although some curves are below appropriate design standards for new construction, all curves can be safely and comfortably negotiated at the prevailing speed limit on the section. The speed limit was not established by the design speed of curves.
3	Infrequent curves with design speeds less than the prevailing speed limit on the section. Infrequent curves may have reduced speed limits for safety purposes.
4	Several curves comfortable and/or unsafe when traveled at the prevailing speed limit on the section, or the speed limit on the section is severely restricted due to the design speed of curves.

Source: HPMS Field Manual, 1998.

- *Speed Limit*. The speed limit, though regulatory in nature, was included as a deficiency to be evaluated because of its important contribution to truck operations, especially in dense areas where partial and non-access controlled facilities are subject to signalization. The stop-and-go nature of urban arterials affects truck performance by introducing speed cycles. The acceleration from a stop for trucks slows the entire traffic stream, increasing congestion, causing safety problems, and greatly increasing operating costs. The regulatory speed limit is unrelated to the design speed of the roadway; rather, it is in response to adjacent development and prevailing speeds in dense areas.

  The WTTN minimum tolerable truck speed limit ranges between 55 mph and 65 mph. The rather high threshold for speed limit will trigger the identification of "speed limit only" deficiencies, especially on urban arterials.

- *Weighted Design Speed (WDS).* The weighted design speed is an expression (in mph) of the maximum speed a vehicle could safely travel on a highway unrestricted by the presence of other vehicles. The WDS is a function of horizontal alignment; thus, the presence of sharp curves will reduce the WDS. Minimum tolerable conditions for WDS are introduced into the WTTN analysis to identify roadway anomalies where a highway's design is severely limited due to curvature. Horizontal alignment adequacy, as defined in the MTCs for WTTN, essentially override the need for WDS assessment.

- *Bridges*. Highway bridges typically affect vehicle operations only when conditions become severe. For example, a bridge becomes seriously deficient when it must be posted to less than legal loads. This causes vehicles to detour around the posted bridge, which significantly impacts speed and cost, and can impact safety if the detour roadway is of a lesser standard. The WTTN bridge minimum tolerable conditions are derived to identify bridges that are in serious structural condition, are under-designed for modern legal limits, have approach roadway alignment or deck geometric deficiencies that cause them to be functionally obsolete, or have vertical/horizontal underclearance restrictions that would impact truck operations.

  Deficient bridges are described in two general ways: functionally obsolete and structurally deficient. A structurally deficient bridge is much more serious, as this classification means the bridge has load-bearing members whose condition has deteriorated to the point that the bridge should be repaired. Structurally deficient bridges should be posted for weight restrictions and undergo significant rehabilitation or complete replacement to restore the legal load-carrying capacity of the bridge. A functionally obsolete bridge is one that has geometric restrictions that hinder the operations of certain vehicles. Functionally obsolete bridges have narrow decks, narrow horizontal underclearance, low vertical underclearance, and/or poor approach roadway alignment.

The minimum tolerable bridge conditions used in the WTTN evaluation are tied directly to the FHWA's National Bridge Inventory Program (NBIP) analysis, which uses the National Bridge Inventory (NBI) database. The bridge MTCs are established "across the board" so there is no difference between facility type or environment. Minimum tolerable ratings of "4" on a 0 to 9 scale correspond to a "poor" condition rating, as defined by the FHWA, in each of the following categories:

- *Deck* – condition rating of the vehicle-carrying surface; a poor deck rating can lead to a bridge being classified as structurally deficient.

- *Superstructure* – condition rating of that part of the bridge above the piers; this is the above-deck steel for a truss bridge and the concrete/steel load-supporting member between the top of the piers and the deck for other typical bridges. A poor superstructure rating can lead to a structurally deficient classification.

- *Substructure* – condition rating of that part of the bridge below the superstructure. This is typically the bridge piers, abutments, piles, footings, etc. Bridges with poor substructure ratings can be classified structurally deficient.

- *Underclearance (vertical and horizontal)* – adequacy of the bridge to allow legal-sized vehicles to operate, both from a vertical clearance perspective (15 feet) and horizontal (8 to 10 feet for arterials). Bridges with inadequate underclearances can be classified functionally obsolete. A bridge receives a reduced rating if its clearances are less than design standard (17 feet vertical and 30 feet horizontal). Many states, notably South Dakota, have identical MTCs and design standards to recognize the importance of moving over-sized loads. A deficiency analysis using identical MTCs and design standards, of course, appreciably increases the number of bridges with deficient clearances.

- *Deck Geometry* – a rating which describes the width of the deck. A poor deck geometry rating can lead to a functionally obsolete classification. The "4" rating for this item corresponds to different bridge widths, depending upon the functional classification, type of operation, and bridge length.

- *Approach Roadway Alignment* – description of the alignment adequacy of the approach roadway. Poor alignment of the approach roadway is defined as a "substantial" reduction in speed being required, as compared with the adjacent highway section.

A rating of "5" is the MTC for Posted Load Limit, which is defined as "no posting required." The bridge operating rating, which is the "absolute maximum permissible load level to which the structure may be subjected," is evaluated at a minimum tolerable level of 28 tons. Low operating ratings can lead to a classification of structurally deficient.

- *Operation (V/C ratio and LOS).* Roadway operational deficiencies are manifested as congestion (i.e., too many vehicles trying to travel a roadway with inadequate capacity). The results include more accidents, slower speeds, and higher costs, especially for trucks. The WTTN deficiency analysis for operations examines the volume-to-capacity ratio and level of service on each WTTN highway. The minimum tolerable level of service (LOS) is "C" in rural areas and "D" in urban environments. The LOS is a qualitative expression of operating conditions (congestion) when a roadway is accommodating various traffic volumes, using an alphabetic rating (A to F), as defined below:

  - A - free flow (low volumes and high speeds)
  - B - stable flow, (speeds restricted somewhat by volume)
  - C - restricted stable flow (lower speed, less maneuverability)
  - D - approaching unstable flow (speed considerably affected by changes in operating conditions)
  - E - unstable flow (at or near capacity, some stoppages)
  - F - forced flow (volumes exceed capacity, slow speeds, frequent stoppages)

  The LOS minimum tolerable condition is related to the volume-to-capacity (v/c) ratio in that v/c is merely an indicator dictated by facility type and level of service. LOS is driven by the most important truck urban operations indicator, operating speed. The Steering Committee establish minimum tolerable truck operating speeds ranging from 35 mph on non-interstate-type urban arterials to 65 mph on interstate-type facilities in flat/rolling terrain. It is from this key truck measure of effectiveness that the minimum tolerable corresponding LOS and V/C were derived for the deficiency analysis.

  The minimum tolerable truck operating speed does not vary by time of day. This study recognizes that operating conditions differ vastly between congested and uncongested conditions, which correspond to peak and off-peak times in urban areas. However, the minimum tolerable truck operating speed is a constant expression regardless of time of day. This is examined in more detail in the performance discussion later in this chapter.

HIGHWAYS DEFICIENCY ANALYSIS

Process: HPMS Systematic Approach

Roadways and bridges in the WTTN Highway Network are considered deficient if their design, condition, or operating attributes fall below the minimum tolerable conditions outlined above. In order to consistently evaluate all WTTN highways without initiating an expensive, new data collection effort, the Steering Committee decided to use an *HPMS Systematic Approach* to calculating deficiencies.

HPMS And Other Data

Because the HPMS is a universal database and has a consistent reporting format across the 17-state WTTN Region, it is the logical data base from which to build an analytical procedure. Under this approach, the consultant identified those HPMS data items needed to determine deficiencies in each MTC outlined in the previous sections. To determine deficiencies for each performance attribute, the following question applied: "What HPMS data are needed to determine if a highway is deficient in this category?"

The consultant reviewed the MTCs for each highway attribute and determined the minimum HPMS-type data required to accurately assess each. The WTTN States were asked to provide this data (see Exhibit 3-5) on their *non-sampled* WTTN highways. Because the consultant owned a copy of the 1996 HPMS Data Base, detailed information was requested only for non-sampled mileage.

The data request was designed to ask states to provide information already on-hand in a familiar HPMS format. The states were also asked to provide materials (map or straight-line diagram) to help the consultant physically associate a data string with a roadway section. By combining the HPMS data and information provided by the states, the consultant was able to create a database for 100 percent of the WTTN Highway Network.

HPMS-type data describes a series of short highway sections of like attributes that are combined to represent a *supersegment*. In rural areas, an HPMS sample section averages several miles in length but, in urban areas, the average sample section is less than one mile in length. The FHWA and states work together to specify criteria for "section breaking," but the idea is to create a section break when certain geometric attributes change (lane width, alignment adequacy, access control, shoulder width, number of lanes), administrative aspects (functional class, county, jurisdiction), or operational characteristics (ADT, % trucks). HPMS section breaks occur frequently, so a section represents a highway length of like characteristics.

The WTTN approach is designed to be less rigorous and demanding than the standard HPMS approach. For example, where an HPMS break may occur with a 10 percent jump in ADT or a two-foot change in shoulder width, these changes are not significant for the purposes of the WTTN deficiency analysis. The approach employed by the consultant, therefore, is to group many HPMS sections to form a WTTN supersegment. The data for the entire segment was then averaged in a weighted fashion (by mileage) to represent the entire section.

Exhibit 3-5
WTTN HIGHWAYS DATA REOUEST

HPMS Item #	Description	HPMS Section	Non-HPMS Section
3	State Code	X	X
6	County	X	X
7A	Section ID	X	X
8	LRS Mileposts	X	X
9	Rural/Urban Designation		X
10B	Urbanized Area Code		X
12	Functional System Code		X
17	Route Signing		X
19	Route Number		X
25	Section Length		X
28	AADT		X
30	Number of Through Lanes		X
32	Access Control		X
35/36	Pavement Condition (IRI and/or PSR)		X
51	Lane Width		X
53	Shoulder Width		X
57	Horizontal Alignment Adequacy (will be calculated if Item 58 is provided)		X
58	Curves by Class (Length)		X
59	Type of Terrain		X
60	Vertical Alignment Adequacy (will be calculated if Item 58 is provided)		X
61	Grades by Class (Length & Number)		X
63	Speed Limit		X
64	Weighted Design Speed (can be calculated by WSA if Item 58 is provided)		X
65A	% Single Unit Commercial Vehicles (Peak & Off-peak)		X
65B	% Combination Commercial Vehicles (Peak & Off-peak)		X
666	K-Factor (will be defaulted if not provided)		X
67	Directional Factor (will be defaulted if not provided)		X
68	Peak Capacity		X
73	Future AADT		X
74	Year of Future AADT		X
79A/B	# At-Grade Controlled Intersections (Signals/Stop Signs)		X

HPMS-Only States - The states worked hard to provide the consultant with the data requested. However, due to non-participation by four states in the Region, the consultant had only the HPMS sample section data to describe the WTTN highways. In addition, several participating states were unable to provide the data requested.

The consultant team suggested the HPMS sample *might* be considered adequate in the HPMS-only states if the HPMS sample covered a significant amount of WTTN highway mileage and the sample was widely distributed. That is, the HPMS sample would be considered representative of the entire supersegment under certain conditions, and the sample's characteristics would be assumed representative of the entire supersegment.

At the San Antonio Steering Committee meeting, it was agreed that coverage of about 40-50 percent was desired for interstates and 20-25 percent for non-interstates. In addition, the sample sections should be distributed so that several portions of the route are represented. This was especially important in urbanized areas, so congestion-related deficiencies would not be weighted by a sample from just the CBD or outlying area. The Steering Committee and consultant reviewed the supersegment data coverage in the HPMS-only states on a case-by-case basis and made a determination concerning whether the sample was adequate to represent the entire length.

The consultant assembled a spreadsheet, which was distributed to the Steering Committee for review (the spreadsheet is contained in Appendix B). The spreadsheet listed each supersegment and provided the complete length and the sample representation. Each supersegment was assigned a rating based upon the sample adequacy (extent and distribution). Based upon the review by the Steering Committee and consultant, it was agreed that insufficient data was available to adequately assess highway deficiencies on all or part of 10 supersegments of the WTTN network.

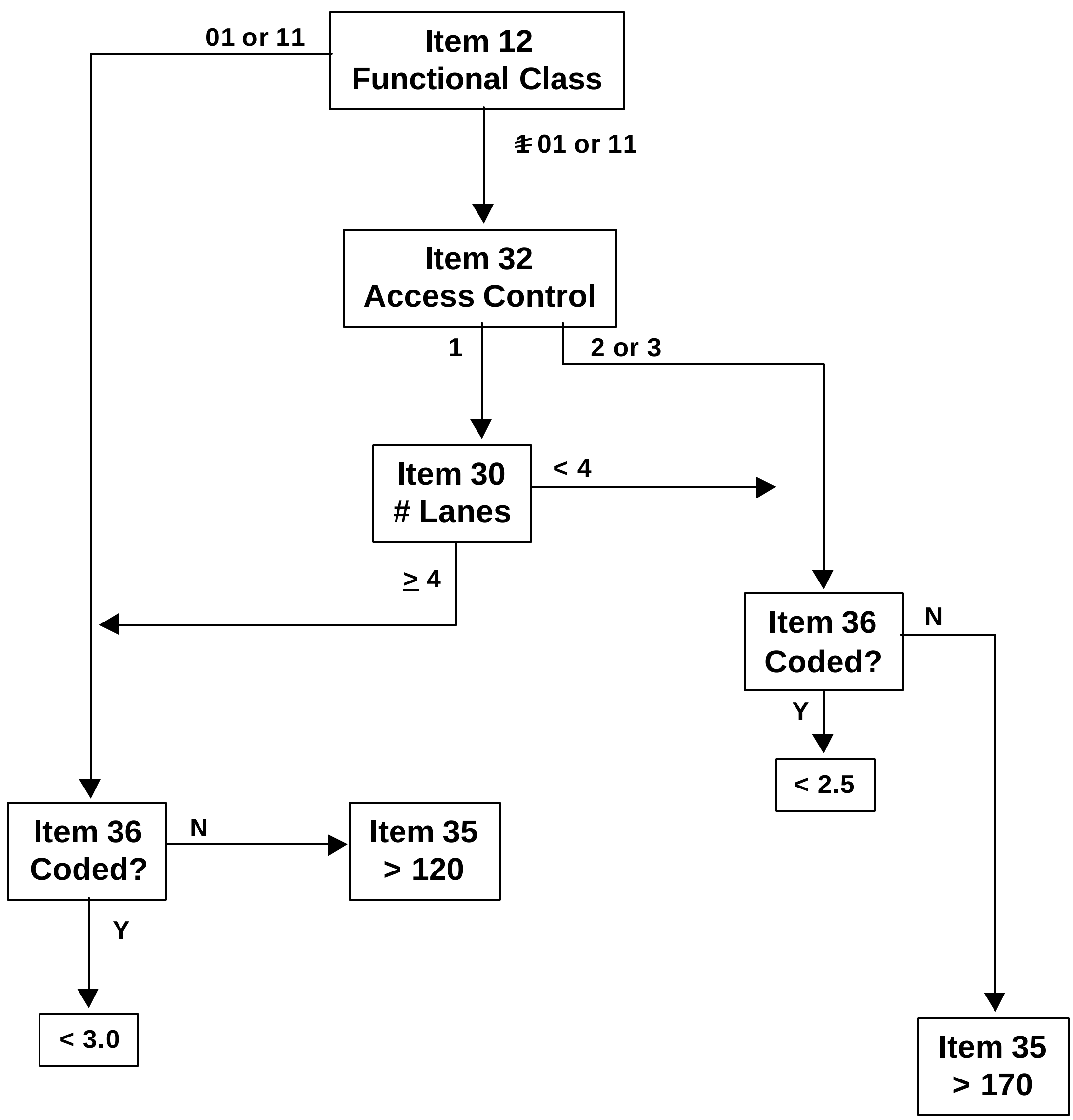
This means the sample is inadequate to the point that individual supersegment analysis is not recommended. However, when these 10 supersegments are combined with other supersegments *on a corridor basis*, the sample size appears adequate for each of the 20 WTTN

Trade Corridors. Missing data items reduce the usable data in some deficiency categories to less than 50 percent in Corridors 12, 14 and 20. However, the consultant believes the data expansion in these instances accurately reflects highway conditions in the corridors.

Deficiency Analysis - Once the data was received by the consultant, the information by sample section ("data string") was assigned to supersegments, combined with data from the HPMS database, and sorted for analysis. A deficiency model was built to analyze available data against agreed Truck Minimum Tolerable Conditions, and estimate/summarize deficiencies by type for each supersegment. Deficiencies are summarized and grouped into the following categories:

- *Pavement* – the consultant's deficiency model separates sections by functional classification, access control and number of lanes before applying the MTC (see Exhibit 3-6)
- *Speed Limit* – the model determines those supersegments that have an average speed limit lower than the minimum tolerable conditions.
- *Alignment* – if complete curve and grade data were available, the HPMS AP model (as modified by the consultant) was used to compute adequacy; otherwise, state-provided assessments of alignment adequacy were used.
- *Congestion* – this deficiency model (see Exhibit 3-7) classifies a section into one of five categories:
    - Multilane, full access control (interstate)
    - Multilane, less than full access control (expressway)
    - Any signalized section
    - Urban, no signals, less than four lanes
    - Rural, no signals, less than four lanes
- *Bridges* – consultant's model compares bridge ratings with bridge MTCs.

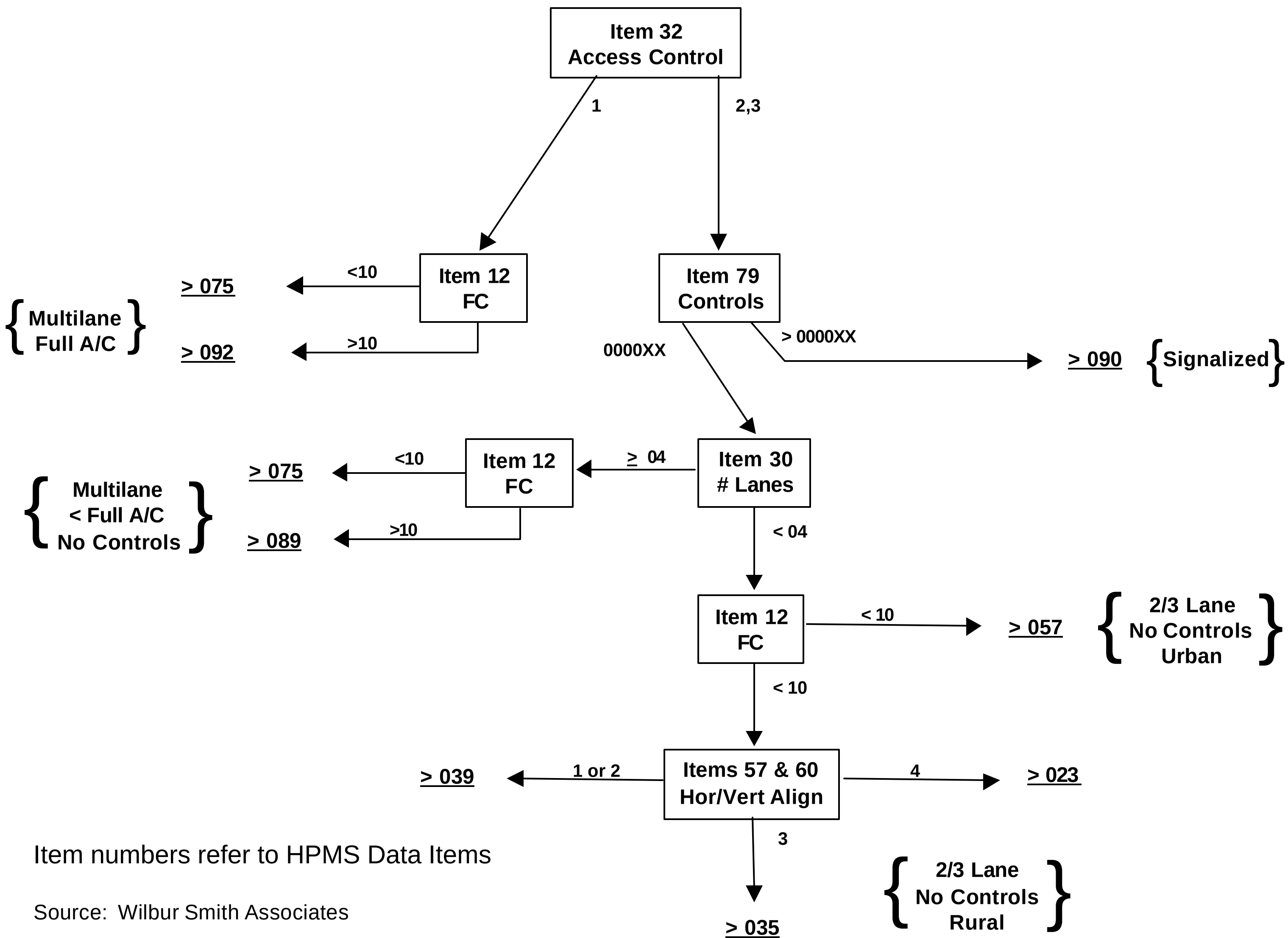
Exhibit 3-6
PAVEMENT CONDITION DEFICIENCY MODEL



Items refer to HPMS Data Items

Source: Wilbur Smith Associates

Exhibit 3-7
CRITICAL V/C DEFICIENCY MODEL



Item numbers refer to HPMS Data Items

Source: Wilbur Smith Associates

DEFICIENCIES

Highway deficiencies were calculated and summarized by supersegment using the process detailed above. Deficiencies, expressed as a percent of length, were identified for each of the following deficiency categories:

- Pavement Condition
- Lane Width
- Shoulder Width
- Vertical Alignment
- Horizontal Alignment
- Speed Limit
- Capacity (1996)
- Capacity (2016)

Rural sections were analyzed separately from urban sections, and the results by supersegment are presented in Appendix C. An example of the Appendix C presentation is shown on the next page (Exhibit 3-8). For each supersegment, urban and rural deficiencies are presented separately, then combined (*ALL SECTIONS*). In the example (SS #82, I-25 in Colorado), the state provided data for 100 percent of the mileage in the supersegment. Therefore, the rural *sample length* of 113.455 miles equals the *expanded length* in most deficiency categories. However, in some deficiency categories (shoulder width, horizontal alignment, 2016 capacity) the data was not available to conduct a complete determination of deficiencies for the entire supersegment length. The *ADEQUATE* and *INADEQUATE EXPANDED LENGTH* still adds to the entire length because the data was deemed sufficient to represent the full supersegment. The *SAMPLE RATE* column shows the percent of the data usable for a particular deficiency type.

<u>WTTN Roadway Deficiencies by Type</u> – Deficiencies were summarized for all WTTN highway supersegments (the *universe*). For the universe mileage, 2016 Capacity, Pavement, 1996 Capacity, and Shoulder Width were the most frequent deficiencies identified in the WTTN Trade Corridors. Future (2016) Capacity was deficient on 22.5 percent of the WTTN highway

Exhibit 3-8

WTTN DEFICIENCY SUMMARY
SUPERSEGMENT #82 EXAMPLE

Super-Segment NO 82 in COLORADO : I-25 Termini: New Mexico SL - Colorado Springs UL

RURAL LENGTH	113.455(36 SECTIONS COVERING	113.455 MILES)
URBAN LENGTH	18.368(29 SECTIONS COVERING	18.368 MILES)
TOTAL LENGTH	131.823(65 SECTIONS COVERING	131.823 MILES)

R U R A L S E C T I O N S

	EXPANDED LENGTH (MI)		SAMPLE	% OF EXPANDED LENGTH		SAMPLE
	ADEQUATE	DEFICIENT	LENGTH	ADEQUATE	DEFICIENT	RATE
PAVEMENT DEFICIENCY	89.933(32)	23.522(4)	113.455	79.27	20.73	100.00
LANE WIDTH DEFICIENCY	113.455(36)	.000(0)	113.455	100.00	.00	100.00
SHOULDER W. DEFICIENCY	102.309(26)	11.146(1)	30.752	90.18	9.82	27.11
VERT. ALIGN. DEFICIENCY	113.455(36)	.000(0)	113.455	100.00	.00	100.00
HORIZ. ALIGN. DEFICIENCY	111.974(34)	1.481(1)	95.177	98.70	1.30	83.89
SPEED LIMIT DEFICIENCY	113.455(36)	.000(0)	113.455	100.00	.00	100.00
CAPACITY DEFICIENCY 1996	113.455(36)	.000(0)	113.455	100.00	.00	100.00
CAPACITY DEFICIENCY 2016	113.455(27)	.000(0)	30.752	100.00	.00	27.11

U R B A N S E C T I O N S

	EXPANDED LENGTH (MI)		SAMPLE	% OF EXPANDED LENGTH		SAMPLE
	ADEQUATE	DEFICIENT	LENGTH	ADEQUATE	DEFICIENT	RATE
PAVEMENT DEFICIENCY	15.034(22)	3.334(7)	18.368	81.85	18.15	100.00
LANE WIDTH DEFICIENCY	18.368(29)	.000(0)	18.368	100.00	.00	100.00
SHOULDER W. DEFICIENCY	18.136(25)	.232(1)	16.704	98.74	1.26	90.94
VERT. ALIGN. DEFICIENCY	18.368(29)	.000(0)	18.368	100.00	.00	100.00
HORIZ. ALIGN. DEFICIENCY	18.368(29)	.000(0)	18.368	100.00	.00	100.00
SPEED LIMIT DEFICIENCY	14.680(20)	3.688(9)	18.368	79.92	20.08	100.00
CAPACITY DEFICIENCY 1996	18.368(29)	.000(0)	18.368	100.00	.00	100.00
CAPACITY DEFICIENCY 2016	16.493(23)	1.875(3)	16.704	89.79	10.21	90.94

A L L S E C T I O N S

	EXPANDED LENGTH (MI)		SAMPLE	% OF EXPANDED LENGTH		SAMPLE
	ADEQUATE	DEFICIENT	LENGTH	ADEQUATE	DEFICIENT	RATE
PAVEMENT DEFICIENCY	104.967(54)	26.856(11)	131.823	79.63	20.37	100.00
LANE WIDTH DEFICIENCY	131.823(65)	.000(0)	131.823	100.00	.00	100.00
SHOULDER W. DEFICIENCY	120.445(51)	11.378(2)	47.456	91.37	8.63	36.00
VERT. ALIGN. DEFICIENCY	131.823(65)	.000(0)	131.823	100.00	.00	100.00
HORIZ. ALIGN. DEFICIENCY	130.342(63)	1.481(1)	113.545	98.88	1.12	86.13
SPEED LIMIT DEFICIENCY	128.135(56)	3.688(9)	131.823	97.20	2.80	100.00
CAPACITY DEFICIENCY 1996	131.823(65)	.000(0)	131.823	100.00	.00	100.00
CAPACITY DEFICIENCY 2016	129.948(50)	1.875(3)	47.456	98.58	1.42	36.00

Note: The numbers in ( ) indicate the number of sample sections

mileage, followed by pavement condition (12.4 %), Current (1996) Capacity (7.2 %), Shoulder Width (6.7 %), Speed Limit (3.9 %), Horizontal Alignment (2.2 %), Lane Width (1.4 %), and Vertical Alignment (0.6 %).

Exhibit 3-9 shows urban WTTN highways have more than twice the pavement condition, 1996 capacity, and speed limit deficiencies, a higher percent of lane width deficiencies, and nearly three times the percentage of 2016 capacity deficiencies as rural WTTN highways.

Exhibit 3-9
WTTN ROADWAY DEFICIENCY ANALYSIS SUMMARY

	% of Expanded Length		
Deficiency	**Adequate**	**Deficient**	**Sample Rate**
Rural			
Pavement Condition	89.6	10.4	81.6
Lane Width	98.7	1.3	70.9
Shoulder Width	92.4	7.6	75.6
Vertical Alignment	99.3	0.7	69.4
Horizontal Alignment	97.4	2.6	69.3
Speed Limit	96.8	3.2	78.8
1996 Capacity	94.1	5.9	67.7
2016 Capacity	82.7	17.3	65.1
Urban			
Pavement Condition	78.0	22.0	79.7
Lane Width	98.2	1.8	72.4
Shoulder Width	97.8	2.2	71.6
Vertical Alignment	100.0	0.0	65.4
Horizontal Alignment	97.8	2.2	65.3
Speed Limit	92.6	7.4	73.2
1996 Capacity	86.1	13.9	72.4
2016 Capacity	52.1	47.9	70.9
Total			
Pavement Condition	87.6	12.4	81.3
Lane Width	98.6	1.4	71.2
Shoulder Width	93.3	6.7	75.0
Vertical Alignment	99.4	0.6	68.7
Horizontal Alignment	97.4	2.6	68.7
Speed Limit	96.1	3.9	77.9
1996 Capacity	92.8	7.2	68.5
2016 Capacity	77.5	22.5	66.1

U.S. Comparison. Limited data is available to compare WTTN highways with like highways across the country. In the following exhibit however, comparisons for lane width, 1996 capacity and pavement condition are shown between the WTTN highways universe and the U.S. National Highway System, weighted by Interstate/non-interstate in the same proportion. Although this does not provide an exact comparison, it does show how WTTN highways compare with similar highways nationwide in some deficiency categories.

Exhibit 3-10 shows WTTN highways have far fewer deficiencies in lane width, pavement condition and urban capacity. Only in rural capacity are the WTTN highways performing worse (5.9% compared with 3.9%). These findings suggest that WTTN corridors are appropriate candidates for creation of a trade network.

Exhibit 3-10
HIGHWAY DEFICIENCIES COMPARISON
WTTN HIGHWAYS vs. U.S. HIGHWAYS
1996

	WTTN % Deficient	U.S. % Deficient
Lane width – rural	1.3	10.9
Lane width – urban	1.8	12.7
1996 Capacity – rural	5.9	3.9
1996 Capacity – urban	13.9	41.0
Pavement condition – rural	10.4	17.9
Pavement condition – urban	22.0	31.6

Source of U.S. Data: FHWA

Deficiencies by Corridor - Deficiencies are initially calculated by supersegment, then summarized for presentation by WTTN Trade Corridor in Exhibit 3-11.

Exhibit 3-11
HIGHWAY DEFICIENCIES BY WTTN CORRIDOR

WTTN Trade Corridor	Miles	Percent Deficient							
		Pavement Condition	Lane Width	Shoulder Width	Vert Align	Hor Align	Speed Limit	1996 Capacity	2016 Capacity
1	4,781	12.1	2.5	14.4	0.8	3.4	5.2	5.0	11.2
2	1,754	18.4	0.5	5.9	2.5	0.0	0.3	8.3	22.7
3	1,126	10.9	1.1	14.2	0.0	1.5	5.4	7.5	18.8
4	1,546	7.9	0.0	0.0	0.0	0.0	2.8	3.8	9.7
5	2,746	10.7	0.2	0.1	0.0	0.7	0.9	4.0	26.5
6	857	2.5	0.0	0.4	0.0	2.0	0.2	1.4	25.3
7	2,162	34.3	0.6	1.8	1.3	2.8	2.6	13.0	64.2
8	734	12.5	0.0	6.9	0.0	3.7	0.0	2.3	5.6
9	672	7.7	11.1	33.9	5.4	18.1	5.9	40.2	65.7
10	2,155	12.2	0.0	15.4	0.9	3.4	7.0	13.1	40.8
11	2,369	14.4	0.5	0.7	0.0	0.6	2.3	3.4	8.9
12	261	3.7	2.5	76.5	0.0	0.0	3.7	0.6	2.5
13	442	5.4	0.0	0.0	0.0	0.0	1.8	0.0	0.0
14	1,738	11.8	2.2	0.1	0.0	1.4	9.9	7.5	17.8
15	337	1.5	0.3	0.2	0.0	0.0	5.0	2.7	8.3
16	1,380	15.9	0.1	3.2	0.1	3.0	2.6	9.3	13.0
17	3,472	9.4	1.0	1.9	0.0	3.0	1.2	5.2	24.6
18	1,013	3.1	4.9	0.0	0.8	3.4	12.3	14.6	29.8
19	2,087	6.9	2.1	3.7	0.0	0.1	4.1	3.8	12.0
20	854	11.9	2.2	19.1	0.9	1.3	9.1	9.9	19.9
Total		**12.4**	**1.4**	**6.7**	**2.6**	**2.2**	**3.9**	**7.2**	**22.5**

Table shows highways deficient by corridor within each deficiency category. Deficiencies are expressed as a percent of length (centerline miles).

Source: Wilbur Smith Associates

A brief summary of deficiencies in each WTTN Trade Corridor follows. A supersegment was determined to have "significant" deficiencies if the percent of deficiency exceeds the average of all corridors for that deficiency. For example, 12.4 percent of all WTTN highway mileage has pavement condition deficiencies. Those supersegments that exceed the average of 12.4 percent are considered to have "significant" pavement condition deficiencies.

To reiterate, the deficiencies mentioned below are measured against the Minimum Tolerable Conditions established for this study, which may not be the same criteria each state uses to determine deficiencies on an individual project basis.

Corridor 1, Pacific NW-Minneapolis-Chicago – Corridor with the most mileage (4,781) stretching from Seattle to Minnesota, including I-90, I-94, U.S. 2, U.S.12, U.S.87, U.S.395 and other routes. The corridor is in the top five in lane width deficiencies (U.S. 2 in Washington, Idaho, and Montana, U.S. 87 in Montana, S18 in Washington) and also has notable alignment deficiencies (U.S. 2 in Washington, Idaho and Montana, U.S. 12 west of Missoula, U.S. 87/S200 in Montana). Pavement condition deficiencies are prominent on I-90 from the Idaho state line to I-25 (MT, WY) and U.S. 2 in western Montana. U.S. 2 in Washington and Idaho and U.S. 12 in from Lewiston to Missoula have notable capacity deficiencies (current and future).

Corridor 2, San Francisco-Chicago – Corridor highways are I-80 (San Francisco-Omaha) and some urban interstate routes in San Francisco. I-80 has significant pavement deficiencies (CA, NV, UT, WY), making Corridor 2 the second highest in pavement deficiency share (18.4%) of the 20 Corridors. Significant 2016 capacity deficiencies also are noted in San Francisco, Sacramento, and Reno, while the Sacramento to Reno section has vertical alignment and shoulder width deficiencies as well.

Corridor 3, Utah-St. Louis – This corridor (mostly I-70) has above average deficiencies in only shoulder width (Utah), with some pavement deficiencies in Colorado, and 1996/2016 capacity deficiencies in Colorado and Kansas.

Corridor 4, Southern California-Memphis – This corridor is mostly I-40 from California to Arkansas. The only significant deficiencies are 2016 capacity (Albuquerque, Oklahoma City) and pavement condition through New Mexico, with the remaining deficiencies isolated.

Corridor 5, Southern California-New Orleans – This corridor includes I-8, I-10, I-20 and several CA state routes. Corridor 5 routes have above average deficiencies in 2016 capacity (San Diego, Los Angeles, El Paso, San Antonio, Houston, Dallas) only, with some pavement deficiencies (I-8 and I-10 in CA).

Corridor 6, Texas-Memphis – (I-20 and I-30 in Texas). These routes have significant deficiencies in only the 2016 capacity category (Dallas).

Corridor 7, Mexico-Canada – (I-5 from San Diego to Canada plus numerous urban interstates and some state routes). This corridor has the highest share of pavement deficiencies of the 20 Corridors (34.3%) and the second highest share of 2016 capacity deficiencies (64.2%). The pavement deficiencies are concentrated mostly in California and Oregon, and most supersegments have current and/or future capacity problems. US 97/S 58 in Oregon also has a myriad of problems (pavement, shoulder width, alignment, capacity). S 99 and S 7/86/78 in California have significant pavement deficiencies as well.

Corridor 8, Pacific NW-Utah – (I-84). This corridor, stretching from Seattle to Salt Lake City, has above average horizontal alignment deficiencies in Oregon (though just 3.7%), and notable pavement deficiencies (12.5%), though scattered.

Corridor 9, Boise-Canada – (U.S. 95, U.S. 195, U.S. 395 in ID and WA). These three two-lane highways traverse rugged terrain between Boise and the Canadian line, and have the highest percentage of lane width (11.1%), vertical alignment (5.4%), horizontal alignment (18.1%), current capacity (40.2%) and future capacity (65.7%) deficiencies of the 20 Corridors.

Corridor 10, Mexico-Canada (Canamex) – (mostly I-15 from Mexico to Canada, I-10/I-19/ U.S. 60/U.S. 93 from Mexico to Las Vegas, and U.S. 20/191 in Idaho and Montana). Highways in Corridor 10 have some of the highest deficiency rates in four categories: horizontal alignment (3.4% deficient), speed limit (7.0%), 1996 capacity (13.1%) and 2016 capacity (40.8%). Capacity deficiencies are prominent on I-15 in California, near Las Vegas, and through Salt Lake City, on I-215, and the two-lane crossing of Hoover Dam on U.S. 93 in

Arizona and Nevada (which also has speed limit deficiencies), U.S. 60/U.S. 93 in and northwest of Phoenix. U.S. 191 in Montana has some alignment deficiencies are on US 191 in Montana.

Corridor 11, Pacific NW-Kansas City – (Interstates 82, 84, 86, 90, 25 and 80 plus US 26 in WY and NE). The only prominent deficiency in Corridor 11 is pavement condition (14.4% deficient). Sections with significant pavement problems include I-25 north of Cheyenne, I-80 in Cheyenne, I-84 in Portland and eastern Oregon, I-86, and I-90 in Montana and Wyoming. U.S. 26 in Nebraska has above average lane width deficiencies.

Corridor 12, Montana-Canada – (U.S. 87/U.S. 191 and S19 in Montana). At 261 miles in length, this corridor between Billings and the Canadian line has the smallest number of miles of the 20 Corridors. It has the highest percentage of shoulder deficiencies (76.5%) and isolated lane width and pavement condition deficiencies.

Corridor 13, Canada-Minneapolis-Chicago – (U.S. 52 and I-94 in ND). This 442-mile corridor has some isolated pavement condition deficiencies (5.4%), but virtually no other problems.

Corridor 14, Wyoming-Galveston – (parts of I-25 and I-70 in WY and CO, U.S. 287 in CO, OK, TX, and I-45). The highways in Corridor 14 are "average" in most every deficiency category, and have above average deficiencies in lane width (2.2%) and speed limit (9.9%). The lane width problems are on U.S. 287 between Amarillo and Dallas, while the speed limit deficiencies are notable on U.S. 287 in Oklahoma and Texas (Wichita Falls to Ennis). All of I-45 has 2016 capacity deficiencies, while pavement condition deficiencies are notable on I-25 in Wyoming and Colorado, and on I-70 from Denver to Limon, Colorado.

Corridor 15, Mexico-Arizona – (Flagstaff to Mexico on I-10, I-17, I-19). This short (337 miles) section has no significant deficiencies except speed limit on I-19.

Corridor 16, Mexico-I-90 – (I-25 plus several state routes in NM, CO, SD, WY). Corridor 16 highways have prominent pavement condition deficiencies (15.9%), with few other notable problems. I-25 has significant pavement condition problems along its entire length and notable horizontal alignment deficiencies, while U.S. 385/S79 from Rapid City to I-80 has significant horizontal alignment, shoulder width, and some capacity deficiencies.

Corridor 17, Mexico-Canada/Midwest – (Interstates 35, 37, 44, 45 and 29 plus parts of U.S. 287 in Texas, U.S. 81 and U.S. 281 in Kansas, Nebraska, and the Dakotas). With 3,472 miles of highways, this north-south corridor has the second highest mileage of the 20 Trade Corridors. Despite its length and diversity, it has above average deficiencies in only 2016 capacity (24.6%). The future capacity deficiencies are prominent along I-35 (San Antonio through Dallas, and in Oklahoma), I-37 (in San Antonio and Corpus Christi), I-44 in Oklahoma City and Tulsa, all of I-45, I-135 in Wichita, U.S. 81 in Nebraska and South Dakota, and U.S. 281 from I-90 to ND (which also has pavement, lane width, shoulder width and horizontal alignment problems). Portions of I-35 (San Antonio through Oklahoma City), I-37 (Corpus Christi), I-44 (Oklahoma City), and I-45 (Houston) have significant 1996 capacity deficiencies, while I-29 (through the Dakotas), U.S. 81 in Nebraska, and U.S. 281 in South Dakota have notable pavement condition deficiencies.

Corridor 18, Laredo-Indianapolis – (U.S. 59, U.S. 77 and U.S. 281 in Texas). These U.S. routes in Texas are among the highest in five of the eight deficiency categories: lane width (4.9%), horizontal alignment (3.4%), speed limit (12.3% -- highest of the 20 corridors), 1996 capacity (14.6% -- second highest), and 2016 capacity (29.8%). Capacity deficiencies are prominent on U.S. 59 from Laredo through Houston, and the Houston to I-30 segment has numerous lane width and speed limit deficiencies. U.S. 77 has significant speed limit deficiencies, while U.S. 281 has alignment problems.

Corridor 19, New Mexico-St. Louis – (I-40, I-44, I-35, I-235, U.S. 54, and U.S. 70 in NM). The 2,087 miles in Corridor 19 have above average deficiencies in lane width (2.1%) and speed limit (4.1%). I-35, I-40 and I-44 each has significant capacity deficiencies through

Oklahoma City. U.S. 54 has lane width and pavement condition deficiencies of note from El Paso to I-40 (TX, NM), and speed limit deficiencies in Oklahoma and Kansas. U.S. 70 in New Mexico also has notable speed limit and 1996 capacity deficiencies.

Corridor 20, Montana-Canada – (parts of I-15 and I-90, U.S. 93 and S 3 in Montana). The 854 miles in this corridor connecting Billings with Canada have above average deficiencies in lane width (2.2%), shoulder width (19.1%), vertical alignment (0.9%), speed limit (9.1%), and 1996 capacity (9.9%). U.S. 93 from Missoula to Canada, a two-lane roadway through rugged terrain, has significant shoulder width, speed limit and capacity deficiencies. S 3 (Billings to Great Falls) has significant deficiencies in shoulder width, speed limit, lane width, and horizontal alignment. I-90 from Missoula to Billings has significant pavement condition deficiencies.

HIGHWAY BRIDGES DEFICIENCIES ANALYSIS

The consultant and Steering Committee agreed to use the National Bridge Inventory (NBI) database as the basis of the bridge deficiency analysis. This database, which is maintained by FHWA with the help of all the states, contains a description of every bridge in the nation more than 20 feet long. In addition to bridge identification and location, the database includes many items concerning the geometry and condition of the bridge.

For this study, it was agreed to focus on a limited number of potential bridge deficiencies. The eight potential bridge deficiency categories and their minimum tolerable conditions were listed earlier in Exhibit 3-2. They include:

- Deck Condition
- Superstructure Condition
- Substructure Condition
- Operating Rating
- Posted Load Limit
- Underclearance (for bridges above a WTTN highway)
- Deck Geometry
- Approach Roadway Alignment

Each of these potential deficiencies corresponds to a data item in the NBI database. The coded values for each relevant bridge were compared with the minimum tolerable thresholds and deficiencies were identified when the minimum tolerable conditions were not met. It should be noted that (1) the agreed upon list of potential bridge deficiencies is limited i.e., a full bridge needs study would analyze many more data items; and (2) the bridge minimum tolerable conditions adopted in this study are not necessarily the same each state would use.

The WTTN bridges were identified in the NBI database by the highway description carrying (or above) the structure. For example, all bridges on or under I-25 in Colorado were selected from the NBI database for further analysis. A total of 25,734 bridges were identified as serving the WTTN corridors.

The results of the bridge deficiency analysis are presented by corridor in Exhibit 3-12. A total of 327 (1.27%) bridges were found to have at least one of the selected deficiencies. The only deficiencies found were *operating rating* and *posted load limit*. These two types of deficiency could prevent some trucks from using the affected routes. There were no bridges with deck condition, superstructure condition, substructure condition, deck geometry or approach roadway width deficiencies. This does not mean that an individual state conducting a deficiency analysis of these same bridges would not find them inadequate. It is simply that all bridges met the minimum tolerable condition selected (rating of "4" corresponds to a "poor" condition) for these deficiency categories in the WTTN study.

Corridor 14, Wyoming-Galveston, has the most (68) deficient bridges, many of them in Texas. Corridor 12, Montana-Canada, has a relatively large number of deficient bridges (16) considering its short length. Corridor 13, Canada-Minneapolis-Chicago is the only corridor with no deficient bridges.

