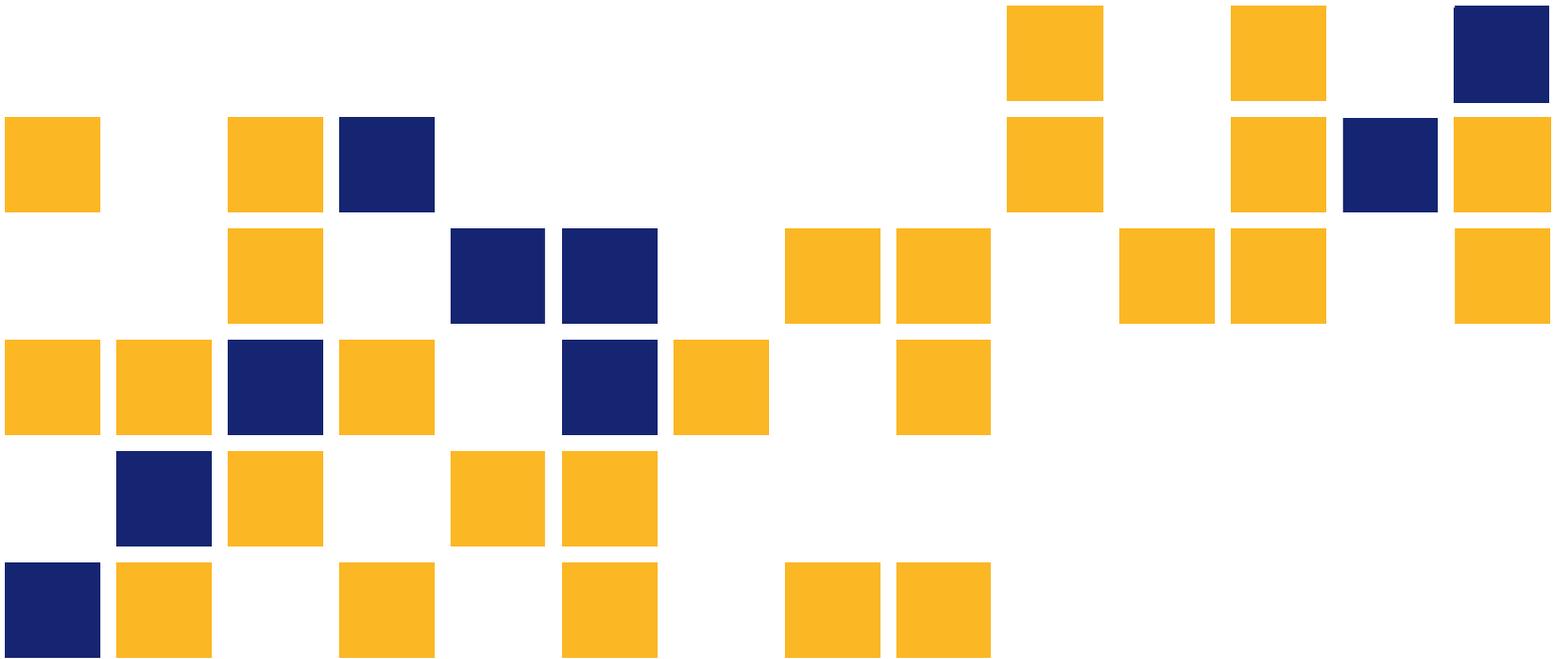


Optimizing the Analysis of Routing Oversize/Overweight Loads to Provide Efficient Freight Corridors

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16 Abstract <p>The subject of this report is limited specifically to Kansas' highways. Current features of the State Highway System were looked at to determine corridors that do not limit Oversize/Overweight (OS/OW) vehicles, or that limit loads to varying degrees. Now that roundabouts are becoming more common throughout the state and the nation, many individuals, both in the public and private sectors, believe that the main concern for efficient movement of oversized loads are roundabouts that were being constructed. However, information that has been collected indicates that vertical clearance, diamond interchanges, curbs, non-removable signs, enhancements at pedestrian crosswalks all limit the ability for over-length loads to make turns to varying degrees. While it is not usually feasible to remove structures with limited vertical clearance, it is feasible to develop policies to better control OS/OW movements.</p> <p>There is a trade-off between what shippers might want to move and what the agencies responsible for the design of the highway/street system can provide. The use of a steerable rear axle has allowed many oversize loads to make crucial turns at intersections or at ramps of interchanges that were previously a barrier. The vertical height restriction of low clearance structures is not easily solved. Developing a freight network which includes segments where selected OS/OW vehicles can be accommodated is becoming increasingly important. There is an economic benefit to the State of Kansas to allow OS/OW loads and this should be balanced with the economic burden of providing this ever increasing demand on public roads.</p>					
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Final Report

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THE KANSAS DEPARTMENT OF TRANSPORTATION
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and

KANSAS STATE UNIVERSITY TRANSPORTATION CENTER
MANHATTAN, KANSAS

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PREFACE

The Kansas Department of Transportation's (KDOT) Kansas Transportation Research and New-Developments (K-TRAN) Research Program funded this research project. It is an ongoing, cooperative and comprehensive research program addressing transportation needs of the state of Kansas utilizing academic and research resources from KDOT, Kansas State University and the University of Kansas. Transportation professionals in KDOT and the universities jointly develop the projects included in the research program.

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CHAPTER 1. BACKGROUND

Superloads, Oversize/Overweight (OS/OW) loads, are becoming more prominent in Kansas. This is especially true in the case of the wind energy industry. Keeping track of OS/OW transportation needs and safe and efficient routing is an ever increasing challenge that requires considerable time and resources.

Truckers and shippers of oversize or overweight loads complain about the inability to take the most direct route because of highway impediments. These impediments may be either sharp turning radii that cannot accommodate the load length or height restrictions (vertical clearance) that are less than the height of the load.

OS/OW (total gross vehicle weight [GVW] of 150,000 pounds or more) loads cannot be broken down to sizes or weights that are equal to or less than legal limits. If these components are produced in Kansas, they benefit the economy. However, if they are being moved through the state, they add little or nothing to the economy and any cost incurred by the permitting process is a subsidy if the full cost is not recovered. In this case it may be viewed as a trade-off since loads produced or destined for Kansas may also travel across other states. There could be costs to Kansas caused by damage to the highway and bridge structures caused by this movement.

If cities or certain parts of the state are eliminated as potential sites for the production or delivery of oversize products, their economic growth opportunities will be diminished. This can be caused by the construction of features in various highway corridors that prevent the efficient movement of oversize loads on state highways.

There are currently two research projects related to roundabouts. One is funded as a pooled fund project by several states, with Kansas Department of Transportation (KDOT) being the lead state. This project is currently underway. The other is a smaller project funded solely by KDOT for the current fiscal year and is the subject of this report. Both of these projects address issues relating to OS/OW loads that are being moved across and within states.

The current pooled fund project is designed to survey the various states to determine their policies concerning OS/OW loads, the sizes and weights of loads, and the design of roundabouts that may affect the ability to accommodate OS/OW loads. It has also been recognized that there are a number of physical features that exist on the highway systems of each state that is as much or more limiting for OS/OW loads than are roundabouts. These include vertical clearance of bridges over the road, cloverleaf and diamond interchanges, elevated railroad grade crossings, to name a few. The limitations caused by the construction of a roundabout becomes a mute issue if other, more limiting features, affect the corridor that the OS/OW load may be using.

The subject of this report is limited specifically to Kansas' highways. It looked at the current features of the State Highway System to determine corridors that do not limit OS/OW vehicles, or that limit loads to varying degrees.

1.1 INTRODUCTION

1.1.1 Research Objective

The main objective of this research project is to supplement several recent and current research studies to make it more efficient to find highway corridors that should be developed or preserved because of features that prevent the efficient movement of oversize or overweight (OS/OW) loads, and suggest guidelines to preserve them.

1.1.2 Work Plan (Paraphrased from the Original Proposal)

Caveat regarding work plan: It should be noted that this project was not fully funded. The authors had requested \$50,000 of which half was to be from KDOT/ K-TRAN and half from the Kansas State University Transportation Center KSUTC. The KSUTC portion was not approved; therefore the project was seriously underfunded. A decision was made to let us go ahead with the project to the extent possible. In regards to the tasks below this basically meant that three and four were not fully completed to the extent indicated. The authors consider the effort that was accomplished with the funds available as a phase 1 project. A proposal to continue this, phase 2, was submitted in the 2012 2013 K-TRAN program. Should that funding become available, a

more comprehensive study and report in regard to optimizing superload corridors in Kansas will then be possible.

Data and recommendations from a previously completed Statewide Truck Study will be incorporated into this research report. Additional data relating to height, weight load limits and turning restrictions, e.g. Kansas Trucking Commission maps, bridge restriction maps, vertical clearance maps etc, will be incorporated into the study to evaluate restricted corridors, as well as those that currently provide reasonable movement of oversize and overweight load.

1.2.3 Tasks (From the Original Proposal)

1. Document all the key parameters used by KDOT for routing oversize and overweight loads and all the key sources of available material to assist in the process.
2. Use the parameters to examine all probable state routes within the given parameters
3. To the extent possible, and within time and budget restraints, determine the main industries in Kansas that have a need for OS/OW loads, their typical origins and destinations and most likely routes
4. Do a more detailed study of the wind energy industry, survey the wind energy components transporters and document their needs in relation to load dimensions and route challenges
5. Write and present a final report for comment by the project monitors
6. Write a final report considering the comments received on the draft report

There is considerable controversy relating to trucks, especially very large trucks using the streets and highways of the state. Truckers and shippers complain about the time required and the conditions set out by permits. These are usually related to the weight restrictions caused by axle loads on bridges that were designed many years ago. The truckers also refer to the restrictions of vertical clearance, and curbs, signs and light poles that prevent the long loads from making turns at intersections. Very large loads, often moving very slowly, can cause or increase congestion, especially when they are wider than a lane or when they are trying to turn at intersections or interchanges.

There is also a concern that very heavy loads can decrease pavement life. Andrew Herrmann, president of ASCE was quoted as saying, “Do you really want to keep these heavy loads, have a lower factor of safety and start wearing these bridges out faster?” He also added, “These bridges already need work. Now we’re saying let’s go back and reinforce all the bridges that need it, when we don’t have enough money to maintain the structures that we have.” This statement was made in response to the States of Maine and Vermont having authorized higher legal truck-weight limits from 80,000 to 97,000 pounds.

Regardless of the pros and cons, the economy of the state and nation depends on transporting OS/OW loads from where the product is manufactured or assembled to where it will ultimately be used. Therefore it is necessary to provide routes for the movement of OS/OW loads that are safe and efficient. It is also important that features are not built into the roadway that totally blocks the transporting of OS/OW to specified regions of the state. However, it has been stated by officials that it is impossible and impractical to provide accessibility to every load, regardless of size. There may be times when the only way to get the finished product to its destination is to assemble it at its ultimate destination.

Data was obtained from the Bridge Evaluation Squad of the Bureau of Design of the Kansas Department of Transportation (KDOT) to analyze the origin, destination, size of load and weight of loads assigned to be evaluated. KDOT assigns loads called “Super Loads”, which are defined as exceeding 150,000 pounds. KDOT, the Kansas Corporation Commission (KCC) and the Kansas Department of Revenue all have a part in the Kansas Trucking Connection (KTC) which administers the OS/OW program as well as certain other commodity movements. Permits for large structures are provided by KTC when the loads exceed 18 feet in height, 16 feet 6 inches in width or 126 feet 0 inches in length. The routes are developed by the KDOT Districts, occasionally in consultation and negotiation with the trucking firms requesting the permits. The information is passed along to the next District, if more than one District is involved in the route. Data were not available for large structures that were permitted by KTC as these files are only paper files. A consultant is developing a computerized routing program and the result will be available after it has been determined that it is satisfying the criteria that was established in the contract.

The network that was used for determining accessibility and routes for analysis for this project was obtained from KDOT's CANSYS Database. The basic network data were used in a previous KTRAN research project, "Developing a Statewide Truck Trip Management System" and supplemented with KDOT Bridge Vertical Clearance data and Bridge Load Ratings. Additional intersection approach data was furnished by KDOT Planning staff.

CHAPTER 2. REVIEW OF LITERATURE AND RELEVANT INFORMATION

There is very little published information on oversize/overweight (OS/OW) freight planning. There are a number of references on freight planning in general, some of which will be reviewed here. It is the belief of the authors that optimizing OS/OW freight routes is a specialized subset of freight route planning in general. For example, it makes sense that if a state has a freight network it should not have been developed without consideration of OS/OW that are important to the economy of the state or the state's industry. Then, OS/OW would be permitted over specific segments of these routes where accommodations for OS/OW can be made. Good OS/OW routing should also document routes where OS/OW cannot be accommodated, e.g. a bridge too narrow or with an unacceptable load rating, or other obstacle that cannot be remedied for economic, legal or policy reasons.

FHWA is interested in having states develop statewide freight plans. Although they do not specifically state anything about OS/OW, the authors believe that OS/OW should be considered as an integral part of any state's freight network planning.

The FHWA Office of Freight Management and Operations, as stated on their website (<http://ops.fhwa.dot.gov/freight/infrastructure/index.htm>) is responsible for promoting investment in cost-effective infrastructure for the efficient movement of freight. They provide technical advice to others of the FHWA and its partners and oversight of four programs authorized by the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: a Legacy for Users, commonly known as SAFETEA-LU. Their website lists the freight network and major freight programs and provides links to them

There are approximately 200,000 miles of highways which are designated for conventional combination vehicles of which 26,000 miles are major freight corridors. These corridors are explained in detail in "Freight Story 2008" and will not be reviewed here. Truck routes generally follow the National Network established by Congress in 1982 as explained in figure 1:

The National Network

The National Network was authorized by the Surface Transportation Assistance Act of 1982 (P.L. 97-424) and specified in the U.S. Code of Federal Regulations (23 CFR 658) to require states to allow conventional combinations on "the Interstate System and those portions of the Federal-aid Primary System ... serving to link principal cities and densely developed portions of the States ... [on] high volume route[s] utilized extensively by large vehicles for interstate commerce ... [which do] not have any unusual characteristics causing current or anticipated safety problems." Conventional combinations are tractors with one semitrailer up to 48 feet in length or with one 28-foot semitrailer and one 28-foot trailer, and can be up to 102 inches wide.

The National Network differs in extent and purpose from the National Highway System (NHS), which was created more than a decade later by the National Highway System Designation Act of 1995 (P.L. 104-59). Both are about the same length, roughly 200,000 miles, but the National Network includes approximately 65,000 miles of highways beyond the NHS, and the NHS includes about 50,000 miles of highways that are not on the National Network. The National Network supports interstate commerce by regulating the size of trucks, while the NHS supports interstate commerce by focusing federal investments.

The National Network has not changed significantly in a quarter century. It is modified only if segments are added to the Interstate highway system or if states petition to have a segment beyond the Interstate highway system added or deleted. Petitions for modifications have not been received in years, even though the geography of interstate commerce has changed significantly with the growth of smaller communities into principal cities and the emergence of new, densely developed areas. Consistency between the National Network and freight-related portions of the more recent NHS is not required.

The definition of conventional combinations is also unchanged, even though 48-foot is no longer the maximum length of a single trailer in the majority of states. Single 53-foot trailers are allowed in 25 states without special permits and in an additional 3 states subject to limits on distance of kingpin to rearmost axle.

Figure 1. The U.S. National Network (source: http://www.ops.fhwa.dot.gov/freight/freight_analysis/freight_story/major.htm).

FHWA has published a manual, "Statewide Freight Plan Template", which will be reviewed here (Keenan et al. June 2011).

This FHWA publication lists several reasons why statewide freight planning is important (Keenan et al. June 2011):

- Increasing globalization and a corresponding economic (National, State and Local) dependence on expanding supply chains and transportation reliability (water, air, rail, highway, and pipeline).
- Recognition by business leaders at all levels that efficient freight transportation is a key factor in economic (National, State, and Local) competitiveness and vitality.
- Heightened awareness from both the private and public sectors that investments from both are needed, if not required, to meet increasing freight transportation demands.
- Increasing demands for transportation among both passenger and freight interests creating stress on the transportation system resulting in congestion and bottlenecks in key locations that are detrimental to productivity.

The FHWA report covers all modes of freight transportation. The report discusses modal infrastructure and points out that it is important to focus on the major commodities for each mode, how they are transported, infrastructure, current issues within each mode, and the important connections between each mode. As stated in the report (Keenan et al. June 2011):

The decisions on routes, modes, time of day, etc. are often very different in terms of who makes the decision, why the decisions are made, where the decisions are made and when they are made.

The highway section covers the National Highway System (NHS), the National Network (NN), State routes and local routes. These all should be considered in statewide freight and OS/OW route planning.

Following in this section are some key points from the “Statewide Freight Plan Template”. (Keenan, et. all June 2011) which will be referred to below as “The Template”

Statewide freight planning needs to address aspects of safety, security, economic development, mobility, and environmental impacts. There should be “outreach” to increase awareness of freight issues to increase public and private understanding and strengthen partnerships and coordination with other transportation agencies, other government organizations private industry and the public. Public outreach is well understood and practiced by states on all projects.

Engaging the private sector may be a new experience for some.

Private industry stakeholders, which provide nearly all of the freight service nationally, statewide and locally, are a valuable resource and source of needed data. They can help identify regional, statewide and multijurisdictional challenges to moving freight.

The template lists a cross section of freight stakeholders that should be included (Keenan, et. all June 2011):

Shippers

- Carriers
- Terminal operators
- Economic development agencies
- Seaport and airport authorities
- State and Local governments and other public agencies
- Receivers (stores, industry etc.)
- Distribution Centers/Warehousing representatives
- Commercial and industrial developers.

The template also lists such activities that may be required (Keenan, et. all June 2011):

Conducting focus groups with private sector stakeholders

- Conducting interviews with private sector stakeholders
- Holding conferences/meetings/workshops with private sector stakeholders
- Implementing a freight advisory council
- Exchanging data
- Implementing the plan (ask them to help make it a reality)

The template makes a point that state freight characteristics should be studied. This should include the major characteristics of a state's freight system and include who needs to be involved with freight movements into and out of the state. As stated in the template, this will provide (Keenan et al. June 2011):

...an overview of the State economic structure and then present supply chains that are required by key industry sectors. This will lay the groundwork for tying the global, national, regional and intrastate freight flows and connections back to the economic activity within the State.

The template discusses the role that freight movements play in maintaining the vitality of a state's economy. It provides a list of economic trends and forecasts that will affect freight, such as: (Keenan, et. all June 2011)

Population

- Employment by industry
- Income
- Imports and Exports
- Industrial production forecast
- Total taxable sales
- Inflation rate

In addition the state and/or regional plans, with respect to economic growth and development, will also affect freight transportation demand. A “Guidebook for Forecasting Freight Transportation Demand”, should be a helpful resource (NCHRP 388).

The template further discusses regional freight systems. Information is needed on primary destinations of interstate freight originating in the state and origins and destinations of interstate freight coming into the state. The amount of freight by commodity, amount of freight by value, and analysis of the importance of adequate highway access should be documented. Key freight corridors should be identified within regions and information on characteristics of routes such as primary interstates or alternates available should be documented.

There are many sources of information on interstate freight characteristics. Some provide data on total freight movement between states and regions. The most comprehensive source of information is the national commodity flow survey (CFS), and a good resource to assist developing state and regional plans is the quick response freight manual, second edition (QRFM).

In addition to interstate freight, i.e., goods into, through and out of the state, intrastate freight must also be considered. Intrastate freight is generally defined as trade and associated freight movement, which originates and ends within the state. As stated in the template (Keenan at all June 2011), *“It is important to understand the intrastate freight context in terms of major*

intrastate movements fully within the state and how the states facilities fit within the surrounding freight networks.”

Key statistics to identify interest rate priority corridors include:

- inbound/outbound destinations by weight/volume/value
- inbound/outbound origins
- vehicle miles traveled (VMT)/vehicle hours traveled VHT)

The template goes on to provide guidelines to determine freight characteristics and needs for a state’s major industry groups which forms the basis of demand and freight transportation and thus the needs within a state. It may be obtained by conducting interviews with key freight stakeholders in the state.

Industry information should include information such as:

- business sectors and locations
- manufacturing versus service industry, etc.
- requirements for each industry

Other things that the template points out that should not be overlooked are terminals, warehousing/distribution centers and support facilities.

As defined by the template, (Keenan at all June 2011) “Warehouses and distribution centers are primarily used for the receipt, temporary storage, possible modification/customization and distribution of the goods that are en route from production sites to where they are consumed.”

The FHWA has a web site that lists National Highway System Intermodal Connectors by state, http://www.fhwa.dot.gov/planning/national_highway_system/intermodal_connectors/

There are many concerns in regard to intermodal facilities and their multimodal linkages, principal commodity flows and infrastructure. The major concerns are:

- Safety

- Security
- Congestion management
- Land use, and
- Environmental Considerations

The template presents several examples of programs and partnership agreements that should be considered with the private sector, federal agencies, other state agencies, metropolitan planning organizations (MPOs), and local agencies. In regard to highways it would be beneficial to forge partnerships with private sector freight carriers, shippers, and industry, as well as local governments, to work toward the goal of improving the freight transportation system including infrastructure, services and business practices (Keenan at all June 2011).

The template discusses the desirability of developing performance objectives and measures. The following section is quoted from the template (Keenan at all June 2011)

Establishing freight transportation performance objectives relative to system performance will provide a focus of action for a state DOT with respect to freight transportation. Performance measures should be implemented so a state can be determined if they are achieving their objectives and to quantify and assess the effects of current and future initiatives on system performance objectives to help determine the impact of investment choices. Performance measures can also serve as indicators of economic health and traffic congestion.

2.1 WESTERN MINNESOTA FREIGHT NETWORK

The FHWA has mentioned three locations in the United States as examples of good freight planning by a state. These are: Minnesota, New Jersey, and Southern California. Minnesota has included OS/OW in their plan and part of the Minnesota report, including the OS/OW part, will be summarized below (Wilbur Smith Associates, September 2009). The others may be studied on their respective web sites by anyone interested.

New Jersey: <http://www.state.nj.us/transportation/freight/plan/pdf/2007statewidefreightplan.pdf>

Southern California:

http://www.dot.ca.gov/hq/tpp/californiainterregionalblueprint/Documents/workshop_docs/CIB_brochure/Freight_Mobility_Plan_12_7_11.pdf

2.2 THE MINNESOTA PLAN BACKGROUND: NETWORK LIMITATIONS

The highway networks in Western Minnesota are comprised of federal, state, county, city, or township roadways that are designated differently according to their intended purpose, and are governed differently regarding truck size and weight.

2.3 FEDERAL TRUCK SIZE AND WEIGHT LIMITS

As pointed out in the Western Minnesota report, (Wilbur Smith September 2009) at the federal level Congress and the Federal Highway Administration (FHWA) have defined a primary network from a policy standpoint for encouraging interstate commerce and heavy truck travel. The National Network of Highways includes: (1) the Interstate Highway System and (2) other highways designated by the states in response to the Surface Transportation Assistance Act (STAA) of 1982. The National Network, sometimes referred to as the national truck network consists of highways submitted to FHWA as being capable of safely handling larger commercial motor vehicles.

The criteria provided to states for guidance in designating NN routes is found in Chapter 23 of the Code of Federal Regulations (CFR), Section 658.9: (Wilbur Smith, 2009)

- (1) *The route is a geometrically typical component of the Federal-Aid Primary System, serving to link principal cities and densely developed portions of the States.*

- (2) *The route is a high volume route utilized extensively by large vehicles for interstate commerce.*
- (3) *The route does not have any restrictions precluding use by conventional combination vehicles.*
- (4) *The route has adequate geometrics to support safe operations, considering sight distance, severity and length of grades, pavement width, horizontal curvature, shoulder width, bridge clearances and load limits, traffic volumes and vehicle mix, and intersection geometry.*
- (5) *The route consists of lanes designed to be a width of 12 feet or more or is otherwise consistent with highway safety.*
- (6) *The route does not have any unusual characteristics causing current or anticipated safety problems.*
- (7) *For those States where State law provides that STAA authorized vehicles may use all or most of the Federal-Aid Primary system, the National Network is no more restrictive than such law. The appendix [to the Smith report] contains a narrative summary of the National Network in those States.*

As stated in the Minnesota report (Smith et al. 2009) there are 4,904 miles of roads that are part of the National Network. This is supplemented by Minnesota's Twin Trailer Network which is a system of other trunk and local highways on which semi-tractor-trailers can operate. Table 1 summarizes the federal size limits that apply to National Network highways.

Table 1. National Network Commercial Vehicle Size Standards (Smith et al. 2009).

Dimension	Regulatory Standard
Overall vehicle length	No federal length limit is imposed on most truck tractor-semitrailers operation on the National Network. Exception: On the National Network, combination vehicles (truck tractor plus semitrailer or trailer) designed and used specifically to carry automobiles or boats in specially designed racks may not exceed a maximum overall vehicle length of 65 feet, or 75 feet, depending on the type of connection between the tractor and trailer.
Trailer length	Federal law provides that no state may impose a length limitation of less than 48 feet (or longer if provided for by grandfather rights) on a semitrailer operating in any truck tractor-semitrailer combination on the National Network. (Note: A state may permit longer trailers to operate on its National Network highways.) Similarly, federal law provides that no state may impose a length limitation of less than 28 feet on a semitrailer or trailer operating in a truck tractor-semitrailer-trailer (twin-trailer) combination on the National Network.
Vehicle width	On the National Network, no state may impose a width limitation of more or less than 102 inches. Safety devices (e.g., mirrors, handholds) necessary for the safe and efficient operation of motor vehicles may not be included in the calculation of width.
Vehicle height	No federal vehicle height limit is imposed. State standards range from 13.6 feet to 14.6 feet.

It should be noted that while federal law imposes a gross vehicle weight limit on Interstate highways of 80,000 pounds, that does not apply to other parts of the National Network. However, many states like Minnesota, use the federal bridge formula to govern gross vehicle weight on non-Interstate highways. (Smith et al. 2009)

As stated in the Minnesota report (Smith et al. September 2009):

“Existing designated transportation networks were used as a basis to designate the new Minnesota truck network. The routes were selected because of their designation for existing truck use and for the specific purpose each serves in the overall transportation network. The networks include:

- Interstate/National Highway System/Strategic Highway Network
- National Network and Minnesota Twin Trailer Network

- Interregional Corridor (IRC) System
- 10-Ton Roadways
- Local Roadways (less than 10 tons)
- Minnesota Tiered Roadway Network (Designated State Trunk Network)”

The roadway networks for the Western Minnesota region are shown in figure 2.

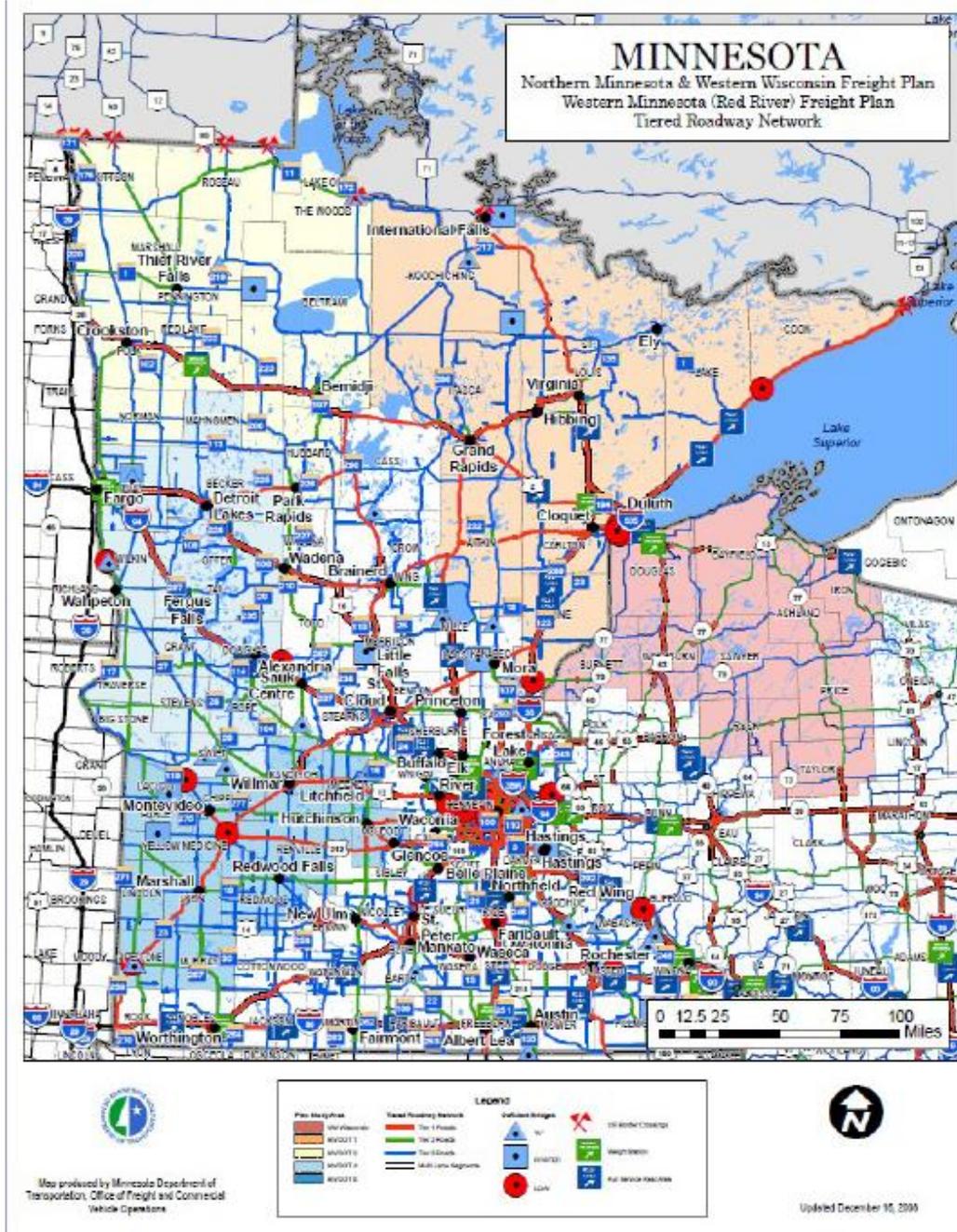


Figure 2. Tiered roadway network for northern MN/WI and western MN (Wilbur Smith 2009).

One of the things the consultant that conducted the Minnesota study was asked to study in detail was super haul truck corridors i.e. they were asked to conduct an analysis documenting the best routes for heavy freight movements.

Minnesota Department of Transportation (Mn/DOT) provides permitting for oversized, overweight loads on trunk highways throughout the state. The report states that the purpose of identifying super corridor routes was to acknowledge that certain routes are currently being used to move OS/OW loads and when designating improvements for these routes engineers should propose solutions that do not interfere with its super corridor function. Main parameters that must be addressed are:

- weight
- width
- links
- height

The report points out that the two most restrictive parameters are weight and height which are typically limited by bridges. As part of developing a super corridor route, key characteristics for these routes must be identified. MnDOT identified Superload corridors that can accommodate a load with a 14 foot height limit, a 10 foot width limit, a 110 foot length limit and an 80,000 pound weight limit. They maintain that these corridors, in combination with portions of an Expanded Envelope Corridors, cover approximately 80% OS/OW loads and Minnesota. (Smith et al. 2009)

As stated in the report (Wilbur Smith, September 2009), *“Expanded envelope corridors are routes that can accommodate much larger loads under super corridors”* and *“---Special Considerations are sections of corridors that may have constraints or special considerations for transporting oversize load services requiring the use of an escort.”* Expanded envelope corridors are routes that can accommodate any permitted vehicle that is 16 feet high, 16 feet wide and 30 feet long with a weight of 205,000 pounds. Special considerations are sections of corridors having constraints or special considerations such as requiring an escort or may include roads

with narrow shoulders or bridge restrictions which could require use of some local road's and/or curvature that may require special, moving consideration.