In Exhibit 3-12, please note that bridges with a "Posted Load Limit" deficiency will likely also be indicated deficient in "Operating Rating." Also, the number of bridges with deficiencies may not add to the total because one bridge may be deficient in more than one category.

While the overall number of deficient bridges may appear small for the total length of highways considered (327 bridges over 32,485 miles), each deficient bridge may cause trucks to detour around the affected bridge on alternate highway routes, which significantly impacts travel time.

PERFORMANCE ANALYSIS

Measures Of Performance

The WTTN Steering Committee and the consultant identified four major potential truck performance indicators: operating cost, operating speed, safety, and reliability. Because some of these indicators are not readily measurable, or require data that is not available on a consistent basis, the WTTN Steering Committee and the consultant agreed to focus on truck operating speed as the key study performance measure. Operating speeds for both single unit trucks and combination trucks were estimated for each road segment based on the conditions of the roadway, including roadway geometry and alignment, pavement condition, speed limit and traffic volumes.

Two types of operating speeds were calculated: one is the *average daily operating speed* and the other is the *peak hour operating speed* as defined by the peak hour factor or "K" factor for each road segment. Because it is not known when a truck would travel over a specific highway section during peak hour, the peak hour operating speed assumes that every section is traveled during peak hour. As a result the calculated peak hour speed and travel time for an entire corridor is pessimistic, as it is unlikely that a truck would travel every section during peak hour conditions.

Exhibit 3-12
WTTN-BRIDGE DEFICIENCY ANALYSIS
Corridor Results

Corridor	Functional Class	Number of Bridges with Following Deficiencies: Deck Condition	Superstr. Condition	Substr. Condition	Deck Geometry	Approach Rdwy. Width	Operating Rating	Posted Load Limit	Number of Bridges Deficient
1	**Pacific NW-Minneapolis-Chicago (4,781 Miles)**								
	Rural Interstate	0	0	0	0	0	1	1	2
	Rural Other PA	0	0	0	0	0	28	2	29
	Rural Minor Arterial	0	0	0	0	0	0	1	1
	Urban Interstate	0	0	0	0	0	2	0	2
	Urban Other PA	0	0	0	0	0	1	0	1
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**32**	**4**	**35**
2	**San Francisco-Chicago (1,754 Miles)**								
	Rural Interstate	0	0	0	0	0	0	5	5
	Rural Other PA	0	0	0	0	0	0	3	3
	Urban Other Fwy./Exp.	0	0	0	0	0	4	0	4
	Urban Other PA	0	0	0	0	0	1	1	2
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**5**	**9**	**14**
3	**Utah-St. Louis (1,126 Miles)**								
	Rural Interstate	0	0	0	0	0	12	0	12
	Urban Interstate	0	0	0	0	0	3	0	3
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**15**	**0**	**15**
4	**Southern California-Memphis (1,546 Miles)**								
	Rural Interstate	0	0	0	0	0	11	6	11
	Rural Other PA	0	0	0	0	0	1	0	1
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**12**	**6**	**12**

Exhibit 3-12
WTTN-BRIDGE DEFICIENCY ANALYSIS
Corridor Results

Corridor	Functional Class	Number of Bridges with Following Deficiencies: Deck Condition	Superstr. Condition	Substr. Condition	Deck Geometry	Approach Rdwy. Width	Operating Rating	Posted Load Limit	Number of Bridges Deficient
5	**Southern California-New Orleans (2,746 Miles)**								
	Rural Interstate	0	0	0	0	0	2	1	3
	Urban Interstate	0	0	0	0	0	2	1	3
	Urban Other PA	0	0	0	0	0	0	1	1
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**4**	**3**	**7**
6	**Texas-Memphis (857 Miles)**								
	Rural Interstate	0	0	0	0	0	15	2	15
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**15**	**2**	**15**
7	**Mexico-Canada (2,162 Miles)**								
	Rural Interstate	0	0	0	0	0	20	1	21
	Rural Other PA	0	0	0	0	0	14	0	14
	Urban Interstate	0	0	0	0	0	7	0	7
	Urban Other Fwy./Exp.	0	0	0	0	0	1	0	1
	Urban Other PA	0	0	0	0	0	3	0	3
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**45**	**1**	**46**
8	**Pacific NW-Utah (733 Miles)**								
	Rural Interstate	0	0	0	0	0	12	0	12
	Rural Minor Arterial	0	0	0	0	0	1	0	1
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**13**	**0**	**13**

Exhibit 3-12
WTTN-BRIDGE DEFICIENCY ANALYSIS
Corridor Results

		Number of Bridges with Following Deficiencies							Number of
Corridor	**Functional Class**	**Deck Condition**	**Superstr. Condition**	**Substr. Condition**	**Deck Geometry**	**Approach Rdwy. Width**	**Operating Rating**	**Posted Load Limit**	**Bridges Deficient**
9	**Boise-Canada (672 Miles)**								
	Rural Other PA	0	0	0	0	0	3	0	3
	Urban Other PA	0	0	0	0	0	0	1	1
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**3**	**1**	**4**
10	**Mexico-Canada (Canamex) (2,155 Miles)**								
	Rural Interstate	0	0	0	0	0	1	0	1
	Rural Other PA	0	0	0	0	0	1	0	1
	Urban Other PA	0	0	0	0	0	1	0	1
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**3**
11	**Pacific NW-Kansas City (2,369 Miles)**								
	Rural Interstate	0	0	0	0	0	1	6	7
	Rural Other PA	0	0	0	0	0	0	5	5
	Urban Interstate	0	0	0	0	0	2	0	2
	Urban Other PA	0	0	0	0	0	0	1	1
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**3**	**12**	**15**
12	**Montana-Canada (260 Miles)**								
	Rural Other PA	0	0	0	0	0	16	0	16
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**16**	**0**	**16**

Exhibit 3-12
WTTN-BRIDGE DEFICIENCY ANALYSIS
Corridor Results

Corridor	Functional Class	Number of Bridges with Following Deficiencies: Deck Condition	Superstr. Condition	Substr. Condition	Deck Geometry	Approach Rdwy. Width	Operating Rating	Posted Load Limit	Number of Bridges Deficient
14	**Wyoming-Galveston (1,738 Miles)**								
	Rural Other PA	0	0	0	0	0	38	3	41
	Urban Interstate	0	0	0	0	0	8	0	8
	Urban Other Fwy./Exp.	0	0	0	0	0	12	0	12
	Urban Other PA	0	0	0	0	0	7	0	7
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**65**	**3**	**68**
15	**Mexico-Arizona (337 Miles)**								
	Rural Interstate	0	0	0	0	0	0	1	1
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
16	**Mexico-I-90 (1,380 Miles)**								
	Rural Interstate	0	0	0	0	0	4	0	4
	Rural Minor Arterial	0	0	0	0	0	1	0	1
	Urban Interstate	0	0	0	0	0	9	0	9
	Urban Other Fwy./Exp.	0	0	0	0	0	1	0	1
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**15**	**0**	**15**
17	**Mexico-Canada/Midwest (3,472 Miles)**								
	Rural Interstate	0	0	0	0	0	16	0	16
	Rural Other PA	0	0	0	0	0	2	0	2
	Urban Interstate	0	0	0	0	0	9	0	9
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**27**	**0**	**27**

Exhibit 3-12
WTTN-BRIDGE DEFICIENCY ANALYSIS
Corridor Results

Corridor	Functional Class	Number of Bridges with Following Deficiencies: Deck Condition	Superstr. Condition	Substr. Condition	Deck Geometry	Approach Rdwy. Width	Operating Rating	Posted Load Limit	Number of Bridges Deficient
18	**Laredo-Indianapolis (1,013 Miles)**								
	Urban Other PA	0	0	0	0	0	13	0	13
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**13**	**0**	**13**
19	**New Mexico-St. Louis (2,087 Miles)**								
	Rural Interstate	0	0	0	0	0	11	6	11
	Rural Other PA	0	0	0	0	0	8	0	8
	Urban Other Fwy./Exp.	0	0	0	0	0	2	0	2
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**21**	**6**	**21**
20	**Montana-Canada (854 Miles)**								
	Rural Other PA	0	0	0	0	0	7	0	7
	Total Corridor	**0**	**0**	**0**	**0**	**0**	**7**	**0**	**7**

Truck Operating Speed Methodology

Truck operating speeds are calculated for each sample section where the necessary data is available. Operating speeds over a combination of segments are then calculated by adding travel time and distance for each segment and calculating the new speed.

Because the necessary data was not available for every segment of the WTTN corridor highways, an expansion process was developed to reduce the potential impact of incomplete roadway segment data. This expansion process was necessary because operating speeds could not be calculated in two cases: (1) if no sample section data was available; or (2) if the sample segment data was incomplete (a minimum number of data items had to be available to calculate operating speeds). The expansion was done primarily at the supersegment level on a state-specific basis. Because operating speeds are very sensitive to functional class, the expansion at the supersegment level was first done by functional class (that is, expanding supersegment sample results to 100 percent of the supersegment). In a few cases (where no data existed for an individual supersegment), results from corridor highway segments were expanded to the total corridor length.

The operating speed calculation for each sample segment or link is based on the methodology of the HPMS Analytical Package (AP) used by FHWA to estimate highway needs. The process is summarized in Exhibit 3-13 and as follows:

1. Based on the type of facility (urban interstate versus two-lane rural arterial, for example) and the ratio of Average Annual Daily Traffic (AADT) to hourly capacity, the AADT is distributed into as many as 12 time periods, each with a specific hourly Volume to Capacity ratio (V/C ratio). Obviously, the higher the AADT compared to capacity, more traffic occurs during congested (high V/C ratio) periods.

2. For a given time period, *initial speed* per vehicle type is then estimated based on the time period, V/C ratio, type of facility, weighted design speed and the speed limit. This initial speed is adjusted to take into account pavement condition and the section’s alignment characteristics (steep grades and/or sharp curves reduce speed). The “initial” speed represents operating speed assuming neither speed change nor stop or idling time.

3. The *initial speed* is translated into *initial time* to travel the length of the highway segment.

4. Next, the average number of speed change cycles and stop cycles per vehicle mile of travel per vehicle type is calculated, based again of the facility type and the V/C ratio. Those cycles are then translated into excess travel time and average idling time is added.

5. *Initial travel time* and *excess travel time* by vehicle type are added for each time period to estimate total travel time for that period.

6. *Average daily operating speed* is calculated by weighting travel time by time period by the proportion of traffic during that period and translating into speed. Implicit in this calculation is that the proportion of trucks in the traffic stream stays constant during the day. However, operating speeds would increase if peak hour truck percentages drop significantly.

Peak hour operating speed is estimated in a similar fashion, but assumes a single time period whose V/C ratio is the peak hour V/C ratio as defined by the peak hour or "K" factor.

EXISTING CONDITIONS

Operating Speeds by Supersegment - Truck operating speeds were calculated and summarized by supersegment using the process detailed above. Results by functional class and supersegment are included in Appendix D. An example of the Appendix D presentation is shown in Exhibit 3-14.

For each supersegment, non-expanded results are first presented by functional class. The total lengths of all the sample segments, which were used in the analysis of the supersegment, are listed first. This is followed by items describing the characteristics of the supersegment, including average number of lanes, target speed (the minimum tolerable operating speed for the WTTN highways as defined earlier), speed limit, design speed and AADT. The purpose of listing these items is to better understand calculated existing operating speeds. For example, two/three-lane highways have lower operating speeds than equivalent four-lane highways because of passing difficulties. Similarly, low speed limits will result in low operating speeds on facilities no matter what the road conditions are. The target speed is listed as a point of reference between the minimum tolerable and actual operating speeds. Once this reference point was established, average daily and peak period speeds/travel times were calculated for single unit trucks and combination trucks. By comparing these speed and travel time values (based on actual conditions) against minimum tolerable speeds discussed earlier (Exhibit 3-2) in the study, it is possible to determine which facilities are most efficient.

Exhibit 3-13
TRUCK OPERATING SPEED METHODOLOGY

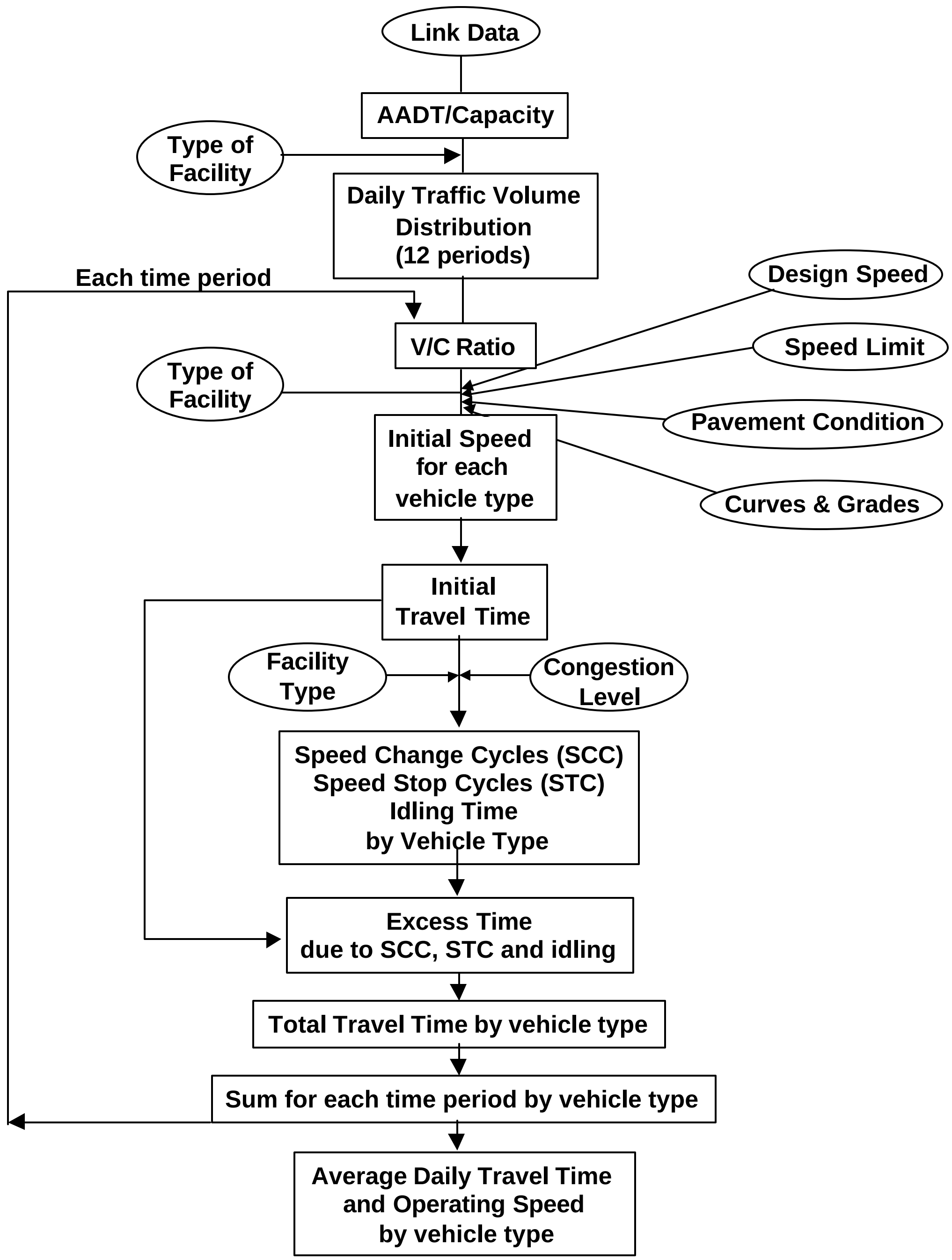


Exhibit 3-14
EXISTING CONDITIONS EXAMPLE

WTTN-Operating Speeds
Colorado Results - Existing Conditions

SSN	GIS Length (MI)	Sample Length (MI)	Average No. Lane	Target Speed	Speed Limit	Design Speed	Average AADT	Average Daily Speed S. Truck	Average Daily Speed C. Truck	Peak Hour Speed S. Truck	Peak Hour Speed C. Truck
82	**I-25**		**New Mexico SL - Colorado Springs UL**								
R.Int		113.5	4.0	64.5	68.6	70.0	12,520	56.7	50.4	56.7	50.4
U.Int		18.4	4.0	40.0	59.1	69.4	25,827	54.9	52.2	50.3	48.0
Total Sample		131.8									
TOTAL	**131.8**		**4.0**	**59.4**	**67.1**	**69.9**	**14,375**	**56.4**	**50.7**	**55.7**	**50.1**
Time (HR)								**2.3**	**2.6**	**2.4**	**2.6**
83	**I-25**		**Through Colorado Springs**								
U.Int		18.8	4.1	40.0	57.5	68.6	68,262	49.4	46.6	22.2	21.9
Total Sample		18.8									
TOTAL	**18.8**		**4.1**	**40.0**	**57.5**	**68.6**	**68,262**	**49.4**	**46.6**	**22.2**	**21.9**
Time (HR)								**0.4**	**0.4**	**0.8**	**0.9**
84	**I-25**		**Colorado Springs UL - Denver UL**								
R.Int		37.2	4.1	65.0	68.0	70.0	51,191	55.7	50.4	43.1	39.9
U.Int		7.2	4.3	40.0	65.0	67.8	56,515	53.7	50.1	39.4	37.8
Total Sample		44.4									
TOTAL	**44.4**		**4.1**	**59.0**	**67.5**	**69.6**	**52,054**	**55.4**	**50.4**	**42.4**	**39.6**
Time (HR)								**0.8**	**0.9**	**1.0**	**1.1**
85	**I-25**		**Through Denver**								
U.Int		31.4	6.6	40.0	56.2	69.8	158,026	44.3	41.5	17.0	16.8
Total Sample		31.4									
TOTAL	**31.4**		**6.6**	**40.0**	**56.2**	**69.8**	**158,026**	**44.3**	**41.5**	**17.0**	**16.8**
Time (HR)								**0.7**	**0.8**	**1.8**	**1.9**

Overall results for the entire supersegment are then listed, as well as the overall time required to travel the entire supersegment. The overall supersegment results have been expanded as outlined earlier. The extent of the expansion can be estimated by comparing the “Sample Length” on the “Total Sample” line with the “GIS Length” on the “TOTAL” line (see Exhibit 3-14).

Daily Operating Speeds by Corridor – The same methodology and the same report format were used to estimate and present the operating speed performance by WTTN Trade Corridor. They are detailed in Appendix D and summarized in Exhibit 3-15.

Only three corridors -- Corridor 6, Texas-Memphis (I-20 and I-30 in Texas); Corridor 7, Mexico-Canada (I-5 from San Diego to Canada); and Corridor 15, Mexico-Arizona (I-10, I-17, I-19 from Flagstaff to Mexico) — meet the target travel times for both single unit trucks and combination trucks. This means that the average speed for travel from one end of the corridor to the other end under existing daily traffic conditions exceeds the minimum acceptable travel speeds developed for this study. Four other corridors -- Corridor 2, San Francisco-Chicago; Corridor 5, Southern California-New Orleans; Corridor 10, Mexico-Canada (Canamex); and Corridor 17, Mexico-Canada/Midwest -- meet the target travel time for single unit trucks only.

Three corridors have “significant” operating speed deficiencies, defined as total travel time more than 10 percent above the target travel time for both single unit trucks and combination trucks. These corridors are Corridor 9, Boise-Canada (U.S. 95, U.S. 195, U.S. 395 in ID and WA); Corridor 12, Montana-Canada (U.S. 87/U.S. 191 and S19 in Montana); and Corridor 20, Montana-Canada (parts of I-15 and I-90, U.S. 93 and S3 in Montana). One common factor among these three corridor highways is that they have some of the lowest average number of lanes (mostly two-lane highways). Two have the lowest average number of lanes of all the corridors and the third ranks 17th. Obviously, it is difficult to travel efficiently on two-lane highways because of passing difficulties and the likely restrictive speed limits. Concurrently, the corridors mentioned above as having the best daily travel time have the highest average number of lanes. However, corridors with the largest average number of lanes tend to suffer the most substantial drop in speed during peak hours.

Exhibit 3-15
Existing Operating Speeds by WTTN Corridor

Corridor Number	Corridor Length	Average No. Lane	Target Speed	Average Daily Speed		Peak Hour Speed		Target	Average travel Time		Peak Hour Travel Time	
				Single Truck	Comb.Truck	Single Truck	Comb.Truck	Time (HR)	Single Truck	Comb.Truck	Single Truck	Comb.Truck
1	4781.3	3.3	56.0	53.3	50.9	50.2	48.0	85.4	89.7	93.9	95.2	99.5
2	1754.3	4.5	58.0	58.5	55.2	47.7	45.6	30.2	30.0	31.8	36.8	38.4
3	1125.7	4.1	57.3	56.8	52.9	54.9	51.2	19.6	19.8	21.3	20.5	22.0
4	1546.2	4.0	59.4	59.2	56.5	57.7	55.1	26.0	26.1	27.4	26.8	28.1
5	2745.6	4.5	56.5	58.8	56.1	47.6	46.0	48.6	46.7	48.9	57.6	59.7
6	857.0	4.5	53.2	60.0	56.8	49.4	47.4	16.1	14.3	15.1	17.3	18.1
7	2162.5	5.0	50.9	53.4	51.0	36.3	35.3	42.5	40.5	42.4	59.5	61.3
8	733.5	4.0	60.3	58.1	54.6	56.9	53.6	12.2	12.6	13.4	12.9	13.7
9	672.0	2.2	51.8	45.2	42.9	41.1	39.2	13.0	14.9	15.7	16.4	17.1
10	2155.3	4.2	54.4	54.9	52.7	46.0	44.5	39.6	39.3	40.9	46.9	48.5
11	2368.9	3.9	58.9	58.4	55.5	56.5	53.8	40.2	40.6	42.7	42.0	44.1
12	259.6	2.2	53.6	45.7	42.7	42.0	39.3	4.8	5.7	6.1	6.2	6.6
13	442.0	3.0	56.7	53.2	51.4	49.8	48.2	7.8	8.3	8.6	8.9	9.2
14	1738.0	3.7	52.7	49.0	46.8	42.6	40.9	33.0	35.4	37.2	40.8	42.5
15	337.4	4.6	52.9	60.4	60.4	45.3	45.3	6.4	5.6	5.6	7.5	7.5
16	1379.9	3.7	57.0	54.1	50.8	48.6	45.9	24.2	25.5	27.2	28.4	30.0
17	3472.5	3.8	54.6	55.3	53.2	46.9	45.5	63.6	62.8	65.3	74.0	76.4
18	1013.0	3.4	48.3	45.4	44.2	40.4	39.4	21.0	22.3	22.9	25.1	25.7
19	2086.7	3.6	55.7	53.6	51.2	48.8	46.8	37.5	38.9	40.8	42.8	44.6
20	853.8	3.2	57.2	50.5	47.5	48.1	45.4	14.9	16.9	18.0	17.8	18.8

Corridor Length =Total mileage of WTTN highways in the corridor.
Avg. No. Lanes = Average number of lanes on the WTTN highways.
Target Speed = Average minimum tolerable speed for all highways.
Average Daily Speed = Calculated 24-hour average speed (mph) for single and combination trucks.
Peak Hour Speed = Calculated average speed (mph) during peak period for single and combination trucks.
Target Time (HR) = Calculated hours needed to travel all corridor highways at target speed.
Average Travel Time = Hours needed to travel all corridor highways at existing average daily speed.
Peak Hour Travel Time = Hours needed to travel all corridor highways at existing peak hour speed.

Time Savings By Corridor

The potential for improvement in truck operating speed in the WTTN corridors was explored by simulating different types of improvements and estimating the likely impact on truck operating speed and travel time. Four types of improvements were considered and analyzed:

- *Pavement Condition*: Pavement condition set to a minimum of 3.1 for interstates and 2.6 for non-interstates.
- *Alignment:* Curves and grades reset to achieve tolerable standards, which vary by functional class and terrain. This improvement was not applied to interstate highways, as it was assumed that interstates have been designed with the best possible alignment given the prevailing local terrain.
- *Congestion:* Level of service not to exceed LOS C for interstates and LOS D for others.
- *Speed Limit*: Speed limits set to a minimum of 65 mph (flat or rolling terrain) or 60 mph (mountainous terrain) for rural interstates and to 55 mph for all others.

These improvements were simulated cumulatively in the order presented above, i.e., congestion improvements are implemented with the pavement condition improvements and the alignment improvements.

The types of improvements considered bring the various design elements to the minimum tolerable levels as defined earlier. They do not correspond to design standards, which might be used when building a new highway. As a result, there is no change for those segments of road which already meet or exceed all the minimum tolerable conditions. The improvements are made "universally" in the sense that no consideration is given to the feasibility of any such improvement. The purpose of this analysis is simply to explore what type(s) of improvement would most improve truck travel time along the various WTTN corridor highways.

The same methodology used to estimate existing operating speeds and travel times was employed for the improved conditions analysis. The results by supersegment are presented in

Appendix D. The results by corridor are summarized in Exhibit 3-16 for average daily travel time savings.

Overall, the potential for average daily time savings from the simulated improvements is relatively small (2.5 percent of existing travel times for single unit trucks and 2.6 percent for combination trucks). The contributions to the travel time reduction from congestion reduction and speed limit improvements are the highest (34 percent each of the savings for single unit trucks, 30 and 31 percent of the savings for combination trucks). The contribution of the pavement condition improvement averages 18 percent for both single and combination trucks. Interestingly, the alignment improvements do more to improve travel time of combination trucks than for single unit trucks. However, these results are not uniform among corridors since the improvements considered affect some corridors more than others. For example, since alignment improvements were not considered for interstates, those corridors with a large proportion of interstate highway mileages would not experience improved efficiency. Similarly, speed limit improvements are likely to have a more pronounced effect on lower functional classes (most interstates are posted at target speed limits).

- Three corridors (Corridor 6, Texas-Memphis; Corridor 8, Pacific NW-Utah; and Corridor 11, Pacific NW-Kansas City) show relatively little potential travel time benefits from the improvements considered. The WTTN highways in these corridors have relatively few major deficiencies.
- The corridors with the highest potential average daily time savings are:
  - *Corridor 7 (Mexico-Canada)* – congestion improvements increase operating speed by 4.0% (both vehicle types);
  - *Corridor 9 (Boise-Canada)* – alignment corrections increase operating speed by 3.2% for combination trucks;
  - *Corridor 12 (Montana-Canada)* – operating speed improves most with alignment and speed limit corrections;

Exhibit 3-16

PERFORMANCE ENHANCEMENT TIME SAVINGS BY CORRIDOR

Daily Average

Corridor Number	Corridor Length	Target Speed/Time	Existing Conditions		Cumulative Improvements: Pavement Condition		Curves and Grades		Congestion		Speed Limit	
			Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck
1	4,781.3											
Speed (MPH)		*56.0*	*53.3*	*50.9*	*53.6*	*51.2*	*54.0*	*51.8*	*54.1*	*51.9*	*54.6*	*52.4*
Time(HR)		85.4	89.7	93.9	89.2	93.4	88.6	92.4	88.3	92.1	87.5	91.3
Time Saving					**0.5**	**0.5**	**1.1**	**1.5**	**1.4**	**1.8**	**2.2**	**2.6**
2	1,754.3											
Speed (MPH)		*58.0*	*58.5*	*55.2*	*58.9*	*55.6*	*58.9*	*55.6*	*59.4*	*56.0*	*59.4*	*56.0*
Time(HR)		30.2	30.0	31.8	29.8	31.6	29.8	31.6	29.5	31.3	29.5	31.3
Time Saving					**0.2**	**0.2**	**0.2**	**0.2**	**0.5**	**0.5**	**0.5**	**0.5**
3	1,125.7											
Speed (MPH)		*57.3*	*56.8*	*52.9*	*57.1*	*53.1*	*57.2*	*53.3*	*57.2*	*53.3*	*57.6*	*53.6*
Time(HR)		19.6	19.8	21.3	19.7	21.2	19.7	21.1	19.7	21.1	19.5	21.0
Time Saving					**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.2**	**0.3**	**0.3**
4	1,546.2											
Speed (MPH)		*59.4*	*59.2*	*56.5*	*59.3*	*56.6*	*59.5*	*56.8*	*59.6*	*57.0*	*59.9*	*57.2*
Time(HR)		26.0	26.1	27.4	26.1	27.3	26.0	27.2	25.9	27.1	25.8	27.0
Time Saving					**0.0**	**0.1**	**0.1**	**0.2**	**0.2**	**0.3**	**0.3**	**0.4**
5	2,745.6											
Speed (MPH)		*56.5*	*58.8*	*56.1*	*59.0*	*56.3*	*59.0*	*56.3*	*60.3*	*57.5*	*60.3*	*57.5*
		48.6	46.7	48.9	46.6	48.8	46.6	48.8	45.6	47.8	45.5	47.7
Time Saving					**0.1**	**0.1**	**0.1**	**0.1**	**1.1**	**1.1**	**1.2**	**1.2**
6	857.0											
Speed (MPH)		*53.2*	*60.0*	*56.8*	*60.0*	*56.9*	*60.0*	*56.9*	*60.0*	*56.9*	*60.0*	*56.9*
Time(HR)		16.1	14.3	15.1	14.3	15.1	14.3	15.1	14.3	15.1	14.3	15.1
Time Saving					**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
7	2,162.5											
Speed (MPH)		*50.9*	*53.4*	*51.0*	*54.2*	*51.7*	*54.4*	*52.0*	*56.6*	*54.0*	*56.7*	*54.1*
Time(HR)		42.5	40.5	42.4	39.9	41.9	39.8	41.6	38.2	40.1	38.1	40.0
Time Saving					**0.6**	**0.5**	**0.7**	**0.8**	**2.3**	**2.3**	**2.4**	**2.4**

Exhibit 3-16
PERFORMANCE ENHANCEMENT TIME SAVINGS BY CORRIDOR
Daily Average

Corridor Number	Corridor Length	Target Speed/Time	Existing Conditions		Cumulative Improvements							
					Pavement Condition		Curves and Grades		Congestion		Speed Limit	
			Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck
8	733.5											
Speed (MPH)		*60.3*	*58.1*	*54.6*	*58.3*	*54.7*	*58.3*	*54.7*	*58.5*	*54.9*	*58.5*	*54.9*
Time(HR)		12.2	12.6	13.4	12.6	13.4	12.6	13.4	12.5	13.3	12.5	13.3
Time Saving					**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.1**	**0.1**
9	672.0											
Speed (MPH)		*51.8*	*45.2*	*42.9*	*45.4*	*43.1*	*46.1*	*44.5*	*46.1*	*44.5*	*46.8*	*45.2*
Time(HR)		13.0	14.9	15.7	14.8	15.6	14.6	15.1	14.6	15.1	14.4	14.9
Time Saving					**0.1**	**0.1**	**0.3**	**0.6**	**0.3**	**0.6**	**0.5**	**0.8**
10	2,155.3											
Speed (MPH)		*54.4*	*54.9*	*52.7*	*55.2*	*52.9*	*55.3*	*53.1*	*56.1*	*53.9*	*56.4*	*54.2*
Time(HR)		39.6	39.3	40.9	39.1	40.7	39.0	40.6	38.4	40.0	38.2	39.8
Time Saving					**0.2**	**0.2**	**0.3**	**0.3**	**0.9**	**0.9**	**1.1**	**1.1**
11	2,368.9											
Speed (MPH)		*58.9*	*58.4*	*55.5*	*58.6*	*55.7*	*58.6*	*55.7*	*58.7*	*55.8*	*58.9*	*56.0*
Time(HR)		40.2	40.6	42.7	40.4	42.6	40.4	42.5	40.4	42.5	40.2	42.3
Time Saving					**0.2**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.4**	**0.4**
12	259.6											
Speed (MPH)		*53.6*	*45.7*	*42.7*	*45.8*	*42.8*	*46.5*	*44.0*	*46.5*	*44.0*	*47.8*	*45.1*
Time(HR)		4.8	5.7	6.1	5.7	6.1	5.6	5.9	5.6	5.9	5.4	5.8
Time Saving					**0.0**	**0.0**	**0.1**	**0.2**	**0.1**	**0.2**	**0.3**	**0.3**
13	442.0											
Speed (MPH)		*56.7*	*53.2*	*51.4*	*53.3*	*51.5*	*53.4*	*51.5*	*53.4*	*51.5*	*54.1*	*52.2*
Time(HR)		7.8	8.3	8.6	8.3	8.6	8.3	8.6	8.3	8.6	8.2	8.5
Time Saving					**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**

Exhibit 3-16
PERFORMANCE ENHANCEMENT TIME SAVINGS BY CORRIDOR
Daily Average

Corridor Number	Corridor Length	Target Speed/Time	Existing Conditions		Cumulative Improvements: Pavement Condition		Curves and Grades		Congestion		Speed Limit	
			Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck
14	1,738.0											
Speed (MPH)		*52.7*	*49.0*	*46.8*	*49.3*	*47.0*	*49.4*	*47.1*	*49.8*	*47.5*	*51.2*	*48.7*
Time(HR)		33.0	35.4	37.2	35.2	37.0	35.2	36.9	34.9	36.6	33.9	35.7
Time Saving					**0.2**	**0.2**	**0.2**	**0.3**	**0.5**	**0.6**	**1.5**	**1.5**
15	337.4											
Speed (MPH)		*52.9*	*60.4*	*60.4*	*60.4*	*60.4*	*60.4*	*60.4*	*62.8*	*62.8*	*63.4*	*63.4*
Time(HR)		6.4	5.6	5.6	5.6	5.6	5.6	5.6	5.4	5.4	5.3	5.3
Time Saving					**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**0.2**	**0.3**	**0.3**
16	1,379.9											
Speed (MPH)		*57.0*	*54.1*	*50.8*	*54.4*	*51.0*	*54.5*	*51.1*	*54.9*	*51.4*	*55.1*	*51.6*
Time(HR)		24.2	25.5	27.2	25.4	27.0	25.3	27.0	25.2	26.8	25.1	26.7
Time Saving					**0.1**	**0.2**	**0.2**	**0.2**	**0.3**	**0.4**	**0.4**	**0.5**
17	3,472.5											
Speed (MPH)		*54.6*	*55.3*	*53.2*	*55.6*	*53.4*	*55.7*	*53.6*	*55.9*	*53.8*	*56.4*	*54.2*
Time(HR)		63.6	62.8	65.3	62.5	65.0	62.4	64.8	62.1	64.6	61.5	64.0
Time Saving					**0.3**	**0.3**	**0.4**	**0.5**	**0.7**	**0.7**	**1.3**	**1.3**
18	1,013.0											
Speed (MPH)		*48.3*	*45.4*	*44.2*	*45.4*	*44.2*	*45.7*	*44.6*	*45.8*	*44.7*	*47.0*	*45.8*
Time(HR)		21.0	22.3	22.9	22.3	22.9	22.2	22.7	22.1	22.7	21.6	22.1
Time Saving					**0.0**	**0.0**	**0.1**	**0.2**	**0.2**	**0.2**	**0.7**	**0.8**
19	2,086.7											
Speed (MPH)		*55.7*	*53.6*	*51.2*	*53.8*	*51.4*	*54.1*	*51.8*	*54.3*	*51.9*	*55.1*	*52.6*
Time(HR)		37.5	38.9	40.8	38.8	40.6	38.5	40.3	38.4	40.2	37.9	39.6
Time Saving					**0.1**	**0.2**	**0.4**	**0.5**	**0.5**	**0.6**	**1.0**	**1.2**

Exhibit 3-16
PERFORMANCE ENHANCEMENT TIME SAVINGS BY CORRIDOR
Daily Average

					Cumulative Improvements							
Corridor	Corridor	Target	Existing Conditions		Pavement Condition		Curves and Grades		Congestion		Speed Limit	
Number	Length	Speed/Time	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck
20	853.8											
Speed (MPH)		*57.2*	*50.5*	*47.5*	*50.8*	*47.8*	*51.3*	*48.5*	*51.3*	*48.6*	*52.0*	*49.2*
Time(HR)		14.9	16.9	18.0	16.8	17.9	16.6	17.6	16.6	17.6	16.4	17.4
Time Saving					**0.1**	**0.1**	**0.3**	**0.4**	**0.3**	**0.4**	**0.5**	**0.6**
All Corridors	32,485.2											
Speed (MPH)		*55.4*	*54.5*	*52.0*	*54.8*	*52.2*	*55.0*	*52.5*	*55.4*	*52.9*	*55.9*	*53.4*
Time(HR)		586.6	595.9	625.2	593.1	622.3	591.1	618.8	586.0	613.9	580.8	608.8
Time Saving					**2.8**	**2.9**	**4.8**	**6.4**	**9.9**	**11.3**	**15.1**	**16.4**

Existing Conditions = Average daily "Speed (MPH)" for both vehicle types over all corridor highways.
Time (HR) = Hours needed to travel all highway mileage at existing speed.
Cumulative Improvements = Simulated improvements to pavement condition shown with resulting speed (mph), time (HR), and Time Savings (hours). Curve & Grade information includes pavement improvement (thus, "CUMULATIVE"). Likewise, congestion improvements include both Pavement and Curve/Grade improvements, and Speed Limit assumes all four categories are in place.

- *Corridor 14 (Wyoming-Galveston)* – largest operating speed gains are due to speed limit improvements.
- *Corridor 15 (Mexico-Arizona)* – operating speed increases nearly 4% due to congestion improvements;
- *Corridor 18 (Laredo-Indianapolis)* – largest gains due to speed limit corrections;
- *Corridor 19 (New Mexico-St. Louis)* – significant operating speed increases due to alignment and speed limit improvements; and
- *Corridor 20 (Montana-Canada)* – alignment corrections contribute most to speed gains.

More significant changes/improvements in operating speed are possible when individual supersegments are analyzed. For average daily conditions, the following supersegments show considerable potential for speed gains when improvements are simulated:

State	Route	Termini	Deficiency
AZ	I-15	Nevada SL – Utah SL	Pavement
AZ	I-17	Flagstaff - Phoenix	Congestion
CA	I-5	In Los Angeles	Congestion
CA	I-10	In Los Angeles	Congestion
CA	I-15	In San Diego	Congestion
CA	I-405	In Los Angeles	Congestion
CA	I-710	In Los Angeles	Congestion
CA	I-880	In San Francisco	Congestion
CA	S60	In Los Angeles	Congestion
CO	I-25	In Colorado Springs	Congestion
CO	I-25	In Denver	Congestion
CO	U.S. 6	Loveland Pass	Congestion
MT	U.S. 12	Idaho SL – Missoula	Speed Limit
NM	I-40	In Albuquerque	Congestion
OR	I-5	In Portland	Congestion
OR	I-84	In Portland	Congestion
SD	I-90	I-29 – Minnesota SL	Pavement
TX	I-45	In Houston	Congestion
TX	U.S. 287	I-44 – Dallas	Speed Limit
WA	I-5	In Seattle	Congestion
WA	U.S. 2	Spokane – Idaho SL	Speed Limit
WA	S 18	In Seattle	Congestion
WY	U.S. 26	I-25 – Nebraska SL	Speed Limit

Exhibit 3-17 presents the same results for peak hour travel times. As could be expected, the potential for travel time savings during peak hours are much larger, due mostly to the congestion relief. Those corridors which showed the largest improvements between target speeds and average peak operating speeds (Exhibit 3-17), are Corridors 2, 5, 6, 7, 10, and 15. The gap between target speed and calculated peak hour speed is a better indicator of congestion problems than the daily capacity deficiency analysis since the latter does not indicate the severity of the problem in peak hours. Overall, peak period speeds would rise by nearly 15 percent, and the variability between peak and off peak truck travel would be substantially reduced with this simulation.