The Smith report goes on to recommend that whenever possible, no roundabouts should be constructed along the identified expanded envelope routes, and counties/cities should provide adequate notice of at least two weeks before a road closes along portions of the routes.

A super corridor route map was developed which is reflective of routes that can support a variety of OS/OW loads. The report goes on to recommend that when planning improvements and/or changes on any of these roads, the district staff should preserve the ability to accommodate the OS/OW loads' characteristics and/or improve upon them when feasible. The Super Haul map is shown in figure 3.

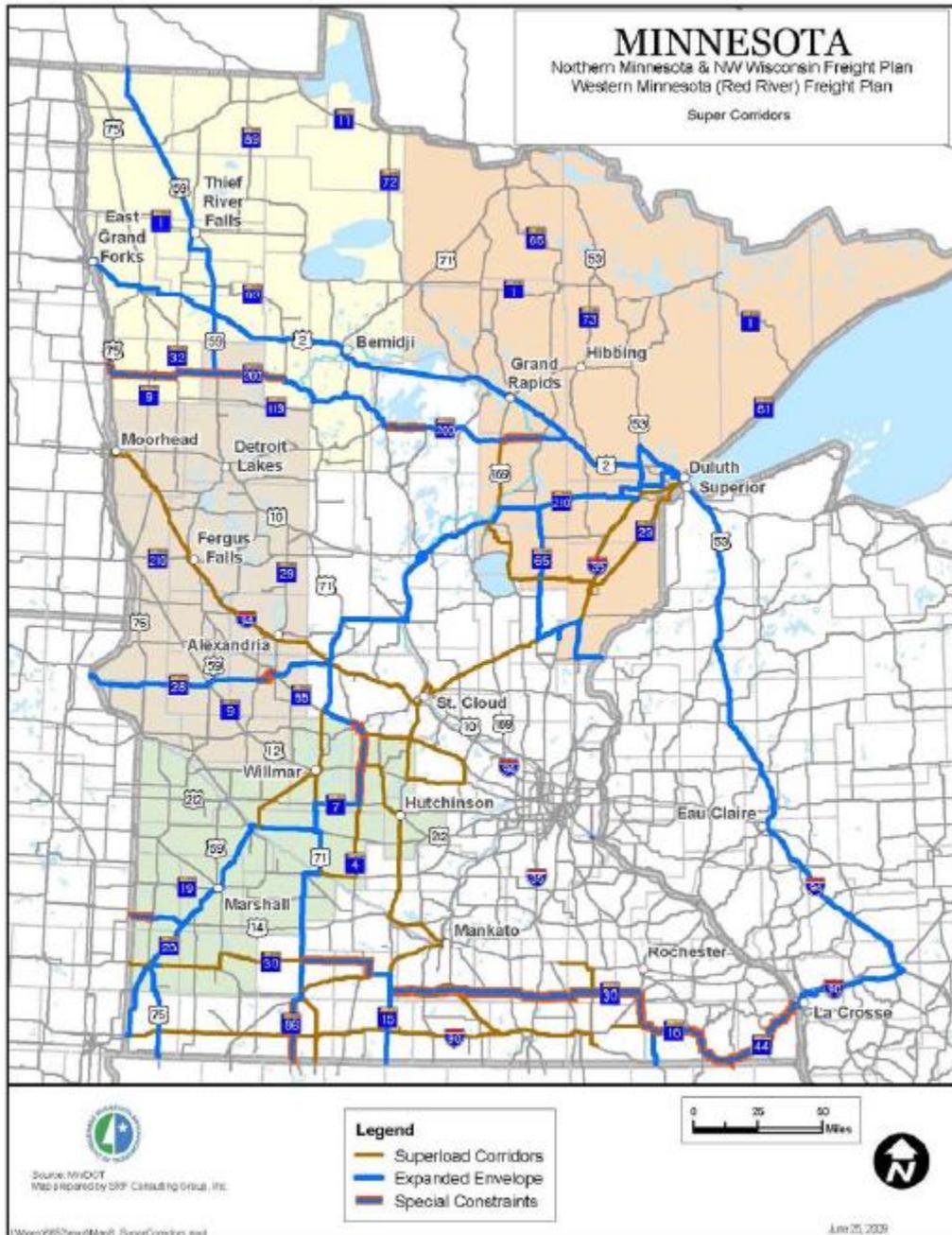


Figure 3. Proposed super-haul corridors in Minnesota (Wilbur Smith September 2009).

The report made a number of recommendations for Super Hall, truck permit corridors in two highway districts in Minnesota that the study had shown would be handling an increasing number of OS/OW and needed a high-clearance route. These recommendations were in addition to those routes designated for commercial commodity corridors for improving regular truck

operations and are presented below as an example of what any state may need to consider (Wilbur Smith September 2009):

As a starting point Mn/DOT may wish to publish web-based maps for specialized carriers who routinely transport over-size loads, to increase efficiency and improve route planning when moving super-haul loads. The route information mapped by this study can serve as a starting point for this purpose, as carriers could better plan movements by understanding “Super Corridors” based on routinely used routes for permitted loads. Freight shippers can also use the map to effectively plan out a route that allows them to best transport over-size loads to a specified destination. The Superload Corridors and Expanded Envelope Corridors allow large freight shipments to be transported north-south and east-west to/from the Duluth-Superior ports, as well as throughout Minnesota.

Another step in support of the “Super Haul Corridor” concept would be the creation of a scheduling procedure for road closures along the Super Corridor routes and create a policy to limit roundabouts on these corridors. For example, roundabouts could be prohibited on Superload or Expanded Envelope Corridors, and counties/cities could provide Mn/DOT Office of Freight at least two weeks’ notice if a roadway along the corridor will be closed. This will help improve over-size freight movements along these routes by effectively rerouting these loads around a closure. In addition, when planning future improvements along Super Corridors, District staff should make every effort to try and preserve the ability to accommodate characteristics associated with each route and/or improve upon them, if feasible.

{Note: the authors of this report do not agree that all roundabouts should be automatically be eliminated without further study of the possibility that they could be designed to accommodate the loads on the route]}

As with other states, there is a lack of uniformity regarding truck size and weight uniformity at Minnesota’s borders. The Smith et al. (2009) report makes the following recommendations:

- Seek truck size and weight harmony on the routes with the most flexibility,

- Seek truck size and weight harmony on the routes with the most flexibility, and
- Join a regional permitting compact.

According to the Smith et al. report (2009), no regional permit compact exists in the Midwestern United States. North Dakota participates in a regional compact developed by the Western Association of State Highway and Transportation Officials (WASHTO). Some limits established by WASHTO include:

Weight

- 600 pounds per inch of tire width.
- 21,500 pounds per axle.
- 43,000 pounds per tandem axle.
- 53,000 pounds per tridem (wheelbase more than 8 feet and less than 13 feet).
- 160,000 pounds gross weight

Length

- 110 feet overall. The agreement does not authorize permits for a semi-trailer longer than 53 feet to carry more than one item, or for any unladen semi-trailer longer than 53 feet used in a truck-tractor and semi-trailer combination.
- Movement of unladen vehicles must comply with the limitations of the jurisdiction being traveled through (i.e. loading jeep and/or booster onto trailer when semi-trailer exceeds 62 feet in Oregon).

Width: 14 feet

Height: 14 feet

The reader is referred to the Smith report for additional details. (Wilbur Smith, September 2009):

2.3.1 Accommodating Oversize/Overweight Vehicles at Roundabouts

This section is paraphrased from a pooled fund study for accommodating OS/OW at roundabouts (Russell et al. Interim Report, 2011). Several surveys were conducted during the pooled fund study. The first survey was conducted through AASHTO member contacts from 50 United States. The objective of the first survey was to find the permits that are required for different states to transport OS/OW loads and to determine the bottlenecks for OS/OW on state roads. A Zoomerang survey was used to electronically distribute the survey to the AASHTO officials. A total of 41 United States responded to the survey. Of those who responded, 37 states responded to the complete survey as prepared and four states responded to a follow-up survey to get their contact information for survey two, planned for a later stage. Among the 37 states that responded to the survey, most of the responses were online responses while a few of the states sent paper responses. The results from the survey are briefly summarized below. More complete summaries can be found in the pooled fund study interim report (Russell et al. Interim Report, 2011).

Thirty one responding states have a category for different types of oversize/overweight (OS/OW) loads. Five States don't have a category. These five states are Alaska, Arkansas, California, Maine, and South Dakota. Thirty five responding states require a permit for transporters to use their state's highway system for loads that exceed state statutes. Among them, 31 States require a permit by State Statute. North Dakota and North Carolina requires a permit by both State Statute and DOT Policy. Maryland requires a permit by State statute, and also regulations are contained in the Code of Maryland Regulations. **Montana and Nebraska don't require a permit.**

In regard to questions about fee schedules, industry served and typical load types, numbers of OS/OW vehicles on highways in an average year and peak periods for a certain type or types of load, the respondents' answers were so diversified as to defy a concise, readable summary. Thus, the reader interested in this information is directed to the appropriate appendices contained in the Russell et al. Interim Report (2011).

Details of the survey respondents answers regarding Fee Schedule for Permits, Data on Industries Served and Typical Load Type for each Industry, Data on Types and Number of

OS/OW Vehicles on Highway in an Average Year, and Peak Period for a Certain Type or Types of Load can be found in the appendices of the pooled fund interim report (Russell et al. 2011 Appendices C through F). Twenty eight of the responding states don't have a typical design vehicle to aid in determining needed roadway geometry for OS/OW vehicles. Eight states have a typical design vehicle to aid in determining needed roadway geometry for OS/OW vehicles.

Twenty five States responded that they have designated truck routes. Twelve states do not have designated truck routes. They are Arkansas, Colorado, Connecticut, Florida, Iowa, Kansas, Montana, Nebraska, Utah, Washington, and West Virginia. Nine states have designated OS/OW routes. They are California, Colorado, Maryland, Missouri, Nebraska, North Dakota, Ohio, Texas, and Wisconsin.

Thirty five states have route restrictions. Montana and Alaska don't have route restrictions.

In regard to the question, "Are any of these route restrictions a problem for your OS/OW loads?" The following is a summary of the reported restrictions with the percentage of respondents reporting that the restriction is a known problem to OS/OW. Table 2 gives restrictions by states.

- Bridges 100%
- Curbs 18.9%
- Interchanges 56.8%
- Intersections 64.86%.
- Overhead structures 89.2%
- Overhead wires 40.5%
- Rail- highway grade crossings, 48.6%
- Raised channelization 18.9%
- Roundabouts 35.1%
- Signs and signals 70.3%
- Utilities 48.6%

Table 2. Number of states having various restrictions as a problem for their OS/OW loads (Russell et al. 2011).

Restriction	Restriction a problem for OS/OW loads
Bridges	37 States
Overhead structures	33 States
Signs and signals	26 States
Intersection	24 States
Interchanges	21 States
Rail- highway grade crossings	18 States
Utilities	18 States
Overhead wires	15 States
Roundabouts	13 States
Curbs	7 States
Raised channelization	7 States

Some solutions to the restrictions provided by the respondents are:

- Utilize an automated routing and analysis system to ensure none of the items listed above in table 2 are involved in a specific route of an oversize vehicle.
- Reroute the vehicle/load to a highway that will accommodate the load.
- Raising overhead wires and on rare occasions use “jumper” bridges.
- Stop use of fixed cross arms for signal lights or have them able to swing out for high loads.
- Requires all utility lines to be higher.
- Design roundabouts to accommodate longer loads at least on major routes.
- Design intersections with more shoulder for better turning radius.

The states that replied that roundabouts are a known problem are Connecticut, Idaho, Iowa, Kansas, Louisiana, Minnesota, Missouri, Nebraska, New York, Nevada, Ohio, Virginia, and Wisconsin.

The respondents were asked to provide a score of 1, 2 or 3 for each restriction, where 1=common, 2=occasional and 3=uncommon, the results are summarized in the following figures:

Figure 4 below shows the states that indicated roundabouts were uncommon, common or occasional restrictions. Figure 5 below shows common, occasional, and uncommon categorization of all reported restrictions for OS/OW loads.

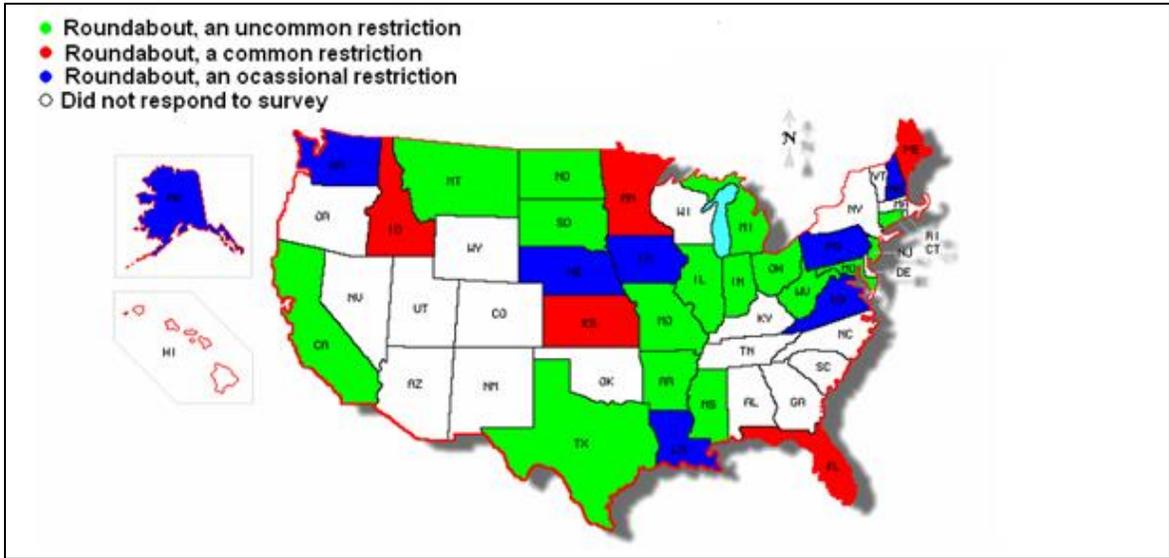


Figure 4. States having “roundabout” as a restriction (Russell et al. 2011).