Examination of Appendix D information by supersegment shows that, for peak hour conditions, considerable improvements in operating speed are possible. This includes all the sections that experience significant average daily speed gains (above), plus:

State	Route	Termini
AZ	I-10	In Phoenix
AZ	I-10	Phoenix – Tucson
AZ	U.S. 60	I-17 – I-40
CA	I-80	In Sacramento
CA	I-80	Sacramento – San Francisco
CA	I-205	In San Francisco
CA	I-215	In Los Angeles
CA	I-805	In San Diego
CA	S 94	In San Diego
CA	I-15	In Los Angeles
CO	I-25	Colorado Springs – Denver
CO	I-70	In Denver
MT	U.S. 20	Idaho SL – I-90
MT	U.S. 93	I-90 – Canada
NM	I-25	In Albuquerque
OR	I-5	Eugene – Portland
OR	I-205	In Portland
OR	I-405	In Portland
TX	I-10	In Houston
TX	I-30	In Dallas – Ft. Worth
TX	I-35	In San Antonio
TX	I-35	San Antonio – Dallas
TX	I-35	In Dallas – Ft. Worth
TX	U.S. 59	In Houston
TX	I-20	In Dallas – Ft. Worth
TX	I-45	Dallas – Houston

Exhibit 3-17
PERFORMANCE ENHANCEMENT TIME SAVINGS BY CORRIDOR
Peak Hour

Corridor Number	Corridor Length	Target Speed/Time	Existing Conditions Single Truck	Existing Conditions Comb.Truck	Cumulative Improvements: Pavement Condition Single Truck	Pavement Condition Comb.Truck	Curves and Grades Single Truck	Curves and Grades Comb.Truck	Congestion Single Truck	Congestion Comb.Truck	Speed Limit Single Truck	Speed Limit Comb.Truck
1	4,781.3											
Speed (MPH)		*56.0*	*50.2*	*48.0*	*50.5*	*48.3*	*50.8*	*48.8*	*52.4*	*50.3*	*52.8*	*50.7*
Time(HR)		85.4	95.2	99.5	94.7	99.0	94.2	98.0	91.2	95.1	90.5	94.3
Time Saving					**0.5**	**0.5**	**1.0**	**1.5**	**4.0**	**4.4**	**4.7**	**5.2**
2	1,754.3											
Speed (MPH)		*58.0*	*47.7*	*45.6*	*48.1*	*46.0*	*48.1*	*46.0*	*58.8*	*55.4*	*58.8*	*55.4*
Time(HR)		30.2	36.8	38.4	36.4	38.1	36.4	38.1	29.9	31.7	29.9	31.7
Time Saving					**0.4**	**0.3**	**0.4**	**0.3**	**6.9**	**6.7**	**6.9**	**6.7**
3	1,125.7											
Speed (MPH)		*57.3*	*54.9*	*51.2*	*55.2*	*51.5*	*55.2*	*51.6*	*57.0*	*53.1*	*57.3*	*53.4*
Time(HR)		19.6	20.5	22.0	20.4	21.9	20.4	21.8	19.8	21.2	19.6	21.1
Time Saving					**0.1**	**0.1**	**0.1**	**0.2**	**0.7**	**0.8**	**0.9**	**0.9**
4	1,546.2											
Speed (MPH)		*59.4*	*57.7*	*55.1*	*57.8*	*55.2*	*57.9*	*55.5*	*59.2*	*56.6*	*59.4*	*56.8*
Time(HR)		26.0	26.8	28.1	26.7	28.0	26.7	27.9	26.1	27.3	26.0	27.2
Time Saving					**0.1**	**0.1**	**0.1**	**0.2**	**0.7**	**0.8**	**0.8**	**0.9**
5	2,745.6											
Speed (MPH)		*56.5*	*47.6*	*46.0*	*47.8*	*46.2*	*47.8*	*46.2*	*59.6*	*56.8*	*59.6*	*56.9*
Time(HR)		48.6	57.6	59.7	57.4	59.5	57.4	59.5	46.1	48.3	46.0	48.3
Time Saving					**0.2**	**0.2**	**0.2**	**0.2**	**11.5**	**11.4**	**11.6**	**11.4**
6	857.0											
Speed (MPH)		*53.2*	*49.4*	*47.4*	*49.5*	*47.4*	*49.5*	*47.4*	*59.2*	*56.1*	*59.2*	*56.1*
Time(HR)		16.1	17.3	18.1	17.3	18.1	17.3	18.1	14.5	15.3	14.5	15.3
Time Saving					**0.0**	**0.0**	**0.0**	**0.0**	**2.8**	**2.8**	**2.8**	**2.8**

Exhibit 3-17
PERFORMANCE ENHANCEMENT TIME SAVINGS BY CORRIDOR
Peak Hour

Corridor Number	Corridor Length	Target Speed/Time	Existing Conditions Single Truck	Existing Conditions Comb.Truck	Cumulative Improvements: Pavement Condition Single Truck	Pavement Condition Comb.Truck	Curves and Grades Single Truck	Curves and Grades Comb.Truck	Congestion Single Truck	Congestion Comb.Truck	Speed Limit Single Truck	Speed Limit Comb.Truck
7	2,162.5											
Speed (MPH)		*50.9*	*36.3*	*35.3*	*36.9*	*35.8*	*37.0*	*36.0*	*54.7*	*52.2*	*54.8*	*52.3*
Time(HR)		42.5	59.5	61.3	58.6	60.4	58.5	60.1	39.5	41.4	39.5	41.3
Time Saving					**0.9**	**0.9**	**1.0**	**1.2**	**20.0**	**19.9**	**20.0**	**20.0**
8	733.5											
Speed (MPH)		*60.3*	*56.9*	*53.6*	*57.1*	*53.7*	*57.1*	*53.7*	*58.5*	*54.9*	*58.5*	*54.9*
Time(HR)		12.2	12.9	13.7	12.8	13.7	12.8	13.7	12.5	13.4	12.5	13.4
Time Saving					**0.1**	**0.0**	**0.1**	**0.0**	**0.4**	**0.3**	**0.4**	**0.3**
9	672.0											
Speed (MPH)		*51.8*	*41.1*	*39.2*	*41.2*	*39.3*	*41.7*	*40.4*	*43.3*	*41.9*	*43.8*	*42.4*
Time(HR)		13.0	16.4	17.1	16.3	17.1	16.1	16.6	15.5	16.0	15.3	15.9
Time Saving					**0.1**	**0.0**	**0.3**	**0.5**	**0.9**	**1.1**	**1.1**	**1.2**
10	2,155.3											
Speed (MPH)		*54.4*	*46.0*	*44.5*	*46.2*	*44.7*	*46.3*	*44.8*	*54.9*	*52.8*	*55.2*	*53.0*
Time(HR)		39.6	46.9	48.5	46.6	48.2	46.5	48.1	39.2	40.9	39.0	40.7
Time Saving					**0.3**	**0.3**	**0.4**	**0.4**	**7.7**	**7.6**	**7.9**	**7.8**
11	2,368.9											
Speed (MPH)		*58.9*	*56.5*	*53.8*	*56.7*	*53.9*	*56.7*	*54.0*	*58.1*	*55.2*	*58.3*	*55.4*
Time(HR)		40.2	42.0	44.1	41.8	43.9	41.8	43.9	40.8	42.9	40.6	42.8
Time Saving					**0.2**	**0.2**	**0.2**	**0.2**	**1.2**	**1.2**	**1.4**	**1.3**
12	259.6											
Speed (MPH)		*53.6*	*42.0*	*39.3*	*42.1*	*39.4*	*42.7*	*40.4*	*44.0*	*41.6*	*44.9*	*42.4*
Time(HR)		4.8	6.2	6.6	6.2	6.6	6.1	6.4	5.9	6.2	5.8	6.1
Time Saving					**0.0**	**0.0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.4**	**0.5**

Exhibit 3-17
PERFORMANCE ENHANCEMENT TIME SAVINGS BY CORRIDOR
Peak Hour

Corridor Number	Corridor Length	Target Speed/Time	Existing Conditions Single Truck	Existing Conditions Comb.Truck	Cumulative Improvements: Pavement Condition Single Truck	Pavement Condition Comb.Truck	Curves and Grades Single Truck	Curves and Grades Comb.Truck	Congestion Single Truck	Congestion Comb.Truck	Speed Limit Single Truck	Speed Limit Comb.Truck
13	442.0											
Speed (MPH)		*56.7*	*49.8*	*48.2*	*49.9*	*48.3*	*50.0*	*48.4*	*50.9*	*49.2*	*51.5*	*49.8*
Time(HR)		7.8	8.9	9.2	8.9	9.2	8.8	9.1	8.7	9.0	8.6	8.9
Time Saving					**0.0**	**0.0**	**0.1**	**0.1**	**0.2**	**0.2**	**0.3**	**0.3**
14	1,738.0											
Speed (MPH)		*52.7*	*42.6*	*40.9*	*42.9*	*41.1*	*42.9*	*41.2*	*48.6*	*46.4*	*49.9*	*47.4*
Time(HR)		33.0	40.8	42.5	40.6	42.3	40.5	42.2	35.7	37.5	34.8	36.6
Time Saving					**0.2**	**0.2**	**0.3**	**0.3**	**5.1**	**5.0**	**6.0**	**5.9**
15	337.4											
Speed (MPH)		*52.9*	*45.3*	*45.3*	*45.3*	*45.3*	*45.3*	*45.3*	*62.1*	*62.1*	*62.6*	*62.6*
Time(HR)		6.4	7.5	7.5	7.4	7.5	7.4	7.5	5.4	5.4	5.4	5.4
Time Saving					**0.1**	**0.0**	**0.1**	**0.0**	**2.1**	**2.1**	**2.1**	**2.1**
16	1,379.9											
Speed (MPH)		*57.0*	*48.6*	*45.9*	*48.8*	*46.2*	*48.9*	*46.2*	*53.8*	*50.5*	*54.0*	*50.7*
Time(HR)		24.2	28.4	30.0	28.3	29.9	28.2	29.8	25.6	27.3	25.5	27.2
Time Saving					**0.1**	**0.1**	**0.2**	**0.2**	**2.8**	**2.7**	**2.9**	**2.8**
17	3,472.5											
Speed (MPH)		*54.6*	*46.9*	*45.5*	*47.1*	*45.6*	*47.2*	*45.7*	*54.2*	*52.2*	*54.7*	*52.6*
Time(HR)		63.6	74.0	76.4	73.7	76.1	73.6	75.9	64.0	66.5	63.5	66.0
Time Saving					**0.3**	**0.3**	**0.4**	**0.5**	**10.0**	**9.9**	**10.5**	**10.4**
18	1,013.0											
Speed (MPH)		*48.3*	*40.4*	*39.4*	*40.5*	*39.5*	*40.7*	*39.8*	*44.8*	*43.7*	*45.8*	*44.7*
Time(HR)		21.0	25.1	25.7	25.0	25.6	24.9	25.4	22.6	23.2	22.1	22.7
Time Saving					**0.1**	**0.1**	**0.2**	**0.3**	**2.5**	**2.5**	**3.0**	**3.0**

Exhibit 3-17
PERFORMANCE ENHANCEMENT TIME SAVINGS BY CORRIDOR
Peak Hour

Corridor Number	Corridor Length	Target Speed/Time	Existing Conditions		Cumulative Improvements: Pavement Condition		Curves and Grades		Congestion		Speed Limit	
			Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck	Single Truck	Comb.Truck
19	2,086.7											
Speed (MPH)		*55.7*	*48.8*	*46.8*	*49.0*	*47.0*	*49.3*	*47.3*	*53.0*	*50.7*	*53.7*	*51.3*
Time(HR)		37.5	42.8	44.6	42.6	44.4	42.4	44.1	39.4	41.2	38.9	40.7
Time Saving					**0.2**	**0.2**	**0.4**	**0.5**	**3.4**	**3.4**	**3.9**	**3.9**
20	853.8											
Speed (MPH)		*57.2*	*48.1*	*45.4*	*48.4*	*45.7*	*48.8*	*46.3*	*50.1*	*47.4*	*50.7*	*47.9*
Time(HR)		14.9	17.8	18.8	17.6	18.7	17.5	18.4	17.0	18.0	16.8	17.8
Time Saving					**0.2**	**0.1**	**0.3**	**0.4**	**0.8**	**0.8**	**1.0**	**1.0**
All Corridors	32,485.2											
Speed (MPH)		*55.4*	*47.5*	*45.6*	*47.8*	*45.9*	*47.9*	*46.1*	*54.2*	*51.7*	*54.6*	*52.1*
Time(HR)		586.6	683.4	711.8	679.3	708.2	677.5	704.6	599.4	627.8	594.8	623.4
Time Saving					**4.1**	**3.6**	**5.9**	**7.2**	**84.0**	**84.0**	**88.6**	**88.4**

The improvements considered in this analysis would reduce average truck travel time, but not as significantly as desired. The only peak hour corridor to meet target speed/time with the improvements considered is Corridor 5, and it already met the target time for single unit trucks without the improvements. To understand these results, it is necessary to look at the corridor's existing performance by functional class, as summarized in Appendix D. The largest discrepancy between target speed and actual speed often occurs on the lower functional classes which have a lower average number of lanes. This could indicate that the best way to improve travel time on these corridors is to improve the design of the roads and to increase the number of lanes for all segments of each corridor to four, which would be an expensive proposition.

SUMMARY OBSERVATIONS

1. There are three WTTN corridors (6, 7, and 15) which currently have end-to-end truck (single and combination truck) travel speeds which exceed the minimum tolerable speeds established for the study on a daily basis.

   - Each corridor is largely composed of interstates.
   - Overall speeds/travel times are up to 14 percent faster than the average daily target speed.
   - As congestion builds in the future, speeds are likely to fall below minimum tolerances.
   - Peak period speeds for these corridors are below peak hour targets.

2. Three corridors have calculated truck travel times which are more than 10 percent worse than the target times. These are Corridors 9, 12, & 20.

   - From a travel time perspective, these are some of the shortest corridors.
   - The corridors are also have the highest proportion of two-lane highways.
   - Peak hour existing speeds are 5 to 10 percent below existing daily average speeds.

3. Four corridors (2, 5, 10, and 17) meet the average daily target travel speed corridor wide for single unit trucks, but not for combination trucks. Considering just peak hour conditions, none of these corridors meet the peak hour speed target. All other

corridors are slightly below daily targets and more substantially below peak hour targets.

4. Simulating various improvements throughout each corridor (rehabilitating pavement, alignment improvements, capacity additions, and speed limit increases) yields only about a 2.5 percent increase in the quality of truck travel (speed/travel time) throughout the network on a daily basis. From a peak period standpoint however, there is a 15 percent improvement.

   - Such improvements would reduce the variability in travel times for peak and off peak periods, which is critical for trucking operations.

   - Almost two-thirds of the daily improvements are related to congestion reduction and speed limit increases (split evenly), an additional 18 percent of the daily improvements are related to upgrade pavement condition. The alignment improvements do more for combination trucks than single units (which can be understood based on the effect of grades and curves on the combination unit power trains).

   - 95 percent of peak period travel time improvements are achieved through capacity additions.

5. The best (and most expensive) way to improve truck travel throughout the region would probably be to widen all two-lane highways to four lanes regardless of whether there is congestion. The most appropriate use of resources may be to concentrate improvements where congestion is bad and expected to become much worse.

MENU OF SOLUTIONS

The potential menu of highway solutions is comprised of a list of 30 solutions that could be implemented to improve truck travel on the WTTN network. As each state may not use the same criteria to identify deficiencies as have been established in the Minimum Tolerable Conditions (MTCs) criteria for this study, this menu of potential solutions tool is intended to provide each state with a list of improvements that *could* be considered to ameliorate deficiencies on the highways, not to give the states specific direction regarding what must be done.

Process

The WTTN Steering Committee developed a list of 30 potential solutions to be included in the menu of highway solutions. These potential solutions were reviewed in light of the eight deficiency types[1] being analyzed for each highway supersegment. The Steering Committee separated the 30 potential solutions into two categories: 1) those whose impacts are easily measured and relate directly to the list of deficiencies, and 2) those whose impacts are not as easily quantified, but which may be equally important to the freight industry. The two categories are called “principal” highway solutions and “supplemental” highway solutions, respectively.

Each of the principal solutions related directly to one or more of the eight deficiency types. Additionally, 16 of the 22 supplemental solutions were found to correspond with one or more of the deficiency types. The results of these findings were grouped into two solution matrices identifying which potential solutions appropriately related to each of the eight deficiency types. The principal and supplemental solutions matrices are shown in Exhibits 3-18 and 3-19, respectively. These matrices are applicable for both urban and rural segments.

The potential solutions matrices were used to identify appropriate principal and supplemental potential solutions for each of the supersegments, based on the deficiencies identified using the minimum tolerable conditions (MTCs) established for this study. A summary of potentially applicable solutions has been prepared in tabular form by supersegment for each state, with the deficiencies and potential solutions for each supersegment listed adjacent to one another for easy reference. Additionally, there are some circumstances where notes of clarification relating to the deficiencies and/or solutions for a supersegment are necessary; these are provided in the table as appropriate. The deficiency/solution tables for all states are in Appendix F.

[1] The eight deficiencies include: pavement condition, lane width, shoulder width, vertical alignment (grades), horizontal alignment (curves), speed limit, existing capacity (year 1996) and future capacity (year 2016) as described on page 3-21.

Exhibit 3-18
PRINCIPAL HIGHWAY SOLUTIONS MATRIX

	Solutions	Deficiencies							
		P Pavement	LW Lane Width	SW Shoulder Width	VA Vertical Alignment	HA Horizontal Alignment	SL Speed Limit	CE Capacity 1996	CF Capacity 2016
1	Improve pavement conditions (resurface, enhance maintenance program, increase pavement strength)	X				X	X		
2	Improve roadway geometrics (curves, turning radii)								
3	Increase lane widths to 12 feet		X						
4	Increase shoulder widths to be in accordance with AASHTO standards			X					
5	Reconstruct existing roadway without adding lanes	X			X	X			
6	Reconstruct existing roadway including additional lanes							X	X
7	Modify existing roadway to control/reduce access							X	X
8	Widen roadway; construct with additional lanes							X	X

Exhibit 3-19
SUPPLEMENTAL HIGHWAY SOLUTIONS MATRIX

		Deficiencies							
	Solutions	P Pavement	LW Lane Width	SW Shoulder Width	VA Vertical Alignment	HA Horizontal Alignment	SL Speed Limit	CE Capacity 1996	CF Capacity 2016
9	Construct new/rehabilitated interchanges							X	X
10	Provide truck by-pass routes in crucial areas							X	X
11	Construct alternative roadway							X	X
12	Construct new/improved tunnels							X	X
13	Provide specified truck lanes (climbing lanes or with special design standards)				X			X	X
14	Provide additional run-away truck ramps				X				
15	Eliminate/improve/grade-separate at-grade rail crossings							X	X
16	(Re-)develop HOV lanes to accommodate trucks							X	X
17	Regulate minimum speeds in left lanes (instead of prohibiting trucks from left lanes)				X			X	X
18	Improve ports-of-entry operations							X	X
19	Utilize ITS (including: permitting/ports-of-entry; weather/accident advance alerts; speed warnings; Commercial Vehicle Operations (CVO) improvements; weigh-in-motion)							X	X
20	Provide incentives to encourage off-peak travel							X	X
21	Consider TDM (improve transit to reduce highway congestion)							X	X
22	Encourage local jurisdictions to provide adequate land to accommodate external distribution centers							X	X
23	Encourage road-railer technology							X	X
24	Support maintenance and improvement in other modes (including piggy-back trailers on trains, pipelines, mode shift)							X	X

Additionally, the following six improvements are of general benefit to the trucking industry, but do not directly relate to any of the eight deficiencies listed above:

25 Design interchanges and connector roadways to terminals to accommodate the longer combination vehicles
26 Expand chain-up areas
27 Provide adequate rest areas and other parking areas that accommodate trucks (in number and size)
28 Encourage and provide driver education
29 Improve truck maintenance and technology (engines, brakes, etc.)
30 Change regulations to allow the longer combination vehicles and heavier loads

Solution Types

Principal Solutions – The principal solutions matrix includes eight potential solutions, with each of the solutions listed relating to at least one of the eight deficiencies. These principal solutions are, as mentioned earlier, those with results that are easily measured and directly related to the deficiencies. These improvements to the highway corridors can be directly applied to truck travel time models to determine improvements in truck travel performance across corridors. Although most of these potential solutions and their application are straightforward, several unique considerations specifically discussed by the WTTN Steering Committee are worthy of note.

Supplemental Solutions – The supplemental solutions matrix includes 16 potential solutions that can be correlated to at least one of the eight deficiencies. These supplemental solutions pertain primarily to the capacity deficiencies; three of the solutions are associated with deficiencies in the vertical alignment of the roadway. Additionally, six supplemental improvements which could be beneficial to the trucking industry, but do not directly relate to any of the eight deficiencies, were identified and are shown below the Supplemental Matrix in Exhibit 3-19.

Unique Considerations

Shoulder improvements are a principal solution which are typically scheduled as part of a larger rehabilitation improvement project. In the deficiency/solutions tables, improving shoulder widths are shown as a potential principal solution when another improvement that would typically include or accommodate shoulder width reconstruction such as roadway widening or reconstruction, construction of additional lanes, or pavement improvements are also shown.

There are a few circumstances where increased shoulder widths is the only potential principal solution for a supersegment, or where it is shown as a potential principal solution along with “improve roadway geometrics” (which would not typically include reconstruction of shoulders). In these cases, improving shoulder widths is shown as a potential solution with a note in Appendix F stating that "shoulders should be widened to meet AASHTO standards as part of a corridor improvement project".

Speed limit is a deficiency that can be affected by a variety of roadway conditions including grades, curves, or lane widths. In most cases, where speed limit is identified as a deficiency there is at least one other deficiency also identified; often the speed limit is deficient, at least in part, as a result of another deficiency identified for that supersegment. Therefore, as a general solution to the speed limit deficiency, "improve roadway geometrics" has been identified as a potential principal solution. However, there are a few circumstances where speed limit is the only deficiency identified for a supersegment. Some of these deficient segments may be locations where the highway goes through a community and the speed limit is reduced primarily for safety. It is *not* recommended that the speed limit be raised to the MTC at these locations.

There are also some circumstances where speed limit is identified as a deficiency along with another deficiency that would not typically affect the speed limit (shoulder width or capacity deficiencies). In this case, or where speed limit is the only deficiency identified but is not a result of being located in a town, it is recommended that the speed limit change be considered to meet the MTC. Therefore, as appropriate, a note in Appendix F has been included on the deficiency/solution table stating that "consider raising speed limit to MTC if no safety or other concerns preclude it."

Solutions by Corridor

As discussed earlier in the chapter, the most common deficiencies found in the WTTN highway supersegments were year 2016 capacity, pavement, year 1996 capacity, and shoulder width, respectively. Consequently, the potential solutions corresponding to these deficiencies were the most commonly identified potential improvements.

A brief summary of deficiencies in each WTTN corridor was presented earlier in the chapter. Appropriately, a summary of the potential solutions by corridor follows. It should again be noted that these potential solutions are based on the MTCs established for this study, which may differ from individual state standards, and should be used as a tool to obtain improvement suggestions.

Corridor 1, Pacific NW-Minneapolis-Chicago - The most prominent primary solution suggested throughout this corridor is to increase the lane widths on narrow two-lane highways to 12 feet. Additionally, there are significant segments within the corridor where improvements to the roadway geometrics, pavement condition, and/or roadway capacity are suggested.

Corridor 2, San Francisco-Chicago – Along I-80, improving pavement conditions is the predominant solutions menu item suggested. Through San Francisco, Sacramento, and Reno 2016 capacity improvements are included in the menu of solutions.

Corridor 3, Utah-St. Louis – Along I-70 in Utah, shoulder width is a stand-alone deficiency. Shoulder widths are recommended to be considered as part of other corridor reconstruction projects (which may be programmed outside of this study). Improving pavement conditions and existing and future capacity issues are included in the menu of solutions for the eastern portion of I-70 in this corridor.

Corridor 4, Southern California-Memphis – Improving pavement conditions and future capacity deficiencies primarily make up the menu of solutions for this corridor. Overall, this corridor has below average deficiencies and therefore a smaller menu of solutions.

Corridor 5, Southern California-New Orleans – Pavement condition improvements and future capacity improvements constitute the majority of the potential solutions for this corridor.

Corridor 6, Texas-Memphis – Future capacity improvements, primarily in the Dallas area, are the main solutions menu items listed for this corridor.

Corridor 7, Mexico-Canada – Pavement condition improvements and future capacity improvements are the predominant potential solutions suggested. Through Oregon, the menu of solutions includes a wide variety of improvements. Correcting urban congestion deficiencies would require a myriad of expensive improvements, especially in Los Angeles, San Francisco, Portland and Seattle.

Corridor 8, Pacific NW-Utah – Improving pavement condition and roadway geometrics, as well as roadway reconstruction without adding lanes, due to pavement deficiencies and curves, are the prevailing menu items for this corridor.

Corridor 9, Boise-Canada – The three two-lane highways in this corridor have the most extensive menu of solutions, and, overall is the corridor in greatest need of improvement, based on the MTCs established for this study. Percentage-wise, all of the menu items, except for improve pavement conditions and increase shoulder widths, are most significant in this corridor. Expensive alignment corrections in rugged terrain would improve speeds significantly.

Corridor 10, Mexico-Canada (Canamex) – This corridor also includes a variety of solutions menu items, primarily improve roadway geometrics, reconstruct roadways without adding lanes as well as both existing and future capacity improvements. The capacity problems would be addressed through a Hoover Dam bypass, adding lanes to U.S. 60/93, and a Phoenix bypass.

Corridor 11, Pacific NW-Kansas City – The most prominent solutions menu item for this corridor is to improve pavement conditions. Additionally, future capacity improvements are shown throughout the states' solutions menus, and pavement condition improvements are shown for US 26 in Nebraska.

Corridor 12, Montana-Canada – Increasing shoulder widths is the primary solutions menu item noted, as approximately three-quarters of the corridor is deficient in shoulder width. However, this menu item is often shown throughout the corridor in conjunction with other potential solutions (such as improving pavement conditions and increasing lane widths) that would naturally include increasing shoulder widths. It is recommended that other improvement projects scheduled include increasing shoulder widths.

Corridor 13, Canada-Minneapolis-Chicago – Isolated pavement condition improvements are suggested in the menu of solutions for this rather short corridor.

Corridor 14, Wyoming-Galveston – This corridor includes a variety of solutions menu items; speed limits should be considered in the menu of solutions. Most of the speed restrictions are on two-lane portions of U.S. 287 and on Interstates 25 and 70 in Denver.

Corridor 15, Mexico-Arizona – No significant menu of solutions items are included for this corridor as there are few deficiencies in this short corridor.

Corridor 16, Mexico-I-90 – Improving pavement conditions is the most recurrent menu item for this corridor. Also included with some frequency are improving roadway geometrics and roadway reconstruction without additional lanes as they relate to horizontal alignment deficiencies, increasing shoulder widths and improving capacity deficiencies. Addressing capacity on I-25 along Colorado’s front range could include expensive bypasses.

Corridor 17, Mexico-Canada/Midwest – Improving capacity deficiencies, both existing and future, along with improving pavement conditions, are the most notable solutions menu items suggested. These are on I-35, I-37 and I-44 in urban areas, requiring expensive treatments. The two-lane U.S. 81 and U.S. 281 highways may require added lanes to improve operating speeds.

Corridor 18, Laredo-Indianapolis – In this corridor, the solutions menu repeatedly suggests increasing lane widths, improving roadway geometrics, and improving pavement conditions. Speed limit should also be considered in the menu of solutions. Four-laning and adding access control may be the best way to address these problems.

Corridor 19, New Mexico-St. Louis – A fairly inclusive menu of solutions is suggested for this corridor, with improving lane width and speed limit more frequently suggested. Extensive investment is needed on U.S. 54 to significantly improve truck speeds.

Corridor 20, Montana-Canada – The menu of solutions for this corridor is an inclusive list of all the potential menu of solutions items with the primary item being to increase shoulder widths. Since increasing shoulder widths is always shown as a menu item along with another menu item that could easily include improving shoulders, it is suggested that shoulder improvements be included with one of these other improvements.

Chapter 4
RAILROAD ANALYSIS

The railroads and the rail system serving the 17 western states were documented in the WTTN Phase I Final Report. The major rail lines comprising that railroad system were shown on Exhibit 2-11. In sum, the railroad system in the West totals over 58,000 miles of trackage. The dominant railroads are the Burlington Northern Santa Fe (BNSF) and the Union Pacific/Southern Pacific (UP).

The WTTN Phase I Study documented this rail system and its utilization; it also identified deficiencies in that rail system in a very generalized sense. What the WTTN Phase I work did not do is address how well the West's rail system is performing. That performance assessment was reserved for WTTN Phase II.

PERFORMANCE STANDARDS

The measurement of railway performance is quite different from that of trucks. For trucks, transit time is a key element, including the actual speed of the trucks. For railroads, performance indicators include time but also include many other things.

Survey of Railroad Users

A reasonable starting point for understanding what is important in terms of railroad performance is to ask those who use the services. Consequently, a survey of western rail shippers was conducted as part of the study. The survey process began in the Spring of 1998 with the identification of a limited number of major rail shippers in California, Oregon and Washington. Shippers served by Union Pacific Railroad (UP) and Burlington Northern and Santa Fe Railway (BNSF), the two dominant carriers in the West, were initially targeted in a series of in-person interviews. Handling a mix of commodities, these shippers shared their insights regarding the service parameters they expect of their rail service providers. Key performance standards named by shippers included such things as reliable transit times and rail car availability.

These preliminary findings were presented to the WTTN Steering Committee in the September 1998 meeting in Portland, Oregon. At the conclusion of the presentation, all states were asked to provide lists of rail shippers within their states. The states listed shippers which, in their opinion, had significant rail operations. Using these lists as a guide, these shippers were then interviewed by telephone.

In total, 53 shippers and two short line railroads were interviewed[1]. The short lines were included, as these are owned by shippers they serve and handle decision making for rail transport on the shippers' behalf. All interviews were conducted over a seven-month period from May 1998 to January 1999. One nationwide shipper, having operations in all 13 WTTN states, was also contacted. The number of shippers interviewed averaged slightly more than four per state. The number of shippers contacted in each state is shown in Exhibit 4-1.

Exhibit 4-1
WTTN RAIL SHIPPERS SURVEYED

Arizona	**3**	**Oregon**	**5**
California	**5**	**South Dakota**	**3**
Colorado	**2**	**Texas**	**7**
Idaho	**4**	**Utah**	**5**
Montana	**5**	**Washington**	**3**
North Dakota	**3**	**Wyoming**	**6**
New Mexico	**3**	***National shipper***	***1***

Total: 55 shippers (including 2 short lines)
Average shippers interviewed per state: 4.2

Survey Results

In large part, the additional interviews reiterated the preliminary findings. That is, among shippers in all the WTTN 13 participating states, reliable transit time and car availability were the primary concerns. Reliable transit time was defined as the ability of railroads to haul shipments between origins and destinations in a reasonable and consistent time frame. Typical railroad transit times are most commonly represented by published schedules or are specified in contracts with individual shippers. Car availability was defined as the ability of the railroads to respond in a timely manner to shipper requests for empty and serviceable rail cars for loading.

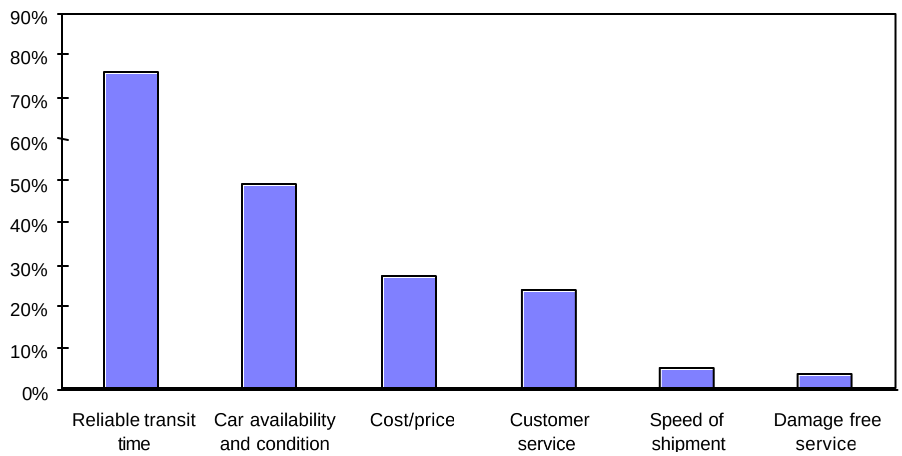
In addition, the shippers also identified two other major performance standards. These were the cost of rail transport services, and customer service. By cost, the shippers were referring specifically to the prices that they must pay the railroads for transportation. By customer service, the shippers meant a number of things. These included the on-time delivery and pick-up of rail cars, and a continuous two-way communication flow whereby railroads keep shippers well informed about the status of shipments. While citing their customer service concerns, shippers recognized the need for railroads to be internally focused on operational improvements. Nevertheless, they desired the railroads to also become more externally focused on the individual shippers' needs.

Other performance standards cited by shippers included the speed of shipments and damage-free service. However, these standards were cited infrequently compared to the four preceding standards. Also, they can be viewed as restatements of concerns regarding reliable transit time and a customer service focus. For these reasons, the analysis described in the following section deals with the four performance standards most frequently cited by shippers. Exhibit 4-2 presents a breakdown of how often particular standards were cited by shippers.

[1] Short line railroads typically haul traffic to and from main line, intercity railroads. In many cases, short lines are former branch line operations of main line or truck line railroads that were sold or leased to private operators.

Exhibit 4-2
WTTN RAIL SHIPPER PERFORMANCE STANDARDS

By Percent of 55 Respondents Contacted May 1998 through Januar



It is noted that beginning in mid-January 1999, the American Association of Railroads (AAR) began publishing four performance measures for eight major North American railroads. These measures included:

- Total cars on line;
- Average train speed;
- Average terminal dwell time; and
- Bill of lading timeliness.

Some of these measures speak directly to the issues of concern which shippers identified in the survey. This was predictable, as the list above was developed through a consensus of shippers and railroads. However, as the AAR began its reporting from January, its information did not provide meaningful corroboration of shipper comments regarding service during most of the study period. It is more likely that this information will be more helpful in judging improvements in rail service from this point forward than in analyzing performance of the past. The AAR makes this data available through the following website: *http://www.railroadpm.org*.

RAILROAD DEFICIENCY ANALYSIS

Having identified those indicators of railroad performance that the shippers view as important, the next step was to identify how well the railroads in the WTTN states are performing (in the view of those who use the railroads).

Subsequent questions posed to the shippers were aimed at determining how well the railroads were doing in relation to the performance standards named by the shippers. Specifically, the questions were aimed at understanding how closely the railroads were performing to expectations of shippers. The difference between expectations and actual railroad performance became the measure of a deficiency in railroad service quality.

For example, if a shipper stated that transit time reliability was a performance standard, that shipper was asked how long it should take for a railroad to move the shipper's freight between origin and destination. If the shipper answered seven days, the shipper was then asked how many days it regularly takes the serving railroad to move the freight. If on balance the railroad makes the delivery in the expected seven-day period, then the railroad was judged to be performing to standard. However, if the railroad is regularly late with shipments, the railroad's service was determined to be deficient. The extent to which the railroad is typically late was calculated as the railroad's deficiency in transit time reliability.

Rail Service Deficiencies by Type

As there were four primary performance standards cited by shippers, there are four types of performance deficiencies analyzed. The foremost standard cited was transit time reliability. Previously, this standard was defined as the ability of the railroad to move freight within reasonable and consistent time frames. The relevant type of deficiency to be analyzed, therefore, pertains to lateness of shipment arrival.

Similarly, the study looked for the most relevant measures of deficiencies in each of the three other performance standards cited by shippers. The particular deficiency types and the evidence of their existence in the WTTN states are discussed below.

Transit Time Reliability - As mentioned before, shippers were asked to cite their expectations of transit time between their major origins and destinations. They then recounted their actual transit time experiences. The difference between the expectation and the actual performance determined the extent of the deficiency. An illustration of how the variances were quantified for this analysis can be seen in Exhibit 4-3.

In this example, Shipper A indicates an expected transit time of five days between an origin and a destination, both of which are located in WTTN Corridor 1 (between the Pacific Northwest and Chicago). That shipper's rail server is found to be making the haul in five days. As a result, there is no variance and therefore no deficiency. Shipper B expects six days between an origin and a destination in Corridor 2 (between the San Francisco Bay Area and Chicago). However, Shipper B's rail server is making the haul in seven days, resulting in a variance of one day and a deficiency of 17 percent (the degree to which existing transit time exceeds the shipper's expectation). Shipper C also is experiencing a one-day variance in Corridor 3 (between Utah and St. Louis). But, because this shipper's expected transit time is four days as compared to six for Shipper B, the extra day in transit time is a greater percentage of Shipper C's total expected transit time. Accordingly, the transit time deficiency suffered by Shipper C is calculated at 25 percent.

Exhibit 4-3
EXAMPLE TRANSIT TIME RELIABILITY ANALYSIS
Example Of Variance Measurement

Shipper	Corridor	Expected (days)	Existing (days)	Variance (days)	Deficiency (percent)
A	1	5	5	0	0%
B	2	6	7	1	17%
C	3	4	5	1	25%

The formula described above provided a methodology to begin a qualitative assessment of rail service in the WTTN rail corridors. Each shipper's description of existing service was treated as a single observation of how much existing performance varied from expectations. As in the illustration above, the variance and degree of deficiency were calculated for each observation. The degrees of deficiency themselves were given ratings. The lesser percentages received a correspondingly lower rating number. The lower the rating number indicated the closer a particular corridor's existing performance was to shippers' expectations. As individual shippers' experiences varied, these ratings were averaged by the number of observations in a corridor. In this way, small shippers' experiences carried the same weight as those of the larger shippers. The rating system applied to corridor performance is seen in Exhibit 4-4.

Exhibit 4-4
TRANSIT TIME RELIABILITY ANALYSIS
Transit Time Deficiency Rating

0-19%	1
20-39%	2
40-59%	3
60-79%	4
80%+	5

- Ratings are averaged for each corridor.
- Small and large shipper ratings have an equal value

The survey results, indicating how corridor performance fared in this analysis, can be seen in Exhibit 4-5. It is noted that observations were obtained for only 16 of 20 WTTN Trade Corridors. Of these 16 corridors, only 11 corridors had four or more observations for at least one railroad. It is suggested that four observations may be sufficient to begin to understand the status of a railroad's service in a particular corridor. While observations are limited, the Exhibit 4-5 analysis nevertheless covers the main routes utilized by rail shippers. BNSF and UP routes in the various corridors are analyzed. Some observations for BNSF were made on services using trackage rights on UP (e.g., Corridor 2 between Stockton and Denver, Corridor 18 between Houston and Corpus Christi).

Exhibit 4-5
TRANSIT TIME RELIABILITY ANALYSIS
WTTN Rail Corridor Performance Score Card

WTTN Corridor	End Points	BNSF Ratings	BNSF Observations	UP Rating	UP Observations
1	Pacific Northwest-Chicago	1.6	14	0	0
2	San Francisco – Chicago	1	3	2.3	30
3	Utah – St. Louis	1.5	4	1	1
4	Southern California – Memphis	2.5	10	0	0
5	Southern California – New Orleans	0	0	4.5	6
6	Texas – Memphis	1	1	2.3	4
7	Canada – Mexico (West Coast)	2	4	2.7	7
8	Pacific Northwest – Utah	0	0	2.5	12
10	Mexico – Canada (Canamex)	0	0	2.3	14
11	Pacific Northwest – Kansas City	1	1	1.8	4
14	Wyoming – Galveston	1.3	3	0	0
16	Mexico – Wyoming	5	1	1.7	3
17	Mexico – Upper Midwest	3	3	2.6	7
18	Laredo – Indianapolis	5	1	0	0
19	New Mexico – St. Louis	3	2	2	2

NOTE: The larger the ratings number, the more deficient the railroad service (in terms of transit time reliability).

While there are other railroads operating in the West, WTTN Trade Corridors mainly consist of routes belonging to these two railroads. Furthermore, shipper comments tended to focus on the performance of BNSF and UP. The major east - west routes of these railroads are included here. These are:

- BNSF's northern tier route between the Pacific Northwest and Chicago (WTTN Corridor 1).
- UP's central corridor route between Northern California and the Midwest (WTTN Corridor 2).
- BNSF's southern tier route between Southern California and Texas (WTTN Corridor 4).

- UP’s southern tier route between Southern California and New Orleans (WTTN Corridor 5).

North-south corridors also are included; three having four or more observations are:

- BNSF and UP routes between the Pacific Northwest and Southern California (WTTN Corridor 7);
- UP’s route between eastern Idaho and Southern California (WTTN Corridor 10); and
- UP’s route between the Midwest and Laredo, Texas (WTTN Corridor 17).

In some cases, shippers cited origin-to-destination routes which required movements across more than one corridor. For example, a shipper in Texas may move freight on UP between an origin in Wyoming and a destination in Texas. In this case, existing performance of the move was assessed for both Corridors 2 and 17; the latter being UP’s main routing from the Midwest to the Gulf Coast. Specifically, if the shipper cited a variance yielding a calculated 35 percent deficiency in transit time for the move, a rating of 3 was ascribed to both corridors. This methodology was followed for all like observations. This was done because it was not possible, based on shipper comments alone, to specifically identify where the problem areas on such multiple corridor routings exist. While UP and BNSF were approached for comment on specific corridor performance, railroad participation in this study was minimal. Neither railroad provided substantial detail on corridor performance.

It should also be noted that, in a few cases, shippers were reluctant to provide specific variance data. In such instances, deficiency ratings were inferred from the shippers’ general assessments of service quality.

While the analysis lacked significant railroad input and was by its nature a non-scientific sampling, it nevertheless is reflective of actual shipper experience on the western rail systems through the latter half of 1998. It was during this period that severe service problems on both UP and BNSF were reported on several key routes. These routes include both UP’s and BNSF’s southern tier routes. In the analysis above, both routes show mediocre to poor performance ratings. A summary listing of the pros and cons on the methodology is seen in Exhibit 4-6.

Exhibit 4-6
TRANSIT TIME RELIABILITY ANALYSIS
Methodology Pros And Cons

PROS	CONS
• Shipper based	• Limited railroad input
• Shippers included from all WTTN participant states	• Non-scientific sampling
• Shippers of numerous commodities surveyed	• More observations in some corridors than others
• Large and small shippers included	• No observations in some corridors
• Includes major corridors	

Car Availability - With regard to car availability, the study sought to understand whether the shippers believe railroad car supply is either "bad," "improving," or "good." Bad was defined as car availability being far from expectations; improving, as approaching expectations; and good, as at or near expectations. To the extent that a railroad's car availability was cited as bad or improving, its car availability was determined to be deficient.

Exhibit 4-7 indicates that shippers reported that car availability conditions were better on the UP than the BNSF. That is, the vast majority of BNSF users reported that railroad's car availability conditions as being bad. By contrast, less than a third of UP users reported UP's car availability conditions as being bad. One reason for the disparity between the two railroads could be that the demand for BNSF service, which was generally perceived to be superior to UP's during most of 1998, exacerbated demand for cars on BNSF and created car availability shortfalls. Overall, shipper comments indicated that only slightly better than one-fourth of respondents believe car supply in the West was good. At the same time, slightly less than three-fourths reported conditions to be either bad or improving - in other words, deficient.

Exhibit 4-7
CAR AVAILABILITY ANALYSIS
Shipper Assessments By Percent Of Respondents

	Bad	Improving	Good	Total
BNSF	69%	8%	23%	100%
UP	31%	38%	31%	100%
TOTAL	48%	24%	28%	100%

Bad: Far from expectations.
Improving: Approaching expectations.
Good: At or near expectations.

Specific car types, whose availability was cited by shippers as bad or improving, are listed in Exhibit 4-8. More than three-fourths of cars reported in short supply consist of four types: box cars, covered hopper cars, gondolas, and open top hopper cars. The most significant availability shortfall was reported for box cars. Historically one of the most versatile of car types, box cars are used for shipments of lumber, paper, and general merchandise, among other things. Most products that can be shipped in box cars can also be shipped in intermodal containers and trailers. So popular has intermodal transportation proven in recent years that car building has focused on intermodal. Nevertheless, the demand for box cars persists. With few if any new box cars being added to fleets, shortages in this car type may continue and even get worse.

Exhibit 4-8
CAR AVAILABILITY ANALYSIS
Car Type Availability Assessed By Respondents as Bad or Improving

Box Cars	24%
Covered Hopper Cars	17%
Gondolas	21%
Open Top Hopper Cars	14%
Other	24%
TOTAL	100%

Though perceived shortfalls in car supply are clearly evident from shipper comments, a review of railroad car fleets showed that the numbers of cars on western railroads, including the BNSF and UP systems (and their predecessor railroads), have increased since 1990 by almost 12 percent. However, as can be seen in Exhibit 4-9, both tons originated and revenue ton-miles have increased by far greater percentages during the same period[2]. If one assumes that the capacity of cars has only made marginal gains over the period[3], one can conclude that increases in demand for these cars (measured by tons originated) has exceeded increases in supply by better than two to one. Furthermore, because of recent rail consolidations (including those creating today's BNSF and UP systems), cars are carrying their loads over longer distances (reflected in increased revenue ton-miles). The longer distances traversed lengthens car turn or cycle times (the time required to return an empty car to an origin for reloading), consequently contributing to shipper complaints about car availability.

[2] Yearly tons originated and revenue ton-mile figures are cited in the AAR's 1998 edition of "Railroad Facts."
[3] According to figures cited in the 1998 edition of "Railroad Facts," average freight car capacity has plateaued at about 92 tons per car. This leveling off is a function of maximization of axle loadings (load tonnage divided by typically four wheel axles per car) and car design limitations.

Exhibit 4-9
CAR AVAILABILITY ANALYSIS
Western Railroads

	Car Supply	Tons Originated (thousands)	Revenue Ton-Miles (millions)
1990	251,004	677,897	665,045
1997	279,932	862,704	917,220
CHANGE	11.5%	27.3%	37.9%

While railroad car supply has grown in the West, this is not the case nationwide. According to the 1998 edition of "Railroad Facts" published by the AAR, the number of railroad-owned freight cars declined 17 percent between 1988 and 1997. On the other hand, car ownership by shippers and other non-railroad entities has increased by almost 42 percent. This trend in private car ownership has served at least partially to bridge the gap in car availability. It has produced benefits for the railroads in that they are responsible for maintaining fewer cars. Railroad operating expenses for leases and maintenance have decreased as a consequence. Car-owning shippers have benefitted in that they no longer have to compete with other shippers for a declining railroad-controlled car supply. However, even in this environment, there can be a negative implication for car-owning shippers. That is, with the railroads decreasingly responsible for car payments (and shippers correspondingly more so), a question remains as to how much of an incentive the railroads have to shorten car cycle times. One possible answer is that railroads will have less of an incentive over time.

Customer Service - The study also examined the expectations of shippers with regard to the railroads' customer service orientation. Typically, a shipper identified a railroad as having substandard customer service if the railroad regularly fails to pick up or deliver a loaded rail car at a specific time. This is because the shipper may have to call a shift of workers to unload the rail car. If the car fails to appear, the shipper still has to pay the idle workers. Thus, the shipper has incurred an expense with no offsetting benefit. Similarly, shipper comments regarding inaccurate railroad information concerning shipment status, too few capable employees, or a railroad's poor problem resolution skills were taken as evidence of deficient customer service. Exhibit 4-10 presents a breakdown of how shippers defined their customer service performance standards.

Exhibit 4-10
CUSTOMER SERVICE ANALYSIS
Definition of Performance Standards by Percent of Respondents

On-Time Pick-Up and Delivery of Cars	Ease of Doing Business
38%	**62%**
▸ Save Cost	▸ Accurate Information ▸ Empowered Employees ▸ Problem Resolution

As can be seen, 38 percent of shippers which identified consumer service as a performance standard indicated that they were very concerned about on-time pick up and delivery of cars. This, they indicated, delivers benefits on the cost side. Generally speaking, these shippers stated that their serving railroads were not performing well in this regard. At the same time, 62 percent of shippers which identified customer service as a performance standard voiced desires for more accurate information concerning shipment status. They also called for more railroad employees with the training and the resources to respond effectively to shipper inquiries and requests, and to fix service problems. These shipper concerns are expressed as "ease of doing business" with a railroad.

Cost of Rail Service - Because the cost of railroad transportation service was cited as a performance standard, the study looked for evidence that the prices or rates which railroads charge have increased, remained the same, or decreased in current dollar and constant dollar (or deflated) terms over time. The extent that rail prices have increased, while deficiencies in service are known to exist as well, would be taken as evidence of a potential deficiency. However, information provided by the AAR indicates that this is not the case; in fact, the opposite seems to be true – railroad rates are declining.

As can be seen on Exhibit 4-11, the cost of freight rail transportation nationally has decreased in both current dollar and constant dollar terms. The key measurement is revenue per ton-mile, which is a surrogate for rail rates. As an example, 100 tons carried 100 miles yields 10,000 revenue ton-miles; given 2 cents per revenue ton-mile, a revenue rate of $2 per mile or $2 per ton can be deduced. In the illustration below, railroad revenues per ton-mile decreased 12 percent in the 10-year period between 1987 and 1997[4]. When the figures are deflated by three percent per year, it can be seen that revenues per ton-mile have decreased 36 percent in constant dollar terms over the same period. From these figures, one can conclude that on balance shippers are paying less for their rail transportation than they have at any time in the recent past. It would appear, therefore, that no substantial deficiency with regard to the cost performance standard exists (although specific exceptions to this may exist, e.g., some shipment situations may have witnessed cost increases).

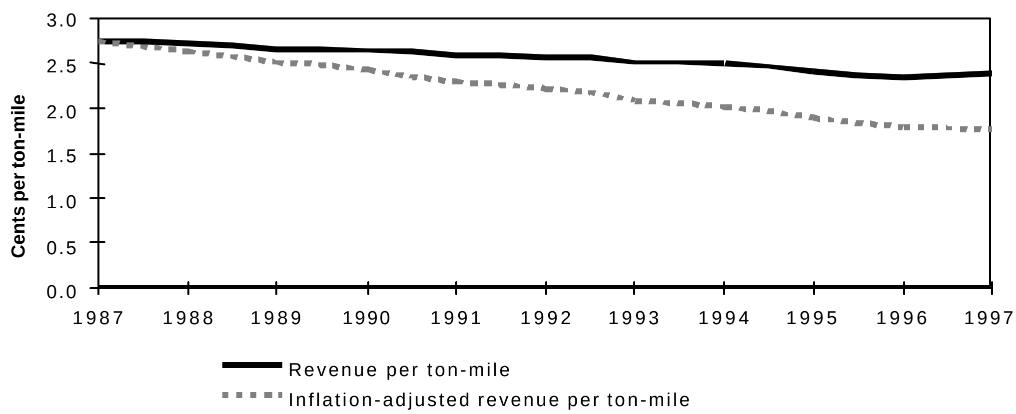
Deficiencies by WTTN Trade Corridor

An attempt was also made to identify railroad deficiencies on a corridor-specific basis.

Transit Time Reliability - Of the four major performance standards mentioned above, only transit time reliability was able to be assessed on a corridor-specific basis. This is because transit time can be measured between origin and destination, which in turn can be matched with a specific WTTN Trade Corridor. As observed in the preceding Exhibit 4-5, deficiencies on a corridor basis can be measured by how far existing performance is from the standard. A deficiency rating of 1 covers transit times varying from 0 percent to 19 percent longer than expected by shippers. Generally speaking, shippers' comments indicated a tolerance of a low level of variance from their expectations. The range represented by a 1, therefore, was meant to reflect this shipper tolerance.

[4] Revenue per ton-mile figures were provided by the AAR.

Exhibit 4-11
RAIL REVENUE PER TON-MILE
Decreases 12% in 10 Years
(Down 36% adjusting for 3% annual inflation)



Those rail routes with average scores equal to and greater than 2 (indicating transit times at least 20 percent longer than expected by shippers) based on four or more observations are listed below.

- UP's central route between the San Francisco Bay Area and the Midwest (WTTN Corridor 2). This route had a rating of 2.3, based on 30 individual observations.
- BNSF's southern tier route between southern California and Texas (WTTN Corridor 4). This route had a 2.5 rating, based on 10 individual observations.
- UP's southern tier route between southern California and New Orleans (WTTN Corridor 5). This route had a 4.5 rating (the worst of all corridors), based on six observations.
- UP's Texas - Memphis route (WTTN Corridor 6). This had a 2.3 rating based on four observations.
- UP's West Coast route between Seattle and Los Angeles (WTTN Corridor 7). This route had a rating of 2.7 with seven observations.
- UP's Pacific Northwest - Utah route (WTTN Corridor 8). This had a rating of 2.5 with 12 observations.

- UP's route between Pocatello and southern California (WTTN Corridor 10). This had a rating of 2.3 with 14 observations.
- UP's Midwest - Texas route (WTTN Corridor 17). This had a rating of 2.6 with seven observations.
- BNSF's Canada-Mexico route (WTTN Corridor 17). This had a rating of 2.0 with four observations.

Most of the problems reported by shippers were on the UP system. These UP problems were largely related to widespread service breakdowns, which persisted between 1997 and most of 1998. However, these service problems were improving through the second half of 1998. In fact, during the course of the seven-month interview period, shippers cited a trend toward service improvement on UP. As a direct result of interviews conducted in the December - January time frame, the average score obtained for UP's southern tier route (WTTN Corridor 5) decreased to a 4.5 from a previously calculated score of 5 (indicating transit times running at least 80 percent longer than shippers' expectations).

Other Performance Standards and Deficiencies - Car availability is typically critical only at origins. Whether car availability is a corridor-specific issue could not be determined from the survey, given the limited shipper responses. The multi-dimensional customer service standard, with a varied emphasis on on-time pick-ups and deliveries as well as an empowered workforce and other factors, is likewise untied to performance on particular corridors. Lastly, costs were looked at in terms of a general trend within the rail industry rather than on either a rail corridor basis or even a rail system basis.

MENU OF SOLUTIONS

Solution Types

A menu of solutions for deficiencies with regard to transit time reliability, car availability, and customer service is discussed below. Solutions for cost of rail services deficiencies were not investigated because the evidence gathered in the study indicated that no such meaningful deficiency exists.

The solutions are generally of two types. One type pertains to *physical solutions* for achieving performance standards. These would include, for example, increasing height clearances through the UP's Cascade Mountain tunnels in Northern California and Oregon in order to accommodate efficient configurations of certain cargo such as double-stack container traffic. The other type pertains to *operational solutions*. These would include such things as decentralizing train dispatching from corporate headquarters to the geographic regions in which trains operate, with the goal of safer and more reliable transportation.

Physical and operational solutions that can be linked with specific corridors are cited in the following entitled "Solutions by Corridor." The more general, system-wide solutions for transit time reliability, car availability, and customer service deficiencies are listed first.

It should be noted that almost all of these solutions were suggested by users of the rail systems - the shippers. In many cases, railroad support for implementing these solutions would be likely. In others, the railroads may disagree with the shippers. However, it was difficult if not impossible to assess the extent the railroads may agree and disagree, lacking any significant input from the railroads representatives. The solutions are underlined below as they were received, with minimal subsequent clarifications provided by the consultants. In some cases, shipper comments are contradictory. This was to be expected, as the comments reflect a broad geographic and commodity mix of shippers, whose interests naturally differ. Also below are public policy and general management policy solutions which shippers suggested to address various rail deficiencies. As numerous shippers expressed their desire for anonymity, no shippers are specifically identified with any suggested solutions.

Transit Time Reliability - General *physical solutions* suggested by shippers include:

- Eliminate at-grade crossings wherever possible. Doing so will both reduce accident potential and increase train speeds.
- Add more track near production centers to keep operations fluid. Shippers related that many times, for lack of sufficient sidings or lead tracks, cars cannot be delivered to production centers. These cars are often left in yards, thereby robbing the yards of much needed capacity.

- Increase railroad capacity in general. This could be done by such investments as double tracking or lengthening sidings.

- Add more locomotives to pull trains.

General *operational solutions* suggested by shippers include:

- Build unit trains for steel and other commodities, like those that exist now for coal, wheat and intermodal shipments. Unit trains typically enjoy lower costs due to the handling of only one commodity in one car type. But of particular relevance here, these trains also typically enjoy much faster transit times, as little or no intermediate switching and sorting of cars are required between origin and destination.

- Decentralize dispatching to provide more customer sensitive and efficient service. Shippers complained that dispatchers working in distant centralized locations often lack detailed knowledge of local conditions. As a result, shipments have been unnecessarily delayed.

- Expand fast, cost-effective intermodal service to lesser markets. Railroads tend to provide intermodal service only between major metropolitan markets like Chicago and Los Angeles. This trend has left more rural markets underdeveloped in terms of intermodal rail service. Intermodal cars to and from these markets may be mixed with carload traffic. As a result, transit times can be longer and less reliable.

- Encourage railroads through incentives to achieve reliable transit times. Railroads could be rewarded for improved service reliability. A model for such a system is Amtrak's inventive program, which rewards host freight railroads for expediting Amtrak trains across their systems.

- Apply statistical analysis to determine service problem root causes. One shipper cited a practice of regular meetings with a rail carrier to identify common and special causes of variability in transit times. The shipper and carrier then jointly pursue potential solutions.

- Address yard-operating problems, which cause rail cars to remain for unnecessarily long periods in yards. Typically yard problems include insufficient capacity to sort traffic efficiently. As a result, yards become congested, with trains unable to enter and leave the yards. Down stream effects include deterioration of main line transit times.

- Hire more crews to man the trains, in order to avoid crews exceeding their maximum allowable work hours per day. Without relief, crews can "die on the law," resulting in trains being left not only stopped but unattended.

- Implement directional running wherever practical. Where a railroad has two more or less parallel lines, directional running allows traffic to move in a single direction on each line. Doing so mimics the efficiencies of double tracking, thereby providing for enhanced transit time reliability. Directional running has been made possible through various western railroad consolidations, as a result of which former rivals have become one. An example can be found in WTTN Corridor 6, where UP now has two lines. Until UP's 1996 merger with the former SP, both UP and SP operated as competitors on roughly parallel routes in the corridor. UP now uses one route for northbound traffic, and uses the other for southbound traffic.

- Perform better hand-offs to and from locals. While main line trains haul rail cars between major markets, local trains are responsible for pick-up and delivery of cars. Poor coordination for interchange of traffic between main line and local trains results in delays and poor transit time performance.

- Deploy more locals, ensuring timely interchanges of rail cars with main line trains.

- View the coal business with a higher priority. One shipper claimed that railroads do not aggressively pursue the coal business as they do other business. As a result, coal train transit times are not as reliable as they could be, the shipper said.

- Run scheduled trains rather than eliminating them due to periodic locomotive shortages. A shipper claimed that a railroad occasionally cancels regular service, and distributes locomotive power arbitrarily to other trains. As a result, transit time for the shipper's freight has increased.

<u>Car Availability</u> – Shipper-suggested *physical solutions* include the following:

- <u>Build more cars of all common types</u>.

- <u>Build more box cars in particular</u>. Box cars have not been built in years, though fairly large numbers have been rebuilt. When they derail, box cars are often scrapped, thereby reducing fleet size even more.

Shipper-suggested *operational solutions* include the following:

- <u>Better utilization of cars</u>. Building more cars would address the car availability issue in one way. Alternatively, improved utilization of existing fleets would address the same issue. Improved utilization implies a heightened consciousness among railroads to position empty cars for reloading as quickly as possible. Railroads have incentive to do this now for their owned cars. However, to the extent that significant car numbers are owned not by the railroad but by non-railroad entities, the railroads have less of an incentive to improve turn or cycle time - the key measure for car utilization.

- <u>More management focus on wheat versus coal and intermodal traffic</u>. One shipper felt that management attention was diverted away from wheat movements. As a result, fewer cars were being made available for wheat movements relative to cars for other types of freight, the shipper claimed.

- <u>Better information systems to allow cars to be delivered as needed</u>. One shipper remarked that poor railroad information systems result too often in “bunching cars together.” That is, the serving railroad often delivers too many cars to the shipper at one time. As a result, many cars remain unused for prolonged periods at the shipper’s loading facility. This practice serves to exacerbate car availability conditions.

- <u>Shippers should order cars earlier than needed, if delivery problems are anticipated</u>.

- <u>Improved yard operations, helping cars through yards</u>. Shippers remarked that cars often traverse the main line well, only to become delayed by yard handling. As every yard is different, there are as many answers to improving yard operations as there are yards. This comment was reflective of a shipper’s concern rather than specific in terms of any technical solution.

- <u>Railroads should encourage shippers to maximize the potential of car ordering systems to guarantee prompt car deliveries</u>. A shipper related that major railroads have car ordering protocols which can be helpful in delivering cars as desired. The core problem may be one of inadequate training for the shipper in the use of these systems.

- Open access will provide for greater car availability by creating a more competitive environment. Open access is currently being promoted in Congress as a means to ensure competition for "captive shippers" - shippers that are served exclusively by one railroad. Some shippers have argued that the lack of competition for their business has resulted in higher rates and less than satisfactory service, inclusive of inadequate car availability. In their opinion, open access would allow other qualified carriers to pick up and deliver cars for a formerly captive shipper, thereby simultaneously stimulating competition for the shipper's business and improving rail service.

- Add to yard crews and supervision so that cars can be "found" in yards. One shipper related his impression that that too often rail cars in effect have been lost in yards. The shipper referred to various instances when cars were not identified properly by number and location. If such information is not noted accurately when cars come into a yard, switching and delivery of cars can be delayed, worsening already tight car availability. It is noted that major railroads have been involved in the development of a technology which may ultimately address this issue. The technology, commonly referred to as Automatic Equipment Identification (AEI), is aimed at gathering car identification numbers electronically. AEI "readers" pick up the car numbers from transponders. With readers located throughout yards, the precise location of cars could be ascertained with every move. Presently, however, AEI readers are commonly found at strategic points such as the entrances and exits of yards rather than on every track.

- Increase car maintenance budgets to get bad-ordered (mechanically non-road worthy) cars back into operation faster. One shipper complained that underfunded equipment maintenance budgets result in cars being out of revenue service longer than they need to be.

- Increase car velocity, thereby increasing utilization. One shipper pointed out one way to decrease turn or cycle times is to increase the speed with which cars traverse rail systems. This can be done by various means, including boosting maximum speed limits, or adding locomotive power to longer, heavier trains. Both solutions may require substantial capital investment.

- Encourage shippers to invest in cars through lower "per diems." These are lease payments for rail cars. They are often quoted on a daily or per diem basis. Low per diems would encourage shippers to lease cars themselves rather than depending on the railroad controlled car supply.

- Railroads need to reduce terminal dwell times. This shipper echoed the impression of many shippers that cars are being unnecessarily delayed in yards. The science for reducing dwell times exists, but this know how is underutilized by the railroads, the shipper said.

Customer Service – Shipper-suggested *physical solutions* include the following:

- More tracks near production centers to allow for more Storage-In-Transit (SIT). SIT typically might occur at a petrochemical plant, where loaded tank cars might be positioned on sidings until the cars' contents are needed for production. Adding more SIT tracks will provide more space for such tank cars and remove cars from yards where they can hinder fluid operations.

- More power both to run trains and to speed them up.

Shipper-suggested *operational solutions* include the following:

- Railroads need more customer focus. One shipper stated railroads have placed their improvement emphasis in recent times on operations rather than the needs of the ultimate users of the systems - the shippers.

- Railroads and shippers need to stay "close" to each other, and seek to work together to resolve problems. One shipper said the relationship between shipper and railroad too often becomes adversarial and consequently unproductive. This trend could be countered with an increased commitment to each other, the shipper suggested.

- Improved internal and external communications so shippers can have accurate information as to the status of their shipments.

- Empower the employee, with whom the shipper has the most contact, to resolve problems. One shipper said that railroad workers closest to shippers often have the best understanding of what is required to improve service for the shipper. However, the shipper related, too many times these employees lack the authority to implement positive changes.

- More crews to run trains. Too often, one shipper believes trains are left idle because of too few employees. As a result, pick-up and delivery times are not made.

- More hands-on supervision by management, which has become too thin as a result of recent railroad mergers.

- Better training to allow employees to respond to the needs of shippers.

- Streamline processes in which shippers interface with the railroad. A clear example of a process in need of improvement pertains to rate quotations and billing, one shipper said. Working with the railroad should be "simple and seamless, like going on line with the Internet."

- Promote open access, which will drive improvements in customer service.

Public and General Management Policy Suggestions for Rail Deficiencies

- Allow funds for highway improvements to be spent on other modal infrastructure projects. These could include rail projects, according to one shipper.

- Encourage on-dock rail facilities at ports to speed trains and lessen road congestion. Such facilities are so named because they are adjacent to traditional container handling facilities at ports. Containers traveling inland need only a short transfer move between the "dock" and the railroad, rather than a highway move to intermodal rail terminal in a more remote location.

- Encourage flexible labor agreements to run shorter, faster trains to lesser markets. Partially to maximize the productivity of labor, some railroads prefer running longer but slower trains between major markets.

- Encourage railroads to extend service to lesser markets. A strategy could include public sector financing of capital and/or operating costs.

- Provide funding options for short lines to modernize their locomotives, cars, tracks, yards, and other facilities. One shipper stated that typically undercapitalized short lines will increasingly become unable to accept rail cars with higher load capabilities. As a result, shippers served by these short lines will find it more difficult to obtain competitive rail services.

- Fix labor contracts to ensure that railroads achieve benefits of mergers. One shipper said that UP has been unable to achieve efficiencies inherent with integrating UP and former SP workers. In some cases, such integration and other workforce rationalization have been precluded by existing labor contracts, the shipper said.

- Coordinate infrastructure investments to ensure sufficient capacity for freight and commuter railroads. One shipper pointed to the growth of commuter railroads, which is coming at the expense of capacity for growing freight volumes. A strategy could include public agency sharing of rail capacity improvement costs.

- Preserve used rail assets. These would include facilities like UP's Modoc Line in northern California and its Tennessee Pass route in central Colorado, one shipper suggested. It is noted that UP announced plans in 1998 to preserve these lines in order to preserve the capacity that they imply for the UP system. States might consider subsidizing operations on uneconomic lines. Also, the lines might be "railbanked." Established by Congress, railbanking is a method by which lines proposed for abandonment can be preserved through interim conversionn to trail use. Lastly, states can buy lines from railroads that otherwise would be abandoned. Washington State has brought two branch lines since the late 1980s in order to keep them in service.

- Ensure that sales of freight lines to commuter operations do not reduce freight rail capacity where it is needed.

- Make state funding available for railroad terminal improvements.

- Utilize state funding to address port/rail interface issues. One shipper cited southern California as one example where port related traffic dominates the capacity of railroads, thereby negatively affecting other traffic flows in the area. State funding could provide for capacity improvements benefiting the movement of all commodities.

Solutions by Corridor

Because transit time reliability was also discussed in terms of performance on specific corridors, it is possible to discuss some solutions, both physical and operational, on a corridor-specific basis. The physical solutions to constraints affecting transit time reliability are cited in Exhibit 4-12. As in the preceding section, most of the solutions were suggested by shippers. In addition, some of the solutions were suggested or are already supported by the railroads.

Exhibit 4-12
RAILROAD PHYSICAL SOLUTIONS BY WTTN TRADE CORRIDOR
Solutions to Transit Time Reliability Deficiencies

Corridor Identification	Solution Description
WTTN Corridor 1 (Pacific Northwest–Chicago)	• Restore the Ellensburg - Lind Cutoff in Washington State to reduce miles to and from Puget Sound on BNSF. • Capacity improvements to BNSF and UP on Columbia River routes in Washington State and Oregon. • Build the FAST (Freight Action Strategy) Corridor on BNSF between Tacoma and Seattle to speed trains and reduce interface with road traffic.
WTTN Corridor 2 (San Francisco-Chicago)	• Increase UP tunnel clearances in the Sierra Nevada Mountains in northern California. • More double tracking and longer sidings on UP's central corridor between California and Utah. • Relocate UP yard operations and main line in Salt Lake City, Utah, to a less urban location. Doing so will minimize conflicts between road and rail traffic and provide for facility expansion. Both consequences could serve to improve reliability. • Fix UP bottlenecks between North Platte, Nebraska and Kansas City, Missouri.
WTTN Corridor 4 (Southern California-Memphis)	• Centralized Traffic Control (CTC) signaling between Barstow and Needles, California on BNSF's heavily utilized southern tier route to provide for more fluid traffic flows. • Double track 250 miles of BNSF's heavily utilized single track between Barstow, California and Belen, New Mexico.
WTTN Corridor 5 (Southern California-New Orleans)	• Build Alameda Corridor East, a proposed major grade separation project of UP main line trackage running east of Los Angeles toward San Bernardino, California.
WTTN Corridor 7 (Mexico-Canada, West Coast)	• Increase tunnel clearances on UP through Cascade Mountains in northern California and Oregon. Doing so will allow for the running of expedited double-stack container trains.
WTTN Corridor 8 (Pacific Northwest-Utah)	• Double tracking and grade improvements on the UP main line through the Blue Mountains in Oregon in order to speed trains and lessen congestion.

Corridor Identification	Solution Description
WTTN Corridor 10 (Mexico-Canada)	• Expand UP's "landlocked" Pocatello, Idaho yard, having limited ability to handle increasing business.
WTTN Corridor 17 (Mexico-Canada/ Upper Midwest)	• New intermodal yard in Laredo, Texas so trains can avoid downtown. Laredo is an endpoint of UP's main line between Texas and the Midwest. • New bridge at Laredo to reduce congestion at current single track bridge. • Fix UP bottlenecks between Taylor and San Antonio, Texas.

Shipper suggested operational solutions for transit time reliability relative to specific corridors are cited in Exhibit 4-13.

Exhibit 4-13
RAILROAD OPERATIONAL SOLUTIONS BY WTTN TRADE CORRIDOR
Solutions to Transit Time Reliability Deficiencies

Corridor Identification	Solution Description
WTTN Corridor 1 (Pacific Northwest-Chicago)	• Directional running on the Columbia River routes. This would require coordination between BNSF which owns a main line on the north side of the river, and UP which owns a main line on the south side of the river. As mentioned before, directional running mimics the efficiencies inherent in double tracking.
WTTN Corridor 5 (San Francisco-Chicago)	• Intermodal trains between the Ports of Los Angeles and Long Beach and the San Bernardino Valley. Such trains will speed container traffic between the ports and the "Inland Empire." At present, container traffic must use congested southern California freeways.

BENEFITS OF ACHIEVING PERFORMANCE STANDARDS

Direct Benefits and Beneficiaries

The solutions suggested above are aimed at addressing performance deficiencies in the three areas most critical to shippers: transit time reliability, car availability, and customer service. If the physical and operational solutions set forth are effective, they should result in direct benefits accruing to the prime freight industry participants - the railroads and the shippers.

Railroads stand to gain from improved infrastructure and lower operating costs. Shippers stand to gain due to improved service and lower total transportation costs. Both railroads and shippers will find their abilities to compete for new revenues enhanced. Various direct benefits resulting from solutions to deficiencies in the critical performance areas are examined qualitatively below.

Freight Industry Benefits

Transit Time Reliability - From a railroad perspective, direct benefits pertaining to reduced cost and enhanced revenue potentials can be predicted by the improved transit time reliability. Expenditures for fuel, maintenance, and labor likely will decline as trains move more efficiently over their systems. On the other hand, more locomotive power and more track capacity will mean railroads can handle more trains and earn more revenues.

The shippers will benefit by having their freight delivered in time frames they can rely on. Reliable transit times will provide shippers with the ability to downsize inventories and carrying costs. Also, by having freight arrive as desired, shippers will have greater ability to respond effectively to the requirements of their customers. Predictably, they will be less likely to be caught out of stock because trains fail to make their expected transit times. Accordingly, shippers' market competitiveness will be enhanced, allowing them to pursue additional revenue opportunities.

Car Availability - With improved car availability, railroads will be able to respond more effectively to the shipper demands for cars. Doing so will mean that that railroads will be able to carry more loaded cars. As railroads carry more freight, they will earn more revenues.

Shippers will gain by having cars delivered when ordered. A western grain shipper reported that he is able to invoice grain shipments once they are loaded onto a grain car. An improved car availability, therefore, can mean that a shipper will realize revenue from a shipment sooner. Cash flow will be improved as a result. This dynamic has a meaningful implication on the cost side. With improved cash flow, a shipper will be able to borrow less to finance operations, and thereby reduce interest cost.

Customer Service - A strong customer service orientation will enhance the image of the railroads' service quality. Being known for on-time deliveries and ease of doing business predictably will enhance the railroads' ability to compete with themselves and with trucks for shippers' business. To the degree they are successful in this competition, revenues will grow.

As railroads gain volume density on their lines, opportunities for bolstering operating income will manifest themselves. A common example pertains to carrying new traffic on existing trains. In cases where trains have capacity available, the incremental cost of carrying new traffic is often minimal as most of the train cost can be allocated to carrying the train's base traffic. As a result, the contribution to operating income provided by the new traffic is high relative to the train's base traffic.

With the railroads performing pick-ups and deliveries in a more timely manner, shippers will be able to schedule their labor forces more accurately, thereby reducing cost due to idle time and improved productivity.

Economic Benefits

The solutions above were suggested as means to improve the utility of Western rail systems in ways most meaningful to shippers. The solutions pertain to specific deficiencies in rail service. Improving transit time reliability, car availability and customer service will benefit shippers directly. For example, double tracking a congested single-track route may provide for more reliable transit times. The resulting transit time improvements may, in turn, allow shippers to maintain lower inventories thereby reduce carrying costs. The positive financial effect of reduced demand on cash flow will be both straightforward and immediate.

By their nature, these solutions will also deliver broader economic benefits. In ongoing research on the quantification of benefits resulting from improvements in rail systems, the Federal Railroad Administration has defined these benefits in terms of user benefits and non-user benefits. These two classifications are described below, along with explanations of how the solutions cited in the preceding section might deliver these benefits.

Solutions, of course, come with the costs to implement them. There are cost trade-offs for benefits. However, quantification of net benefits was not attempted here. Rather, the benefits were assessed in a more qualitative manner.

User Benefits – As the name implies, these are benefits that accrue to the users of the transportation systems. The carrying cost savings that a shipper might experience because of improvements in transit time reliability are an illustration of a user benefit, for the shipper is clearly a user of a rail system.

Such benefits can be further defined in terms of ***direct benefits*** and ***indirect benefits***. The aforesaid carrying cost savings is a direct benefit, for it represents an out-of-pocket savings to the shipper. Indirect benefits accrue to users of adjacent transportation systems, such as highways. An example would be the travel timesavings and vehicle operating cost savings experienced by truckers and motor vehicle operators. That is, to the extent that truckloads are drawn off congested highways and onto reliable railroads, there will be less congestion on highways for the trucks and cars that remain. Less congestion will result in faster transit time and less delay resulting in wasted fuel.

Non-user Benefits – These are benefits that accrue to the society at large. Five typical non-user benefits are:

- Fuel savings;
- Emission savings;
- Reduced highway maintenance costs;
- Reduced public tax bill; and
- Reduced highway congestion.

In the preceding example of a double tracking solution for enhanced transit time reliability, the improvement will allow trains to cross a formerly congested section of single-track expeditiously. Fuel, which had been consumed wastefully, as trains idled, unable to move, will be saved. Fuel savings will also develop from diversions of truckloads to more efficient rail systems[5]. As a result of improved transit times and diversions of truck traffic to rail, emissions will be reduced[6].

Also, as shippers divert their truckloads to railroads more capable of moving trains reliably, highway maintenance costs will be reduced. Reduced highway maintenance costs will represent savings in public taxes needed to pay for them. As more loads are handled on efficient and reliable rail systems, highway congestion will also be ameliorated. Consequences include increased transit times for trucks that remain on highways, fuels savings resulting from less idle time for trucks and cars, and emission savings.

Other Benefits – It can be argued that industries served by safe, reliable, and efficient transportation systems enjoy a competitive advantage. If transportation system deficiencies ultimately raise transportation costs, then finding solutions to these deficiencies will lower

[5] According to the AAR, one locomotive can move one ton of freight almost 300 miles on one gallon of diesel fuel, while a truck move a ton only about 100 miles per gallon. The AAR further claims that if 10 percent of freight moving by highway were diverted to rail, the nation could save 200 million gallons of fuel annually. See the AAR Website at www.aar.org.

[6] According to the AAR, railroad locomotives emit one-tenth the hydrocarbons and particulate matter for every billion ton-miles of transportation, and one-third the nitrogen oxide and carbon monoxide, as compared to trucks. The AAR quotes the American Society of Mechanical Engineers as predicting that 2.5 million fewer tons of carbon dioxide would be emitted to the air annually, given a 10 percent diversion of intercity truck borne freight to rail. See the AAR Website at www.aar.org.

transportation costs. Lower costs can lead to lower prices for goods sold, making them more attractive in the marketplace. Industries reaping the benefits of transportation system improvements, therefore, may be well-positioned to experience growth in revenues. As businesses grow, employment likely will follow. Service industries, catering to the needs of producers, will find new opportunities. Also, new industries will be drawn to areas served by efficient transportation systems so that they can benefit from lower transportation costs.

Justification for solutions to transportation system deficiencies may be found in that efficient transportation systems can be a fundamental factor setting the stage for a robust economy. According to figures frequently cited by the AAR, railroads account for nearly 40 percent of the ton-miles generated in the U.S. Ton-miles, in fact, is a means of quantifying freight activity by representing weight and distance. By this measure, railroads are a major component in the nation's transportation system. Improvements to the efficiency of the nation's rail system, accordingly, can yield lower national transportation system costs. These lower costs, in turn, can help keep U.S. industry competitive, and thereby contribute to national economic development.

Chapter 5
INTERMODAL FACILITIES ANALYSIS

In addition to the highways and rail lines comprising the WTTN system, the system also includes "intermodal facilities." Intermodalism is sometimes confused with *multimodalism* and, for purposes of the WTTN study, it is relevant to distinguish between the two terms. The definitions for these terms have evolved through the ISTEA era into TEA-21 and beyond, as follows:

> An intermodal transportation system is an operationally-based transportation network consisting of public and private infrastructure for moving people and goods **using combinations of transportation modes** for the same trip. Multimodalism refers to modal **choices in the same corridor**, essentially serving the same origin/destination pair. An intermodal transportation system connects these elements in a seamless manner that emphasizes the efficiency, safety, and environmental needs of passengers and freight.

This WTTN study chapter focuses on intermodal facilities where cargo is transferred between the modes. For example, goods are transferred between the modes at such facilities as:

- *Ports* – from rail or truck to water transportation, and vice versa, and between barges and ships;
- *Airports* – usually to/from truck from/to airplanes;
- *Grain Elevators* – usually from trucks to rail or water, sometimes from rail to water, sometimes from barge to ships;
- *TOFC/COFC* – usually from/to truck from/to rail, or at ports to/from rail from/to water transportation;
- *Other* – including reloads, timber and wood products loading from trucks to rail, or automobiles from/to truck to/from rail.

Excluded in this definition are truck-to-truck transfers, warehouses, etc.

SURFACE FREIGHT VOLUMES

In order to place intermodal traffic into perspective, total truck and railroad volumes in the western states were developed in WTTN-Phase I.

Commodity Types

As shown in Exhibit 5-1, the WTTN database reveals that almost 1.5 billion commodity tons moved to/from BEAs within the study area in 1994. Of the 1.5 billion tons, 670 million moved by rail and 810 million by truck.

The rail traffic is dominated by a single commodity -- coal. Almost half (44 percent) of the rail tonnage falls into this category. Although coal is not an "intermodal" commodity, because it typically is not exchanged between the modes, it has dramatic impacts on the capacity of the rail system within some of the WTTN corridors and is therefore relevant to the WTTN intermodal issue.

The next largest rail commodity, and based on the study definition, a true intermodal move, is farm products (unprocessed from the farm), or at least the grain component of that commodity group. The next is Food Products (processed foods) followed closely by Chemicals. Neither of these groupings is typically an intermodal move because each is produced at plants and typically loaded directly into trucks or rail cars. The fifth largest commodity tonnage, Miscellaneous Mixed Shipments, is intermodal because it is comprised of containers and piggyback truck trailers (TOFC/COFC). Thus, two of the five top rail commodities are largely intermodal traffic. The two together comprise about 15 percent of the rail tonnage, or about 7 percent of total truck and rail tonnage.

Commodities carried by truck are not dominated by single commodity groups. Lumber or Wood Products, Clay, Concrete, Food and Petroleum are major truck commodities (in terms of tonnage carried).

Exhibit 5-1
PRINCIPAL WTTN REGION FREIGHT TONNAGE BY COMMODITY [1]
1994

STCC	DESCRIPTION	TRUCK TONS	RAIL TONS	TOTAL
01	Farm Products	24,711,307	64,293,256	89,004,563
08	Forest Products	21,704	5,702	27,406
10	Metallic Ores	1,500,792	4,711,024	6,211,816
11	Coal	43,501,462	294,330,349	337,831,811
13	Crude Petroleum Or Natural Gas	4,547,826	2,168,321	6,716,147
14	Nonmetallic Minerals	23,535,193	23,686,846	47,222,039
19	Ordnance Or Accessories	40,067	100,944	141,011
20	Food Or Kindred Products	140,715,587	58,536,185	199,251,772
21	Tobacco Products	91,648	22,824	114,472
22	Textile Mill Products	700,549	182,488	883,037
23	Apparel Or Related Products	237,968	79,356	317,324
24	Lumber Or Wood Products	167,149,492	28,190,873	195,340,365
25	Furniture Or Fixtures	367,817	113,056	480,873
26	Pulp, Paper Or Allied Products	10,016,539	7,655,422	17,671,961
27	Printed Matter	926,720	138,705	1,065,425
28	Chemicals Or Allied Products	67,022,486	53,061,369	120,083,855
29	Petroleum Or Coal Products	125,420,371	35,496,830	160,917,201
30	Rubber Or Misc Plastics	3,154,621	963,402	4,118,023
31	Leather Or Leather Products	76,939	47,147	124,086
32	Clay, Concrete ,Glass Or Stone	162,313,793	35,164,777	197,478,570
33	Primary Metal Products	8,148,153	9,796,403	17,944,556
34	Fabricated Metal Products	3,083,704	685,940	3,769,644
35	Machinery	2,428,243	719,883	3,148,126
36	Electrical Equipment	1,520,412	466,264	1,986,676
37	Transportation Equipment	5,051,965	8,127,801	13,179,766
38	Instrum, Photo Equip, Optical Eq	381,707	89,484	471,191
39	Misc Manufacturing Products	606,331	196,662	802,993
40	Waste Or Scrap Materials	3,438,211	2,912,474	6,350,685
41	Misc Freight Shipments	168,288	175,585	343,873
42	Shipping Containers	134,412	698,757	833,169
43	Mail Or Contract Traffic	59,295	36,020	95,315
44	Freight Forwarder Traffic	13,205	121,611	134,816
45	Shipper Association Traffic	9,401	31,128	40,529
46	Misc Mixed Shipments[2]	9,360,581	37,581,896	46,942,477
47	Small Packaged Freight Shipments	3,247	2,643	5,890
	TOTAL [3]	810,460,036	670,591,427	1,481,051,463

(1) Cargo with an origin and/or a destination in the WTTN states.
(2) Principally containers and piggyback.
(3) This is total of the 3 top commodity groups for each study area state. Grand total of all tonnage is another 20 percent "

SOURCE: Reebie Associates

Commodity Movements

Seven commodity groupings comprise 90% of all tonnage moved by rail and truck in the WTTN states. The volumes, BEA zones of origin or destination in the West, and the modes (truck or rail) for these dominant commodities are shown on Exhibits 5-2 through 5-8. BEA zones are groupings of counties as developed by the U.S. Department of Commerce, Bureau of Economic Analysis.

COFC/TOFC Flows – Exhibit 5-2 shows the container volumes moved by rail and truck. A number of observations are made:

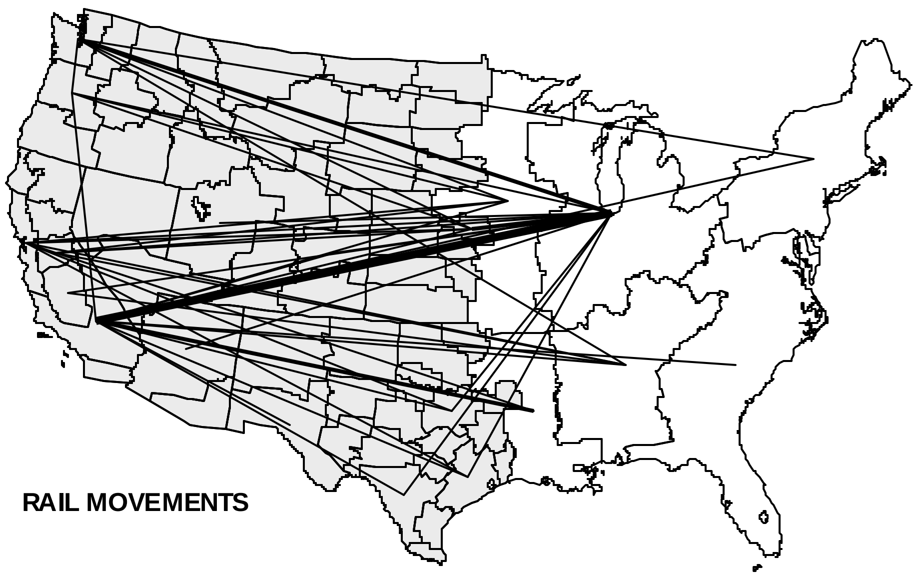
- The principal moves generally are east-west (rather than north-south);
- The principal moves are long distance;
- On the west end, they start (or end) at the major port city (and major population centers) BEAs – Los Angeles/Long Beach, San Francisco-Oakland, Seattle-Tacoma, Portland;
- This implies that much COFC/TOFC cargo is international in nature or at least indicates port use;
- The Chicago gateway to the east dominates;
- The truck moves tend to be in the same direction as the rail moves; and
- The north-south moves include Southern California-Pacific Northwest and between Texas and the Midwest.

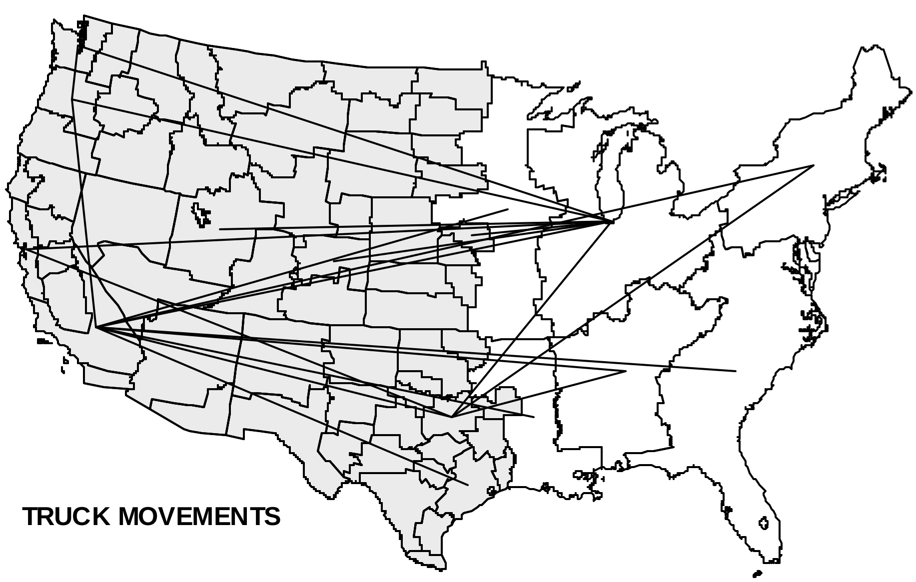
Virtually all COFC/TOFC traffic is "intermodal" in nature, at least using trucks at one end point, port on the other end, rail in between or, if hauled by truck, usually port on one end. In addition, some containers move by barge between the other modes. COFC/TOFC is therefore very relevant to the WTTN intermodal facilities issue.

Exhibit 5-2

MISCELLANEOUS MIXED SHIPMENTS (1994)

(Containers)





LEGEND

Commodity Movement Values in Tons

Not shown Less than 100K
100K to 1 Million
1 to 2 Million
2 to 5 Million
5 to 10 Million
More than 10 Million
Eastern Regions
WTTN BEA Zones

Farm Products Flows – Exhibit 5-3 presents the principal farm products flows by rail and truck. Farm products comprise wheat, barley, corn, and other crops, and exhibit very different movement patterns than do containers. For example.

- Both east-west and north-south movements by rail are notable;
- There are numerous grain origin/destination pairs; they are not dominated by only a few destinations;
- Considerable volumes are destined to Texas and Louisiana, implying Gulf Coast port use;
- There are major moves to the West Coast port cities; and
- Long distance truck farm products typically comprise perishables.

Because grains are typically collected by truck and carried over the roadway system to the grain elevator, then carried by rail or barge, then often passing through the West Coast and Gulf Coast ports, the Farm Products are also "intermodal" in nature.

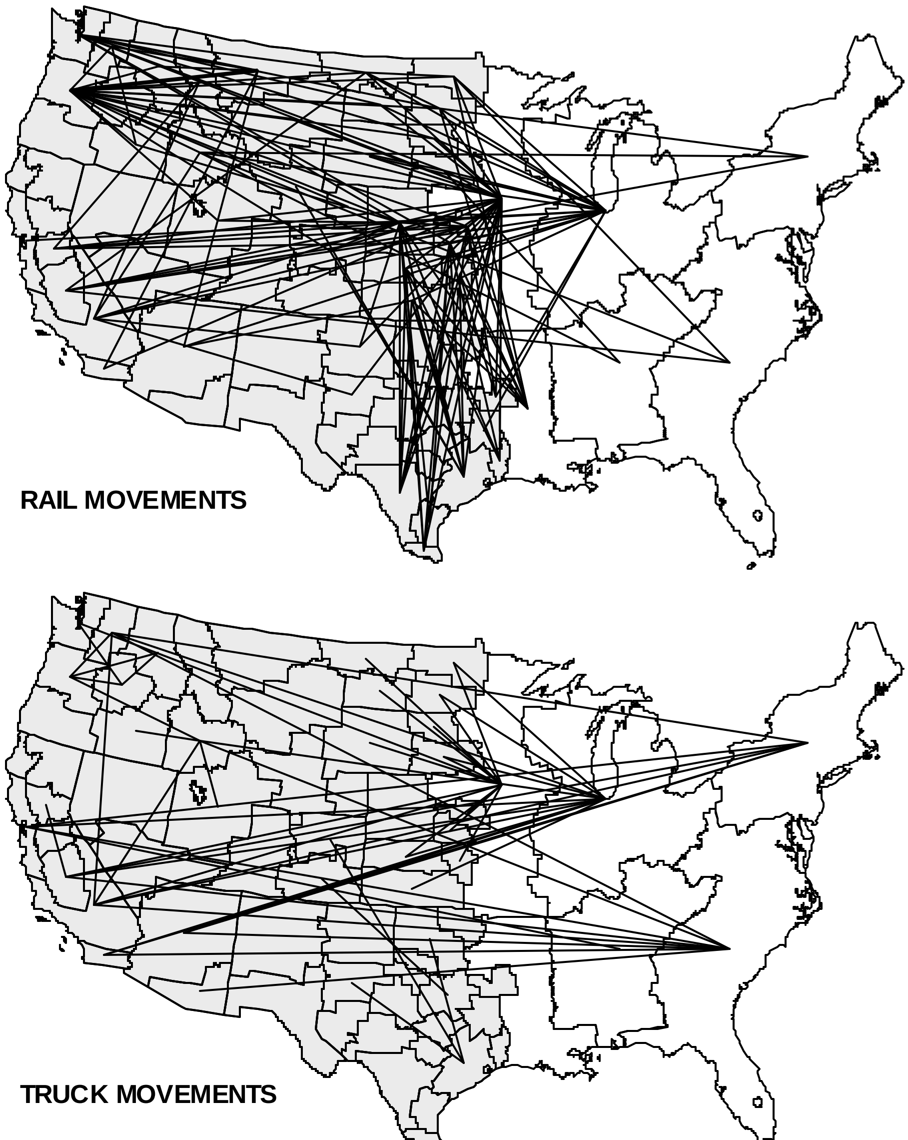
Coal Flows – Exhibit 5-4 presents the principal coal flows in the West. Observations include:

- There are few coal origins, with the Powder River Basin of Wyoming dominating;
- The coal movements tend to be concentrated on a few corridors, implying that the coal is routed over certain predominantly west-east rail main lines, all of which are included in the WTTN corridor designations;
- The coal destinations lie principally in the midwest and south central U.S.; and
- Very little coal moves by truck for long hauls.

Because western coal is typically loaded directly onto rail cars from off-road vehicles, conveyors, and mines, coal is not really an "intermodal" commodity, nor are coal mines intermodal facilities.