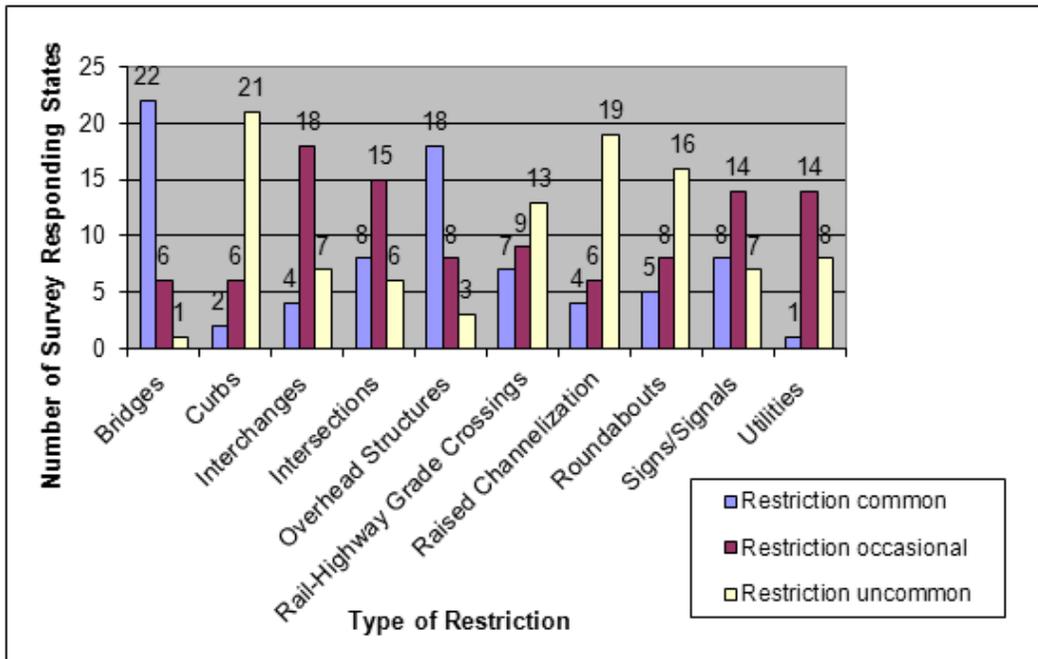


Figure 5. Common, occasional, and uncommon categorization of all reported restriction for OS/OW loads (Russell et al. 2011).

Figure 6 below illustrates the different restrictions that respondents reported were little or no problem to for OS/OW loads.

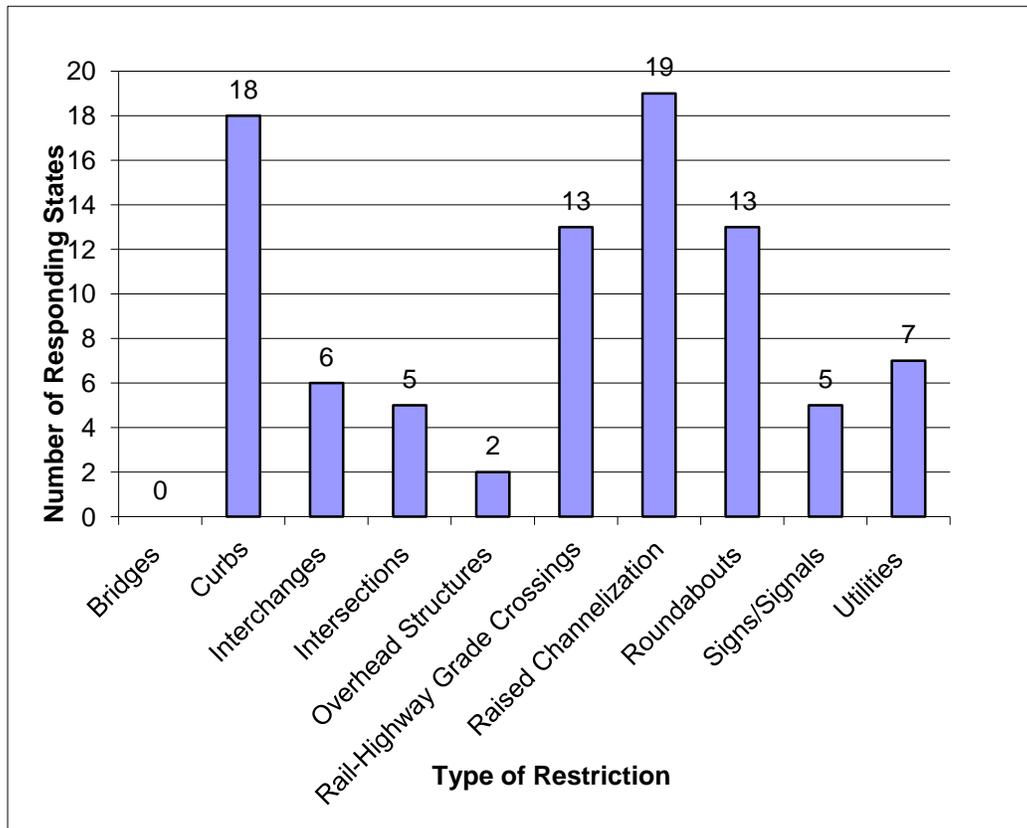


Figure 6. Restrictions are of little or no problem to OS/OW loads (Russell et al. 2011).

For certain extreme loads, a route survey could be done by a company to physically measure clearances and pre-clear on an anticipated route before the move. Thirty-one states require route surveys. Among these states, 26 states answered that the transporter is responsible for the route surveys.

2.3.2 Routing Software

Fourteen responding states use routing software and 23 states don't use routing software. Table 3 shows the routing software used by different states.

Table 3. Routing software used (Russell et al. 2011).

State	Routing Software Used
Illinois	ArcGIS Navteq
New Jersey	Bentley SUPERLOAD
Minnesota	Bentley System Inc product called RouteBuilder
West Virginia	WVPASS/Superload from Bentley Systems.
Florida	In house developed software
Nebraska	We use Superload for bridge analysis and Bentley systems for routing
Michigan	MiPARS (Bentley product)
Texas	TxPROS (Texas Permitting and Routing Optimization System) by ProMiles Software Development Corporation.
Pennsylvania	AMPL and XPRESS-MP
Virginia	ARS Routing Software
California	AutoTurn's latest version.
Arkansas	ARPARS which was developed by Bentley Systems
Missouri	Bentley
Wisconsin	Developed by C.W. Bielfuss which was purchased by current vendor Bentley Systems, Inc.

2.3.3 Kansas Statewide Truck Study

In the statewide truck study (Landman et al. 2010) a traffic assignment network was prepared that included from one to approximately eight zones per county and a station for each state highway connection at the state line. The speeds used in this network were computed by KDOT staff from the CANSYS database as a weighted average of the speeds of the control sections that made up the link. For example, if there was 10 miles from the county line to the edge of town with a speed limit of 65 mi/h, 1/2 mile on the edge of town with a 45 mi/h speed limit and 0.1

miles within the city limits of 20 mi/h. The weighted average speed would be something less than a link that contained only a control section with a speed limit of 65 mi/h. This network is being used to evaluate the effect of roundabouts on the movement of OS/OW loads for the pooled fund study and for determining corridors that are available for OS/OW loads throughout the State System.

A number of modifications were made to the network for this study to address weight, height and geometric restrictions that an OS/OW load may encounter. KDOT staff provided the load ratings for every bridge on the State System. These were appended to the network. If there were more than one bridge in a link, the lowest rating was appended into that link. Before the network was loaded with OS/OW trips, an internal program was executed to adjust the speeds on the network. If it were decided to use 200 K (K-1000 lb) loads as a limit, every link with an appended rating of less than 200 K was given an additional time of 100 minutes, an indication of a route impediment. The 100 minute adjustment was an arbitrary number to divert the load to other links but not prevent the load from reaching its destination, if all possible paths contained bridges with load ratings of less than 200 K. Since the 200 K loading was an arbitrary limit, a comparison was also made with 150 K loads. It was found that there was considerably more flexibility for loads under 150 K than for those between 150 and 200 K.

A second adjustment was made for bridge height. Most of the height restrictions occur along freeway route crossings, such as crossing under the Interstate System and an occasional railroad grade crossing. One of the comments made by representatives of the trucking firms hauling OS/OW loads in Kansas is that it is difficult to cross I-70 north and south. Examination of the bridge clearances showed that the Interstate System goes over the major non-Interstate routes and under the more local routes. In other words, the grades for the major non-Interstate routes were maintained and a pair of bridges was built to carry the Interstate traffic over the roads and the clearance provided was usually less than 15 feet. For more minor routes and local roads, the cross road is carried over the Interstate and clearance crossing the Interstate was no issue. When there are bridges at the intersections of two highways (i.e. Interchanges), the vertical clearance was added to the intersection node and an additional code was included to indicate which road crossed over the other. (1 for cross road over and 2 for mainline over).

A representative of a trucking firm that hauls many of the wind generator components indicated that 15 feet 6 inches is required and 15 feet 10 inches is desirable. To determine the effect of a vertical clearance of less than 15.5 feet, an additional 100 minutes was added to the through movement of the cross traffic. Special codes were necessary to not penalize the through movement on the Interstate. Additionally, special coding was necessary to prevent left turns off the Interstate when the movement had to go under the separation which had less vertical clearance than needed.

A third adjustment was made for a restriction to prevent turns for one route to another. It was conceived at the beginning of this project that this would be the principal part of the research since there was a perception that roundabouts were the biggest barrier to the movement of OS/OW loads. This adjustment was the most difficult to analyze. First, whether a load can maneuver through a roundabout or make a corner depends a great deal of the ability of the driver. Second, many of the firms now have steerable rear axles to assist in turning the corners, and third, there is so much variability in the geometrics of the locations. For example, the placement or lack of curbs; placement of signs, including overhead sign structures; location of guardrails; center islands, etc. all can affect the ability of OS/OW trucks to negotiate intersections. Details of accommodating OS/OW at roundabouts are beyond the scope of this study and should be covered in the pooled fund study mentioned previously.

Based on initial assignments of truck trips to the Kansas State Network, it was discovered that, over height loads could cross the Interstate by using a pair of interchanges. The following sketch (Figure 7) shows several alternatives that may allow over height trucks to cross the Interstate even though they cannot cross directly.

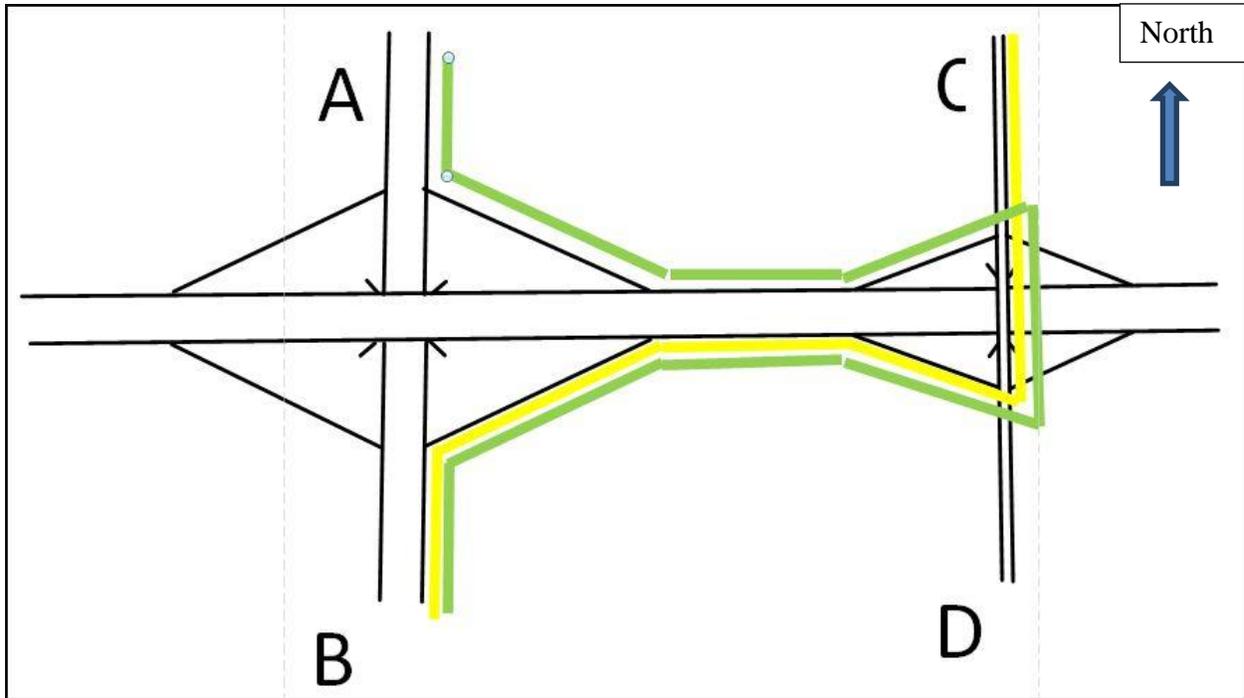


Figure 7. East-West freeway route with two north and south routes crossing the freeway (original sketch by author, Landman, E.D.).

Figure 7 depicts an east-west freeway route with two north and south routes crossing the freeway. Route AB is a major route that crosses under the freeway and Route CD is a minor route that crosses over the freeway. This configuration is a typical result of Bureau of Public Roads/FHWA design policy at the time the Interstate was built. It is assumed that the vertical clearance is less than an over height load that wants to move from south of the freeway to a destination north of the freeway.

One alternative is to follow the route depicted in yellow, with several assumptions: 1. the load can make the turns on and off of the freeway at the diamond interchanges, and 2. there are no restrictions on Route C to prevent the load from reaching its destination. The second alternative is to essentially make a U-turn at the interchanges on Route CD and return to exit onto Route A. Again, this assumes that the load can make the turns on and off of the freeway.

There are examples of modifications made to intersections, including freeway on-off ramps, in order to accommodate OS/OW loads. One, shown below, is the west-bound off ramp at the west junction of I-70 and K-14 in Kansas. The Google photo (Figure 8) shows the fill that was added

to the end of the off ramp so that trucks carrying wind generator blades could be delivered to a wind farm just north of the interchange. Details of the westbound off ramp with added fill are shown in figure 9.

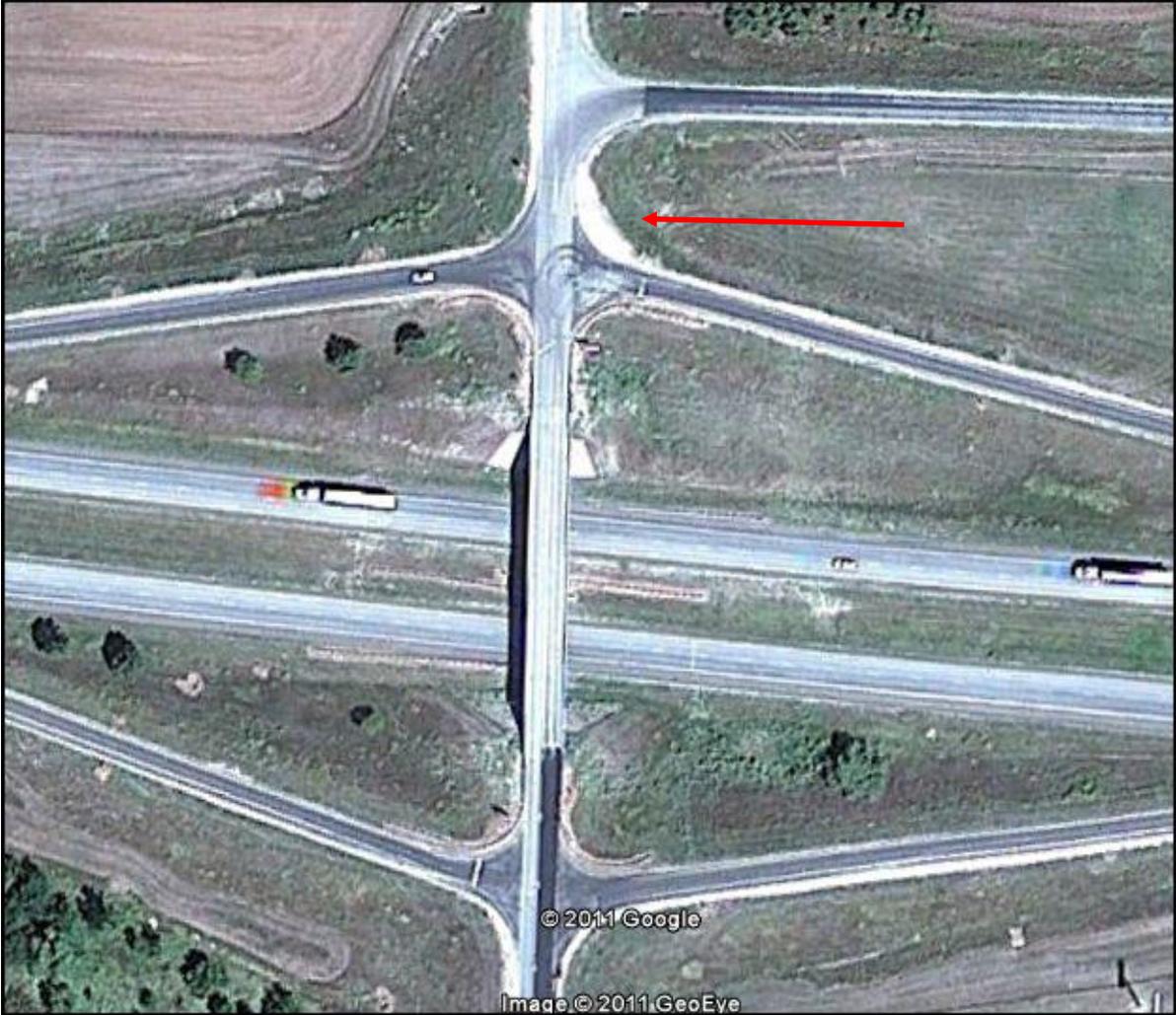


Figure 8. I-70 K-14 west interchange (Google photo).



Figure 9. I-70 and westbound off-ramp at west junction of K-14 (Google photo).

It became evident that additional study is desirable to determine how restrictions of all types can be eliminated or managed to allow access to all parts of the state and for an efficient movement in or across the state for OS/OW loads. **The results of additional study on this project are contained in Chapters 3 and 4.**

While an initial assumption was that roundabouts were the chief intersection restriction, others have been identified. The detailed study of roundabout intersections is being covered in the pooled fund study. Further research should be pursued to reduce the restrictions of the various intersection types other than roundabouts, as well as develop criteria to assure that areas are not isolated by restrictive intersections.

Finally, one must consider the policy of law enforcement agencies, and the legal “authority” of escort services, which is beyond the scope of both this study and the pooled fund study. Some movements can often be made if the OS/OW loads are allowed to cross the center line to use the ramp in the opposite direction of normal travel or go around a roundabout in the opposite direction, or make other moves that would normally be illegal for drivers. Legislation may need to be proposed to lessen or remove any liability for crashes if recommended practices on permitted routes are undertaken. Finally, KDOT or other highway agencies should be able to temporarily modify elements of the system as necessary if the transporting company or the

company owning the load is willing to pay for the modification. Policy in this regard should be clear. Additional insight into needed legal issues is presented in a section below.

2.4 AN OVERVIEW OF WISCONSIN'S FREIGHT NETWORK

The following section is based on conversations and e-mails with Peter Lynch and Pat Fleming in regard to their statewide truck routing network. (Lynch and Fleming, private phone conversations and e-mails February 2012)

A policy study was conducted with pooled funds from Minnesota and Wisconsin. A consultant worked with Lynch to build a statewide freight network. This network was a general highway freight network and not specifically related to any specific concern like roundabouts. There were other studies done for Wisconsin DOT that did study the network to determine where OS/OW are needed to be accommodated on roundabouts within the state. Every truck route has to be designed for a "WB67 Vehicle" (AASHTO designation), shown in figure 10. On the OS/OW portions of the freight network, six check vehicles as shown in figure 10, must be accommodated.

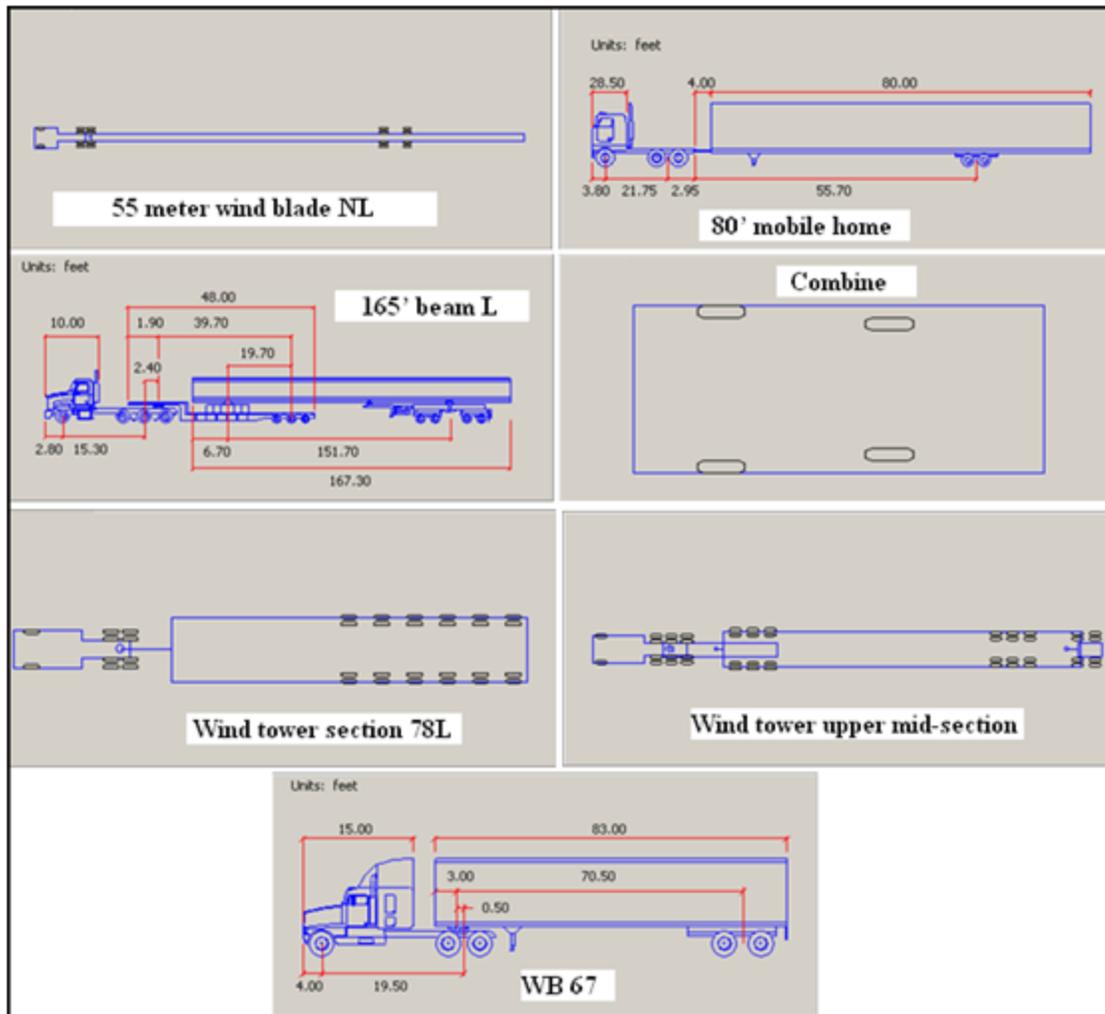


Figure 10. OS/OW check vehicles from the Wisconsin DOT vehicle library (E-mail from Patrick Fleming, Wisconsin DOT; study by Mark Lenters).

2.4.1 Wisconsin Permits and Route Descriptions

Wisconsin requires the following types of permits and the Wisconsin freight network (FN) (Lynch, E-mail February 2012):

2.4.2 Multiuse Permits

These are permits carriers can obtain per VIN (Vehicle Identification Number) and are within a defined envelope size and weight as prescribed in Wisconsin state law for a given commodity

type (Mobile Homes, Construction Equipment, Mobile Cranes, Raw Forest, etc). Use is unlimited up to a year and carriers do not have to submit a route to the state before departure.

2.4.3 Transactional Permits (Tier 1)

These are single trip permits that are completely handled by an online permit routing system (pretty much the same vehicle size as the multiuse permit vehicles).

2.4.4 Specific Permits – Single Trip (Tier 2)

These are loads that often require bridge weight and/or geometric (Length, width, or weight) reviews (Bridge Beams, Wind Industry, Large Tanks, and Cranes in some cases). Clearance is first determined in the routing system. This is what the OS/OW Freight Network (FN) was designated to handle. OS/OW Freight Network Routes (specified portions of the Freight Network) where the seven “check” vehicles shown in figure 10 must be accommodated are referenced on this network, and appropriate design guidance has been adopted in the state’s Facilities Development Manual. **Note: this is for all intersection and interchange designs not just roundabouts.**

2.4.5 Mega Load (Tier 3)

For the “real big and heavy stuff”, no specific routes are preserved for them beyond the OS/OW freight network (OS/OW FN). No check vehicle is referenced for this class of OS/OW truck either. These vehicles have cutting edge technology and capabilities and in some cases that are not as constrained in turning movements as OS/OW Tier 2. For example, they may have hydraulic lifts and multiple points of articulation.

2.4.6 OS/OW Freight Network Summary

Wisconsin has identified a subset of roads in the FN, including interstates on the state highway network, that are ideal or would be ideal with some improvements for OS/OW transport vehicles

(Tier 1 and Tier 2), that have logical connections with neighboring states' OS/OW routes as well as between WisDOT's 5 regions. It is comprised of optimal routes historically used with the goal to consolidate OS/OW traffic of similar size and dimension as opposed to letting them use the whole state system and multiple routes.

Long Truck Routes (WB 67 Long "check vehicle" - not shown on the 7 OS/OW vehicle reference sheet)

These are longer tractor trailers with sleeper cabs or longer than what some call your standard semi-trucks. (or sometimes "18-wheelers") This is a larger network than OS/OW FN but not the whole state system. See figure 11 below. Due to some geometric limitations, some routes are limited to 65' (Red) where others are 75' (Blue) while others have no set limit (Green).

2.4.7 Legal Issues Overview: General

An in depth analysis of legal issues is beyond the scope of this study; however, they are very important and should be studied. An overview of the gaps that need to be studied in routing large trucks and OS/OW can be summarized in a proposed synthesis study sent to NCHRP by the TRB Roundabout Committee and supported by KDOT. (Russell, February 2012) Whether or not this synthesis is funded and a nationwide study done, the authors believe a similar study in Kansas would be beneficial. The proposed synthesis is reproduced here as follows: (Russell, February 2012)

The Influence of State and Local Laws on Roundabout Operations

There appears to be a significant degree of inconsistency between states and among municipalities concerning statutes, ordinances, policies and procedures that affect the operations of roundabouts. This can have a profound impact on the movement of freight, in particular, due to routine and widespread movement across political boundaries – the essence of interstate and intrastate commerce. As roundabouts are continuing to become more popular across the United States, it is likely that these inconsistencies will become more problematic in the absence of a national effort to understand the related dynamics and begin to craft a general consensus going forward.

One very specific example of these inconsistencies involves how vehicles are expected to behave on approach to and circulating through a roundabout. At some locations, a roundabout may have been designed to allow for larger vehicles (i.e. multiple-unit trucks) to encroach into adjacent lanes, or to use a traversable apron (if provided), while at other locations those same vehicles may be expected to maintain lane discipline. The size of the roundabout is directly influenced by decisions regarding encroachment. However, size also influences the speed of vehicles through the roundabout, which in turn can negatively affect safety performance. Designers are challenged to strike a balance with respect to size, speed, safety and accommodation of various user characteristics.

Not explicitly understood by most designers is how the enforcement and education influences should be brought to bear on design decisions. Variation among states, and possibly within states at municipal levels, will foster uncertainty and confusion. The oversize/overweight (OS/OW) community is at greater risk of being affected by these inconsistencies, since some degree of encroachment is usually necessary when negotiating an intersection. Legal problems can be encountered depending on permit policies and procedures, such as whether police or non-police escorts are usually required, and how traffic control is handled. Furthermore, in the case of an incident/crash, how the responding law enforcement agency assigns fault may or may not be another matter altogether. At least one state's trucking association (Oregon) has lobbied for a change in state statute so that encroachment by a truck is not considered a moving violation, which had been resulting in large monetary awards to plaintiffs in court cases when involving a crash where the truck had been "at fault" and liable for damages based on lane encroachment.

A synthesis of existing roundabout-related statutes, ordinances, policies and procedures is needed in order to begin to address inconsistency in practice. This would include examining how police assign fault in the case of a crash. Also valuable would be an assessment of driver manuals (including commercial driver literature) and state vehicle codes, and examples of commercial driver training/curriculum that speak to roundabout operation. A synthesis that captures these issues will provide valuable and timely information to road agencies working to address these issues, and will ultimately serve as a basis for future efforts toward national consistency.

2.4.8 Large Truck and OS/OW Routing Issues in Oregon

The state of Oregon, and truckers and their associations in Oregon, have been trying to work out differences between the State DOT and the trucking industry in regard to roundabouts.

Opposition by one or more truckers led to a state representative passing a law with severe limitations on the use of roundabouts. The state of Oregon put a moratorium on building roundabouts until the issue could be worked out. As stated in the Bend Bulletin: (October 25, 2011)

ODOT halted its support of roundabouts on state highways this year after the freight industry raised concerns about the difficulties they pose for large trucks.”

“We’re taking a time-out on roundabouts on state highways,” said ODOT spokesman Peter Murphy, noting that ODOT won’t reconsider its position until the completion of a two-year study examining the effects of roundabouts on freight movement.

The above information illustrates that freight routing is an important issue that must be dealt with and should be dealt with by all states. Oregon is unique in that the trucking associations have more influence than appears to be the case in all other, or at least most states. Legislation was introduced in the Oregon Legislature around the year 2000 and passed into law (ORS 366.212), which formed a Freight Mobility Advisory Committee. This legislation provides for an advisory committee for multimodal freight interaction and of which highway trucking is a key factor between the modes. Following this legislation, the ODOT Motor Carrier Group created a subcommittee - the Motor Carrier Transportation Advisory Committee (MCTAC) dealing specifically with truck freight mobility.

Then in 2004 a bill was introduced and passed in the Oregon Legislature, referred to as the “reduction of vehicle – carrying capacity”, (ORS 366.2151). The final definition of “vehicle-carrying capacity followed the freight haulers definition of “the hole in the air” concept, necessary for a truck to traverse a section of highway. ORS 366.215(2) states:

Except as provided in subsection (3) of this section, the commission may not permanently reduce the vehicle carrying capacity of an identified freight route when altering, relocating, changing or realigning a state highway unless safety or access considerations require the reduction.

For the Oregon DOT to change the “the whole in the air” concept on an identified freight route, they have to have the freight communities agreement, or lacking that, apply to the Oregon Transportation Commission for a decision. An “identified freight route” is now interpreted as not only the Oregon Highway Plan Freight Route designation, but in addition, any nationally recognized truck route, e.g. NHS routes, NN routes and possibly local jurisdiction truck routes as well.

The Oregon DOT Highway Mobility Operations Manual provides more detailed information. One paragraph from this manual illustrates the policy of dealing with the trucking industry:

NOTIFICATIONS AND APPROPRIATE FOLLOW-UP (ODOT Highway Mobility Operations Manual, p 10) “The Motor Carrier Transportation Division (MCTD) is the primary contact to engage industry stakeholders for all of ODOT’s maintenance, construction, and engineering activities. The MCTD Freight Mobility Coordinator needs to be involved in all communications with industry stakeholders. When contacting local industry stakeholders, the MCTD Freight Mobility Coordinator must be included. Local contact with the trucking industry absent MCTD involvement does not satisfy the project communication requirements addressed in this manual. The audience of potentially impacted freight stakeholders extends well beyond known familiar local users of the road system. MCTD tracks and relays information to all industry stakeholders within the United States and Canada that are authorized to use Oregon’s state highway system. The MCTD Freight Mobility Coordinator can also set up meetings with industry representatives when needed.