Exhibit 5-3

FARM PRODUCTS (1994)



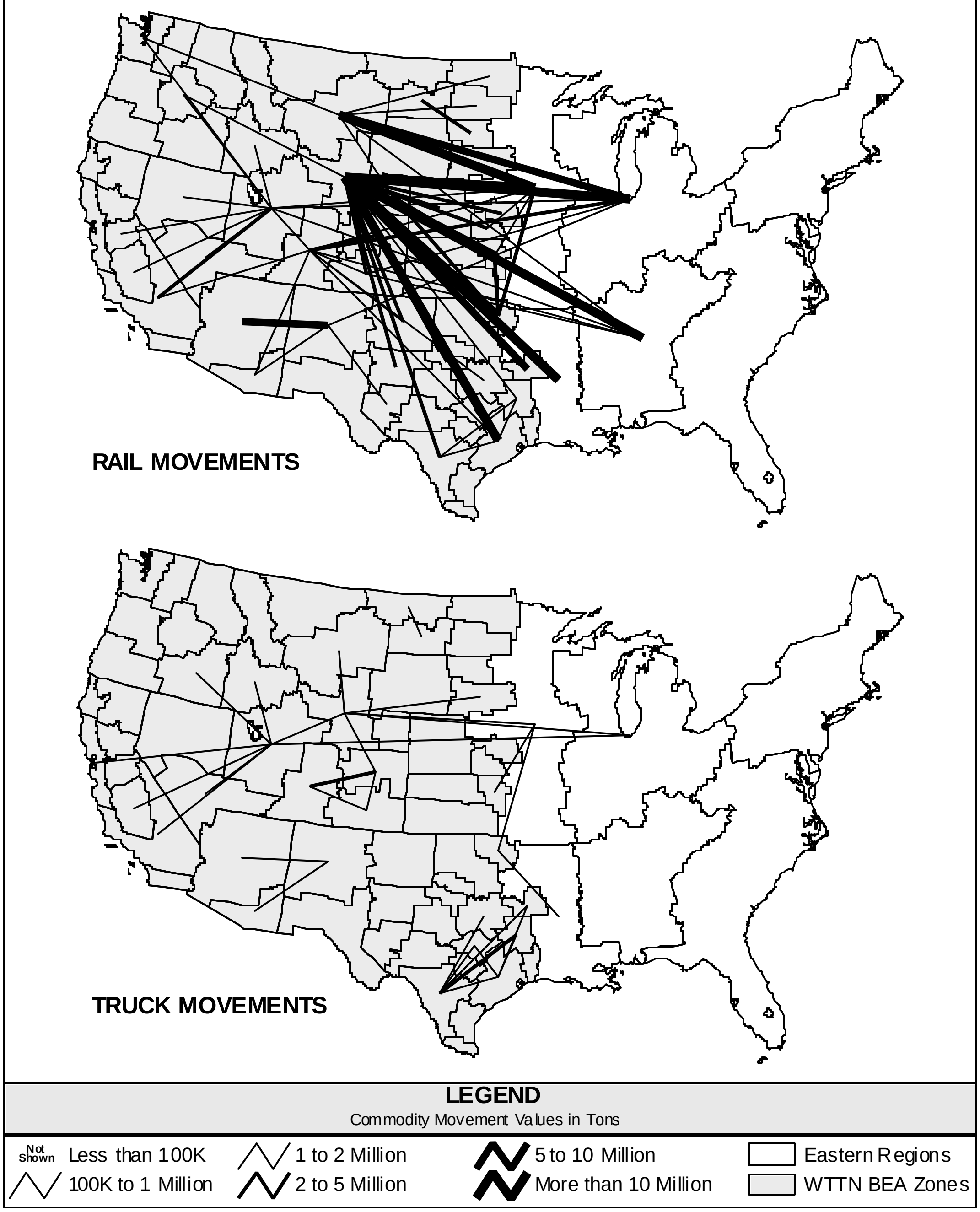
LEGEND

Commodity Movement Values in Tons

Not Shown: Less than 100K	1 to 2 Million	5 to 10 Million	Eastern Regions
100K to 1 Million	2 to 5 Million	More than 10 Million	WTTN BEA Zones

Exhibit 5-4

COAL (1994)



Lumber or Wood Products – Exhibit 5-5 presents the principal wood products movements. These movements indicate that:

- There are a few specific movement pairs, most notably the north-south move in the Pacific Northwest (the I-5 corridor);
- Trucks carry more lumber and wood products tonnage than does rail, although rail carries it further; and
- The I-5 truck moves are very dense, and the moves are also dense into the port BEAs on the West Coast.

Food and Kindred Products – These comprise principally processed foods, and the moves are shown on Exhibit 5-6. As shown:

- Commodity flows involve many origin/destination pairs, meaning that these moves occur on many different highways and rail lines;
- Trucks carry almost three times as much as does rail; and
- There is more movement all the way across the country than for many other commodities, especially by truck.

There is nearly always processing involved prior to the truck and rail moves for this commodity grouping. Therefore it is not treated as an intermodal commodity type.

Clay, Concrete, Glass and Stone – This is a major commodity group comprised of several different commodities, some of which, such as sand and gravel, are used in large quantities. As shown on Exhibit 5-7:

- These commodities often are carried very short distances;
- Those carried longer distances are usually specialty items; and
- Trucks carry nearly five times the volume of rail, generally due to the short distances and delivery to construction sites.

These are not treated as intermodal in the WTTN study, because the study is regional (multi-state) in nature.

Exhibit 5-5

LUMBER OR WOOD PRODUCTS (1994)

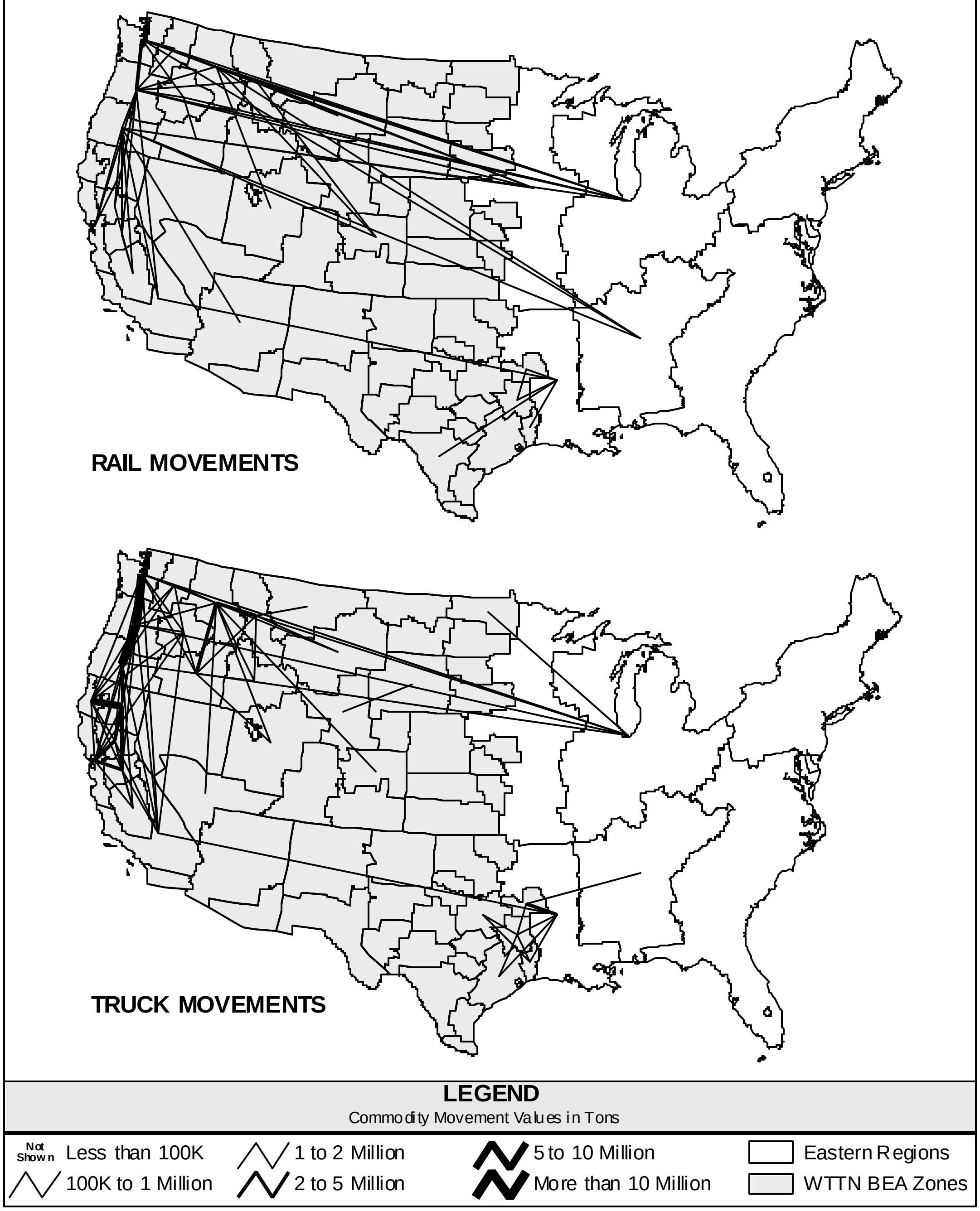
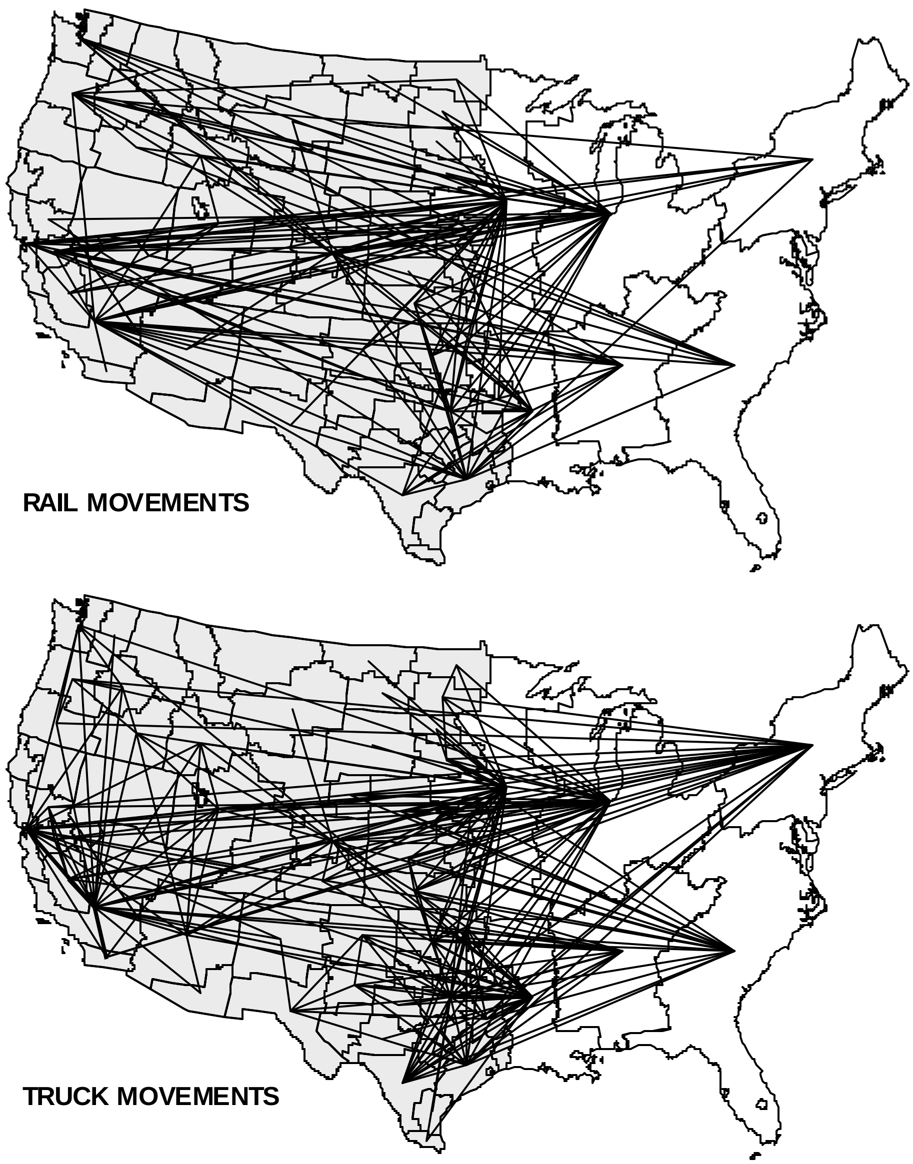


Exhibit 5-6

FOOD OR KINDRED PRODUCTS (1994)

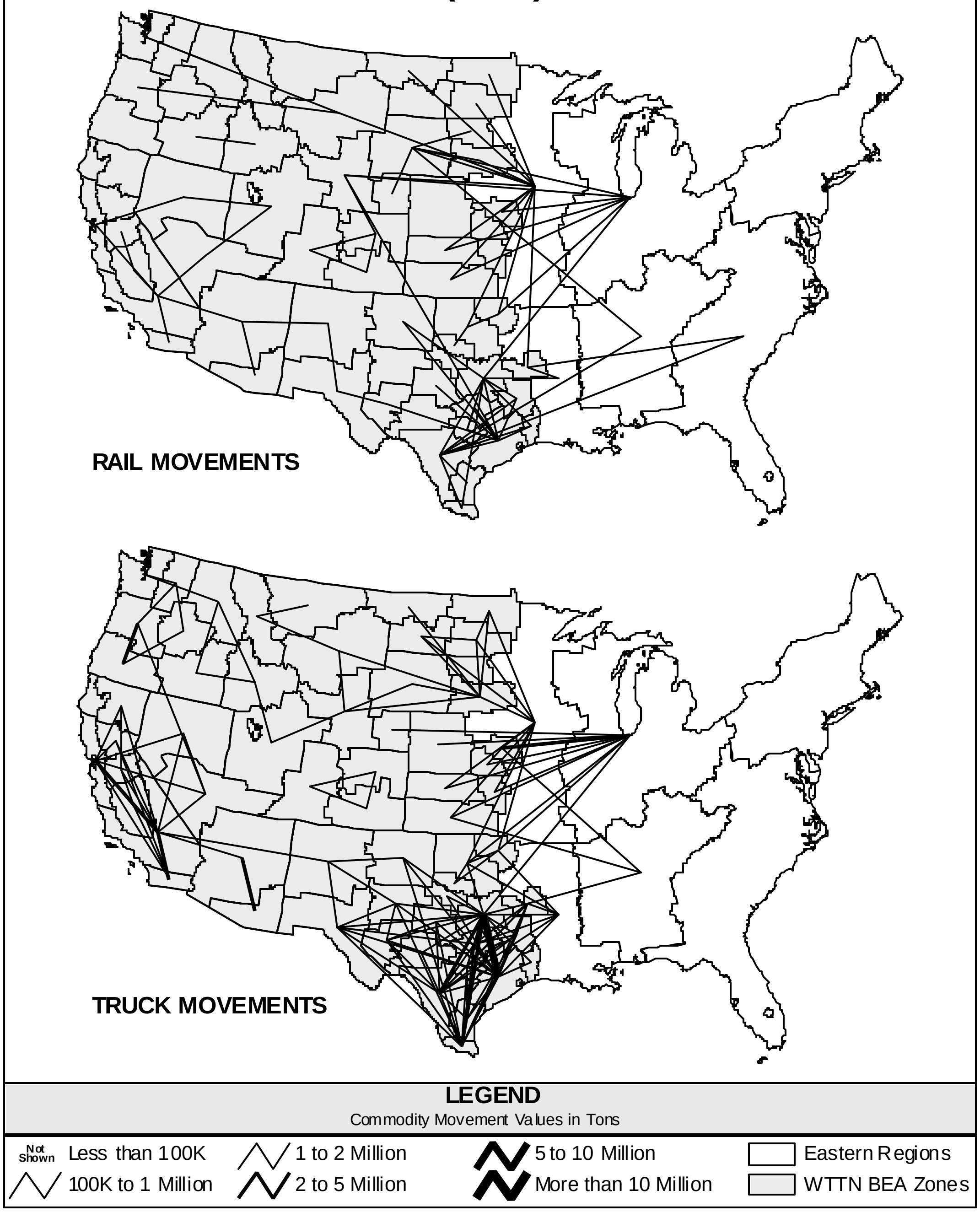


LEGEND

Commodity Movement Values in Tons

- Not shown: Less than 100K
- 100K to 1 Million
- 1 to 2 Million
- 2 to 5 Million
- 5 to 10 Million
- More than 10 Million
- Eastern Regions
- WTTN BEA Zones

Exhibit 5-7
CLAY, CONCRETE, GLASS OR STONE PRODUCTS (1994)



Chemicals and Allied Products – Chemical moves are shown on Exhibit 5-8. These moves are typically:

- From the chemical production centers of Texas, Louisiana and other states;
- Nationwide;
- Equally split between rail and truck.

Seldom are these true intermodal moves, since the chemicals are typically moved to/from large storage facilities on both ends of the journey, although considerable volumes move by barge (with truck or rail used at the endpoints).

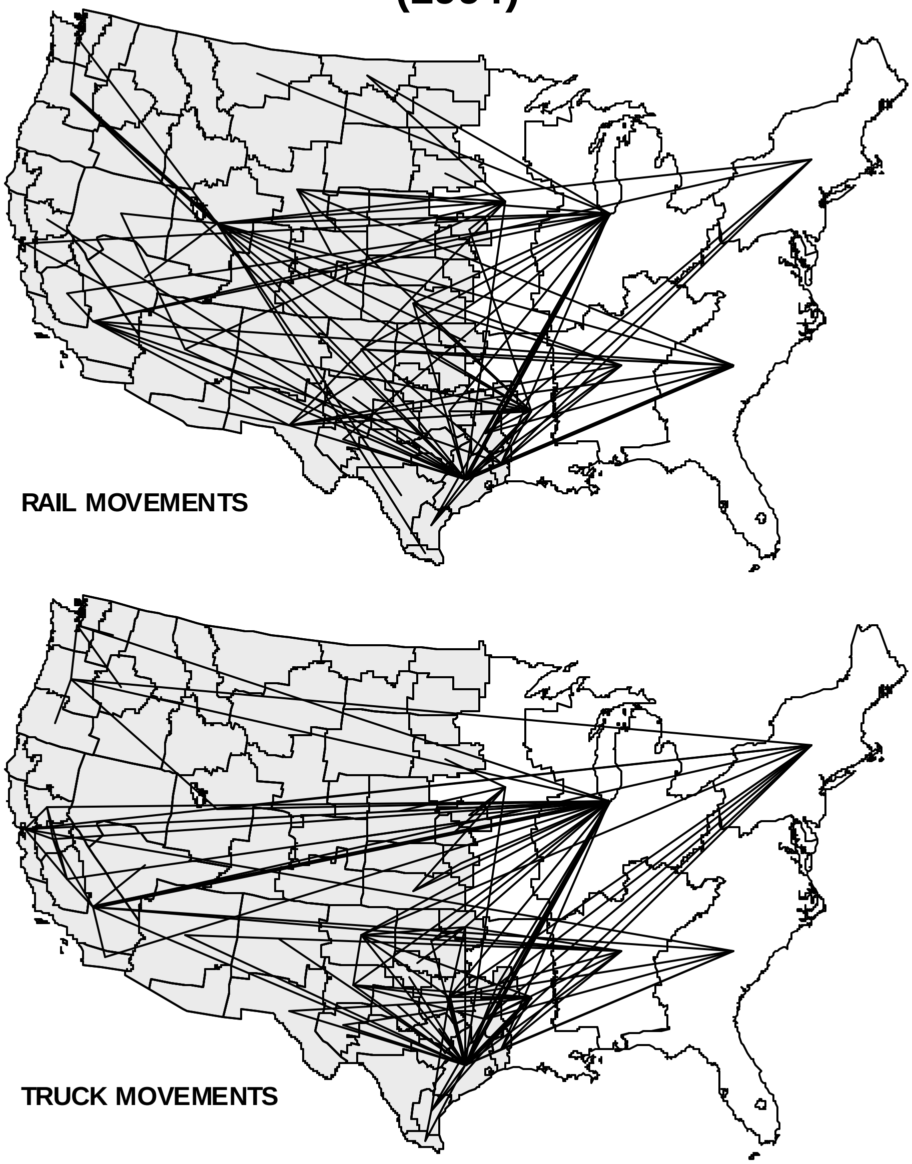
Petroleum or Coal Products – These moves are shown on Exhibit 5-9. This commodity grouping is processed fuels, by-products of processing, or derivatives. These flow maps suggest:

- Trucks are the dominant mode of carriage; and
- Flows are multi-directional, but there are still several principal origin-destination patterns.

Again, these are not true intermodal flows but rather start at a processing plant, ending at a warehouse or retailer, with less substantial intermodal exchange. There may be an intermodal component if movements also involve water or pipelines.

Exhibit 5-8

CHEMICALS OR ALLIED PRODUCTS (1994)



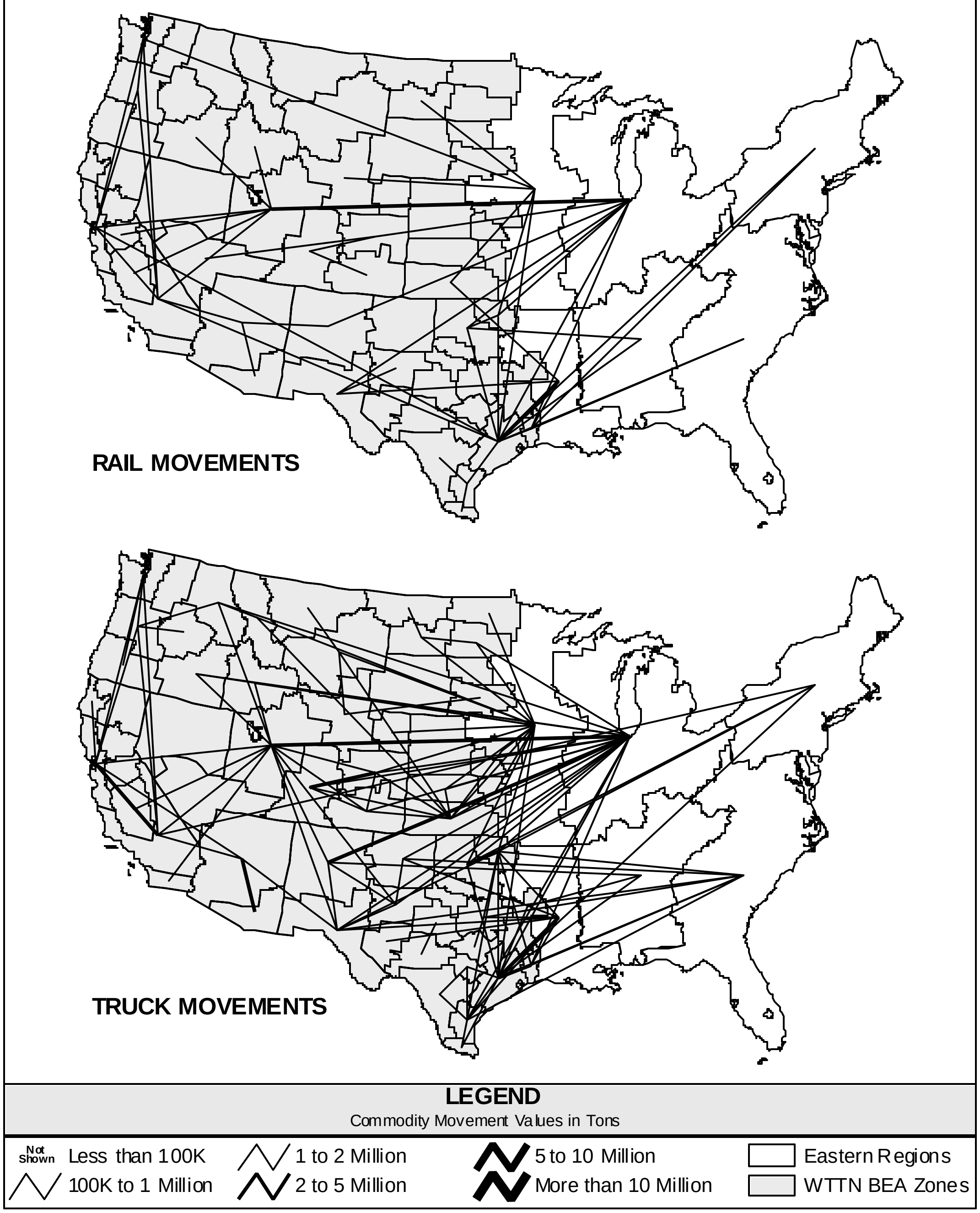
LEGEND

Commodity Movement Values in Tons

Not shown	Less than 100K
	100K to 1 Million
	1 to 2 Million
	2 to 5 Million
	5 to 10 Million
	More than 10 Million
	Eastern Regions
	WTTN BEA Zones

Exhibit 5-9

PETROLEUM OR COAL PRODUCTS (1994)



FEDERAL INTERMODAL CONNECTORS CONDITION AND INVESTMENT STUDY

TEA-21 directed that FHWA conduct a “freight connectors” study. FHWA developed a study scope and methodology and, working through each state, developed data relative to each intermodal connector to a major intermodal facility as defined by FHWA. The results of this federal study are not yet available.

The Federal Study

The federal work was intended to identify impediments for connector roads to major intermodal facilities in the U.S. Intermodal facilities were defined as “... facilities which provide for the transfer of freight or passengers from one mode to another.” [1] Major freight facilities were identified primarily on the basis of volume criteria such as number of tons, trucks, or containers.

Intermodal Facility Criteria – The FHWA study attempted to focus on those intermodal facilities which generated and attracted large volumes of traffic. For example, the freight criteria used to identify and select the intermodal facilities to be included were:

- *Airports* – 100 trucks per day in each direction, or 100,000 tons per year arriving or departing;
- *Ports* – 50,000 TEUs (a TEU is a twenty-foot long container, or equivalent) per year, or more than 100 trucks per day in each direction. For bulk ports, 500,000 tons per year or 100 trucks per day.
- *Truck/Rail* – 50,000 TEUs per year or 100 trucks per day in each direction.

Identified Intermodal Facilities – In applying these criteria, the western states identified the numbers of intermodal facilities to be in the FHWA study listed on Exhibit 5-10.

[1] “Guidelines and Criteria for Identifying National Highway System Connections to Major Intermodal Terminals,” FHWA, April 14, 1995.

Exhibit 5-10
U.S. DOT STUDY FREIGHT INTERMODAL FACILITIES IN THE WEST
April 24, 1998

	NUMBER OF FREIGHT INTERMODAL FACILITIES				
State	***Airports (1)***	**Ports**	**Rail**	**Pipeline**	**Total**
Alaska	7	7	0	1	15
Arizona	3	0	0	0	3
California	13	13	16	4	46
Colorado	5	0	5	4	14
Hawaii	5	7	0	0	12
Idaho	1	1	0	1	3
Kansas	1	0	2	1	4
Montana	1	0	0	0	1
Nebraska	1	0	2	1	4
Nevada	2	0	0	0	2
New Mexico	1	0	0	0	1
North Dakota	2	0	0	0	2
Oklahoma	2	0	1	1	4
Oregon	3	9	5	1	18
South Dakota	2	0	2	0	4
Texas	23	19	14	14	70
Utah	1	0	2	2	5
Washington	14	11	6	0	31
Wyoming	0	0	0	0	0
TOTAL	**87**	**67**	**55**	**30**	**239**

(1) Many airports may have been designated due to their passenger volumes

SOURCE: Intermodal Connectors Condition and Investment Study, FHWA.

Intermodal Connector Data – FHWA then asked each state to prepare inventory information pertaining to the connector road which connects the intermodal facility with the nearest NHS highway. The data which each state prepared relative to each intermodal connector included:

- *Geometric and Physical Features* – pavement condition, road width, shoulders, turning radii, vertical clearances, weight limitations, drainage issues, etc.;
- *At-Grade Railroad Crossings* – numbers, warning devices, sight distance, rough crossing surface, delays, etc.;

- *Traffic Operations and Safety* – congestion, traffic signals, turning issues, queues at gates, accidents, problems at junction with NHS highway, truck route signs, etc.; and
- *Past and Programmed Investments* – including improvements made or planned.

Relevance to WTTN Study

The Intermodal Connectors Conditions and Investment Study being conducted by FHWA and the states is relevant to the WTTN study because:

- It is interested in the need for better access to intermodal facilities in the West, including those in the WTTN states;
- It assessed the intermodal facilities that were identified prior to the study;
- The NHS and the WTTN highways are, in some instances, one and the same; and
- It is comprehensive across the states, and represents work that the WTTN study need not duplicate.

However, the federal study departs from the WTTN study in that the FHWA study:

- Includes only roadway connectors; and
- Includes only the very largest intermodal facilities (excluded many other facilities important to local economies).

As a result, the FHWA study is useful to the WTTN intermodal work.

INTERMODAL FACILITIES IN THE WESTERN U.S.

In WTTN Phase I a modest effort was made to identify intermodal facilities that might be relevant to the WTTN issues. In Phase II, the effort was continued, in greater depth.

Intermodal Facilities Criteria and Process

General guidelines were developed which were used by the states to identify their intermodal facilities. These included:

- The WTTN intermodal facilities refer to freight and commodity facilities only; passengers and passenger facilities are not part of the WTTN study.
- Cargo Ports – The WTTN facilities include only public use ports (not private terminals) and public port authorities (that include either public or private terminals).
- Airports – Although cargo volumes are generally quite low relative to the other modes, the value of the cargo handled is quite high. Therefore the major airports are included in the study.
- Rail Intermodal Facilities – The study includes COFC/TOFC, grain elevator, reload, bulk transfer and other facilities that bring cargo in or out by water or truck (and are therefore intermodal). For purposes of the WTTN study, the selected grain elevators are large and capable of handling unit trains, or with high storage capacity or a high number of railcars shipped annually.
- The study excludes facilities that are truck-to-truck only. These are not "intermodal."
- The study excludes facilities that involve significant processing or manufacturing, such as: a beer brewery, gasohol plant, timber yard or mill where logs are received and cut into lumber, corn sweetener plants, etc. These are processing facilities, not intermodal transportation facilities.
- The study excludes study facilities located at a source when the incoming cargo is not handled by over-the-road trucks. For example, the study excludes coal or ore loading facilities at the mine where off-road vehicles or conveyors are used to carry the material to the rail or truck or barge loading facilities.
- The study excludes liquid bulk centers wherein one mode is pipeline, since pipelines are not part of the WTTN study.

Due to the diverse economic composition and character of each state, it was decided essentially that each state, within the general guidelines, would identify the facilities that it wanted included in the study. Each state was requested to:

1. List intermodal facilities that it would like to include in the WTTN study;
2. Provide a rationale for including each facility; and
3. Provide information regarding the identified intermodal facilities.

Number and Type of Intermodal Facilities in the West

Exhibit 5-11 lists the number and type of intermodal facilities designated in this study. The general locations of these identified intermodal facilities are shown on the map on Exhibit 5-12. The precise numbers shown on the map may differ from those on the table, due to the need to simplify the map.

Exhibit 5-11
NUMBER OF INTERMODAL FACILITIES [e]
WTTN – 1999

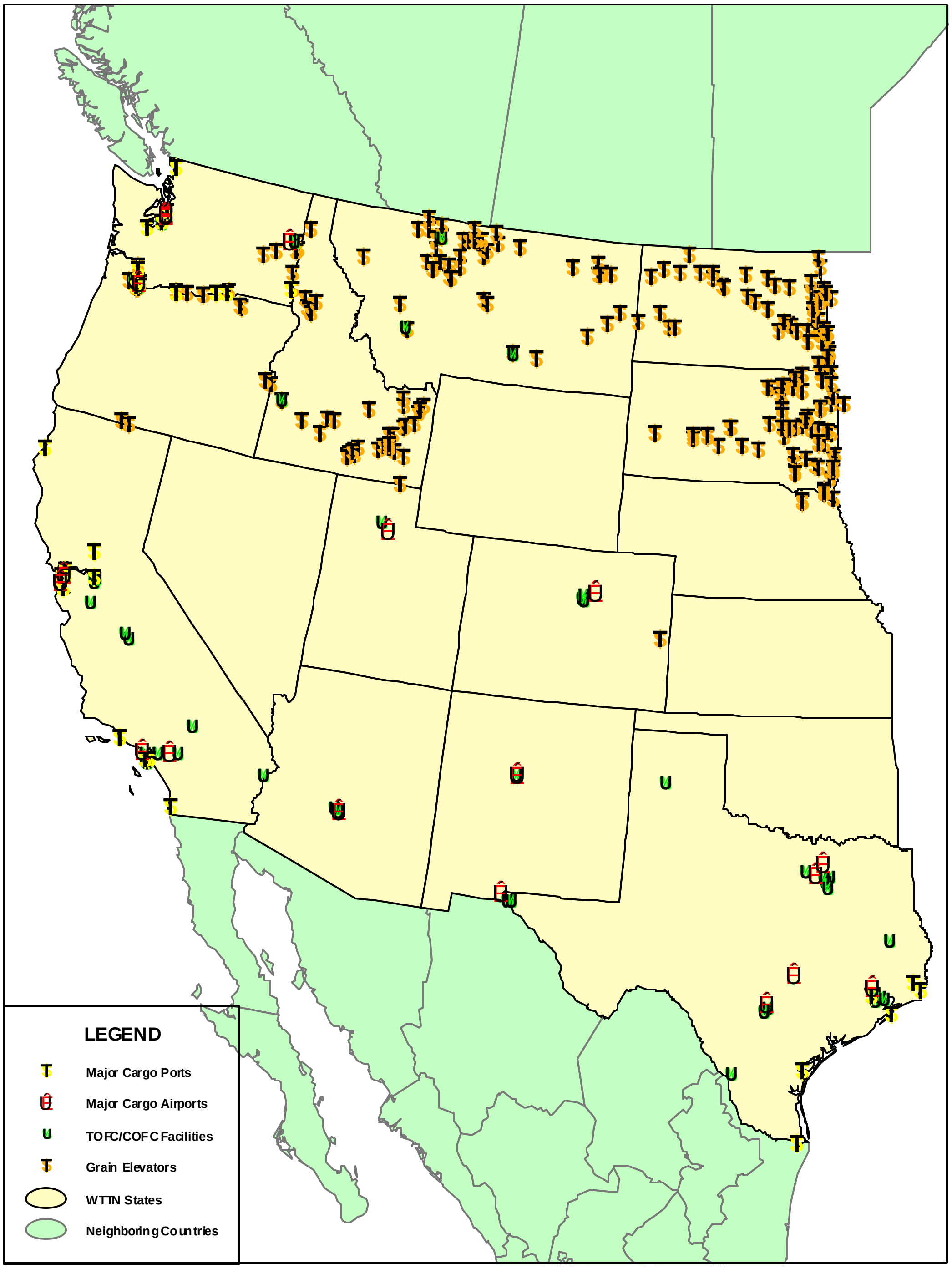
STATE	Air Ports	Grain Elevators	Railroad Intermodal	Water Ports	Other	Total
Arizona	1	0	2	0	0	3
California	4	0	16	11	0	31
Colorado	1	1	2	0	1[b]	5
Idaho	0	40	1	1	0	42
Montana	0	43	3	0	2[c]	48
New Mexico	2[a]	0	2[a]	0	0	4
North Dakota	0	54	0	0	0	54
Oregon	1	21	3	4	0	29
South Dakota	0	67	0	0	0	67
Texas	5	0	16	6	0	27
Utah	1	0	1	0	1[d]	3
Washington	3	8	4	6	1[b]	22
Wyoming	0	0	0	0	0	0
Total	**18**	**234**	**50**	**28**	**5**	**335**

SOURCE: Individual participating states.

a. One proposed.
b. Auto terminal on railroad.
c. Lumber and forest products.
d. Coal loading.
e. This exhibit only depicts the number of intermodal facilities designated for inclusion in the WTTN study. Some states chose not to include certain facility types (California and Texas chose not to include grain elevators). Other states (Nebraska, Kansas, New Mexico, Nevada) did not participate. Therefore, this exhibit is not an accurate estimate of intermodal facilities; it only identifies those selected for inclusion in the WTTN Phase II Study.

Exhibit 5-12

INTERMODAL FACILITIES IN THE WESTERN UNITED STATES



Designation Inconsistencies Among the States - While general criteria were used in identifying the intermodal facilities, the actual designations were developed by the individual states. As a result, there are two types of inconsistencies:

- Some states chose to designate some things (grain elevators, for example) and other states did not. As a result, for example, California and Colorado chose to not designate any (or many) grain elevators. This does not imply that no grain elevators exist; rather, only that the specific state chose not to include them.
- Four western states (Nevada, Nebraska, Oklahoma and Kansas) did not participate in WTTN-Phase II. Therefore, intermodal facilities for those states are not shown in the data and on the maps, although a few of the most obvious intermodal facilities are added (they are not all-inclusive for the non-participating states). Lack of an intermodal facility designation in these four states means nothing other than non-participation in the WTTN study.

AIRPORTS AS INTERMODAL FACILITIES

The West's airports, especially the large airports, are important cargo transport centers which are truly intermodal in nature, principally transferring cargo to/from airplanes from/to trucks. Cargo access into airports includes both truck access and airplane access; however, this WTTN study addresses only surface truck access as an intermodal issue.

Air Cargo Trends and Forecasts

One of the great growth industries of the last 20 years in the western U.S. (and elsewhere) is air cargo. Most of the western states' economies are now tied, directly or indirectly, to using the airplane and airport as a key form of freight transportation for highly valued commodities. And, national and international forecasts indicate that dependence on air cargo will increase in the future, possibly at an accelerating rate.

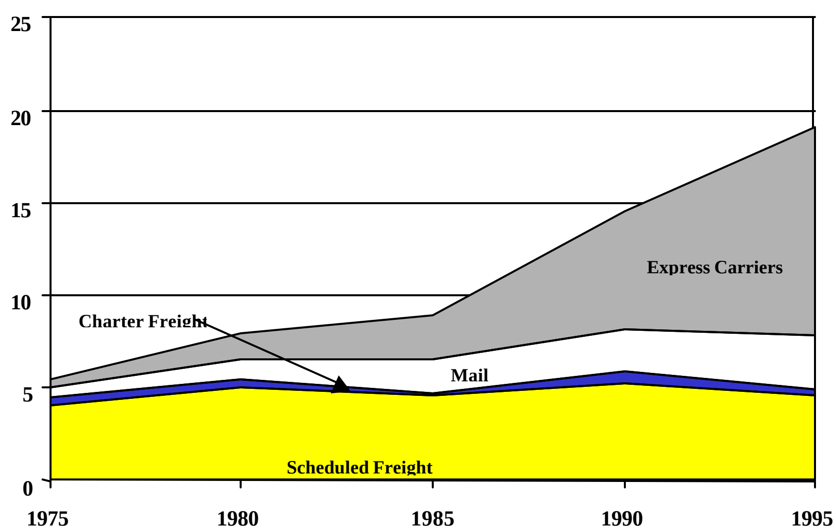
Air Cargo Types – There are three types of air cargo that are relevant to this WTTN study:

- *Air Freight* – Typically carried airport-to-airport by one company (airline), either as scheduled or charter service, in sometimes large shipments. This form of cargo in the western states (and worldwide) is stable, it is not growing.
- *Air Mail* – Carried for the national postal services, air mail is increasing at mild rates of growth.
- *Express Cargo* – Cargo (mainly small overnight parcels) carried by the integrated carriers (Federal Express, UPS, DHL, TNT/GD, others). This cargo form is escalating rapidly in use, and is forecast to keep growing in the western U.S. and worldwide.

Domestic Air Cargo – As shown on Exhibit 5-13, domestic U.S. air cargo has grown dramatically over the past 20 years. This exhibit suggests that:

- The growth in air cargo use is fueled almost entirely by the integrated express carriers (Federal Express, DHL, UPS, etc.);
- Air mail is growing but, as a share of the total, is declining; and
- Scheduled and charter conventional air freight is somewhat stable.

Exhibit 5-13
U.S. DOMESTIC AIR CARGO TRENDS
Revenue Tons Kilometers (billions)

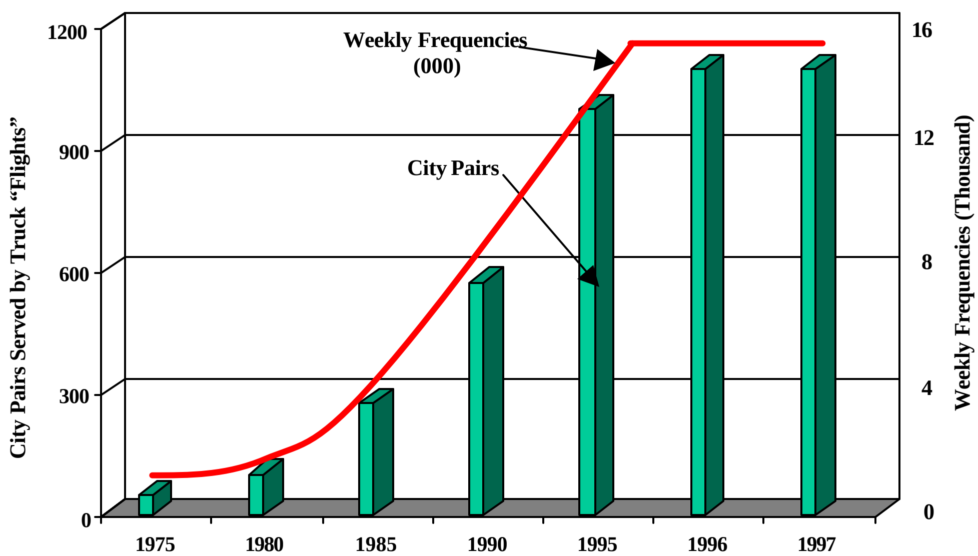


SOURCE: Boeing Commercial Airplane Group

U.S. domestic air express has been growing by 10% annually, a rate which might not be sustained as the market matures. If this is the case, the need to provide additional intermodal truck access capacity at the West's airports would appear to be chiefly for the integrated carriers – which are growing.

Truck to Truck "Flights" – A rather new form of "air cargo" is to use an integrated carrier who, for efficiency reasons, is able to carry some portions of the "air cargo" entirely by truck instead of by aircraft. As shown by Exhibit 5-14, this national trend increased dramatically in 1985-1995, but has since stabilized.

Exhibit 5-14
TRUCK TO TRUCK AIR CARGO TRENDS



SOURCE: Boeing Commercial Airplane Group

This type of carriage is generally less popular in most western states than in the East because of the vast distances involved between most western markets (great distances imply air must be used).

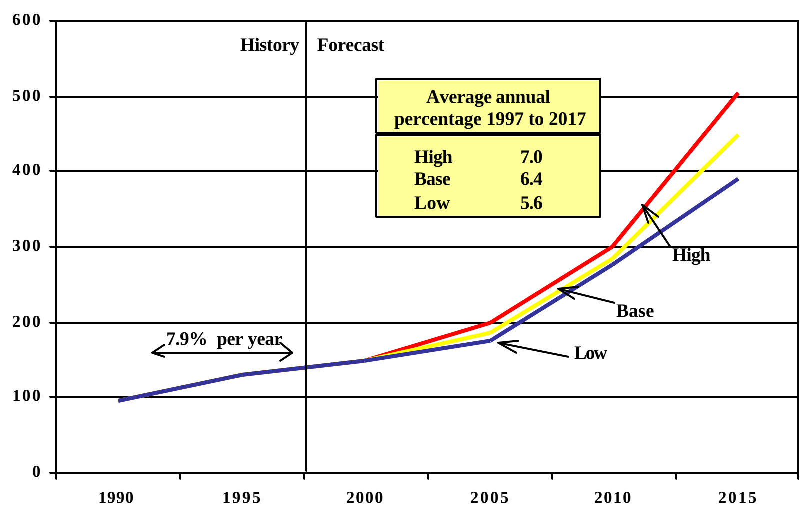
The implication of this truck carriage is that the need to carry the goods to/near the airports to sort (some interchanges to airplanes, some interchanges to other trucks) increases truck access needs to/from airports beyond simply the air cargo demands.

North American Air Cargo Forecast – Air cargo within Mexico-U.S.-Canada has been increasing by 5.6% per year. Available forecasts suggest:

- 5% per year growth through 2020;
- Transborder growth will be higher, at 7.7%;and
- Most of the growth will be express cargo.

International Air Cargo – Worldwide, air cargo is forecast to increase faster than North American air cargo. This means that international cargo through the West's airports will likely continue and could accelerate. Exhibit 5-15 indicates that air cargo worldwide could more than triple in the next 20 years.