In regard to the impasse regarding roundabouts on the Oregon state highways, a freight/roundabouts steering committee made up of DOT and freight industry representatives was formed to work out whatever differences there are in building roundabouts on Oregon state highways. They are working toward a process of inclusion of freight representatives that has their input into creating roundabout design criteria in general and then having review capacity at specific locations when the design occurs. (Rich Crossler-Laird, email 02/06/2012)

CHAPTER 3: KANSAS OS/OW NETWORK DATA

3.1 COMMODITY DATA

Kansas, being in the center of the 48 states provides for movement of OS/OW loads across the state in both the east-west and north south directions as well as coming into the state and traveling wholly within the state. This chapter provides a summary of this data, based on the latest available. Table 4 shows the state to state interchange of OS/OW loads for 2010.

Table 4. OS/OW permitted by KDOT in 2010 (Kansas DOT 2010 data).

		Departing To					
		Kansas	Nebraska	Missouri	Oklahoma	Colorado	Total
Entering From	Kansas	210	125	60	130	39	565
	Nebraska	85	11	22	399	40	559
	Missouri	72	13	1	40	70	199
	Oklahoma	129	697	35	10	551	1426
	Colorado	39	2	26	114	1	187
	Total	535	848	144	693	701	2921

As can be seen, only 210 of 2921 loads, less than 10%, are internal to Kansas. There are 355 loads starting in Kansas destined to other states and 325 coming from other states and terminating in Kansas. It should be noticed that states listed in this table are the states that the loads enter or leave Kansas and not their origin or destination. The available data only shows the point of entry or exit at the state line. Note that there were 11 loads between origin and destination locations in Nebraska and 10 loads between origin and destination locations in Oklahoma. It is apparent that the shipper was willing to pay the cost of the permit and travel the extra distance to get from their origin to destination by traveling through Kansas. The reason for this choice is not known. One would assume they picked the best routes or roads.

Figure 12 shows the range of weight for the OS/OW loads traveling on Kansas roads in 2010. The most common range of loads was between 162,500 pounds and 187,500 pounds (175K) with approximately 750 loads being hauled on Kansas highways. Loads over 250,000 pounds were rare but each one that weighs that much was significant with the maximum load entering the state from Oklahoma on US-83 and departing on K-96 into Colorado. It was a generator that weighed 915,000 pounds. It was loaded on a truck with 25 axles, was 20 feet wide, 15.916 feet high and 293 feet long.

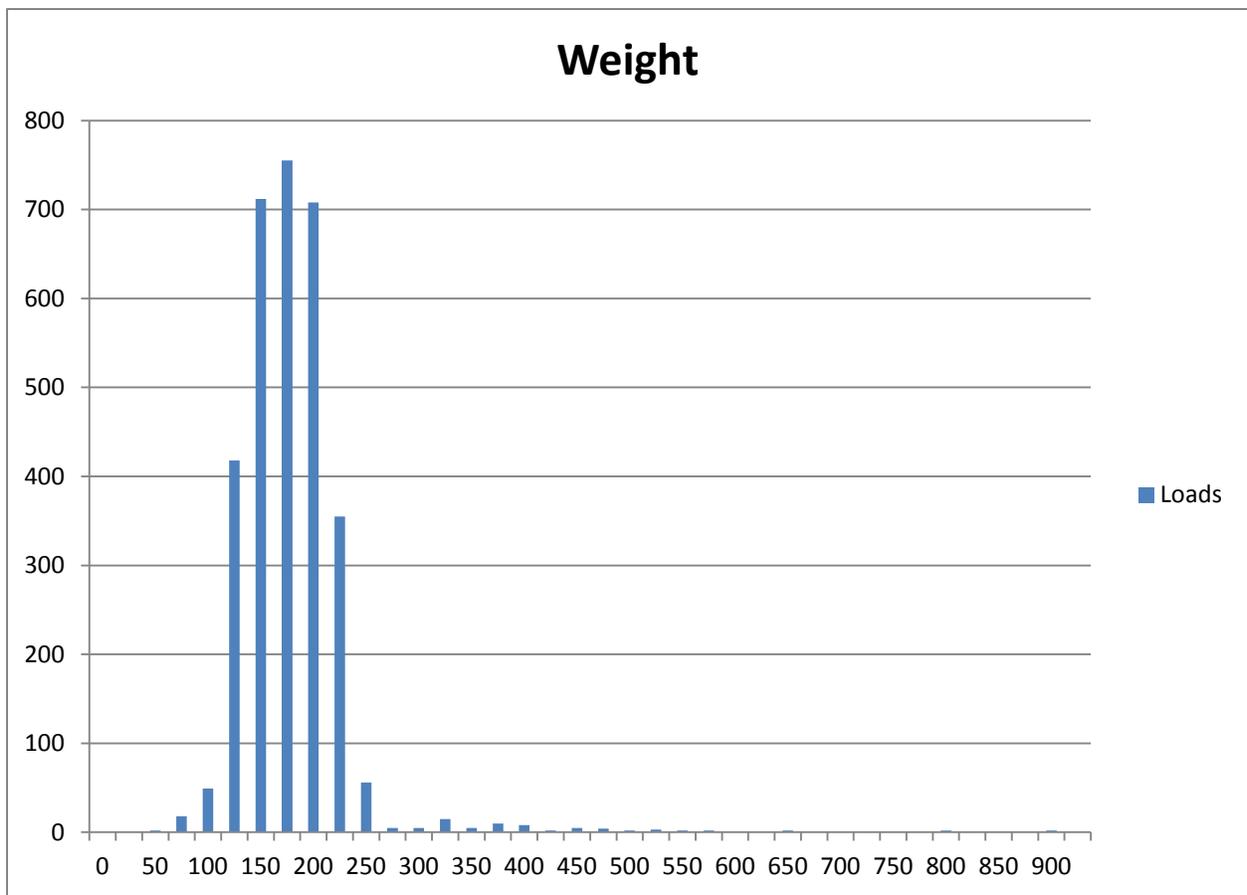


Figure 12. OS/OW Load Weights in 2010 on Kansas Highways (Kansas DOT data 2010).

Figure 13 shows the heights of the OS/OW loads using Kansas Highways during 2010. Almost half of the loads were 14 feet tall with almost all of the rest being higher. The highest load was a building 34 feet high on a trailer that was moved a short distance south of Abilene. Over 1/3 of the loads cannot clear the bridges where the road crosses under the Interstate.

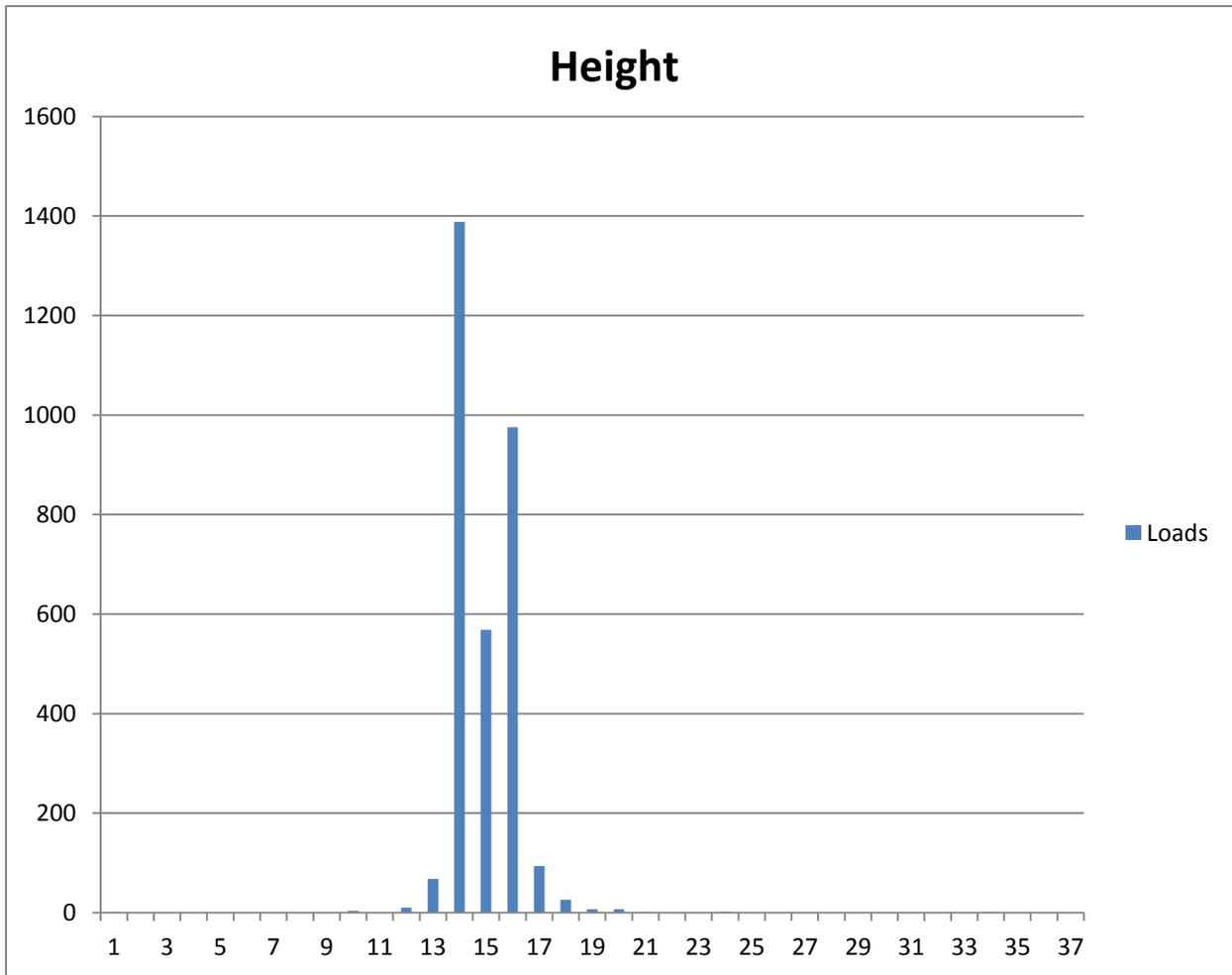


Figure 13. OS/OW Loads Heights in 2010 on Kansas Highways (Kansas DOT data 2010).

Figure 14 shows the lengths of the OS/OW loads using Kansas Highways during 2010. Approximately 1200 of the loads are 100 feet in length with some as long as 300 feet. There were more than 200 loads that were 150 feet or greater. At the scale of the graph in this report, the small bars do not show.

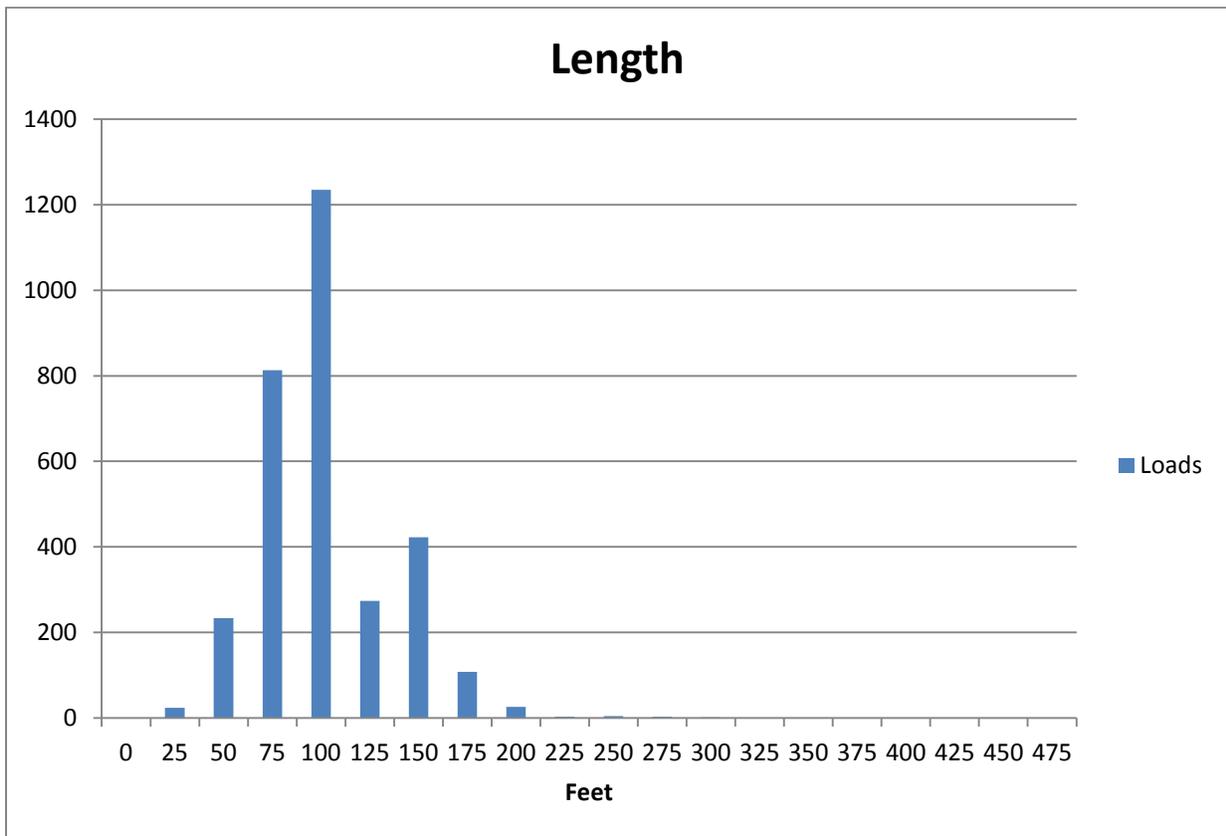


Figure 14. OS/OW Loads Lengths in 2010 on Kansas Highways (Kansas DOT Data 2010).

Figure 15 shows the widths of the OS/OW loads using Kansas Highways during 2010. Almost all of the loads were over 8 feet wide with the majority (approximately 850) being 12 feet wide. There are over 1000 loads that are 14 or 15 feet wide, with the widest being the building that was 34 feet high and was also 34 feet wide. Fortunately, it was moved only about ½ miles and did not encounter any bridges or other restrictions.

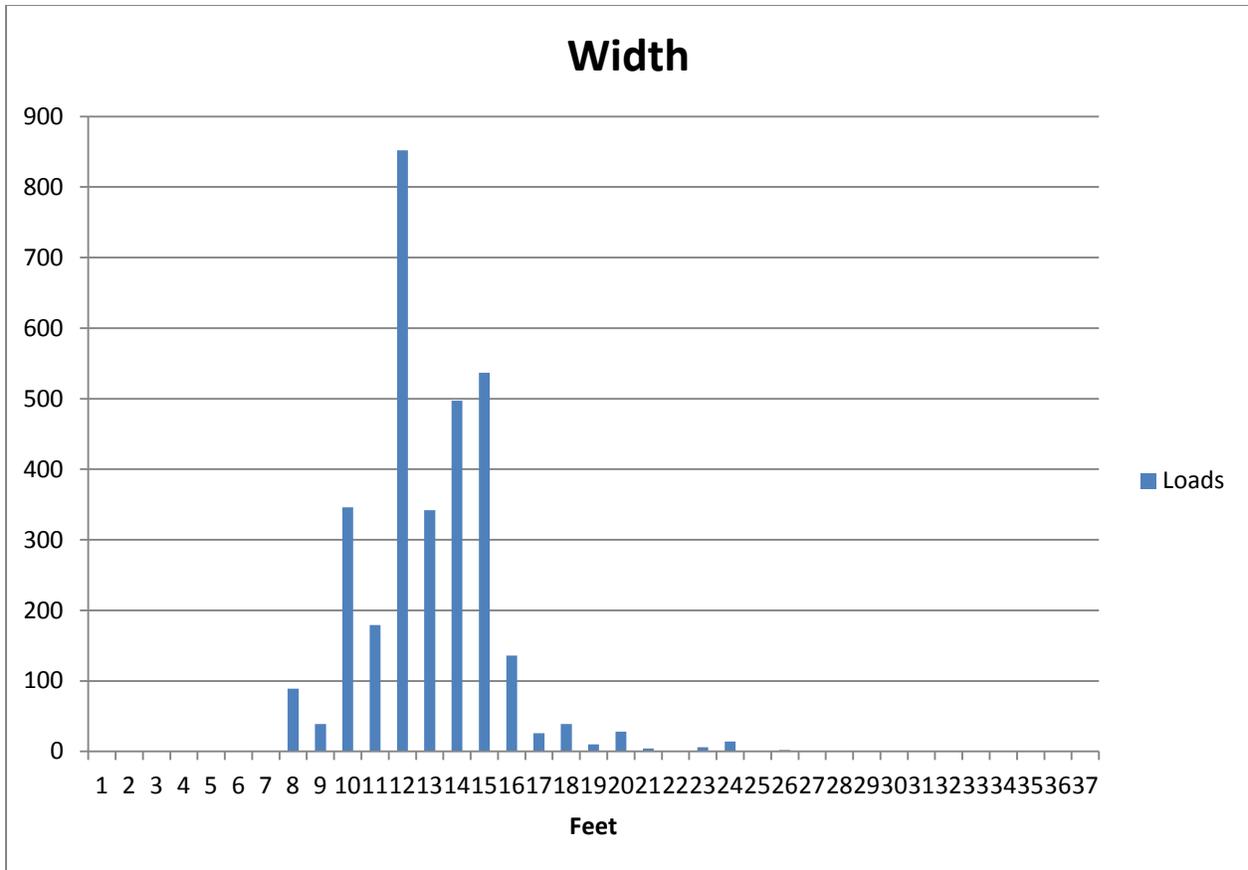


Figure 15. OS/OW Loads Widths in 2010 on Kansas Highways (Kansas DOT data 2010).

The following two figures, figure 16a and 16b, show the 2010 loads that exceed 150,000 pounds assigned to the State System. The paths in figure 16a were determined by the weighted average speed limit with no other restrictions. The weighted average speed was provided by KDOT staff and was based on the rural speed limit, the reduced speed limit on the fringe of cities and the speed limit on the connecting links within cities. The attractiveness of a route was affected by the number of cities along the route. Figure 16b depicts the routes that were used for the same loads when links of the system were restricted by bridge ratings that were less than 150,000 pounds. There were many route changes across the state but the most significant one was the diversion away from US-83 by a restriction near Garden City.

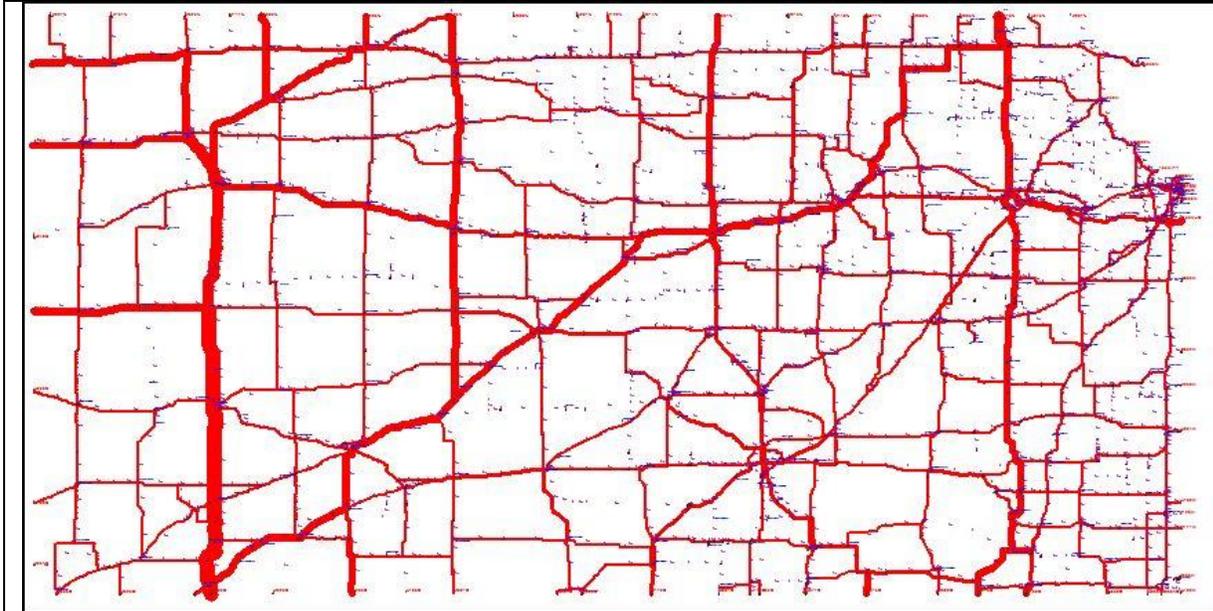


Figure 16a. Loads using fastest route, no restrictions.

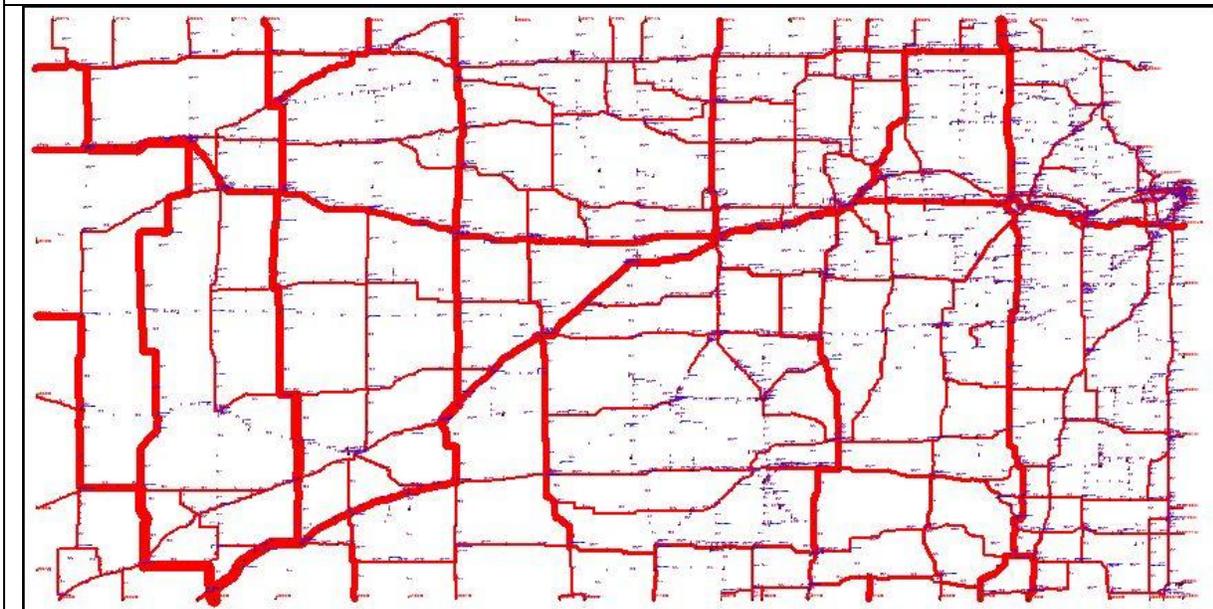


Figure 16b. Loads using only routes with bridge rating > 150,000 pounds.

Figure 17 shows the path of loads of 300,000 pounds or greater loaded on paths that allowed loads of that weight. Either, there were no bridges along these routes or they had a bridge rating equal to or greater than 300,000 pounds. These were extremely heavy loads and there were very few of them. Most (15 loads) came out of Oklahoma and traveled through the state, with the most coming into the state on US-83 and leaving into Colorado or Nebraska. The economic impact of those few loads that began or ended within Kansas is unknown.

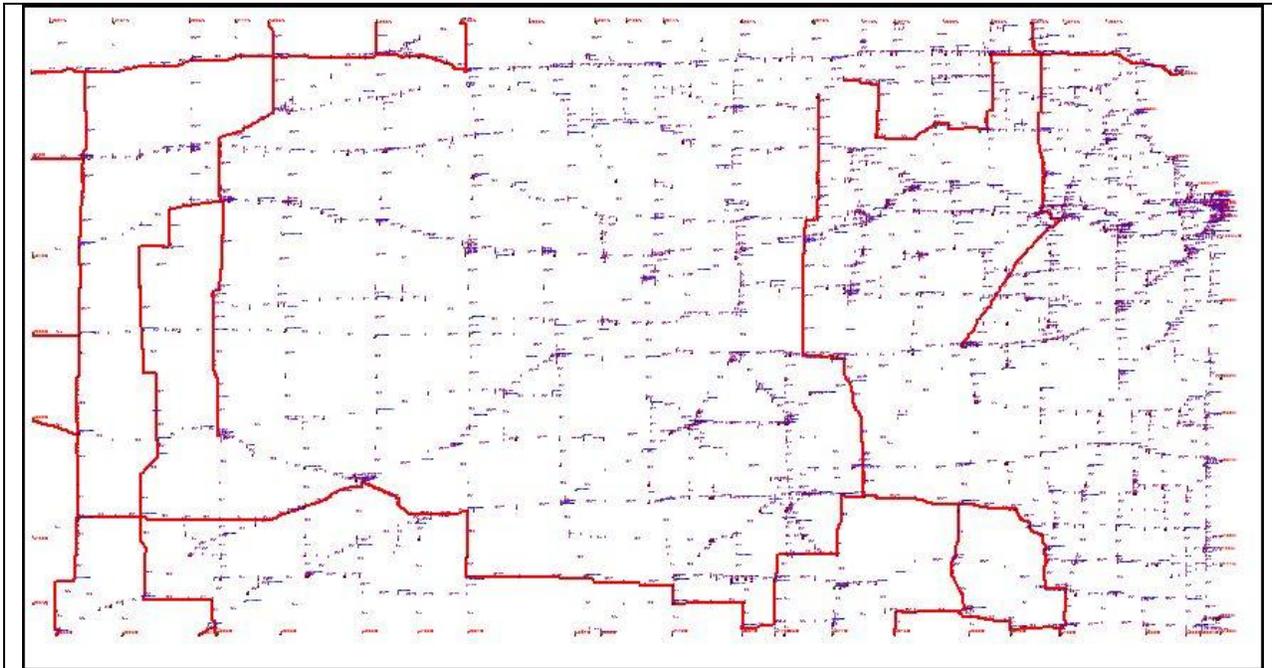


Figure 17. Loads equal to or greater than 300,000 pounds.

When preparing an individual permit, KDOT's Bridge Evaluation Squad checks every bridge of the proposed route and every axle of the individual truck proposed for carrying the load. The combination of axle weight and axle spacing is compared to the each bridge. This effort is beyond the scope of a system-wide analysis. The KDOT Bridge Evaluation Squad Leader, indicated that the use of the bridge rating was one that could be done on a system-wide basis and was satisfactory to be used. However, there will be incidences where the two methods will differ.

Figures 18, 19 and 20 show three routes shown on individual permits that were studied by the authors. Two of the permits are for loads moving across Kansas from Oklahoma to Nebraska and the other is from a location in Neosho County to Nebraska. These selected permits were from 2006 and 2007. The route permitted in figure 18 enters Kansas on US-77 from Oklahoma and leaves Kansas on US-77 into Nebraska. However, only a small portion of the trip is made on US-77 in Kansas.

The load depicted in figure 19 is a very large load, weighing 481,000 pounds, 212 feet in length, 20 feet wide and 17 feet high. Note the very circuitous route the must be taken to get from S.E. Kansas to Nebraska.

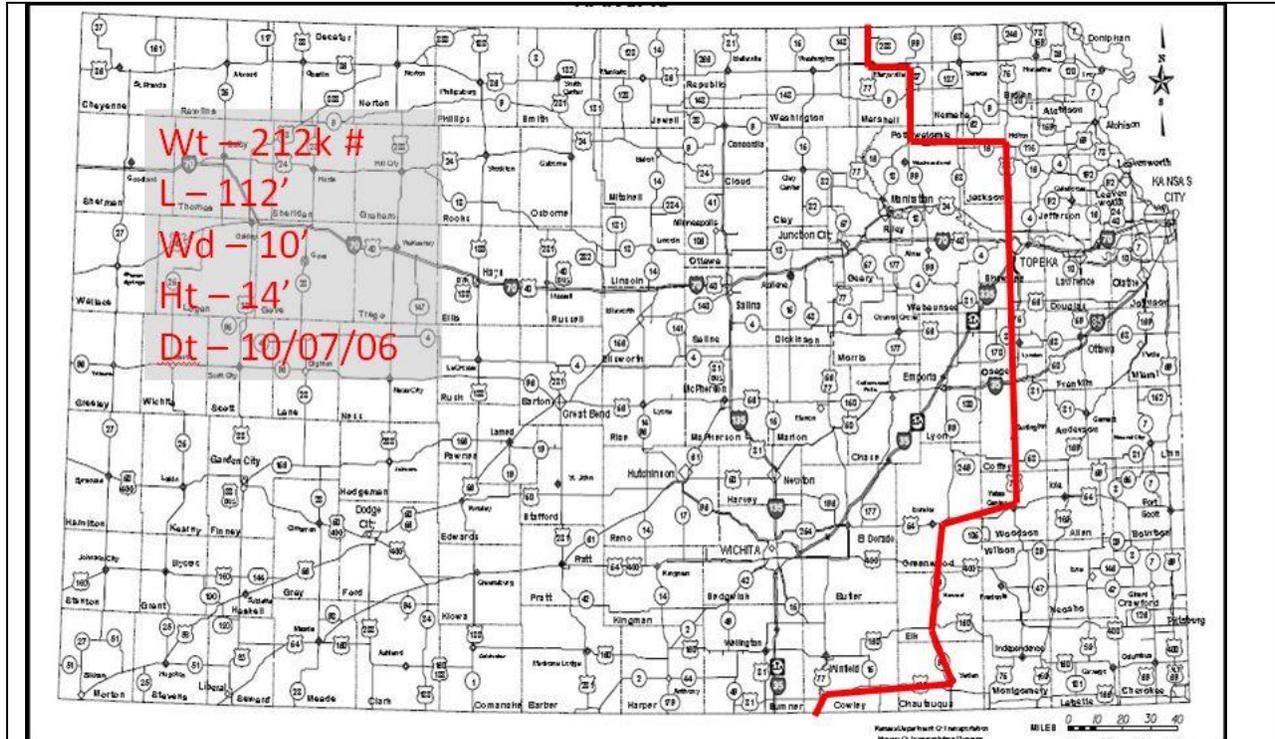


Figure 18. Permitted Route 1.