Exhibit 5-15
WORLD AIR CARGO FORECAST
RTKs (billions)

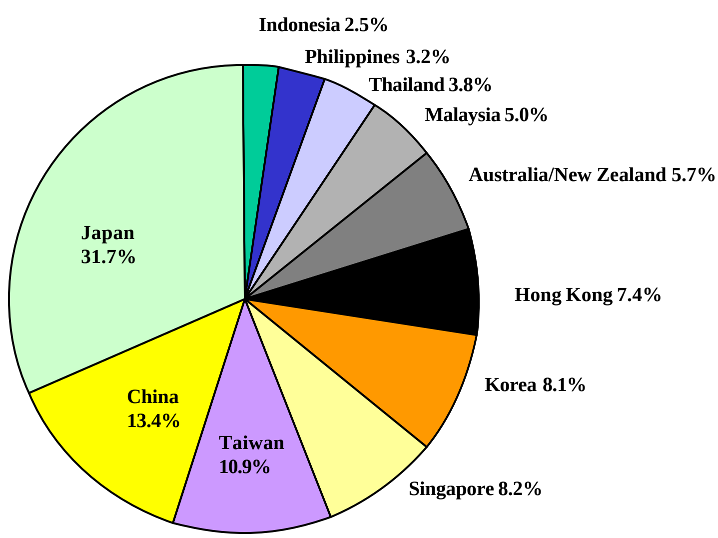


SOURCE: Boeing Commercial Airplane Group

The West's airports have traditionally served as the U.S. gateways to Asia. This should continue, although today's longer range aircraft now allow Chicago, Atlanta and even New York to now offer direct flights to Asia. This could possibly erode the West's airport tonnage statistics.

Expected to lead the way in terms of international air cargo growth will be the Asian economies (despite the recent economic downturns); the transpacific market in 1997 grew by 12.3% in 1997, and then evaporated in 1998. The current Asian market shares for U.S. air cargo are shown on Exhibit 5-16. Japan is the major Asian trading partner and, with economic recovery, should retain its position in the near tern. The China market will eventually be huge, and the others of Asia should recover as their economies recover.

Exhibit 5-16
ASIAN - USA AIR CARGO SHARES

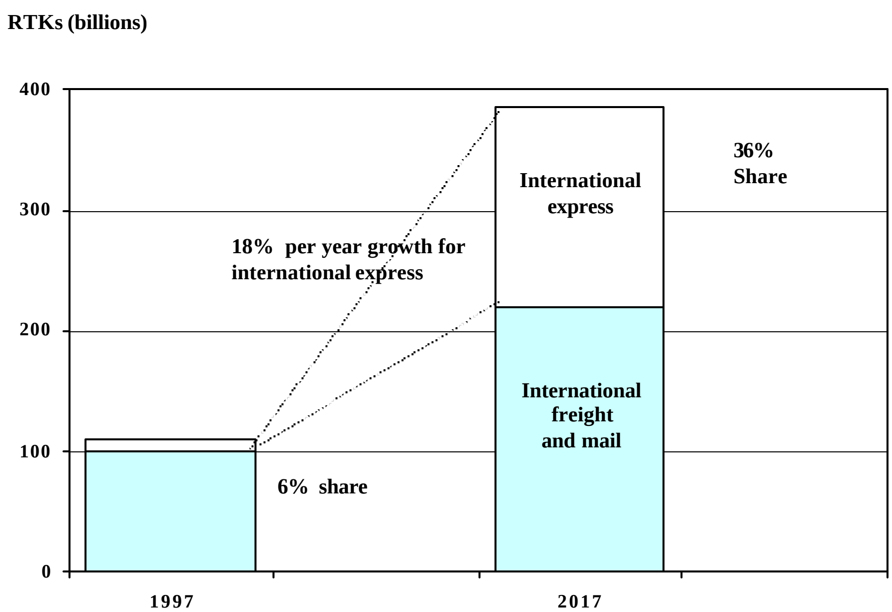


2.2 Million Tons

SOURCE: Boeing Commercial Airplane Group

International Express Forecasts – The U.S. has led the world in moving toward the use of the integrated carriers to carry express packages – but the world is expected to quickly catch up. Exhibit 5-17 shows that express has only 6% of the international air cargo traffic market, but is expected to have a 36% share by the year 2017. Also shown, total international cargo will increase dramatically. This is most encouraging, and indicates that states and airports desiring to be a part of this growth will need to invest in airports, air cargo facilities, and airport access.

Exhibit 5-17
INTERNATIONAL AIR CARGO FORECASTS



SOURCE: Boeing Commercial Airplane Group

Near Term Air Cargo Outlook

These statistics present an enthusiastic picture of air cargo growth – in the long term. The immediate term, however, is not nearly so optimistic.

Asian Economic Crisis – Beginning in 1997 and continuing into 1999, the Asian economies have suffered due to financial and other problems. Recessions have occurred in Japan and Korea, currency devaluations in Thailand, and political instability in Indonesia. Statistics indicate that international trade, and especially air cargo, closely follow the health of the national economies. When the economies flounder, air cargo flounders.

Implications for the West's Airports – The year 1998 was not a good one for the West's major airports. Rather than experience air cargo growth, airports were pleased to "hold their own." The Asian downturn is part of the reason, the other part includes the new "open skies" policies and the longer range aircraft so that Asia can now be served by Chicago, Atlanta, and elsewhere.

In 1998 the most noticeable adverse air cargo trends occurred in U.S. exports to Asia carried by air through the West's airports. U.S. air cargo exports to Southeast Asia plunged by over 20% in 1998, down from 25% growth in 1997. Example results:

- Denver International Airport has not been able to attract significant Asian air cargo business;
- Portland International Airport experienced losses in Asian air cargo, and air cargo carriers cancelled some flights to Asia;
- Sea Tac, on the other hand, witnessed Asian air cargo growth in 1998; and
- Directional imbalances (reduced exports to Asia) increased.

While international traffic stalled in 1998, domestic traffic continued to increase – especially by the integrated express haulers.

NAFTA Impact on Air Cargo – Of total North American international cross border air cargo involving the U.S., three-quarters is with Canada, one-quarter with Mexico, combined totaling 540,000 tons. Air cargo trade between the U.S. and Canada/Mexico increased by 18% between 1996 and 1997, but is now expected to more closely follow economic growth in the three countries.

The West's Cargo Airports

Air cargo utilizing the West's airports has been increasing even faster than has air cargo in the U.S. as a whole. This is due to both the economic growth rates in the West, and the historical growth for the Asian economies.

Air Cargo Growth by State – Exhibit 5-18 presents air cargo tonnage by state.

Exhibit 5-18
AIR CARGO TRENDS BY STATE

State	Metric Tons [1] 1990	Metric Tons [1] 1997	Percent Change
Arizona	131,500	350,100	166.2%
California	2,377,700	4,101,600	72.5%
Colorado	283,200	459,900	62.4%
Idaho	13,400	32,700	144.0%
Kansas	18,800	38,000	102.1%
Nebraska	50,300	99,300	97.4%
Nevada	30,300	71,300	135.3%
New Mexico	35,500	80,700	127.3%
North Dakota	1,900	2,000	5.3%
Oklahoma	33,300	50,100	50.5%
Oregon	141,500	284,200	100.8%
South Dakota	7,100	30,100	323.9%
Texas	840,400	1,349,900	60.6%
Utah	115,700	253,200	118.8%
Washington	245,100	393,800	60.7%
Wyoming	400	7,300	1725.0%
Total	**4,326,100**	**7,604,200**	**75.8%**

(1) Airports listed on Exhibit 5-19.

SOURCE: Airports Council International.

As shown on Exhibit 5-18:

- California and Texas, with their huge airports and economies, dominate the West's air cargo tonnage;
- Total air cargo in the West increased by 75.8% 1990-1997, a very impressive growth rate;
- Air cargo growth occurred in every western state; and
- Nine states witnessed growth rates of in excess of 100%.

Air Cargo by Airport – Exhibit 5-19 lists 34 western airports and their cargo tonnages. Interestingly, every listed airport is experiencing air cargo growth. Over half experienced more than a doubling of air cargo tonnage from 1990 to 1997.

Principal Air Cargo Airports – As part of the WTTN study, the state DOTs identified 18 airports as the principal airports with which ground access for cargo may be an issue. These are shown in bold on Exhibit 5-19. For each, the Federal Intermodal Connector Conditions and Investment Study identifier code is also shown. These 18 airports handle over 90% of the West's total air cargo.

All WTTN principal cargo airports are shown in Exhibit 5-20.

Airport Access Issues

Access into airports is overwhelmingly a highway/roadway issue, and is viewed by most people as an automobile access issue (congestion, queuing, parking, signage, rental cars, etc.). But since air cargo has increased so much in recent years, and as many more pickup and delivery trucks are added to the airport access problem, the issue of truck access to the airports has been increasing in importance at many of the West's airports. In fact, many of the West's airports have grown to the point where they could now be viewed as industrial sites, with huge numbers of trucks of all sizes coming and going.

Exhibit 5-19
AIR CARGO BY WEST'S MAJOR CARGO AIRPORTS

State	Associated City	Metic Tons 1990	Metic Tons 1997	Percent Change	Federal Intermodal Connector [1]
Arizona					
	* **Phoenix**	114,200	314,900	175.7%	AZ1A 1
	Tucson	17,300	35,200	103.5%	
California					
	Long Beach	18,200	31,500	73.1%	
	* **Los Angeles**	1,164,900	1,872,900	60.8%	
	* **Oakland**	212,700	678,100	218.8%	
	* **Ontario**	247,300	418,800	69.3%	
	Sacramento	29,500	76,000	157.6%	
	San Diego	52,800	112,900	113.8%	
	* **San Francisco**	567,200	780,000	37.5%	
	San Jose	83,200	111,300	33.8%	
	Santa Ana	1,900	20,100	957.9%	
Colorado					
	Colorado Springs	3,100	22,700	632.3%	
	* **Denver**	280,100	437,200	56.1%	CO22A 1
Idaho					
	Boise	13,400	32,700	144.0%	
Kansas					
	Wichita	18,800	38,000	102.1%	
Nebraska					
	Omaha	50,300	99,300	97.4%	
Nevada					
	Las Vegas	30,300	71,300	135.3%	
	Reno	15,800	40,000	153.2%	
New Mexico					
	* **Albuquerque**	35,500	80,700	127.3%	NM1A 1
	* **Santa Teresa** [2]				No
North Dakota					
	Fargo	1,900	2,000	5.3%	
Oklahoma					
	Oklahoma City	33,300	50,100	50.5%	
Oregon					
	* **Portland**	141,500	284,200	100.8%	OR8A 1, 2, 3, 4
South Dakota					
	Sioux Falls	7,100	30,100	323.9%	
Texas					
	* **Austin**	35,500	91,000	156.3%	TX5A 1
	* **Alliance**	NA	NA	NA	
	* **Dallas-Ft. Worth**	556,700	810,700	45.6%	TX109A 1
	* **Houston Int**	223,000	328,300	47.2%	TX73A 1
	* **San Antonio**	25,200	119,900	375.8%	TX33A 1
Utah					
	* **Salt Lake City**	115,700	253,200	118.8%	UT1A 1
Washington					
	* **Seattle-Tacoma**	245,100	393,800	60.7%	WA41A 1
	* **Boeing Field**	NA	NA	NA	No
	* **Spokane Int.**	NA	NA	NA	WA3A 1
Wyoming					
	Casper	400	7,300	1725.0%	

* Indicates principal cargo airport in WTTN study.
(1) Principal WTTN cargo airport listed as included in the Intermodal Connectors Conditions Investment Study, by FHWA, August 7, 1998.
(2) Proposed Airport.
NA: Data not available

Source: Airports Council International

Exhibit 5-20
MAJOR CARGO AIRPORTS

Changing Nature of Air Cargo – Air cargo is one of the most dynamically changing forms of freight transportation in the western states. This is exhibited by:

- *Emergence of "Integrated" Carriers* – Air cargo has evolved from principally air mail to larger palletized and then containerized airport-to-airport cargo and now to the emergence of the integrated carriers. These include Federal Express, United Parcel Service, TNT, DHL, and others. They are integrated in the sense that they pickup, carry, and deliver the package, generally on a time sensitive and overnight basis.
- *Growth of Air Cargo* – Air cargo, especially of the overnight-integrated type, is rapidly growing, as shown below.

Changing Nature of Truck Trips Into Airports – As the cargo types and volumes carried to/from airports has changed, so have the trucks. For example:

- *Pickup and Delivery Truck Growth* – The types of trucks serving airports has changed to the point where they are now overwhelmingly parcel type trucks, sometimes in great numbers, always on a very constrained time sensitive basis. Access road routings and congestion on the roadway approaches to the airports therefore are becoming more of a problem at some western airports.
- *Service and Catering Trucks* – Many of the trucks arriving/departing are not carrying air cargo but are instead service trucks, e.g., telephone repair, or trucks carrying vendor supplies to the terminal, e.g., food for restaurant, or catering trucks, or others. These trucks are not destined for the airport's cargo terminals but are instead intermingled with arriving passenger traffic.
- *Truck-to-Truck Transfers* – The integrated carriers site their terminals at the airports (either on airport property or in proximity to the airport). Yet much of the cargo that people think is going by overnight air is actually overnight truck. Therefore, there are increasing volumes of overnight-integrated parcels whose trucks go to/from the airports, but whose freight is simply transferred at the airport from one truck to another.

Airport Locations – As places to which cargo can be readily carried by truck, not all airports are ideally located. Some airports are essentially located in the city, surrounded by development and served by an existing surface street system through which trucks destined for the airport must meander. Phoenix Sky Harbor Airport, San Diego, and San Antonio International, for example, have complex street systems through which trucks must maneuver.

Other airports are at new, but distant, locations. Denver International Airport and Dallas Ft. Worth International Airport are examples wherein the access highways are well designed for both auto and truck access, with the key access issue being one of long distance from the city.

Multiplicity of Access Points and Multiple Cargo Facility Locations – The largest western airports have numerous cargo facility locations and numerous route options by which trucks can access the airports from the WTTN corridors. For example, Los Angeles International Airport has cargo facilities spread over much of the airport, and also has more than a dozen surface street options for truck drivers to chose from in accessing the airport from the nearest WTTN corridor (I-5). This means that truck routing guides, truck route designations, etc., have limited potential at some of the West's airport.

Passenger Access Priority – In planning access into the airports, priority is typically given to passenger access since that is the perceived overwhelming need at most of the West's airports. Truck access is typically viewed as a secondary problem, and often one in which the desire is to route the trucks away from the passenger access.

Large Airports/Smaller Airports Access – The West's largest airports have very significant truck access needs and issues. These include, for example, Los Angeles and San Francisco International, Oakland, Portland, Ontario, Sea Tac, and others. The West's smaller airports have significantly less of a truck access issue. For example, Colorado Springs, Austin, Boise, Tucson, etc., have truck access issues only insofar as the trucks intermingle with car traffic and, at times, there is a measure of congestion.

Lack of Good, Designated Airport Connectors – In an ideal world, there would be good, high capacity designated roads capable of connecting each airport's cargo facilities with the NHS and/or WTTN corridors. Due to location, history, funding and other reasons, few of the West's airports have such access opportunities, especially for trucks. This is a problem that can only get worse, as airport use (passengers and cargo) continues to increase relative to roadway capacity.

Solutions and Benefits of Improved Cargo Access to Airports

The issue of cargo access to the West's airports is a trucking and roadway issue, as described above. The extent of the issue varies widely from airport to airport.

Menu of Solutions – Each airport has a master plan, and most of the master plans include access as one of the plan elements. Solution types, from the cargo/truck access perspective, include:

- Isolate cargo truck issues and access from passenger issues and access, by
  - Placing cargo facilities away from the passenger terminal;
  - Designating other (non-passenger terminal) roads as truck access roads;
  - Encouraging non-peak period access by trucks;
  - Managing existing capacity better or expanding capacity on roads leading to the airport's air cargo facilities
- Recognize truck characteristics in the roadway planning and roadway design process, including:
  - Heavy truck weights;
  - Truck turning radii;
  - Truck peaking characteristics; and
  - Queues at airport cargo gates.
- Improve truck routing to airports by
  - Planning of truck routes;
  - Recognizing and resolving land use conflicts; and
  - Incorporating proper truck route signage.
- Improve the ways that truck access is included in the airport and jurisdictional transportation planning process by
  - Explicitly addressing truck cargo access issues;
  - Recognizing that some trucks are cargo trucks, some are service (non-cargo) trucks. Both have airport access needs; and
  - Developing a truck access plan for each airport that is perceived to have truck access issues.

Potential Benefits – The benefits of resolving the truck access issues into the West's airports are many, and include not only the benefits to the air cargo community but also benefits to air passengers, the surrounding community, and even the local economy. For example:

- *Increasing Air Cargo* – The forecasts call for air cargo to triple in 20 years, due principally to express freight. Many airports therefore need to increase their cargo access capabilities. Also, some will take advantage by attracting new integrated cargo hubs. Ontario International Airport attracted UPS; other integrated carriers will be attracted to other airports – if the airports have the necessary capacity features needed.
- *On-Time Delivery* – If the overnight carriers are to meet their deadlines, no component in the transport link can be weak. Airport access must be good, for the freight industry to benefit.
- *Local Shippers/Receivers* – If deliveries are on time, local industry benefits through reliability.
- *Local Economy* – If local industry benefits, the local economy benefits due to increased production, jobs, tax base and value added.
- *Passengers* – If passenger access does not compete for space on the same access roads as trucks, the arriving/departing passengers benefit.

Clearly, the airports of the West need to be viewed as important intermodal facilities for cargo. They are not just passenger facilities.

GRAIN ELEVATORS AS INTERMODAL FACILITIES

The western states vary from state to state and sub-region to sub-region in terms of what is perceived to constitute an important intermodal facility and intermodal issue. Within that context, the intermodal facility type of the greatest importance to some states is the grain elevator, as reflected in those state designations of intermodal facilities. The economic well-being of vast portions of North Dakota and South Dakota, Montana, Idaho, and other states is dependent on agriculture (principally grains), and agriculture depends on the ability to efficiently move large quantities of grains (principally wheat) when and where needed. No where in the plains states is the tie between the economy, the product and the transportation system more pronounced than in the grain business.

Furthermore, the U.S. is the largest exporter of grains in the world. This fact means that the national economy, and the world's need for basic foodstuffs, have a significant stake in the U.S. grain transportation system.

Wheat as a Basis of Some States' Economy

Agriculture is very important to the Upper Great Plains region. Within that, wheat is one of the principal cash crops that can be exported to the rest of the U.S. and to the world. As such, it is a cash crop of immense importance.

Wheat Production – Exhibit 5-21 lists wheat production trends for two regions: the Northern Plains region and the Pacific Northwest region. Between the two regions, the Northern Plains out produces the Pacific Northwest by nearly a two to one ratio for the years 1993/94 to 1996/97. When comparing total production between these same years, both regions show only modest gains: 9% (Northern Plains), 5% (Pacific Northwest). These wheat trends have a number of WTTN implications:

- Production (harvest) is not increasing significantly. Therefore, transportation capacity enhancement may not be a significant issue;
- The issue has more to do with the retention of needed direct access rail service and, in some cases, barge access;
- The need for transportation to be increasingly efficient, to ensure the competitiveness of the West's grain in the global marketplace is a significant issue; and
- The need to be able to react to abrupt marketplace changes, by being able to ship to a diverse set of market destinations, is also important.

Exhibit 5-21
WHEAT PRODUCTION TRENDS BY REGION
Bushels (Millions)

	1993/94	1994/95	1995/96	1996/97	Perc. Chng. 93/94 - 96/97
Northern Plains (1)	660	628	595	717	9%
Pacific Northwest	353	293	318	369	5%

(1) See Exhibit 5-22 for the states in each region.
Source: USDA and Wilbur Smith Associates

Exhibit 5-22 lists wheat production by state. The West produces almost one billion bushels annually.

Exhibit 5-22
WHEAT PRODUCTION BY STATE
Bushels (Millions)

	1998	Percent of Total
Northern Plains		
Montana	169	17%
North Dakota	311	32%
South Dakota	121	12%
Wyoming	68	7%
Total	**669**	**68%**
Pacific Northwest		
Idaho	102	10%
Oregon	57	6%
Washington	157	16%
Total	**316**	**32%**
Total Wheat Production	**985**	**100%**

Source: USDA

Wheat Movements – The wheat of this production region is transported in bulk to distant markets throughout the U.S. and the world. These long distance hauls are handled principally by unit grain trains, the Mississippi River system, and the Columbia-Snake River system. Much of the wheat is exported, either through the major West Coast bulk ports such as Portland, or via New Orleans. The grain markets are very competitive, and movements are seasonal. The ability to move large volumes in limited time periods is the key to the success of the grain sale, and a key to the economic well being of the grain producing regions of the U.S.

The Grain Elevators

The grain elevators represent one link in the total grain distribution system which includes:

- Store on farm or at country elevator;
- Truck to elevators;
- Load into railcars or barges or trucks;
- Transport to port or processing plant; and
- Transfer to barge or ship.

The act of transporting grain therefore comprises:

- Trucking, from farm to elevator, over the collector system of roads which includes everything from gravel section line roads to Interstate Highways and other WTTN highways;

- Carriage by truck or rail, over the branch line collector system and/or the railroad main line system; and

- Carriage by barge or ship, especially to export markets.

At intermediate points are the intermodal and non-intermodal grain elevators. Seven of the participating WTTN states felt that grain elevators are so important as intermodal facilities as to include them in this study (several other states that have grain elevators chose to not include them in the WTTN study).

Elevators Included – The map on Exhibit 5-23 together with the listing on Exhibit 5-24, identify the 234 grain elevators identified by the participating states as key relevant intermodal facilities. The states identified only those elevators that are large operations which are mainstays to the regional economy. The identified elevators generally met the following criteria:

- On roads and a rail line or navigable waterway; and

- Handle at least 500 rail carloads per year, or equivalent; or

- Capable of handling unit trains, with most able to handle 50-car trains or more, although a few handle 25-car unit trains; or

- Handle at least 500,000 bushels of grain.

Exhibit 5-23
WTTN INTERMODAL GRAIN ELEVATORS

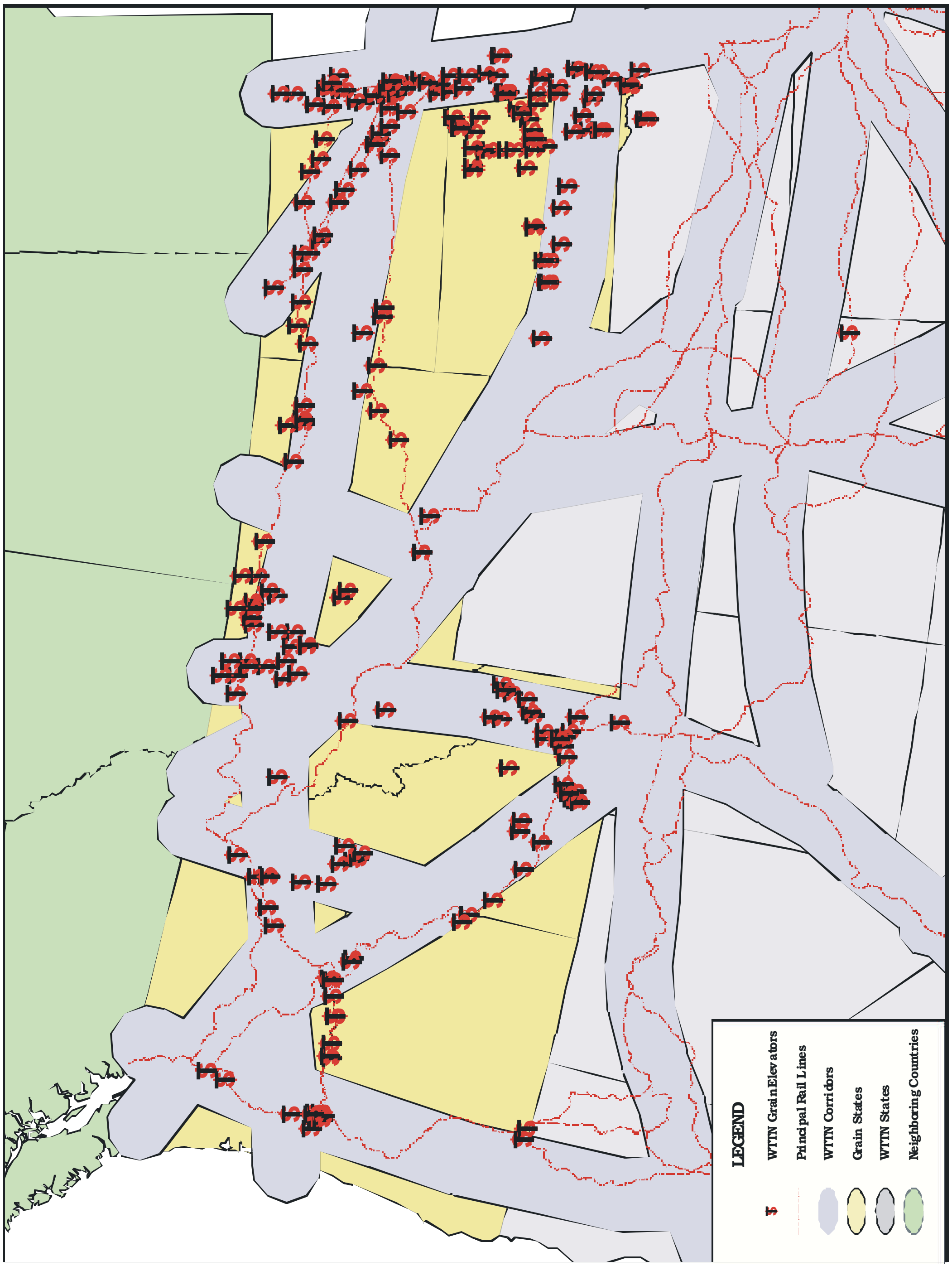


Exhibit 5-24
WTTN GRAIN ELEVATORS

State	Location	Elevators	Criterion	Federal Int. Connector [(2)]
South Dakota	Aberdeen	4	>500 carloads/yr	No
	Mansfield	1	>500 carloads/yr	No
	Mellette	1	>500 carloads/yr	No
	Redfield	1	>500 carloads/yr	No
	Tulare	1	>500 carloads/yr	No
	Wolsey	1	>500 carloads/yr	No
	Alpena	1	>500 carloads/yr	No
	Mitchell	1	>500 carloads/yr	No
	Dimock	1	>500 carloads/yr	No
	Beardsley	1	>500 carloads/yr	No
	Tripp	1	>500 carloads/yr	No
	Vermillion	3	>500 carloads/yr	No
	Jefferson	1	>500 carloads/yr	No
	Huron	1	>500 carloads/yr	No
	Yale	1	>500 carloads/yr	No
	Bancroft	1	>500 carloads/yr	No
	Willow Lake	1	>500 carloads/yr	No
	Vienna	1	>500 carloads/yr	No
	Watertown	4	>500 carloads/yr	No
	Labolt	1	>500 carloads/yr	No
	Sisseton	1	>500 carloads/yr	No
	Milbank	1	>500 carloads/yr	No
	Claire City	1	>500 carloads/yr	No
	Rosholt	1	>500 carloads/yr	No
	Lake Preston	1	>500 carloads/yr	No
	Arlington	1	>500 carloads/yr	No
	Brookings	2	>500 carloads/yr	No
	Aurora	1	>500 carloads/yr	No
	Madison	2	>500 carloads/yr	No
	Wentworth	1	>500 carloads/yr	No
	Corson	1	>500 carloads/yr	No
	Garretson	1	>500 carloads/yr	No
	Emery	1	>500 carloads/yr	No
	Marion	1	>500 carloads/yr	SD17R 1
	Parker	1	>500 carloads/yr	No
	Canton	2	>500 carloads/yr	SD19R 1
	Beresford	1	>500 carloads/yr	No
	Ipswich	1	>500 carloads/yr	No
	Craven	1	>500 carloads/yr	No
	Groton	1	>500 carloads/yr	No
	Bristol	1	>500 carloads/yr	No
	St. Lawrence	1	>500 carloads/yr	No

Exhibit 5-24
WTTN GRAIN ELEVATORS

State	Location	Elevators	Criterion	Federal Int. Connector (2)
South Dakota (cont'd)	Pierre	1	>500 carloads/yr	No
	Ft. Pierre	1	>500 carloads/yr	No
	Midland	2	>500 carloads/yr	No
	Philip	2	>500 carloads/yr	No
	Claremont	2	>500 carloads/yr	No
	Amherst	1	>500 carloads/yr	No
	Britton	2	>500 carloads/yr	No
	Murdo	1	>500 carloads/yr	No
	Kennebec	1	>500 carloads/yr	No
	Chamberlain	1	>500 carloads/yr	No
Montana	Hardin	1	≥ 52-car track	No
	Harlem	1	≥ 52-car track	No
	Great Falls	3	≥ 52-car track	No
	Big Sandy	1	≥ 52-car track	No
	Carter	2	≥ 52-car track	No
	Fort Benton	1	≥ 52-car track	No
	Miles City	1	≥ 52-car track	No
	Glendive	1	≥ 52-car track	No
	Moore	1	≥ 52-car track	No
	Cut Bank	2	≥ 52-car track	No
	Meriwether	1	≥ 52-car track	No
	Box Elder	1	≥ 52-car track	No
	Gildford	1	≥ 52-car track	No
	Havre	2	≥ 52-car track	No
	Hingham	1	≥ 52-car track	No
	Rudyard	2	≥ 52-car track	No
	Moccasin	1	≥ 52-car track	No
	Chester	1	≥ 52-car track	No
	Joplin	1	≥ 52-car track	No
	Conrad	2	≥ 52-car track	No
	Fallon	1	26-car track	No
	Macon	1	≥ 52-car track	No
	Poplar	1	≥ 52-car track	No
	Wolf Point	3	≥ 52-car track	No
	Butte	1	≥ 52-car track	No
	Choteau	1	≥ 52-car track	No
	Dutton	1	≥ 52-car track	No
	Fairfield	1	≥ 52-car track	No
	Shelby	2	≥ 52-car track	No
	Glasgow	1	≥ 52-car track	No
	Billings	1	≥ 52-car track	No
	Broadview	1	≥ 52-car track	No

Exhibit 5-24
WTTN GRAIN ELEVATORS

State	Location	Elevators	Criterion	Federal Int. Connector (2)
Montana (cont'd.)	Huntley	1	10-car track	No
North Dakota	Devils Lake	1	≥ 100-car track	
	Colfax	1	≥ 100-car track	
	Jamestown	1	≥ 100-car track	
	Gladstone	1	≥ 100-car track	
	Voltaire	1	≥ 100-car track	
	Joliette	1	≥ 75-car track	
	Minot	1	≥ 75-car track	
	Hankinson	1	≥ 50-car track	
	Lakota	1	≥ 50-car track	
	Valley City	1	≥ 50-car track	
	Casselton	1	≥ 50-car track	
	Arvilla	1	≥ 50-car track	
	Williston	1	≥ 50-car track	
	Churchs Ferry	1	≥ 50-car track	
	Amenia	1	≥ 50-car track	
	Portland	1	≥ 50-car track	
	Buffalo	1	≥ 50-car track	
	Hunter	1	≥ 50-car track	
	Thompson	1	≥ 50-car track	
	Clifford	1	≥ 50-car track	
	West Fargo	1	≥ 50-car track	
	Prosper	1	≥ 50-car track	
	Lidgerwood	1	≥ 50-car track	
	Berthold	1	≥ 50-car track	
	Kindred	1	≥ 50-car track	
	Reynolds	1	≥ 50-car track	
	Mooreton	1	≥ 50-car track	
	Portland	1	≥ 50-car track	
	Horace	1	≥ 50-car track	
	Durbin	1	≥ 50-car track	
	Buffalo	1	≥ 50-car track	
	Galchutt	1	≥ 50-car track	
	Grand Forks	3	≥ 50-car track	
	Minot	2	≥ 50-car track	
	Carrington	1	≥ 50-car track	
	Rugby	1	≥ 50-car track	
	Dickinson	1	≥ 50-car track	
	Rogers	1	≥ 50-car track	
	Beach	1	≥ 50-car track	
	Forest River	1	≥ 50-car track	
	Ross	1	≥ 50-car track	

Exhibit 5-24
WTTN GRAIN ELEVATORS

State	Location	Elevators	Criterion	Federal Int. Connector [2]
North Dakota (cont'd)	Ray	1	≥ 50-car track	
	Drayton	1	≥ 50-car track	
	Valley City	1	≥ 50-car track	
	Enderlin	1	≥ 50-car track	
	Velva	1	≥ 50-car track	
	Fessenden	1	≥ 50-car track	
	Harvey	1	≥ 50-car track	
	Wimbledon	1	≥ 50-car track	
	Bowbells	1	≥ 50-car track	
	Leal	1	≥ 50-car track	
Oregon	Portland [3]	7	≥ 500,000 bu	OR13, 14, 15, 24P 1
	North Plains	1	≥ 500,000 bu	No
	Merrill	1	≥ 500,000 bu	No
	Worden	1	≥ 500,000 bu	No
	The Dalles	2	≥ 500,000 bu	No
	Nyssa	1	≥ 500,000 bu	No
	Umatilla	1	≥ 500,000 bu	No
	Vale	1	≥ 500,000 bu	No
	Arlington	1	≥ 500,000 bu	No
	Boardman	2	≥ 500,000 bu	OR2P 1
	Biggs	1	≥ 500,000 bu	No
	Pendelton	1	≥ 500,000 bu	No
	Mission	1	≥ 500,000 bu	No
Idaho	Acquia	2	≥ 25-car track	No
	American Falls	1	≥ 25-car track	No
	Ashton	2	≥ 25-car track	No
	Bancroft	1	≥ 25-car track	No
	Bussell (Dubois) [1]	1	≥ 25-car track	No
	Beetville (Burley) [1]	1	≥ 25-car track	No
	Bliss	1	≥ 100-car track	No
	Burley	1	≥ 25-car track	No
	Camas (Dubois) [1]	1	≥ 25-car track	No
	Collins (Blackfoot) [1]	1	≥ 25-car track	No
	Cottonwood	1	≥ 25-car track	No
	Craigmont	1	≥ 25-car track	No
	Declo	1	≥ 25-car track	No
	Fenn	1	≥ 25-car track	No
	Grangeville	1	≥ 25-car track	No
	Idaho Falls	1	≥ 50-car track	No
	Inkum	1	≥ 25-car track	No
Idaho (cont'd.)	Kamiah	1	≥ 25-car track	No

Exhibit 5-24
WTTN GRAIN ELEVATORS

State	Location	Elevators	Criterion	Federal Int. Connector [2]
	Lewiston	3	≥ 50-car track	No
	Lincoln (Idaho Falls) [1]	1	≥ 50-car track	No
	Michaud (Pocatello) [1]	2	≥ 25-car track	No
	Minidoka	2	≥ 25-car track	No
	Mountain Home	1	≥ 25-car track	No
	Nampa	1	≥ 25-car track	No
	Newdale	3	≥ 25-car track	No
	North Kenyun (Burley) [1]	2	≥ 25-car track	No
	Pocatello	1	≥ 50-car track	No
	Rockford (Blackfoot) [1]	1	≥ 25-car track	No
	Rupert	2	≥ 25-car track	No
	Tybee (Pocatello) [1]	1	≥ 25-car track	No
Washington	Ritzville	1	≥ 50 cars	No
	Sprague	1	≥ 50 cars	No
	Kalama [3]	2	≥ 50 cars	WA12P 1
	Vancouver [3]	1	≥ 50 cars	WA11P 1
	Tacoma [3]	1	≥ 50 cars	WA44P 1
	Seattle (Pier 86) [3]	1	≥ 50 cars	WA45P 1
	Plymouth	1	≥ 50 cars	WA13P 1
Colorado	Cheyenne Wells	1	Unit Train Capability	No

(1) Nearest town.
(2) One or more roads to/from the elevator has been designated as a National Highway System Connector in the 1999 Intermodal Connectors Condition and Investment Study, FHWA.
(3) Rail-Water Export Elevators.

Source: The individual participating WTTN states. Elevators not on this list were not selected by the participating states.

Access Characteristics – All of these elevators use trucks to collect the grains, with those trucks travelling on different combinations of roadways. Most of these elevators use unit grain trains and/or barges/ships to carry the product to its longer distance destination. The elevators have the ability to store the grains and to aggregate/sort it for its outward move.

Grain Elevator Access Issues

These grain elevators, and consequently the entire grain business including each farmer, are confronted with a complex transportation system which involves quite a number of problems of relevance to the WTTN study. One of these problems is access to the grain elevator.

Evolving Nature of Grain Transportation – Over the past decade or so the single-unit farm truck has given way to the multi-axle combination tractor-trailer. The use of larger grain trucks means that the loads per truck are as much as ten times heavier than they once were. Yet, these large, modern trucks carrying the nation's grain supply are often traveling on rural gravel roads, and on rural paved roads with inadequate pavements and/or bridges connecting to paved roads (for short and high-density segments) to roads that access the grain elevators. As railroad branch lines and country elevators are closed, the truck loads are also carried further (to fewer but larger elevators or terminals), and the damage to the roads is potentially greater.

Another aspect of the greater distance is that farmers that are near the large elevators, or that have good access to the large unit train elevators, have a competitive advantage over those which were served by now closed elevators. Those farms more distant to the large grain elevators are at a competitive disadvantage.

Evolving Nature of Railway Grain Transportation – The manner by which the railroads carry the grains has also evolved and changed:

- *Branch Line Abandonments* – The railroads once had an extensive system of branch lines throughout the grain producing states. Through the 1970's and 1980's the railroads sought to "rationalize" their systems, one part of which was an aggressive program to abandon many of their light density rail lines. As a result, many of these branch lines have been abandoned or required preservation through public assistance programs and/or the institution of short line railroads. Some states, e.g., South Dakota and Montana, have even found it necessary to purchase and operate (under contract) some rail lines. As the number of branch lines serving the grain production areas has declined, the need to carry grain further by truck (hence the need for larger trucks) has increased.

- *Unit Trains* – As the railroads moved toward a main line emphasis, they have also moved toward the use of unit trains, ranging between 25/26-car unit trains; 50-52 cars, and 100+ cars. The advantage to the railroad is increased efficiency; the advantage to the farmer is cost savings and competitiveness. Caught in the middle is the grain elevator incapable of handling unit trains, and the farmer located great distances from the unit train elevator. Overall, the unit trains and main lines emphasis has made North American grains increasingly competitive in the world market. However, these improvements are made to the disadvantage of those farms and elevators on the branch lines and/or located at greater distances from the large elevators on the rail main lines.

- *Railcar Sizes* – With the trend toward size economies comes the ever-increasing sizes of railcars to carry the grain. Once carried in narrow-door 40-foot boxcars with 2,000-bu capacity, the railroads switched to100-ton "jumbo hoppers" with up to 3,850-bu capacity, and now may be going to 115-ton hoppers. These efficiencies are passed on to the elevators and farmers able to use them. Unfortunately for some regions of the states, many rail branch lines do not have the ability to handle larger cars. Light weight rail, poor ties, soft roadbed, and low rated bridges prohibit increases in car weights without major improvement expenditures. Therefore, once again, those growers served by branch lines will be at a competitive disadvantage. Furthermore, those states that have invested in branch lines (either rail line rehabilitation, or rail line purchase, or both) will find it necessary to make further investments.

- *Railcar Availability* – Railcar availability is also a significant problem, especially during the harvest season. As an aid to solving this issue, some agencies (Washington) have purchased railcars.

- *Railroad Rates* – Complementing these railroad operational changes, the railroads were effectively deregulated in the 1970's. Therefore, while they once offered regulated single-car rates, the railroads moved to published unit-train tariffs, then to negotiated unit train contract rates. All this favored the large elevator and the larger farms.

Evolution of the Intermodal Grain Elevator – The grain elevators of the West have had to adapt to those changing realities. Years ago the country elevator existed within one day's horse-pulled cart journey of the farm. As the single-unit farm truck gave way to the multi-axle truck, as the branch lines gave way to the rail main lines, the number of country elevators declined and in their place arrived the HTE (High Throughput Elevator). These are typically on rail main lines, capable of handling unit grain trains, and emphasize throughput rather than storage. These HTE's typically have catchment areas of 50-100 miles, thereby requiring efficient collection roads and efficient trucking. Therefore, the type of road, and the condition of that road which connects the farm with the elevator, is becoming more important to the farmer and to the economy.

The evolution of the trucks, the railroads and the grain elevators therefore all occurred simultaneously and all led to efficiency. But, the efficiency gains have been more favorable to some than to others.

Evolution of Grain Markets – The markets for grains were once domestic (initially to the east, then everywhere), but now they include much of the world. Grain trains now move to both coasts, the Midwest, and to the Mississippi River System. The export market was once principally Europe; then it moved to Asia. Now it is many nations.

The result is that the grain producing states and their farmers, and the entire grain industry, must now be able to react to sudden worldwide shifts in the market place. This means that the transportation system must be flexible, able to carry the grains in whichever direction the market dictates, and in whatever volumes and mix of grain strains that the market demands. These needs are not necessarily new. What is new is the need to be increasingly flexible and efficient in order to meet increasingly competitive market demands that change more frequently and volatilely than they once did.

Competitiveness of North American Grain – Many of the farms of the WTTN states are located great distances from the major U.S. markets and from the major ports of export. In order for these grains to be able to compete, the costs (and uncertainties) of grain transportation must be low. The shipping season is short (although it is getting longer), the need to transport vast quantities of grains at peak periods is great, and the ability to have capacity at the elevator, in the trucks, or the trains, and at the ports of export is requisite. Any part of the physical distribution system can be the chokepoint, which in turn can be fatal.

The Farmer Bears the Cost – In the final analysis, it is the individual farmer who must compete with all other sources of grain. If his grain cannot be moved when the market is ready, if he cannot access the unit train facilities, if the port has insufficient capacity, the farmer is the one that suffers. No single element can be allowed to break down. To remain competitive, the farmer, the intermodal grain elevator, the truck and roadway, the railroad and rail line, and the port must all have the requisite capacities.

Solutions and Benefits of Retained and/or Improved Grain Elevator Access

The issue of grain access to/from the West's grain elevators is a railroad and barge (egress) issue and a roadway (access and egress) issue. The extent of the issue varies, depending on each elevator's location and other factors.

Menu of Railroad Solutions – The rail solutions differ, depending on whether the elevator is on a railroad branch line or main line, as well as the elevator circumstances itself.

- If on a railroad branch line, possibly served by a short-line railroad, the solutions include:
  - Upgrade of the rail line physical condition to handle larger hopper cars;
  - Seek state or federal assistance to maintain and/or upgrade trackage; and
  - Seek retention of branch line services, via a variety of public sector and private sector actions including funding, acquisition, etc.

- If on a railroad main line, likely served by a Class I railroad, the solutions include:
  - Assure line capable of handling heavier cars; and
  - Become knowledgeable of railroad competition issues and potential remedial actions such as through the Surface Transportation Board.

- The elevator and its immediate environs might also need to take a number of actions, including:

  - Lengthen rail sidings to handle larger unit trains;
  - Assure that elevator trackage is physically capable of handling heavier cars;
  - Install new elevator equipment to increase railcar loading rate; and
  - Seek rates that reflect railroad efficiency gains.

Menu of Roadway Solutions – The road access issue includes the connector access to the NHS/WTTN corridors, and also the system of collector roads connecting the elevator with the farms. Solutions could include:

- Seek greater awareness of truck-to-elevator access issues by state, county and municipal transportation personnel;
- Seek greater awareness of the grain truck weights, turning radii, and queuing needs;
- Develop more roadway turning lanes at and near the elevators;
- Seek increased roadway pavement and bridge weight capacity, combined with roadway surface and bridge maintenance near the elevators; and
- Seek improved treatments at intersections and at-grade railroad crossings, to reflect the heavy grain truck traffic.

Menu of Waterway Solutions – The waterway solutions apply to Idaho, Washington, Oregon, California and those states served by the inland river system. Potential solutions include:

- Continue investment in lock and dam improvements;
- Dredge channels; and
- Balance economic concerns and environmental concerns.

Benefits of These Solutions – The benefits of improving and retaining access to these elevators are potentially sizable.

- *Roadway Benefits* – These have to do principally with trucking efficiency and roadway safety, and include the ability to turn trucks rapidly, resulting in more trips per truck, road improvements that result in less wear and tear, and turning lanes for trucks.
- *Benefits of Continued Railway Access* – The benefits of continued rail access are potentially large to the individual farmer. If the elevators, especially those located on branch lines and/or served by short line railroads, were to lose their rail line, they, like many county elevators before them, would either change function or go out of business. The benefits are therefore:
  - The farms in the region have a better chance to be competitive and viable; and
  - The small communities have a better chance to continue to be viable.

RAILROAD TOFC/COFC AS INTERMODAL FACILITIES

The activity associated with railroad intermodal, or, more specifically, trailer-on-flat-car (TOFC) and container-on-flat-car (COFC) once commonly called piggyback, has increased along with the use of intermodal transportation. In its formative years, dating back to the 1930s, "intermodal" was a means for the railroads to compete with the motor carrier industry which was just coming into its own.

TOFC/COFC Trends and Forecasts

Rail intermodal traffic has grown at significant levels over the last two decades and, because of the value of the goods shipped in containers, has become a major component of the rail traffic mix. The development of large-scale trade with Asia, land bridge operations, and the use of rail by large truckload carriers have all contributed to this growth.

Rail Intermodal Traffic Types – Railroads handle both domestic and international intermodal traffic. International traffic tends to move in containers, and domestic traffic can move in either containers or trailers.

Much of the western intermodal traffic is international in nature derived from the Pacific Ocean seaports of Los Angeles-Long Beach, Oakland, Portland, Tacoma and Seattle. A lot of it moves in some form of "bridge" service where land transportation is substituted for water transport (land bridge which connects water movements on both oceans; mini-bridge which connects one ocean with a destination port on the other shore, i.e., Los Angeles with New York; and micro-bridge which has an interior point on one end of the move).

Domestic intermodal is a substitute for what is typically a long-haul truck movement. This form of intermodal tends to concentrate in so called "lanes" where there are significant traffic volumes which produce economies of scale and permit service frequencies sufficient to compete with truck movements.

Equipment and Operations - In the beginning, railroad intermodal consisted principally of trailers on flat cars. The trailers were loaded mostly using ramps in a manner similar to the way circus trains were loaded and unloaded (and the term circus loading stuck). Cranes were useful in loading trailers, but were expensive. They were required, however, in loading/unloading containers.

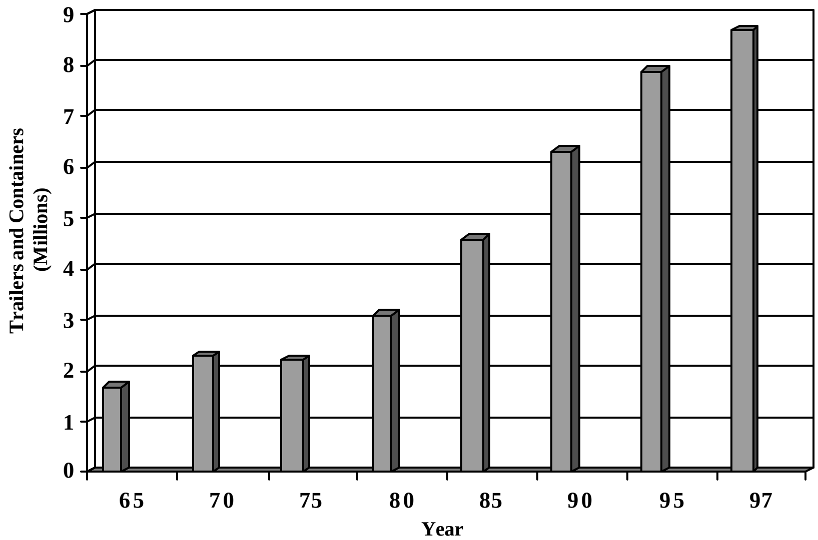
As containers became more commonplace, so did the use of cranes for loading and unloading. Railroad intermodal facilities began to grow in size and become more mechanized, the investments became much larger, and the number of facilities began to shrink as railroads consolidated existing ramps and terminals. As a result, sufficient volumes to justify dedicated and frequent service between major facilities and economies of scale in both train and terminal operation began to develop.

The container revolution in marine transportation led to the development of the double-stack car in the 1980s and subsequent stack-train operations which were initiated by American President Lines. By 1993, 240 eastbound stack-train departures were being made weekly from West Coast container ports. The development of this service necessitated a nationwide effort to improve overhead clearances to accommodate double-stack trains. Tunnels and bridges became impediments to the development of many routes until improvements could be made. Many routes in the East still have yet to be cleared of obstructions, and isolated cases still exist in the West, but the principal routes are open and operating at record levels.

Historic Trends – In 1957, railroads in the U.S. handled just over 400,000 trailers and containers. By 1997, 40 years later, this traffic had increased (22 times) to 8.7 million trailers and containers (see Exhibit 5-25). The real growth, however, did not start until the early 1980s when the 3.0 million threshold was crossed.

The number of containers exceeded the number of trailers for the first time in 1992 -- 3.36 million vs. 3.26 million. In 1997, the number of containers had risen to 5.2 million while the number of trailers remained virtually static at 3.45 million.

Exhibit 5-25
RAILROAD TOFC/COFC TRAFFIC
1965-1997



SOURCE: Association of American Railroads

Forecasts – Six to ten percent annual growth in rail intermodal traffic has been a common range of TOFC/COFC forecasts. Recent problems such as the downturn in the Asian economy and deterioration in western rail service have tempered those forecasts for at least the short term.

The West's Railroad TOFC/COFC Facilities

Due to the long-haul nature of railroad intermodal traffic, railroad TOFC/COFC facilities are particularly significant in the West.

TOFC/COFC Facility Locations – The locations of the 50 WTTN TOFC/COFC facilities are shown on Exhibit 5-26. This illustration depicts those intermodal facilities in all western states, including those not participating in WTTN. Recent railroad mergers have resulted in the two principal railroads having duplicate facilities in several locations. Some carriers already had more than one facility in major metropolitan areas.

Exhibit 5-26
WTTN TOFC/COFC FACILITIES

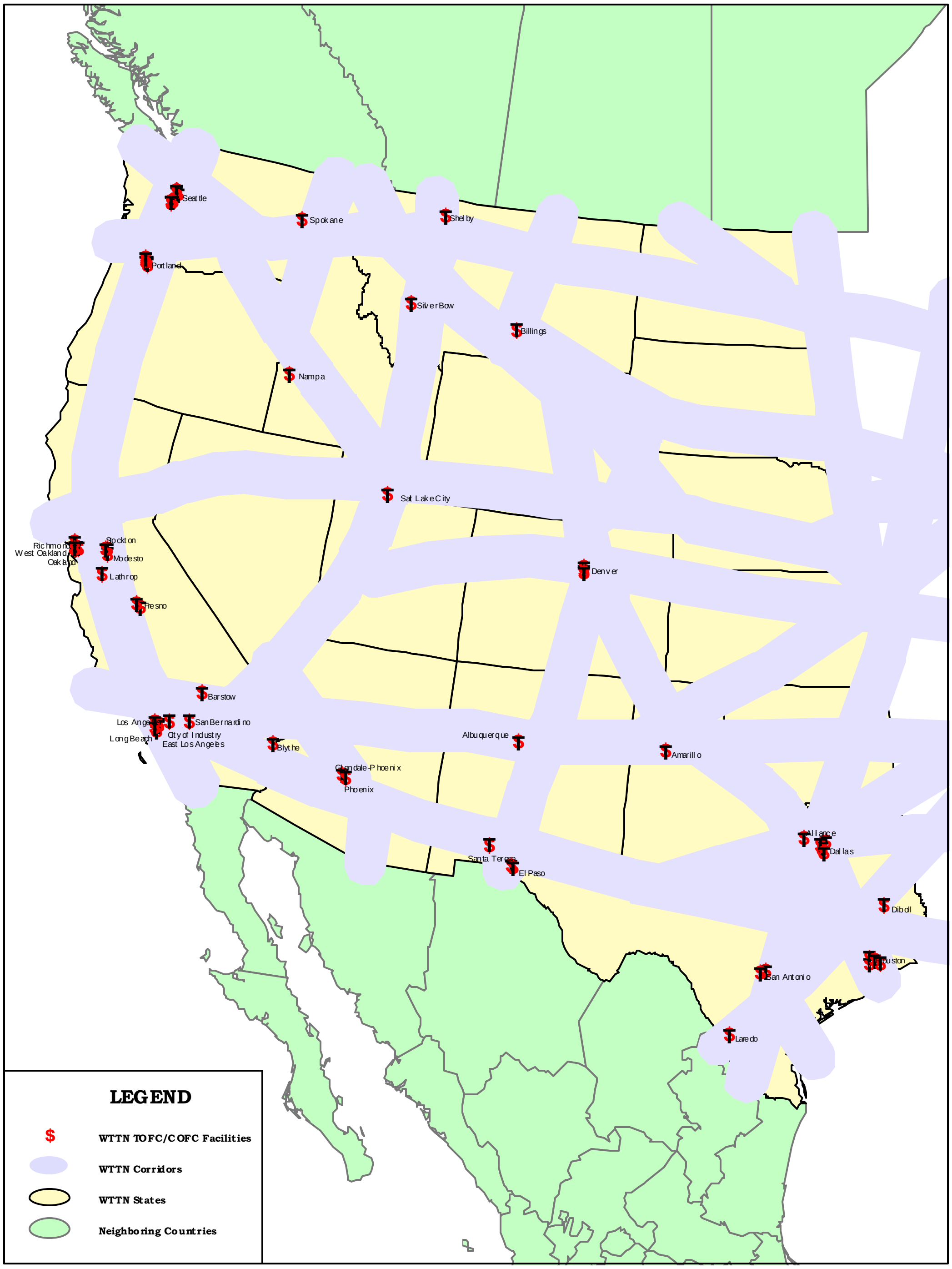


Exhibit 5-26 is accompanied by Exhibit 5-27 which is a list of those facilities identified by the participating states. It contains more detailed location data, lift capacity by terminal and, if applicable, the designated federal intermodal connection.

Seaport Intermodal Facilities – The designated TOFC/COFC locations are exclusive of on-dock or near-dock port-related container facilities. These facilities are typically owned and operated separate from the railroad facilities and are part of the port infrastructure.

TOFC/COFC Access Issues

Railroad TOFC/COFC facilities typically handle domestic as well as international freight traffic (although they have been separated in some locations such as Seattle). In the beginning they were quite often located at the railroad's local yard and remained there as TOFC traffic grew and even took over parts of the yard, or all of the yard, formerly dedicated to the classification of freight cars as carload traffic decreased (and/or as the growing use of unit trains decreased the need to classify cars), and intermodal traffic grew. These yards were not always located where they were readily accessible to the highway system, much less to marine terminals.

Roadway Access - Access to railroad TOFC/COFC facilities are not a lot different than truck access issues anywhere. Typical problems for example are:

- Inadequate vertical and horizontal clearances;
- Lack of traffic signals or turn signals on a signal;
- Lack of turning lanes;
- Inadequate turning radii:
- Excessive grade crossing delays;
- Excessive time required for processing at TOFC/COFC terminal gates;
- Lack of direct access; and
- Too much roadway congestion.

There are really two aspects of the roadway access problem. First is that of local and long-haul domestic movements which might be arriving/departing from many different directions and over several roadways. The second is the port - rail intermodal facility dray, which tends to occur over the route and roadways.

Exhibit 5-27
WTTN RAIL INTERMODAL FACILITIES
TOFC/COFC

City	Identification/ Location	Railroad[1]	Lift Capacity[3]	Federal Int. Connector[5]
		ARIZONA		
Phoenix	1301 E. Harrison Street	UP	60K	AZ16R 1
Phoenix	5281 Tom Murray Road (Glendale)	BNSF	134K	AZ15R 1
		CALIFORNIA		
Blythe	Lovekin Avenue & 16th St.	ARZC	N.A.	
Barstow	H & Main Street	BNSF	83K	
Modesto	300 Condoni Road	BNSF	109K	
Fresno	2989 S. Golden State	BNSF	117K	
Fresno	3135 N. Weber Avenue	UP	38K	
Los Angeles	3770 E. Washington Blvd.	BNSF	945K	
	L.A.T.C. [1] 750 Lamar Street	UP	300K	
Richmond	303 S. Garrard Blvd.	BNSF	215K	
San Bernardino	1535 W. 4th Street	BNSF	278K	
Stockton	1001 South B Street	BNSF	137K	
East Los Angeles	4341 E. Washington Blvd.	UP	425K	
City of Industry	650 S. Stimson	UP	240K	
Lathrop	1000 E. Roth Road	UP	300K	
Long Beach	I.C.T.F.[1] 2401 E. Sepulveda Blvd.	UP[2]	840K	
Oakland	1776 Middle Harbor Road	UP[2]	200K	
West Oakland	1750 Ferro Street	UP	200K	
		COLORADO		
Denver	585 W. 53rd Place	BNSF	201K	CO1OR 1
Denver	1851 40th Avenue	UP	120K	CO12R 1
		IDAHO		
Nampa	2618 Second Street South	UP	40K	No

City	Identification/ Location	Railroad[1]	Lift Capacity[3]	Federal Int. Connector[5]
	MONTANA			
Billings	3311 1st Avenue South	BNSF	25K	No
Shelby	198 BN Right of Way	BNSF	21K	No
Silver Bow	Port of Montana, 119041 German Gulch Rd.	BNSF/UP	N.A.	No
	NEW MEXICO			
Albuquerque	100 Woodward Street S.E.	BNSF	27K	No
Santa Teresa	Camino Real Intermodal [4] Facility	BNSF/UP	N.A.	No
	OREGON			
Portland	Albina Yard, 2745 N. Interstate Avenue	UP	165K	OR12R 1
	Brooklyn (SP), 5424 S.E. McLoughlin Bldv.	UP	120K	OR6R 1
	Willbridge Yard, 3930 NW Yeon Avenue [2]	BNSF	198K	OR9R 1
	TEXAS			
Dallas	Miller-Central Expressway	UP	192K	TX119R 1
	Mesquite-Forney Road	UP	250K	TX118R 1
	N. Main	TCS	N.A.	No
	Shiloh Road	KCS	N.A.	No
San Antonio	Sherman Street (SP)	UP	100K	TX34R 1
	Quintana Road	UP	50K	No
El Paso	Santa Fe Street	BNSF	19K	TX48R 1
	Dodge Street	UP	100K	TX49R 1
Houston	Englewood-Wallisville Road	UP[2]	252K	TX72R 1
	Settegast-Kirkpatrick Blvd.	UP	200K	TX71R 1
	Barbours Cut-Barbours Cut Blvd. (Port of Houston)	UP	72K	TX107R 1
	Strang, TX Brisbane Road	BNSF	198K	TX106R 1
Alliance (Dallas/Fort Worth)	Intermodal Parkway (Haslet, TX)	BNSF	401K	TX120R 1

City	Identification/ Location	Railroad[(1)]	Lift Capacity[(3)]	Federal Int. Connector[(5)]
Amarillo	Farmers Avenue	BNSF	31K	No
Laredo	Port Laredo (I-35, mile #12)	UP	130K	TX21R 1, 2
Diboll		TSE	N.A. (Ramp)	No
	UTAH			
Salt Lake City	1800 N. Beck Street	UP	140K	UT5R 1
	WASHINGTON			
Seattle	4700 Denver Avenue South (ARGO)	UP	275K	WA10R 1
	Seattle International Gateway (SIG), 44 S. Hanford Street	BNSF	329K	WA30R 1
	South Seattle ,12400 51st Place	BNSF	255K	WA64R 1
Spokane	Yardly –1800 N. Dickey	BNSF	54K	WA73R 1

(1) I.C.T.F. – Intermodal Container Transfer Facility
L.A.T.C. – Los Angeles Transportation Center
ARZC – Arizona & California Railroad
BNSF – Burlington Northern Santa Fe
CSXI – CSX Intermodal
KCS – Kansas City Southern
SP – Southern Pacific, now UP
TCS – Triple Crown Services
TSE – Texas South – Eastern
UP – Union Pacific
(2) Also used by CSXI
(3) Annual
(4) Proposed
(5) One or more roads to/from the TOFC/COFC facility have been designated as a National Highway System Connector in the 1999 Intermodal Connectors Condition and Investment Study, FHWA.

Solutions and Benefits of Improved Access

Problems related to access to railroad TOFC/COFC terminals varies by location. For example, some are well located in regard to highway facilities and others are not. Facilities located away from navigable waterways do not have port-related drayage problems.

Menu of Solutions - Both physical and operational problems must be addressed.

- Physical - adequate lane widths, intersection improvements (turn lanes and adequate turning radii), more direct access, etc.; and
- Operational - intersection improvements (traffic signals, turning signal phases), terminal gate improvements, rail-roadway grade separations, etc.

Potential Benefits - Benefits to be generated by improved access to TOFC/COFC facilities fall largely into the transportation efficiency category. While the line-haul element of railroad intermodal transportation is very efficient, the pick-up and delivery function is one of the largest cost elements. More efficient transportation also leads to environmental improvements.

OTHER RAILROAD INTERMODAL FACILITIES

Exhibit 5-28 contains a list of five rail-highway facilities which are very similar to TOFC/COFC facilities in terms of access problems. These facilities handle automobiles or permit the transfer of bulk commodities or lumber.

Due to the limited number of facilities and their similarity to other types of rail-highway transfer, they are included in this presentation, but not discussed further.

Exhibit 5-28
WTTN RAIL RELOAD AND MISCELLANEOUS FACILITIES

State	Location	Facility	RR [(1)]	Federal Int.Con. [(2)]
MT	Sunburst	Transload Service Of MT	BNSF	No
	Eureka	Gwynn Lumber	BNSF	No
CO	Rolle	Automobile	BNSF	CO7R 1
UT	Sharp	Canyon Fuel Company Coal Transload	UP	UT7L 1
WA	Seattle	Interbay (Automobile)	BNSF	WA28R 1

(1) BNSF – Burlington Northern Sante Fe
(2) One or more roads to/from the facility have been designated as a National Highway System Connector in the 1999 Intermodal Connectors Condition and Investment Study, by FHWA, August 7, 1998.

PORTS AS INTERMODAL FACILITIES

The volumes of marine traffic and the rapid growth in the numbers of containers handled at western ports have created not only waterway and harbor issues, but a number of landside access issues for the railroads, highway users, and the communities in which the ports are located. The increasing size of ships, especially those transporting containers, with increasing demand for rapid loading and unloading, will continue to exacerbate the problem. These issues are being addressed at some locations, but many still exist.

Water Port Cargo Trends and Forecasts

The 28 water ports of the WTTN study area (see Exhibits 5-29 and 5-30) contain some of the largest ports in the country, both from a tonnage standpoint as well as in terms of the numbers of containers handled. Many of the ports have been major players in waterborne commerce for some time. More recently, the major seaports of the West have become gateways to trade with the Pacific Rim.

Domestic and International Cargo - Exhibit 5-31 displays total tonnage, domestic and international, for 1997 for the 13 largest (in terms of tonnage) western ports. The 13 listed rank in the top 50 nationwide. Note that six of the 13 are located in Texas. Tanker traffic accounted for almost 250 million tons of foreign trade at these Gulf ports.

Total Tonnage vs. Containerized Cargo - Total tonnage handled at six of the West Coast's major ports (Long Beach, Los Angeles, Oakland, Portland, Tacoma and Seattle) between 1975 and 1997 is the subject of Exhibit 5-32. The total consists of both domestic and international trade and all forms of cargo -- bulk, break-bulk and containers. Note that while total tonnage rose from just over 100 million to almost 190 million, an increase of 67 percent, the largest jump in growth for a five-year period occurred between 1975 and 1980. From 1980 to 1997, the increase amounted to just over 40 million tons or 30 percent.

Exhibit 5-29
WTTN WATER PORTS

State	City	Port	Terminals	RR[1]	Federal Int.Connector[2]
ID	Lewiston	Port of Lewiston	4	CSP	ID5P 1
WA	Bellingham	Port of Bellingham	1	BNSF	WA26P 1
	Seattle	Port of Seattle	19	BNSF/UP	WA 38, 45P 1
	Tacoma	Port of Tacoma	8	BNSF/UP	WA44P 1
	Olympia	Port of Olympia	1	BNSF/UP	WA17P 1
	Vancouver	Port of Vancouver	3	BNSF/UP	WA11P 1
	Kalama	Port of Kalama	2	BNSF/UP	WA12P 1
OR	Portland	Port of Portland	5	BNSF/UP	OR13, 14, 15, 24P 1
	The Dalles	Port of The Dalles	1	UP	No
	Boardman	Port of Morrow	1	UP	OR2P 1
	Umatilla	Port of Umatilla	1	UP	No
TX	Port Arthur	Port of Port Arthur	1	KCS/UP	TX154P 1
	Beaumont	Port of Beaumont	6	BNSF/KCS/UP	TX161P 1
	Houston	Port of Houston	9	BNSF/PTRA/UP	TX55, 56, 57, 58, 79P 1,
	Galveston	Port of Galveston	7	BNSF/UP	TX78P 1
	Corpus Christi	Port of Corpus Christi		BNSF/TM/UP	TX12, 13, 14, 15, 16, 84P 1
	Brownsville	Port of Brownsville		BRG/TFM/UP	TX28P 1
CA	Eureka	Humboldt Bay Harbor	4	NWP	
	West Sacramento	Port of Sacramento	5	BNSF/UP	
	Stockton	Port of Stockton	1	BNSF/UP	
	Richmond	Port of Richmond	1	BNSF/UP	
	San Francisco	Port of San Francisco	8	UP	
	Oakland	Port of Oakland	11	BNSF/UP	
	Redwood City	Port of Redwood City	1	UP	
	Port Hueneme	Port of Hueneme	2	VCY	
	San Pedro	Port of Los Angeles	26	BNSF/UP	
	Long Beach	Port of Long Beach	23	BNSF/UP	
	San Diego	Port of San Diego Encinal Terminals	3	BNSF/SDIY	

(1) BNSF – Burlington Northern Santa Fe
CSP – Camas Prairie Railnet
BRG – Brownsville and Rio Grande International
KCS – Kansas City Southern
PTRA – Port Terminal Railroad Association
TM – Texas Mexican
TFM – Transportation Ferrovioria Mexicana
NWP – Northwestern Pacific
SDIY – San Diego & Imperial Valley
UP – Union Pacific
VCY – Ventura County

(2) One or more roads to/from the facility have been designated as a National Highway System Connector in the 1999 Intermodal Connectors Condition and Investment Study, by FHWA, August 7, 1998.

Exhibit 5-30
MAJOR CARGO PORTS

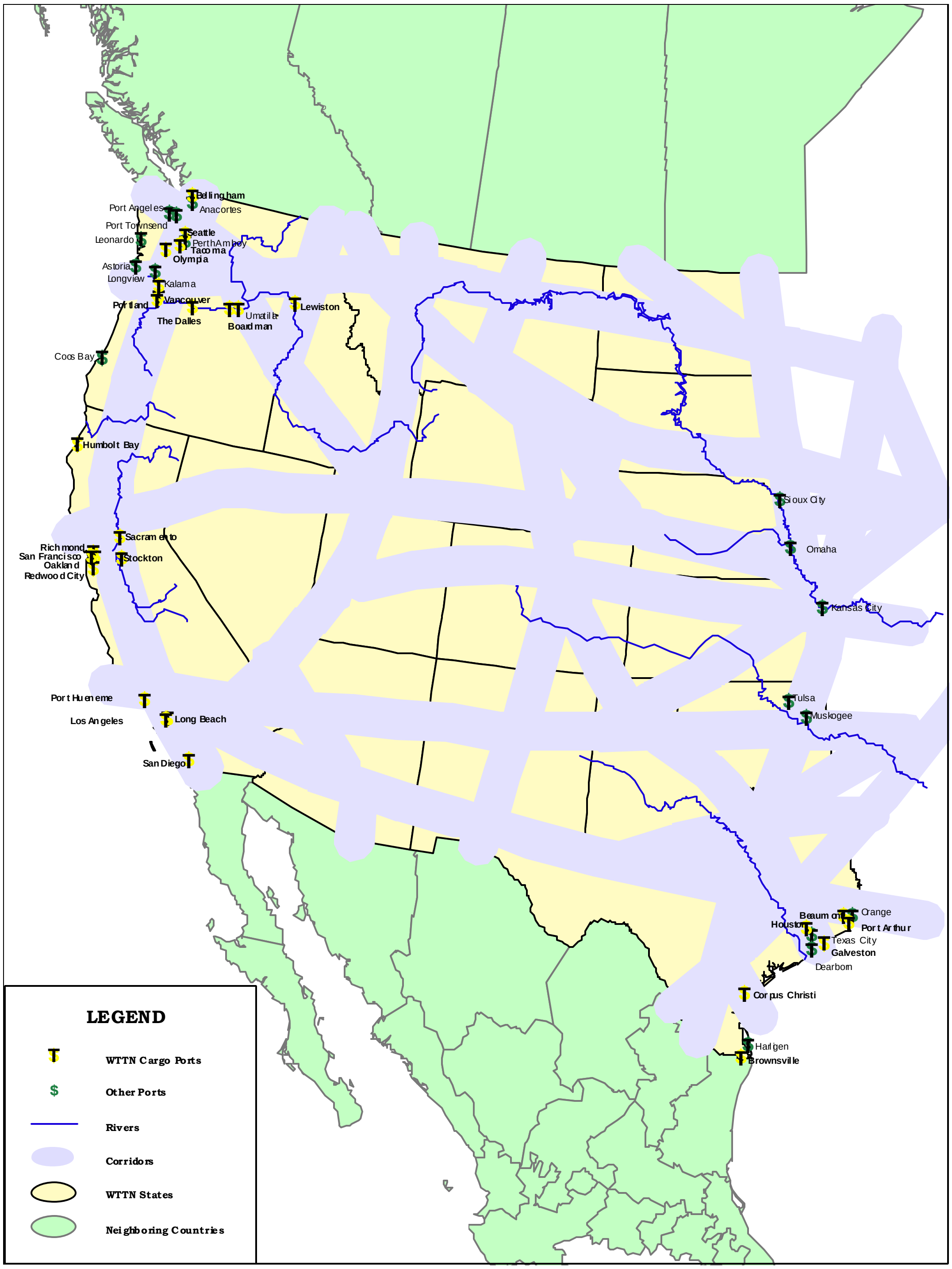


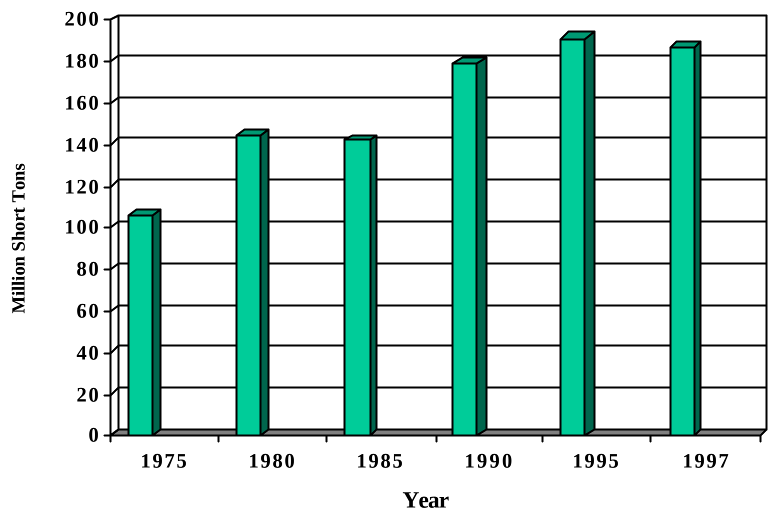
Exhibit 5-31
TOTAL CARGO VOLUME
MAJOR WTTN PORTS - 1997
(Short Tons)

Port	National Rank	Foreign Trade (1)	Domestic Trade (2)	Total Trade
Houston, TX	2	102,846,554	62,609,724	165,456,278
Corpus Christi, TX	5	62,218,692	24,625,068	86,843,760
Long Beach, CA	10	38,356,545	18,898,756	57,255,301
Texas City, TX	11	37,430,678	19,214,997	56,645,675
Beaumont, TX	16	33,626,741	15,038,639	48,665,380
Los Angeles, CA	19	28,579,542	13,194,710	41,774,252
Port Arthur, TX	21	29,728,939	7,589,290	37,318,229
Portland, OR	24	16,538,732	13,022,044	29,560,776
Seattle, WA	25	18,650,546	7,913,684	26,564,230
Freeport, TX	26	21,140,066	5,140,665	26,280,731
Richmond, CA	30	5,220,841	16,484,842	21,705,683
Tacoma, WA	33	13,079,680	7,603,646	20,683,326
Anacortes, WA	46	1,719,226	12,184,288	13,903,514

(1) Foreign Trade = Imports + Exports.
(2) Domestic Trade = Cargo handled coastwise, internally (via the nation's inland waterways, and lakewise (between U.S. Great Lakes ports) as well as "local" and "intraport" shipments.

SOURCE: U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center, New Orleans (LA)
Compiled by American Association of Port Authorities

Exhibit 5-32
WATERBORNE CARGO
Major West Coast Ports
1975-1997



NOTE: Ports are Los Angeles, Long Beach, Oakland, Portland, Tacoma and Seattle
SOURCE: U.S. Army Corps of Engineers, compiled by the American Association of Port Authorities

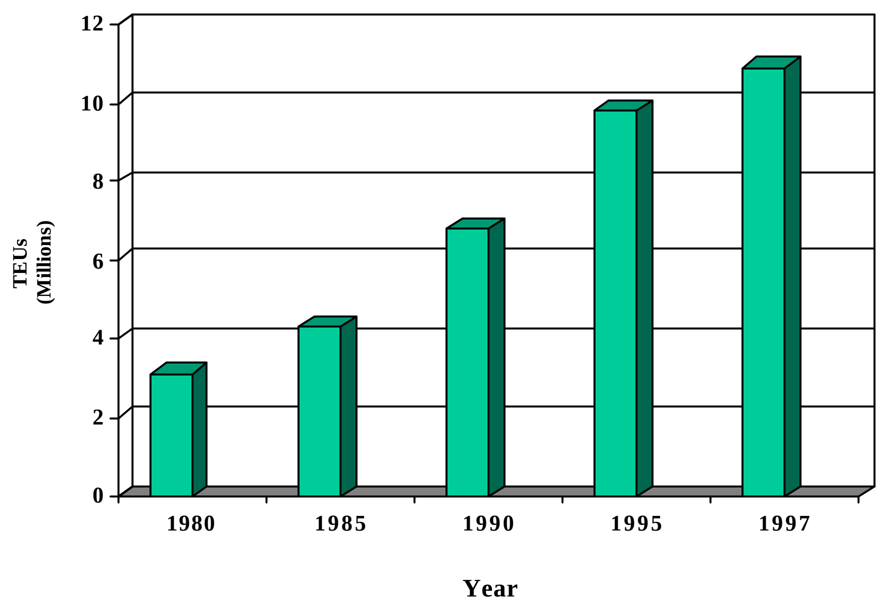
Outstripping total tonnage growth at the six major ports has been the trend toward containerized cargo. For the period between 1980 and 1997, this growth has amounted to 250 percent, from 3.1 million TEUs to almost 11.0 million (see Exhibit 5-33). This growth equates to a 7.7 percent average annual growth rate.

Access Issues

There are numerous waterside and landside access issues surrounding ports today. The landside issues are the focus of this section and are divided into roadway and railway.

Roadway Access - Freight service providers that depend on roadway access to port terminals are confronted with a variety of problems. These impediments generally fall into two broad categories -- operational and physical.

Exhibit 5-33
CONTAINER TRAFFIC
Major West Coast Container Ports
1980-1997



NOTES: Ports are Los Angeles, Long Beach, Oakland, Portland, Tacoma, and Seattle
SOURCE: American Association of Port Authorities

- *Operational Impediments* - Most of the study area ports which experience problems are also located in major cities which are continuing to grow and are having roadway congestion problems. The growth in marine traffic, creating congestion problems of its own, exacerbates the problem. Congestion leads to delays, which in turn increases costs and degrades service.

  The lack of, or poor functioning of traffic signals (lack of turn signals, poor sequencing, lack of synchronization) at key locations adds to congestion and is a common problem for trucks. The absence of, or lack of clarity of, signing and route and pavement marking is another common complaint.

- *Physical Impediments* - As tractors, trailers and containers become larger, roadway design in terms of pavements, bridges, geometrics, and clearances becomes obsolete. This obsolescence manifests itself in short interchange ramps, inadequate turning radii, narrow pavement widths, bridge weight limitations, absence of or not enough grade separations, and similar characteristics.

Railway Access - Operating and physical impediments due to the growth in marine traffic has also been a problem for railroads. The at-grade crossing of roadways has presented problems for both rail and roadway users.

- *Operating Impediments* – Rail access to marine facilities has become increasingly congested, which has manifested itself in both main lines as well as local access lines. Railroads in the West were ill-equipped to handle the onslaught of traffic resulting from overall economic growth combined with the explosion of demand for Powder River Basin coal and the maritime trade with the Far East.

  At-grade rail-roadway problems are discussed in more detail elsewhere, but they are of particular concern in port and other terminal areas where railroad switching and/or slow operations are common, tying up roadway traffic for much longer periods than faster trains on main lines and creating operating and safety problems for the rail operator.

- *Physical Impediments* - Lack of the necessary overhead clearances for double-stack containers was a major problem when that type of shipment began. These problems have been largely resolved, but a few isolated locations still exist. Congestion problems are also being addressed with the addition of capacity by a variety of means, but here again, isolated situations still exist.

  A new problem is the impending increase in car weights from 263,000 lbs. to 286,000 lbs. Most of the western main line rail systems are capable of handling these increased weights, but many secondary lines and branches, as well as individual structures, do not. Bulk shipments to ports, such as minerals and grain, will be impacted.

Solutions and Benefits of Improved Landside Access

Port access issues have attracted considerable attention and commanded the allocation of sizable resources. This attention has been due in large part to the focus on intermodal transportation.

Menu of Solutions - Solutions range from improvement of specific problems at individual locations that are independent of others, to "corridor" approaches where issues are resolved using a coordinated approach. On- and near-dock rail facilities may help solve the off-port dray issue. Many ports, however, do not have the space available for such facilities.

Heavily publicized projects such as the Alameda Corridor in Los Angeles-Long Beach, and the FAST Corridor in the Seattle-Tacoma area, fall into the "corridor" category. The Alameda Corridor is a dedicated freight corridor which will eliminate 200 at-grade rail-roadway crossings, improve freeway access for truck traffic and access to rail intermodal facilities, and vastly improve railroad access to main tracks for trains loaded on-dock. The FAST Corridor is a coordinated approach to the at-grade rail-roadway crossing issue from Everett to Tacoma, Washington.

The port access solution options generally fall into the categories listed below:

- Technology improvements to facilitate port/WTTN access (ITS)
    - Surveillance cameras to identify traffic congestion areas;
    - Incident response on port access routes;
    - Variable message signs on major routes (identifying alternate routes with sufficient advance notice);

- Improved communication between ports and trucks to better manage truck arrivals and departures (alleviating congestion at ports);
- Ramp metering; and
- Weight-in-motion/AVI.

- Truck access improvements to ports on local roads, highways, and at interchanges
  - Signalization improvements;
  - Roadway widening (including turn lanes);
  - Improved intersection geometrics (channelization, turning radii);
  - Structure improvements (widening, clearance);
  - Improved signage (better directions, improved visibility);
  - Pavement treatment (including lane (re-)striping and pavement/roadway bearing capacity to accommodate heavy trucks);
  - Truck only lanes to/from/around ports;
  - Alternate routes to ports;
  - Roadway weight limits.
- Improved efficiency of container transfer between truck/rail and truck/ship
  - Coordinate operation/arrival/departure intervals.
- Longer gate hours at marine terminals, allowing off-peak truck access
- Rail facilities
  - New/expanded on-dock rail facilities;
  - Improved intermodal terminals, including shared or joint facilities;
  - New/improved rail terminals and yards at port access (including space to build

trains);

- Grade separations along rail lines into ports and through urban regions;
- Consolidation of rail lines into ports for more efficient operations (e.g., Alameda Corridor);
- Increased rail capacity from ports to main lines
  - unit trains (including grain, coal, etc.);
  - car load traffic.

Potential Benefits - The benefits of landside access improvement are numerous. First and foremost are the economic gains from the improvement in transportation efficiencies and related cost of operations. Improvements in the environment can result from transportation efficiencies such as decreased energy usage and related emissions. A variety of safety improvements usually follow also, resulting from improvement in modal operations and the separation of rail and roadway traffic.

The continued growth of the region's water ports depends on adequate landside access as well as waterside operations.

AT-GRADE CROSSINGS

The fact that roadways with cars and trucks, and rail lines with passenger and freight trains, cross at-grade in many locations throughout the western states implies inefficiency and inconvenience (highway vehicles wait for trains), and accident risks. This railroad grade crossing problem is a significant issue, and it is a problem gaining greater recognition.

At- Grade Crossings Issues

Increasingly Significant Problem – The rail-roadway at-grade crossing problem is becoming increasingly more important in the West because:

- *Railroad Mergers and Focusing of Rail Traffic* – As the western railroads have merged, and as they have rationalized their systems, selected rail lines have been abandoned or downgraded. As a result, rail traffic is concentrated on the remaining lines. This means that the at-grade crossings on the main lines receiving the additional rail traffic are witnessing significant growth in train traffic, due to railroad corporate operational decisions in addition to normal growth in traffic.

- *Growth of Railroad Traffic* – Compounding the effects of mergers has been sizable growth in railroad ton-miles, which increased from 160 billion in 1929 to 370 billion in 1970 to 917 billion in 1997. This growth is yielding increased train traffic over the West's grade crossings.

- *Funding for Grade Crossing Elimination* – While the states have done what they can to address this problem, sufficient funding has not been available for at-grade crossing elimination. For example, a typical highway grade separation costs $3 - $5 million. Complex urban separations can cost several times that amount. There are rail lines in the western states that could justify dozens or even hundreds of grade separations.

Railroad Main Lines Split the West's Communities – Many of the WTTN's small communities were initially established in the 1800's because of the location of the railroad and their communication and commerce linkage with the rest of the U.S. This typically meant that the town grew up around the railroad (both sides of the track). Increasingly rail and roadway traffic has contributed to problems in communities split by the rail line.

This problem in the western states is much greater than merely delaying highway vehicular movements. Many small towns have only one medical facility, and it is on one side of town. The only fire station is also on one side of the tracks. The result is that emergency vehicles can be delayed by trains, with disastrous results. This small community issue is especially prevalent along the principal main lines in the West.

Train Traffic Densities – One measure of the main line grade crossing problem is the number of trains daily crossing through western communities. For example:

Exhibit 5-34
EXAMPLE TRAIN DENSITIES

Community	Railroad	Trains Per Day
Cochise, AZ	UP	45
Green River, WY	UP	66
Big Sandy, TX	UP	36
Spokane, WA	BNSF	39
Campbell, WY	BNSF	40
Shelby, MT	BNSF	24

SOURCE: Railroad Merger Documents

Coal Trains Benefit the Entire U.S. – The West's coal is a valuable national resource which benefits the receiving state (Midwest, East Coast, etc.) and the production state (Wyoming, etc.). In between, in the "bridge" states, the grade crossing problems intensify, with little benefit to the disrupted communities. For example, coal production in Wyoming has increased from 7.0 million tons in 1970 to 192 million tons in 1993[2] to 315 million tons in 1998[3]. Nearly all of this coal is transported by rail. Examples of increases in rail traffic densities resulting basically from coal trains follow.

Exhibit 5-35
EXAMPLE MAIN LINE TRAFFIC DENSITY INCREASES

Line Segment	Prior Tonnage (1) (Date – Tons)	Post Merger Tonnage (2)
BNSF East of Donkey Creek, MT	1977 - 49	131
BNSF "South Line" West of Bismarck, ND	1978 - 10-20	50
UP between North Platte-Gibbon, NE	1975 - 100	265

SOURCE:
(1) State Rail Plans.
(2) Respective Merger Documents (BN and ATSF, UP and SP)

[2] Wyoming Rail Plan, prepared for the Wyoming Department of Transportation by Wilbur Smith Associates in association with Banner Associates, May 1996.
[3] Geological Survey of Wyoming.

DM&E Prospective Rail Line Grade Crossings Issue – The Dakota, Minnesota & Eastern Railroad (DME) has filed an application with the Surface Transportation Board (February 20, 1999) to construct approximately 280 miles of new railroad into the Powder River Basin (PRB) coal fields. The purpose of the project is to provide more efficient access to this low-sulfur coal for Midwestern utilities. The project will also involve upgrading of 600 miles of the existing railroad from western South Dakota to the Mississippi River. Initial project cost is estimated at $1.2 billion.

Initially, 40 million tons of coal per year are estimated to move over the newly created route. Annual tonnage would increase to 100 million within 10 years. This latter tonnage represents approximately 10 percent of total current domestic demand, and 20 percent of the PRB's projected year 2010 production of over 500 million tons.

The initial demand will require the operation of approximately 14 trains (7 loaded and 7 returning empties) per day. Adding the 14 trains to the 3 trains per day on the existing route, results in a total of 17 trains per day which will increase as the coal traffic increases. The DME route will be equipped with a Centralized Traffic Control system or with positive train control, the latter currently in the development and testing stage. Major at-grade rail-roadway crossings are to be equipped with state-of-the-art lights and gates with the effort coordinated (and prioritized by) the Federal Railroad Administration and individual state Departments of Transportation (the existing 600 miles contain 446 public at-grade crossings, of which only 17 have active warning devices). Communities along the route will experience grade crossing impacts of a greater proportion than with current DME operations, especially if projected levels of traffic materialize resulting in up to 37 trains per day.

This proposal will indeed divert trains that would operate over other main lines. However, as the demand for PRB coal continues to increase with new air quality regulations, there will still be an overall increase in the number of coal trains on railroad main lines throughout the West.

Urban At-Grade Crossings – There are also grade crossing problems in the WTTN's cities. The urban grade crossing issues are perhaps similar to the rest of the U.S. Many cities (Seattle, Portland, Oakland, Long Beach, Los Angeles, etc.) have grown up around their ports. The result is that the ports are now located in completely developed, congested parts of town. These ports are served by a multiplicity of urban rail lines, most of which now cross streets at-grade. Some of the West's most expensive projects, e.g., the Alameda Corridor, are attempts to address these issues. Similarly, the West's COFC/TOFC terminals are often located in cities which have grown up around the railroad yards with at-grade crossings being a major problem. These issues are discussed in more detail in other sections of this chapter.

Solutions and Benefits of Grade Crossing Solutions

The rail-roadway at-grade crossing issue is probably one of the industry's largest issues and, ironically, one in which the public sector has a significant role.

Menu of Solutions - Potential solution types consist of those which eliminate grade crossings and those which improve safety and/or operations.

- Eliminate at-grade crossings by
  - Closing crossing;
  - Grade separating crossing (using overpasses or underpasses);
  - Rerouting either the rail line or roadway to eliminate the need for crossings; or
  - Separating the operating times of the different modes.
- Improve safety at at-grade crossings (if not eliminated) by
  - Improving sight distance;
  - Improving warning devices – improve inactive warning devices, replace inactive devices with active devices, add travel lane gates, create four quadrant gates; and
  - Installing roadway median barriers.
- Improve crossing operations by

- Maintaining crossing surfaces;
- Maintaining crossing warning devices;
- Installing smooth crossing surfaces;
- Installing roadway traffic control preemption devices;
- Devising improvement plans on a corridor-wide basis; and
- Fully considering area roadway traffic operations when planning crossing improvements.

Potential Benefits - The railroads, motor vehicle operators, pedestrians, bicyclists and the community at large all can benefit from the broad spectrum of potential grade crossings improvements. For example:

- *Improving Safety* - Reductions in property damage, personal injury and the loss of life for both modes are potential benefits of improving at-grade crossing safety. Ready and speedy access by emergency vehicles will also be a benefit.
- *Improving Operations* - Crossing blockage results in delays, increasing vehicle and operator costs. Rough crossing surfaces increase vehicle maintenance expenses. Reduced operating speeds for railroads over areas of concentrated crossings produce the same results. Grade separations would benefit both vehicles and operators.
- *Installation and Maintenance Costs* - At-grade crossings are expensive to install and maintain. The larger the crossing surface, and the more advanced and extensive the warning devices, the larger the costs. Maintenance expenses relate not only to the warning devices and crossing surface, but become an added burden to the railroad when maintaining track. The crossing surface has to be removed, for example, to install cross ties and surface track. Grade separations therefore benefit the railroad by reducing these costs.

At-grade crossings are a problem for both the public and the rail carriers. Both parties benefit from workable solutions and should be involved in the process.

Chapter 6
CONCLUSIONS AND RECOMMENDATIONS

This two-phase WTTN study addresses surface freight transportation systems, issues and needs throughout the 17-state western region. The study was conducted because:

- The state DOTs recognize the importance of properly incorporating freight issues and needs into their transportation planning programs;
- There is increasing interest in trade corridors, border crossings, the relationship between transportation and economic development, and freight transportation in general;
- There is a need to place each "trade corridor" into its proper perspective; and
- Trade and freight transportation needs seem to be increasing in importance as the nation moves into the 21st Century.

TRADE AND TRANSPORTATION: INCREASINGLY IMPORTANT

The need for the west's shippers to be able to have their cargo moved quickly and efficiently is increasing in importance. Logistics, "seamless transportation," "intermodalism," "trade corridors," and other facets of freight transportation have increasingly become a topic of state DOT and U.S. DOT interest and concern.

By sponsoring this study, the western state DOTs have demonstrated their interest. The states are aware that development of customer-responsive transport logistics infrastructure is fundamental to the economic development success of the region. There are fundamental trends and factors that need to be considered in relating transportation systems and infrastructure to economic development and freight and logistics needs. These trends stem from the increasingly global economy, and the ways in which firms are trying to be competitive in this evolving climate. For the WTTN states, trade with Canada and Mexico (the NAFTA nations) and with the Pacific Rim nations is expected to have an influence on how logistics infrastructure is shaped.

Trade between nations and between states is requiring more from each WTTN state's transportation system. These increasing requirements are a result of many changes that are occurring, including:

- *Trade Growth* – Trade, especially international trade, through the western states is expected to more than double over the next 20 years. The sheer magnitude of this increase will significantly impact the need for additional transportation infrastructure capacity (highways, railroads, ports, airports, intermodal facilities).
- *Redistribution of Industrial Production Centers* – Companies are constantly changing the way they manufacture, and where they manufacture. This impacts the way goods flow, which in turn creates new freight densities and corridors. Emerging corridors provide challenges and opportunities for both transportation facilities providers (providers of highways, rail lines, intermodal facilities) and sellers of transport services (trucking companies, railroads, grain elevators, etc.).
- *Changes in Manufacturing Practices* – As new industries come on line, traditional industries are being forced to restructure and change the way they do business. These changes are impacting freight shipment requirements such as modes used, service levels required, etc.
- *Changes in Freight Transport Needs* – Since the onset of Just-In-Time (JIT) and other manufacturing practices, transport needs have changed, and will continue to change. The JIT industries look at reliability, transit time, efficiency, cost and damage control when evaluating transportation service. State DOT programs influence all of these factors.

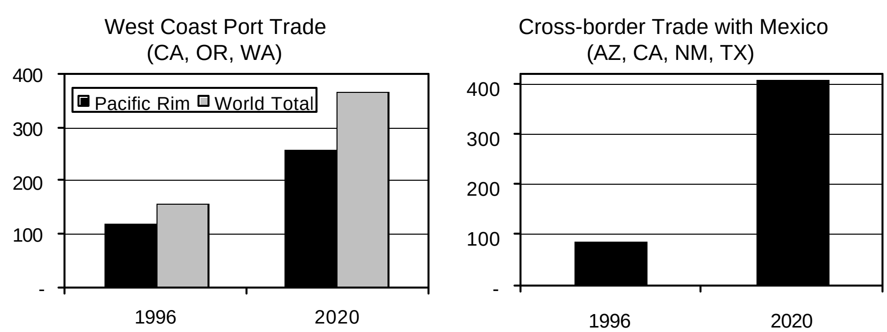
Magnitude of Trade Growth

Trade through the western states is expected to more than double over the next twenty years. The international portion of this growth is largely with the Pacific Rim and the NAFTA countries.

The Pacific Rim Countries - Despite an economic downturn during 1997-1999, ocean trade with the Pacific Rim countries is expected to more than double by 2020, growing from an estimated 120 million tons in 1996 to 260 million tons by 2020. This includes container trade such as manufactured products, as well as bulk and break bulk products such as agricultural products and natural resource products (excluding crude petroleum and natural gas). China is seen as the "sleeping giant" that will drive trade once it eventually undergoes all of its institutional, political and economic changes. Asian "Tigers" like Thailand and South Korea have reportedly bottomed out of their economic woes and are on their way to recovery. Their weaker currencies were a key to boosting exports and that has helped them fight to their way out of their financial crises.

NAFTA Trade – The border states have experienced a great deal of trade growth since the introduction of NAFTA. This is particularly true for the states bordering with Mexico - Arizona, California and New Mexico. And trade through these states is expected to grow by a factor of almost five times by the 2020, from just over 21 million tons in 1996 to over 100 million tons by the year 2020.

Exhibit 6-1
EXAMPLES OF WTTN STATE INTERMODAL TRADE FORECASTS
(Million Metric Tons)



SOURCE: Latin American Trade and Transportation Study, Wilbur Smith Associates, 1999.
NOTE: Trade in all commodities, excluding Crude Petroleum and Natural Gas.

Notwithstanding the other segments of the trade picture (cross-border trade with Canada, ocean trade with other global regions, air cargo), this forecast trade will significantly impact freight transportation infrastructure needs. These would include gateway facilities such as ports, airports, and border crossings, as well as the surface modes (highways, rail and waterways, etc.).

Changing Industrial Production Centers

Although all the trade data is not yet available, it appears that NAFTA has spurred trade growth among the NAFTA partners. For western states, there are several key industrial trends and opportunities stemming from NAFTA trade.

- NAFTA has led to the development of a North American trade and industrial complex.
- The growth in NAFTA related freight densities is helping to improve transportation service levels.
- NAFTA trade is characteristically high value and JIT, placing pressure on more efficient modes of delivery.

Western states, through the continuous development and improvement of their regional freight transportation logistics infrastructure, stand to gain from these trends and opportunities.

The NAFTA Industrial Trade and Production Complex – NAFTA has lead to the development of a de facto trade and industrial complex that stretches across North America. While NAFTA is conventionally viewed as a tool for expanding markets into neighboring countries, it is more than that. NAFTA trade includes trade in intermediate goods between plants/suppliers located in member countries. U.S. manufacturers have established multinational production bases across North America that allow them to effectively manage their factors of production (labor, capital and raw materials), thereby allowing them to maintain a competitive advantage in the global market place. An example is the popularity of “maquiladora” factories in Mexico which are used by U.S. companies to lower production costs for labor intensive processes. Maquiladora activities largely involve manufacturing plants in Mexico which assemble products using U.S. or other foreign components[1].

This trend presents an economic development opportunity for the western states. Developing a logistics infrastructure to support the growth of this new industrial complex will give the WTTN states an edge in attracting industrial development.

The key target industries are makers of, and suppliers to makers of, high tech consumer durables with a relatively short product life cycle. Such sectors rely on the cost efficient movement of parts and components between suppliers, plants, warehouses, and delivery to customers. They include the automotive, electronics, computer, communications, and household appliances sectors. Other sectors that offer opportunities are food and agriculture.

Freight Densities and the New North-South Trade Corridors – Freight densities are fundamental to the quality, level, frequency and cost of freight service. High freight flow densities allow service providers to build cost-effective service networks and routes for their customers. In turn, improvements in freight service lead to efficiencies for industrial customers, thereby improving their competitiveness. Freight densities therefore provide the basis for sustained industrial advancements in the WTTN states. NAFTA trade is impacting the distribution of freight densities throughout border states, as well as the routing of the trade.

For example, U.S.-Mexico maquiladora trade is primarily concentrated between the U.S. and Mexican border states and, between the Mexican border states and the United States' industrial northeast. Traditional trade, by contrast, is more diverse in terms of product origins and destinations and is usually shipped further into the interior of Mexico or the U.S.[2]

NAFTA's emerging north-south freight densities are manifesting themselves in the form of north-south trade corridors that intersect with the traditional east-west corridors. A case in

[1] Binational Border Transportation Planning and Programming Study; 1997, La Empresa, Barton-Aschman
[2] Ibid.

point is the development of the I-5 (High Priority Corridor 30), Canamex (High Priority Corridor 26), and I-35 (High Priority Corridor 23) corridors.

The emergence of the north-south trade routes presents an opportunity for the western states to capitalize on freight densities as a means of attracting industry. Lower transportation costs are an important site location criterion for industry. Developing adequate logistics infrastructure is a step toward drawing the freight densities to western states, thereby improving their competitive edge.

Trucking Will Continue to Play an Important Part in NAFTA Trade – Putting aside trade in natural resource commodities, which moves via the bulk modes, NAFTA trade is characteristically high value and JIT oriented. On the surface, trucking is the most efficient means of transporting such trade because trucks can deliver goods between virtually any two points. The majority of freight movements in the U.S. are by truck. Therefore, as NAFTA trade continues to grow, so will the importance of an efficient trucking logistics system.

Balancing the need of an increasingly efficient truck freight logistics system, and the economic benefits derived from a competitive U.S. economy, with the safety and efficiency needs of the other highway users, will require coordinated multi-faceted planning. States that fall into the existing and new NAFTA trade routes have to plan to adequately accommodate truck freight traffic, or stand to lose the economic benefits of NAFTA.

(Inter)Modal Optimization – While trucking will continue to play an important role, modal optimization is another key to gaining benefits from the NAFTA trade. An efficient transport logistics infrastructure that allows shippers and logistics service providers to conveniently choose between modes, so as to balance cost savings objectives with customer delivery time needs, is important to sustaining the NAFTA industrial trade and production complex. As NAFTA trade densities continue to grow, so do the opportunities for modal choices for shippers. High densities produce the economies of scale necessary for transport service providers to cost effectively consolidate shipments to lower cost modes.

Opportunities for intermodal optimization are best for a key group of freight lanes with specific density, length and commodity characteristics. Rail intermodal opportunities are best for:

- High value commodity lanes, with moderate densities and distances of more than 500 miles; and
- Dry goods commodity lanes, with high densities and relatively shorter hauls.

The opportunity for the WTTN states to enhance intermodal optimization is to develop an intermodal infrastructure of reload centers, especially at the border post interface points and at inland freight intensive markets, in tandem with the private sector, that is consistent with NAFTA's commodity freight lane structure.

Changes In Manufacturing Practices

There are a core set of manufacturing practice changes that relate to trade. These are summarized as[3]:

- Shorter Product Life Cycles;
- Specialized Freight;
- Remanufacturing;
- Globalization;
- Core Competencies; and
- E-Commerce.

[3] Role of the National Highway System Connectors: Industry Context and Issues, FHWA; February 1999.

Shorter Product Life Cycles – Consumer demand domestically and internationally is driving the growth of the new high tech consumer industries such as computing, communications, household electronics, computer games, and the automotive sectors. These industries, to varying degrees, all have short product life cycles. For example, computer chips double their speed every 18 months. The result is, high tech industries have less time to get a product from the drawing board to the shelf, which translates into shorter transport windows, which in turn places great demands on the transportation systems.

Specialized Freight Requirements – High tech industries also have special freight requirements. Their products tend to be smaller in size (cube and weight) and higher in value. These characteristics, combined with the aforementioned time sensitivity, differentiate them from traditional freight handling requirements. Such shipments tend to be more frequent, smaller in size, and to a more far-flung customer base. Because these shipments have the price margins to overcome the cost of more efficient and faster modes, they are biased toward air and truck (LTL) modes. A great deal of the Asian air cargo growth is driven by the high tech industries. Also, NAFTA trucks are laden with high tech parts and components to and from the maquiladoras.

Remanufacturing and Replacement – The onset of remanufacturing, especially on the high tech end, is increasing and also impacting the nature of freight shipments. Although this segment is arguably small when compared with the more traditional volumes, it is unique in the way it influences advances in logistics services. An example of remanufacturing are printer cartridges that are shipped to service centers to be cleaned, retooled and refilled for resale. This is an example of small, frequent shipments that come in from a far-flung customer base, before being redistributed. Again, small frequent shipments tend toward more efficient, and costly, modes such as trucking. Another example is replacement parts and accessories for the automotive after sales market. These are typically time definite shipments that tend towards air and/or trucking.

Globalization – Globalization certainly changes the nature and extent of international trade and freight. In this context, "NAFTAzation and Asiazation" are trends that refer to the development of new markets to sell in, and to produce in. For example, the devaluation of some Asian currencies produced a boon for Asian exports to the U.S. Aside from the sheer magnitude of trade, it severely impacted the balance of equipment. West coast ports built up large inventories of empty containers as a result the trade imbalance. Furthermore, this came at a time of the rail mergers, which were ill-prepared for the Asian surprise. In a less global economy, these shocks would not have been as severe.

Core Competencies – Complexity breeds specialization. In order to cope with all of the challenges of operating in far flung markets such as Asia, Mexico and Canada, industries are turning to their core competencies. In other words, industries are outsourcing, including parts of or all of their transport, warehouse, distribution and logistics activities. While this is not the case with all industries,[4] many industries reason that they are not in the trucking and logistics business. Transport and logistics is viewed as one of the frontiers for cutting costs, and to effectively do so typically requires specialization in that business. Industries are therefore looking at third party specialists to cut costs and improve efficiencies, thereby allowing them to focus on their core competencies. One example in the high tech semiconductor business is National Semiconductor which relies on air freight integrators (like FedEx and UPS) to manage their entire logistics chain, including ground and air transportation (makers of semiconductors rarely use ocean freight), as well as warehouse and distribution.

E-Commerce – The Internet is the driver behind the growth in ecommerce trade. Customers are able to order products online and expect delivery within hours or days. Vendors are able to delay the final assembly and packaging of products until the order is taken. The benefits include allowing vendor to customize products, improve cash flow by delaying final stage costs until the order is taken and lowering distribution/retail costs by cutting out a whole

[4] In fact some industries are doing the opposite by focusing on these functions, specifically the warehouse, distribution and logistics of service and replacement parts, which is seen by some as a valued added business activity.

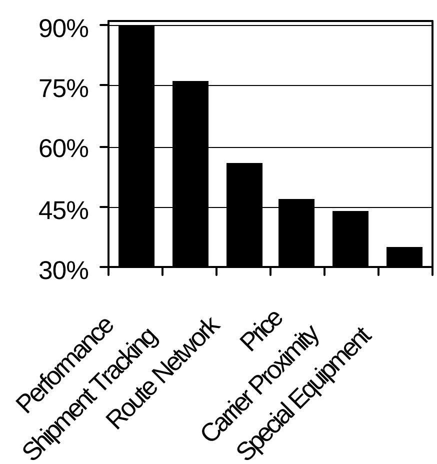
layer of distributors/resellers and the cost of retail shelf space. The impact on transportation is that shipments are small, frequent and high in value. As stated earlier, such shipments tend toward the more efficient and costly modes such as air and trucking (LTL).

Freight Transport Service Requirements

The economy is increasingly customer driven, a phenomenon that is spilling over to the transportation and logistics service sectors. High value markets, the ultimate customers as well as intermediate businesses, are demanding service reliability. Even for the lower value commodity where there is little perceived product differentiation, service is key. A logistics system that allows companies the flexibility to respond to customer needs is important to maintaining a competitive edge. Modal choice is central to the ability to balance customer cost needs versus time delivery needs on a shipment by shipment basis.

The growing emphasis on speed, efficiency and reliability is changing the service requirements expected from the freight transport and logistics sellers.

Exhibit 6-2
CUSTOMER EXPECTATIONS FOR FREIGHT TRANSPORTATION SERVICES
(Since the Onset of Just-In-Time Practices)



SOURCE: Comprehensive TS&W Study, Working Paper 8; FHWA
NOTE: This data represents JIT oriented industries.

A recent study revealed that a carrier's ability to respond quickly and reliably to customer needs is the leading trend among customer expectations.

WTTN PHASE I FINDINGS

Within the context of these logistics events and needs, the WTTN study examined that freight logistics system. The WTTN Phase I work is found in the Final Report dated May 9, 1997. Phase I identified the WTTN state key freight transportation corridors, identified the region's modal systems, identified transportation issues and deficiencies, and assembled interstate freight transportation statistics by mode used, origin/destination and commodity. Following are some of the findings from the WTTN Phase I report.

Multi-State, Regional Approach to Trade Corridors

The WTTN study represents an attempt at multi-state coordination and cooperation in addressing trade corridors and freight transportation in general. The study generated a number of conclusions, from that multi-state regional perspective.

- Long-distance trade does travel in defined trade corridors, most of which are multi-state in nature and most of which are multimodal in nature. These trade corridors are identified in this WTTN study.
- Trade generally moves from origin to destination without regard for state and even international borders. The private sector makes its plans and carries its freight with little attention to such boundaries. States, however, tend to be constrained by such boundaries since their planning and funding is limited to their single state. Improved decisions regarding mult-state trade might be possible if the states were able to develop multi-state trade corridor planning and program approaches.
- There is considerable diversity among the states relative to trade emphasis and attention to freight transportation. Some states have excellent trade data, freight studies and knowledgeable freight expertise; others do not maintain such expertise or interest.
- Because so much freight moves between states, deficiencies or activities in one state can affect trade activities in another state. Therefore, regional (multi-state)

approaches and sharing of information between states are potentially important to the creation of an efficient regional freight system.

- To reflect the multi-state nature of trade corridors, the U.S. could develop some type of mechanism whereby multi-state corridors can be cooperatively planned, programmed and funded.
- The western U.S. has many of the fastest growing population centers in the U.S. This means increased demands on the freight transportation system; it also means continued conflict between the need to move large volumes of freight through communities, and the impact of such movements on those communities.
- The seamless movement of trade across state and national borders is essential for the economic vitality of the western states, the nation, and international trade. This implies similar or common regulations, reporting requirements and operating standards.
- The WTTN states are well positioned to reap the benefits of increased trade, of the North American Free Trade Agreement (NAFTA) and the General Agreement on Tariffs and Trade (GATT), the huge Asian economies, and of freight transportation in general. Coordinated action by the western states may be needed to enable those benefits to occur. WTTN believes that the western states should promote such action from a coordinated, multi-state perspective.

Trade Flows and Freight Data

This study collected, reviewed, and summarized commodity movement, freight transportation, and trade data that are currently available. That information proved useful in identifying the trade corridors. The study yielded a number of observations regarding trade flows:

- Trade flows move overwhelmingly in the historical east-west directions, with more limited movement north-south (there are exceptions – the north-south I-5 corridor on the west coast; the Wyoming to southeast direction coal movements). This helps to explain the historical development of the west's east-west rail and highway networks.
- Trade flows have become increasingly intricate and interdependent, with the global economy depending on the exchange of goods and services. Increasingly a single product (an auto, for example) may have component parts from more than a dozen states and foreign countries. Efficient trade and efficient freight transportation will help the western states to be competitive in the global economy.

- International trade is accelerating. U.S. foreign trade doubled in the past decade, and comprises 12.3 percent of the nation's commerce. Clearly the WTTN states need to do everything possible to reduce barriers to efficient international trade.

WTTN Corridors in the Western U.S.

Considerable effort was expended in this study to identify the major trade corridors of the western U.S. This designation process, and its results, yielded a number of trade corridor conclusions.

- The trade corridors identified in this study comprise the "WTTN Network," shown previously in Exhibit 1-1.

- The trade corridors are all multi-state and/or international in nature. Cooperative and coordinated multi-state approaches to the transportation corridors may therefore have merit and may in fact be essential.

- While some trade corridors dominate in terms of tonnage moved or value handled, everything is relative. On a proportionate basis, a less used corridor in a sparsely populated state could be relatively more economically significant to that state than is a heavily travelled route in a heavily populated state. Hence, there is a need for trade corridor designations throughout the western U.S.

- The interrelationships in trade movements suggest that it is too simplistic to regard trade as comprising a series of individual trade corridors. Instead, as is the case with passenger transportation, the WTTN is a true "trade network" – just as the name implies.

- The trade origin/destination statistics support the contention that there are many trade "bridge" states; that is, much of the freight carried in a certain state is merely passing through on either rail or highway. Maintenance costs and operational impacts are incurred by the bridge state, with little or no economic benefit. The need for multi-state coordination and approach is once again apparent.

- Multi-state highway corridor coalitions (interest groups) are becoming increasingly prevalent. These groups are corridor specific and multi-state in nature. Multi-state corridor-specific coordination by the states might be a timely approach.

- The technical advances offered by Commercial Vehicle Operations (CVO) and other Intelligent Transportation System (ITS) approaches to improving freight transportation efficiency especially lend themselves to multi-state approaches to corridor evaluation.

Corridor Deficiencies Which Affect Efficient Freight Transportation

Phase I then identified perceived transportation facility deficiencies in the designated trade corridors, from the freight perspective. The deficiencies work suggests the following conclusions:

- Every defined WTTN Trade Corridor has some identified transportation infrastructure deficiencies both in urban and rural settings, although the deficiency magnitudes and types differ considerably. From the freight perspective, therefore, there is work to be accomplished in every WTTN corridor.

- Geometrics/surface conditions and capacity/congestion deficiencies are noted on most WTTN highway routes. These affect both freight transportation efficiency and passenger transportation efficiency.

- According to the states, most WTTN corridors with rail lines have some type of noted deficiency. Therefore, the WTTN states should be concerned about both the highway systems and the rail systems, as well as the intermodal facilities and services.

- The deficiencies have been identified in rather broad terms. Specific projects, investments and associated costs were not attempted in this study.

- There are insufficient funds available to the states, federal and local agencies, to effectively deal with this magnitude of infrastructure deficiencies. Therefore, priorities and prioritization processes (using, for example, performance measures of some type) are needed – within corridors, between corridors, within and between modes, between projects of various types, and within and between the participating WTTN states. The states do not collectively have a procedure whereby trade-oriented projects or investments can be prioritized.

- Public investment in transportation infrastructure in the WTTN corridors is but a small part of the total economic cost of freight transportation. The larger part is the huge cost of using that infrastructure, especially the cost of shipping and carrying goods to market. A balance between the costs of public infrastructure investment and the costs of freight carriage is requisite.

- Portions of the western U.S. have economies which require an efficient and safe railroad network. Although most of the rail system is privately owned, with investment decisions made based on market forces, there is still a role for the public sector. Public programs which assist in the maintenance of needed railroad infrastructure are beneficial to the WTTN states. At the federal level, the Local Rail Freight Assistance and the Rail-Highway Crossing programs are needed, and

Congress is encouraged to continue to fund those worthwhile programs. They are important to the western states.

- Efficient freight transportation across the Mexican and Canadian borders is important. Multi-state and multi-national (border crossing) efforts should be continued, e.g., the bi-national border crossing studies and the bi-national discussions.

- Because the capital investment needs are so large, and the available funding so limited, the deficiencies cannot be resolved solely by investment in infrastructure. The western states also need to be more technologically and operationally efficient via the use of ITS, CVO, and other low cost and technologically advanced ways of increasing transportation efficiency.

- The evolution of some forms of freight transportation has moved from cost based decisions to speed based decisions. Freight transport speed, and delivery reliability, have replaced cost as key decision criteria for many in the trade industry. Speed and reliability implies an efficient transportation system.

- The freight modes (rail, highway, pipeline, water, and air) were basically developed independently of each other. It is little wonder, therefore, that intermodal transfer facilities need attention. Locations of many intermodal facilities are not optimum; new facilities may be needed; and others need investment for improvements.

The WTTN Phase I work went on to suggest that additional, more detailed work was needed. Among other things, this more detailed work should include:

- Review of intermodal freight facilities in the WTTN states, including their identification and discussion of their issues;

- Identification of how well the west's highway systems are performing (from the freight industry's perspective); and

- Identification of solution possibilities, and explanation of how the alleviation of deficiencies might help the economies of the WTTN states.

These results led to the conduct of WTTN Phase II.

A SUMMARY OF WTTN PHASE II

Based in part on the generalized results of WTTN Phase I, the WTTN states decided to proceed with Phase II. Phase I was a regionwide investigation of transportation and trade; Phase II is a more detailed review of deficiencies and performance of specific transportation facilities. The “facilities” examination in Phase II covers all modes and intermodal facilities such as rail/truck COFC/TOFC terminals, water ports, airports, and grain elevators. The overall purpose of Phase II is to assess truck and freight transportation performance against a unique set of performance criteria, and then explain potential economic benefits associated with implementing a variety of possible solutions that address deficiencies and improve performance.

Freight Facility Identification

A significant goal in WTTN Phase II was to identify actual freight transportation performance in each WTTN corridor. To accomplish this, the study identified those specific freight facilities (specific highways, rail lines, intermodal facilities) that are construed as being of regional freight importance to the trade corridor.

- *Highways.* The states identified a 26,346-mile network of higher order roadways for inclusion in the WTTN analysis. The WTTN Highway Network is comprised of 94 percent of all interstate highways in the Region, 18 percent of the other National Highway System (NHS) routes, and several isolated non-NHS arterials. The WTTN highways are divided into sections, called *supersegments*, which facilitates analysis; the highway network was divided into 206 supersegments. Separate supersegments were made for most urbanized areas and when WTTN highways intersected, representing a routing decision point. Supersegments average about 130 miles in length.

- *Rail Lines.* Most principal rail lines in the western U.S. are part of the WTTN Rail Network, including most trackage on the BNSF and UP systems. Because the principal rail lines handle most of the freight traffic, most low-density lines were excluded from the WTTN network.

- *Intermodal Facilities*. A unique aspect of the WTTN analysis is the inclusion of intermodal facilities in the WTTN facility network. These facilities handle a significant portion of freight volumes headed to/from the WTTN Region. Because the transportation efficiency aspects of freight movements are so essential to regional competition, evaluation of intermodal access issues at these facilities helps extend the understanding of intermodal obstacles. The states designated 335 freight intermodal terminals for inclusion in the WTTN study.

- *Airports* – Although airports handle relatively low volumes of freight, the value of commodities transported by air is quite high, making them important components of the freight system. The growing nature of air cargo, especially in the overnight parcel business, makes efficiency of the truck/air transfers an important intermodal consideration. The WTTN states identified 18 airports for inclusion in the study.

- *Water ports* -- 28 public-use/public port authority water ports are included in the WTTN evaluation. These include sea ports as well as river ports.

- *Rail intermodal* – TOFC/COFC facilities (50), grain elevators (234), and rail reload terminals (5) are designated.

Highways Evaluation – A systematic process was established whereby each highway included in the WTTN network is assessed in terms of estimated truck performance compared with performance goals.

- For highways, a *performance-based process* focused on four basic indicators of truck performance (operating speed, operating cost, safety and reliability).

- This performance-based process used pavement/bridge condition, roadway geometry, roadway alignment, and congestion to assess truck performance.

- Each performance measure was translated into a set of Minimum Tolerable Conditions (MTCs), which were applied uniformly across the WTTN Region. An MTC is the lowest acceptable threshold for condition, geometry and operation in specific, measurable areas.

- Models were developed that used highway data to calculate existing conditions on the WTTN highways and to compare them with the MTCs to determine if a roadway *deficiency* exists.

- An HPMS *Systematic Approach* to assess deficiencies, based on the FHWA database and analytical package, was utilized to assess highway conditions.

- Highway deficiencies were determined in the following areas for each WTTN Trade Corridor:

- Pavement condition
- Lane width
- Vertical alignment adequacy
- Horizontal alignment adequacy
- Shoulder width
- Speed limit
- Current capacity (1996)
- Future capacity (2016)

- The quantification of deficiencies allowed the calculation of truck operating speed for both peak and average daily conditions to assess *truck-operating speed* versus calculated target speeds. *Thus, operating speed became the key indicator of truck performance calculated in the WTTN Phase II study.*

- The *potential for improving operating speed* on WTTN highways was also estimated. This was done by simulating unspecified improvements that address highway deficiencies and calculating the potential improvement in operating speed (and time). The effort was conducted to estimate the potential for speed improvements only.

Highway Performance and Deficiencies – A significant portion of the effort associated with WTTN Phase II concerned deficiencies and performance of the specific highways included in the 20 WTTN Trade Corridors. A critical early step in performing these evaluations was the identification of Minimum Tolerable Conditions and applying available data through deficiency models to identify deficiencies that affect performance (operating speed). The HPMS database was used as the starting point.

The states were asked to supplement the data available (HPMS database) by providing roadway characteristics information for the non-sampled portion of their WTTN highway network. With all of the available data included, the highways were evaluated against the Minimum Tolerable Conditions on a supersegment basis. Supersegment deficiency data was expanded (when less than 100% of the highway was sampled) and summarized on a corridor basis. The following highway results were noted:

- Highway Deficiencies – The most frequent deficiency in the WTTN Highway Network is capacity, especially future capacity (22.5% deficient), followed by pavement condition (12.4%), and current capacity (7.2%).

- Urban WTTN highways have significantly higher deficient mileage than do rural WTTN highways in the following categories: pavement condition, current capacity, speed limit, lane width, and future capacity.

- Of the 25,734 bridges serving WTTN highways, only 327 were found to have a deficiency (48 with posted load limit, 279 with low operating rating), which can lead to operational problems, delays and extra costs due to detours. Eighty-four of the deficient bridges (nearly 26 percent) are in two corridors (12 and 14). Corridor 13 had no deficient bridges.

- WTTN highways have fewer deficiencies, on average, than similar highways nationwide in lane width (rural and urban), current capacity (urban), and pavement condition (urban and rural). Rural WTTN highways have a higher share of current capacity deficiencies than the national average.

- WTTN Trade Corridors with a higher share of rural two-lane highways generally have more deficiencies than those with mostly multi-lane highways. The rural two-lane facilities, especially those in the mountain states, generally have more alignment, speed limit, and capacity deficiencies.

- Specific observations regarding deficiencies in WTTN Trade Corridors include:

    - Corridor 7 (Mexico-Canada) has the highest percentage of pavement deficiencies (34.3%) and nearly the highest amount of future capacity deficiencies (64.2%).

    - Corridor 9 (Boise-Canada), with its mostly two-lane highways through rugged terrain, has the highest amount of lane width deficiencies (11.1%), vertical alignment deficiencies (5.4%), deficient horizontal alignment (18.1%), current capacity deficiencies (40.2%), and future capacity deficiencies (65.7%).

    - The corridor with the most narrow shoulder mileage is Corridor 12 (Montana-Canada (76.5%).

    - Corridor 18 (Laredo-Indianapolis) has the highest share of speed limit deficiencies (12.3%).

    - The corridors with the fewest deficiencies are Corridor 13 (Canada-Minneapolis-Chicago) and Corridor 15 (Mexico-Arizona).

- Only three WTTN corridors (6, 7, and 15) meet the target truck operating speed for both single unit and combination trucks. Four corridors (2, 5, 10, and 17) meet the operating speed target for single unit trucks.

- Three WTTN corridors have truck operating speeds significantly less than the target speed; Corridor 9 (Boise-Canada), Corridor 12 (Montana-Canada), and Corridor 20 (Montana-Canada).

- The greatest potential improvement for *average daily times* in operating speed (and time saving) is in addressing speed limit, congestion, and pavement condition deficiencies. However, the overall cumulative estimated benefit from all potential improvements is only 2.5%.

  - Alignment improvements provide more benefits to combination trucks than to single unit trucks.

  - Improvements are not uniform among the corridors because of the deficiency mix and the mixture of interstate/non-interstate type highways. Larger improvements were noted in corridors with more two-lane highways.

  - Speed limit improvements tend to have greater benefit on lower functional classifications.

  - Corridors showing little potential for speed/time improvement include Corridor 6 (Texas-Memphis) and Corridor 11 (Pacific NW-Kansas City).

- Potential time savings during peak hour are higher, mostly due to congestion relief. The corridors with the highest potential benefits are those with the most urban mileage (Corridors 2, 5, 6, 7, 10, and 15).

Railways Evaluation – For the analysis of deficiencies in rail performance in WTTN corridors, 55 rail shippers were surveyed. The focus of analysis was on the main line routes of the Burlington Northern and Santa Fe Railway (BNSF) and the Union Pacific Railroad (UP), the predominant operators in the WTTN corridors. A summary of findings follows.

- Four types of performance standards were identified by rail shippers. Deficiencies in these performance standards were defined as the extent to which actual railroad performance varied from shippers' expectations. These standards pertained to transit time reliability, car availability, customer service, and the price of rail transportation services. Of these**, transit time reliability and car availability** were the standards of primary concern to the shippers.

- Shippers reported that both BNSF and UP were delivering **mediocre transit time reliability** on many routes. These observations persisted through most of 1998, a time when both railroads were known to be having substantial operating problems.

- Shippers also reported **shortages in car supply** on both railroads. BNSF was seen as having a worse supply condition than UP. However, only a minority of responding shippers reported supply conditions to be good on either railroad. More than three fourths of cars reported in short supply consisted of four car types: box cars, covered hopper cars, gondolas, and open top hopper cars.

- Many shippers also reported being less than satisfied in various performance areas grouped together here as **customer service**. Specifically, shippers reported deficiencies with regard to the on-time pick-up and delivery of cars, accurate information on shipments, sufficient resources and training enabling employees to respond effectively to shippers' needs, and the ability of employees to fix service problems.

- While the **price of rail transportation services** was cited as a performance standard, the evidence found in the course of this study indicated that, on balance, shippers are paying less for their rail transportation than they have at any time in the recent past.

- Of the performance deficiencies cited above, only the deficiencies with regard to transit time reliability truly lent themselves to analysis on a corridor basis. Nine rail routes in WTTN corridors were identified as having transit times at least 20% longer than expected by shippers. Two of these routes belong to BNSF, and seven belong to UP. However, it should be noted that shippers were reporting an improving transit time reliability on UP toward the conclusion of the survey.

Intermodal Facilities

The WTTN intermodal facility evaluation identified transfer, access and efficiency issues by type of intermodal facility (air, rail, water, truck). Therefore, the study was not able to examine the 335 intermodal facilities *individually*. The observations made in Chapter 5 of this report generally apply to each intermodal facility type.

Airports – Air cargo trends and issues were identified, and 18 airports in the WTTN states were identified as important air cargo intermodal terminals. Example findings included:

- The growth in air cargo is almost entirely due to the success of the integrated carriers (overnight parcels).

- U.S. domestic air express is growing at about 10% annually, creating a need for additional truck access capacity at western airports.
- International air cargo could increase dramatically (triple) over the next 20 years. However, recent economic problems in Asia make the near term outlook for growth less optimistic.
- Air cargo utilizing the west's airports is increasing faster than air cargo growth nationwide.
- Truck-to-truck freight transfers are also prevalent at airports.
- Multiple truck access points at large airports and the intermingling of trucks and cars limit the potential for addressing access problems.
- Priority to passenger access at major airports often relegates truck access to a "secondary" problem.
- Truck access problems at the west's large airports are much more severe than at medium/small airports.

Grain Elevators – Elevators were viewed as important intermodal facilities by six of the states. These states identified 234 grain elevators for inclusion in the WTTN study**.**

- Grain elevators as freight transportation facilities are of great importance to states with a large agricultural sector.
- The U.S. is the world's largest exporter of grain, making transportation efficiency crucial to a region's competitiveness.
- Transportation must be able to react to abrupt changes in the grain market for the WTTN states to be competitive.
- Grain elevators, as both storage and transfer facilities, are a crucial link in the grain distribution system.
- Transport between the grain elevators and farms, other terminals, and other modes, has been greatly impacted by changes in truck design, rail abandonments, formulation of unit trains, increasing rail car capacity, and rail car availability.
- Evolution of the grain elevator has seen the decline of small country elevators being replaced by larger High Throughput Elevators located on rail main lines.

Rail Intermodal Facilities – TOFC/COFC traffic is increasing, thereby causing rail intermodal to be a major, growing component of freight transportation. Fifty rail intermodal facilities were identified for inclusion in the WTTN study.

- Containerized traffic is growing very fast due to growth of international markets.
- Typical roadway access problems common at railroad intermodal facilities include clearance restrictions, geometric deficiencies, delays (at-grade rail crossings, terminal gate processing) and congestion.

Water Ports – Water ports include west coast and Gulf of Mexico seaports and inland river ports. The WTTN study includes 28 water ports.

- Growth of container traffic has impacted port volumes as well as created numerous landside access issues for both roadway and rail.
- Cargo volumes handled at the six WTTN west coast ports increased by 67% between 1975 and 1997.
- Roadway access to water ports is restricted by operational impediments such as roadway congestion, antiquated/inadequate traffic signals, and poor signage.
- Physical restrictions, such as narrow lanes, inadequate bridge clearances, tight geometrics, weight restrictions, and at-grade conflicts, also impede truck access to water ports.
- Rail access deficiencies include both operational (at-grade crossings, slow speeds through congested areas) and physical (clearances, weight limits off main lines).

Menu of Intermodal Facility Solutions

The WTTN study then identified a variety of access oriented solutions that might be considered at the facilities. A wide range of generic solutions was developed that could help states address individual deficiencies. Once the deficiencies were quantified, one or more potential solutions were drawn from the solutions *menu* as an example of actions that could be taken. In no sense were the solutions to be considered specific capital recommendations.

Potential airport access solutions include:

- Isolate/separate cargo traffic from passenger traffic.
- Incorporate critical characteristics of truck traffic (weights, turning characteristics, etc.) into roadway design.
- Improve truck routing at airports through signage, truck route planning, resolving land use conflicts.
- Improve methods for including truck access features into airport planning.

Potential grain elevator solutions include:

- Identify financial assistance to retain/improve service to elevators located on low density or branch lines.
- Improve elevator capability of handling larger, heavier rail cars.
- Increase load-handling ability of sidings (including length).
- Upgrade equipment to increase car-handling rate.
- Seek a greater awareness of grain truck issues/needs (weights, turning requirements, queuing characteristics, turning lanes).
- Improve main and secondary roadway capabilities of handling trucks, including roadway foundations, surface maintenance, bridges, at-grade rail crossings, intersection geometrics.
- Invest in lock/dam improvements, dredge channels.
- Balance economic/environmental concerns.

Rail Intermodal access solutions include:

- Address physical deficiencies (widen lanes, improve intersection geometrics, provide more direct access).
- Implement operational improvements (new/improved signals, signal timing, turn phases, terminal gate improvements, grade separations).

Suggested water port access solutions include:

- Implement technology improvements (communications, AVI, incident detection, congestion surveillance).
- Address truck access problems through roadway/bridge widening and rehabilitation, traffic signalization, geometric enhancements, signage, weight limitations, truck-only routes.
- Improve truck/rail and truck/ship transfer by coordinating operation/departure arrival intervals.
- Finance/implement rail capital improvements, including new on-dock rail facilities, larger/more efficient yards, new grade separations, rail line consolidation, increased capacity between ports and main lines.

RECOMMENDATIONS

The WTTN study (both phases) addressed the subject of trade and surface transportation on a multi-state, multimodal basis. It took a “trade corridor” approach, and sought to be helpful to the participating states, individually and collectively. No state was asked to adopt the study or its findings. Rather, the study is simply meant to be informative, and perhaps thought provoking, and to help the states to deal with the various trade corridor proposals being proposed by various groups.

But, the study does lead in certain directions. These directions, in the form of recommendations to the states, are as follows:

1. **Trade Corridor Funding** – There is great interest nationally regarding trade corridors. This is exemplified by the overwhelming interest in TEA-21 Section 1118 – the National Corridor Planning and Border Infrastructure Programs. With only $123.6 million available this year for the trade corridors and border crossings program, states and local jurisdictions sent funding applications to U.S. DOT for over $2 billion (the program was greatly oversubscribed). In addition, U.S. DOT was inundated with communications and comments indicating interest in the trade corridors program. Hopefully the U.S. Congress and U.S. DOT are listening, and will more adequately address and fund trade corridors work in the future.

2. **Use of Available Trade Corridors Funds** – The western states were allotted $60.6 million of the $123.6 million available this year in trade corridor/border crossing funds (49% of the total nationally). This is a good sign that the west's freight transport needs are being recognized by U.S. DOT. This WTTN study should be used by the WTTN participating states to seek additional available TEA-21 trade corridor funding in future fiscal years.

3. **Multi-State Corridor Planning** – The characteristics of interstate and international trade, corridor special interest groups and the corridors themselves suggest a need for multi-state coordinated approaches to corridor planning and decision making. The trade does not recognize borders, nor do the corridor interest groups, nor do the carriers or the shippers. Multi-state coordination in the planning for trade corridors makes sense.

4. **Freight Network Planning** – Similarly, network planning as opposed to corridor-by-corridor planning also makes sense. Freight and trade moves over complex networks, just as passengers do. Corridor-specific approaches may therefore be overly simplified. All corridors should be placed into perspective, one with the others.

5. **Inclusion of Freight in Statewide Planning** – As called for in ISTEA and again in TEA-21, and as advocated in WTTN, the 17 western states should strengthen the inclusion of freight issues and needs in their statewide and metropolitan transportation planning processes. Several western states are already doing so, others should consider it.

6. **Inclusion of Freight Interests** – As the individual states include freight in their planning processes, they should include freight stakeholders in the deliberation process. For example, freight advisory councils and other methods should be considered.

7. **Western Freight Partnership** – The Western Freight Partnership suggested by the Western Governors Association in 1996 should be supported, as a logical forum for ensuring that private sector concerns and issues are considered in the public sector transportation decision process. The best way for the states to understand freight industry issues and needs is to have a dialogue with representatives of the freight

industry. State specific, corridor specific and multi-state regional dialogue with the trade industry are all to be encouraged.

8. **Inclusion of the General Public** – The general public needs to be informed of the serious transportation issues confronting the western states, the implications for the inefficient movement of freight, and how those inefficiencies will affect the general populace. The public should also come to understand that many freight transportation projects can effectively reduce highway congestion during peak commuter periods.

9. **Improved Communications** – Improved communications may therefore be at the heart of any attempt to improve trade and freight transportation efficiency. This should include:

   - Improved communications between the states and among the state agencies responsible for providing portions of the freight transportation infrastructure.

   - Improved communications between the state representatives and the freight transportation community.

   - Improved communications with the general public, who should be made aware of the challenges concerning freight transportation in the WTTN states.

10. **Support for Short Line Railroads** - As main line railroads continue to sell-off branch lines to short line operators, these operators increasingly are responsible for a significant share in the gathering and distribution of the nation's rail-borne freight. However, because many of these short lines are under-capitalized, capital budgets to ensure that these lines are maintained to a similar degree as the main lines are also under-funded. Predictable consequences include delays in rail shipments as well as embargoes of cars with heavier axle loads from certain branch lines. Shippers on branch lines that cannot accommodate cars with heavier axle loads will be at a competitive disadvantage as compared with shippers on main lines. The WTTN states, therefore, should review conditions on branch lines in the west to determine if there is a role for supporting capital improvements on branch lines critical to the efficient movement of the west's freight.

11. **Rail Car Availability** - WTTN research reflected significant dissatisfaction of rail car supply conditions in the west. This may have been a result of the severe operations problems experienced by the major carriers during the course of the study. These would have served to lengthen transit times and thereby worsen car availability. As service improves, car supply can be expected to improve as well. Nevertheless, car availability may not improve linearly with operating improvements in all cases. Particularly this could be true for short haul markets, which may find themselves in chronic short car supply conditions. A case in point was in the Pacific Northwest, where grain shippers reported difficulty in obtaining consistent car orders from

railroads for the haul to nearby Columbia River ports. As a result, Washington State purchased 47 100-ton covered hopper cars to help handle these grain shipments. The purchases had corollary benefits of maintaining services on branch lines and ensuring shipments by rail which otherwise would have gone by highway. Other states might review the experiences of short haul shippers to see what might be done to alleviate car supply conditions.

12. **Funding of Intermodal Facilities Access** – Access to intermodal facilities continues to be a major issue. The WTTN states should continue their efforts to seek sufficient funding for highway and railway access to ports, airports, elevators, COFC/TOFC facilities and reload facilities. The FHWA's Intermodal Condition and Investment Study can be a major resource in this effort.

13. **At-Grade Rail/Highway Crossings** – With increasing highway and railroad traffic, and as traffic densities focus on certain rail lines, grade crossing alleviation needs are increasing. The states need to consider the commitment of additional resources to this issue.

14. **Greater Priority for WTTN Corridors and Facilities** – This study demonstrates the great importance of these WTTN transportation corridors to trade, and therefore to the economy. Corridor issues, from the trade perspective, include capacity in urban areas, pavement condition, bridge and structure postings, and some two-lane highways. All are shown to impede efficient freight services. Perhaps the states could place greater emphasis in their prioritization processes on the WTTN corridors.

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