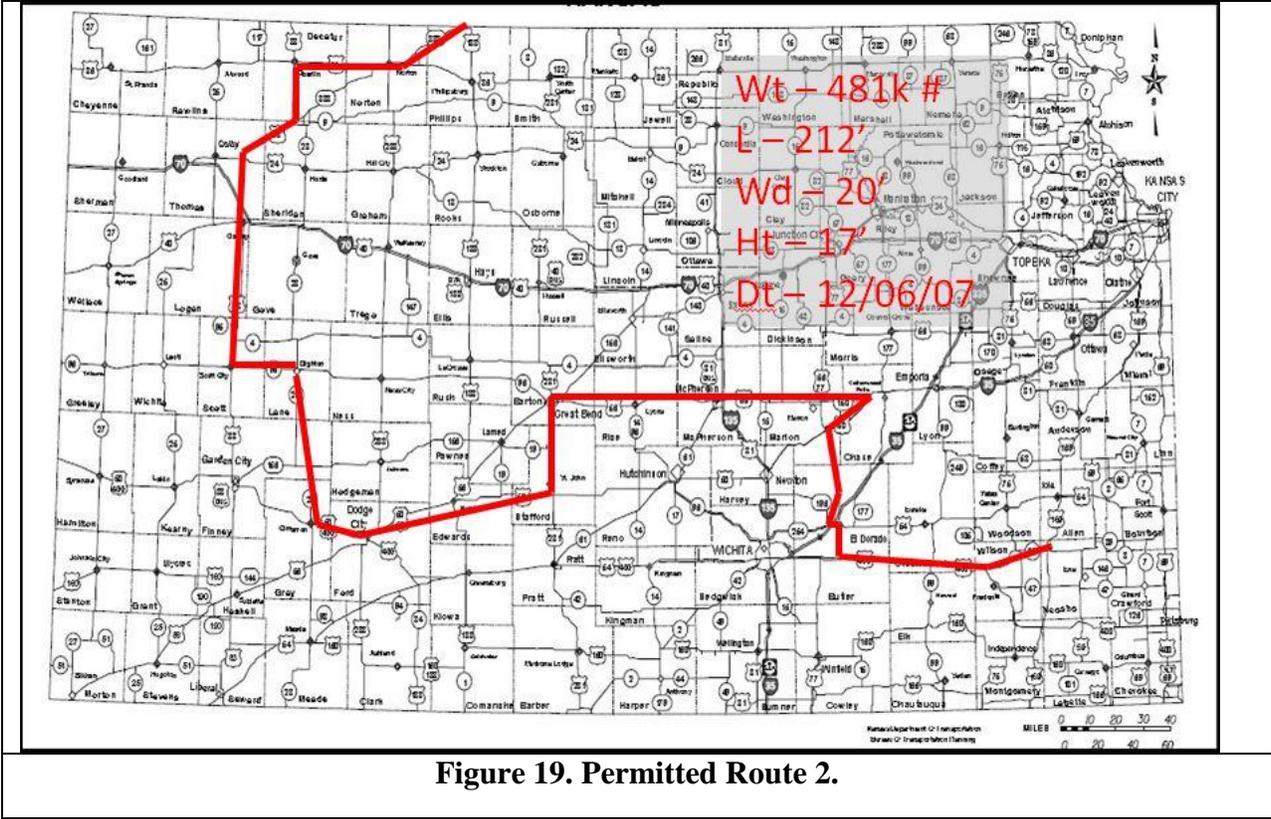


Figure 20 shows a more typical load and path from 2007 that was found in the 2010 data. Fortunately, US-83 goes over I-70, north of Oakley, so vertical clearance was not a problem. However, there are a number of cities and at rural intersections where it may be difficult if not impossible to make a turn with a load 129 feet long. Without further analysis, it is not possible to determine if this route is a feasible route for a long load, particularly one without a steerable rear axle on the load. The trucking firm requesting the permit is subject to a fine if the actual route taken has been modified by the driver or escort vehicle. There is an exception to this rule in cities where turns cannot be made without restricting parking during the maneuver and a nearby combination of local streets or roads will accommodate the maneuver. Steerable rear axles have reduced the problems facing the trucking companies in making turns at intersections.

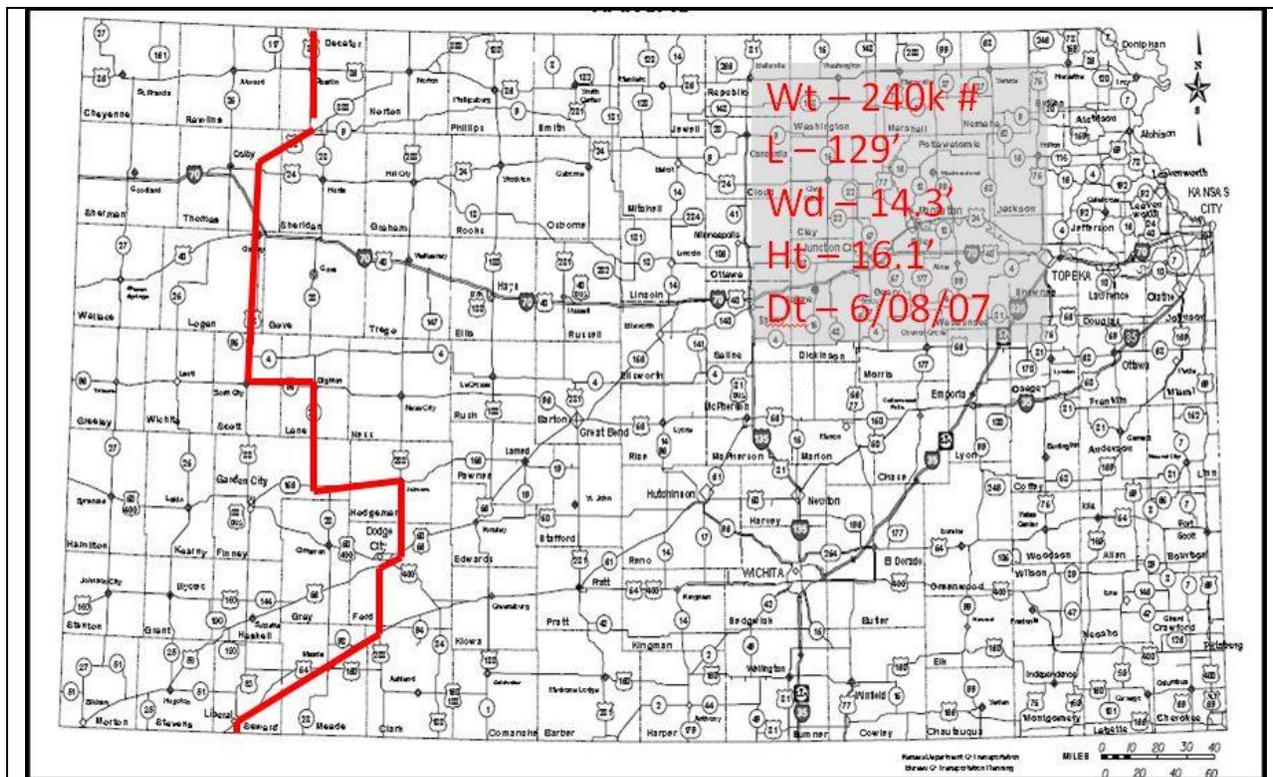


Figure 20. Permitted Route 3.

The authors made a review of some selected transportation companies that had obtained permits in 2010 to see if there was any that made multiple trips on Kansas highways.

ATS Specialized, Inc., of St. Cloud, Minnesota made numerous trips through Kansas and for the most part carried wind generation components. A set of diagrams of their geometric requirements for various truck configurations is found in Appendix A. The first five pages of Appendix A shows the roadway widths necessary for five trailer configurations to successfully turn a corner. The remaining pages show the various trailer configurations that ATS Specialty, Inc. has available for hauling OS/OW loads. Some of these are designed for loads never used on Kansas Highways, but may have similar turning criteria.

Figure 21 shows ATS' opinion of the worst intersections for ATS OS/OW shipments.

- Coffeyville will not allow use of local roads any more.
- Roundabout not a real big problem, except where there are curbs
- US-75 has numerous sharp turns as does US-77
- Difficulty crossing I-70 (Overhead limitations)
- Worst corners (See Figure below) the corner of K-25 & K-96 in Leoti (red) is the most of the group.

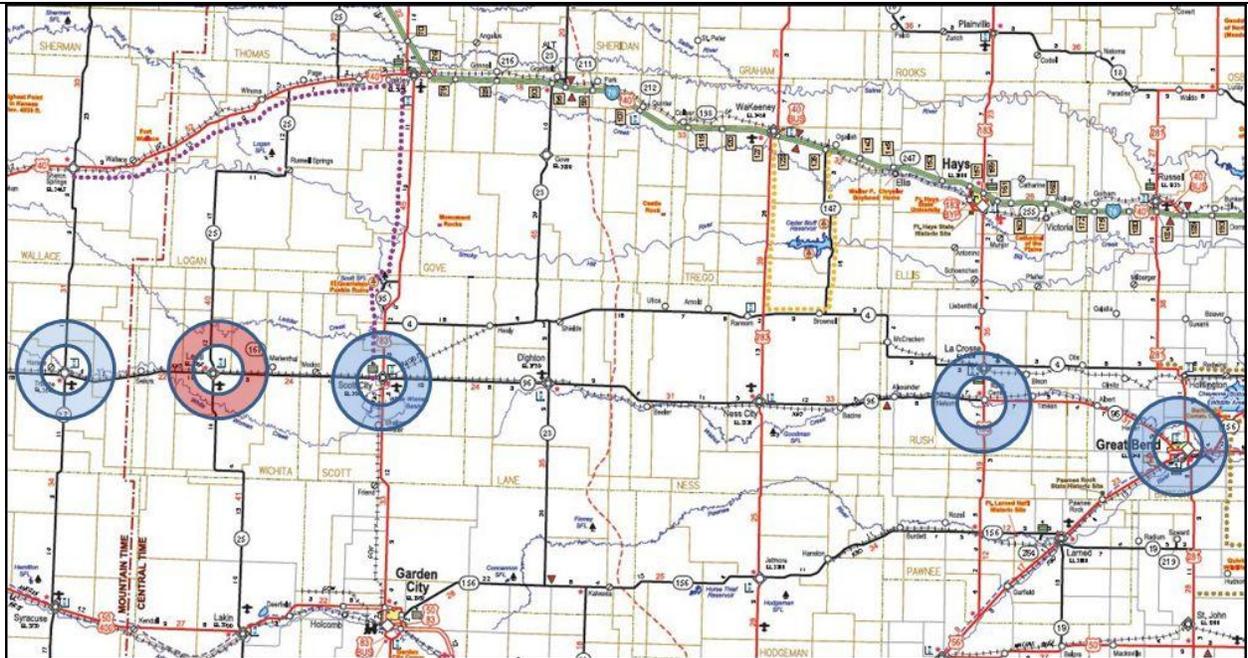


Figure 21. Worst intersections for ATS loads (telephone conversation. Joanna Jungels, OD Permit Manager, for ATS Specialized, Inc).

The issue here is that loads must move east or west to a highway that crosses over I-70, which has vertical clearance problems on north-south highways, particularly those that cross I-70 within a city. In this location, the interstate was carried over the other roadway so there would be no approach grade to limit access to businesses near the interstate.

Moving Iron, Inc. of Red Bay, Alabama, no longer moves any loads in Kansas and referred the authors to STI Trucking, Inc., also of Red Bay, Alabama. The respondent indicated that they didn't have the equipment to haul long loads.

Another respondent of West Freight Systems, Inc. of Lima, Ohio, indicated that he was not aware that they encountered any problems anywhere they needed to go in Kansas. They use steerable rear axles for long loads and that they had never had any problems with roundabouts.

CHAPTER 4: KANSAS STATE NETWORK

The state network used in this analysis is the statewide network used in a previous study mentioned earlier. (Landman et al 2010). In addition to the state system, two additional non-state links were included. They were the Yoder Road in Reno County linking K-96 to the eastern side of Hutchinson, and Turner Diagonal in Kansas City, from I-70 to K-32, then K-32 from that point back to I-70 near 55th Street. These routes in Kansas City had been on the state system and removed. The state system data was provided with numerous attributes in the form of a shape file. This data was then converted by the network software package, Graphics Network Editor (GNE), which is the network editing component of Quick Response System (QRS) written and maintained by Alan J. Horowitz, Professor of Civil Engineering, University of Wisconsin, Milwaukee.

GNE and QRS can use any of three default formats to describe a network, “Easy” with 10 attributes for links and seven attributes for intersections (nodes); “Detailed” with 22 attributes of links and 11 attributes for nodes; and “Dynamic” with 29 attributes for links and 11 attributes for nodes. However additional attributes may be added to links, up to a total of 35, and the attributes names can be changed. Caution must be used to not try to redefine an attribute that the software is using as part of the assignment process. Table 5 shows the default format and the format used to assemble the data necessary to compute the restrictions caused by features of the highway network.

Table 5. Network link formats.

Dynamic Default Link Format

Revised OS/OW Link Format

Name	Format	Variables	Name	Format	Variables
Approach Codes [e.g., 0S30S3U]	Category	7	Approach Codes [e.g., 0S30S3U]	Category	7
Speed (Mi or Km/Hour)	Real	0	Speed (Mi or Km/Hour)	Real	0
Travel Time A to B (Minutes)	Real	5	Travel Time A to B (Minutes)	Real	5
Travel Time B to A (Minutes)	Real	5	Travel Time B to A (Minutes)	Real	5
Base Volume A to B	Real	0	Base Volume A to B	Real	0
Base Volume B to A	Real	0	Base Volume B to A	Real	0
Capacity (Sat Flow) A to B	Real	0	Capacity (Sat Flow) A to B	Real	0
Free Travel Time	Real	2	Free Travel Time	Real	2
Capacity (Sat Flow) B to A	Real	0	Capacity (Sat Flow) B to A	Real	0
Distance	Real	0	Distance	Real	0
Extra Time A to B	Real	0	Extra Time A to B	Real	0
Extra Time B to A	Real	0	Extra Time B to A	Real	0
HV PCE A to B	Real	0	HV PCE A to B	Real	0
HV PCE B to A	Real	0	HV PCE B to A	Real	0
HV Proportion A to B	Real	0	HV proportion A to B	Real	0
HV Proportion B to A	Real	0	HV Proportion B to A	Real	0
g TR Override A to B ('00)	Real	0	Lane Class	Real	0
g L Override A to B ('00)	Real	0	Terrain	Real	0
g TR Override B to A ('00)	Real	0	STP	Real	0
g L Override B to A ('00)	Real	0	DV/UnDiv	Real	0
Capacity Change Start Interval	Integer	0	IJK	Integer	0
Capacity Change End Interval	Integer	0	RtNo	Integer	0
Capacity Change A to B	Real	0	County	Real	0
Capacity Change B to A	Real	0	MilePost	Real	0
Ground Count A to B	Real	0	Ground Count A to B	Real	0
Ground Count B to A	Real	0	Ground Count B to A	Real	0
Ground Count Weight	Real	0	Ground Count Weight	Real	0
VOLUME A TO B ==>	Real	0		Real	0
VOLUME B TO A ==>	Real	0		Real	0
			Load Limit A to B	Real	0
			Load Limit B to A	Real	0
			Struct. Height A to B	Real	0
			Struct. Height B to A	Real	0
			VOLUME A TO B	Real	0
			VOLUME B TO A	Real	0

Additional attributes were also added to the node description to define elements of the intersections that would restrict turns at the intersections, or in the case of an interchange, restrict the load on the basis of weight or vertical clearance Table 6 shows the additional attributes and those that were redefined.

Table 6. Network node formats.

Dynamic Default Format			Revised OS/OW Format		
Name	Format	Variables	Name	Format	Variables
Through Adjustment	Real	0	Through Adjustment	Real	0
Left Adjustment	Real	0	Left Adjustment	Real	0
Immediate Right Adjustment	Real	0	Immediate Right Adjustment	Real	0
Other Movements Adjustment	Real	0	Other Movements Adjustment	Real	0
Cycle Length	Real	0	Cycle Length	Real	0
Minimum Unsignalized Capacity	Real	0	Minimum Unsignalized Capacity	Real	0
U-Turns Allowed (0=no, 1=yes)	Real	0	U-Turns Allowed (0=no, 1=yes)	Real	0
Area Weight	Real	0	Area Weight	Real	0
Production Extra Time	Real	0	Production Extra Time	Real	0
Attraction Extra Time	Real	0	Attraction Extra Time	Real	0
Unit Extension	Real	0	Unit Extension	Real	0
			Intersection/Type (At Grade)	Real	0
			Interchange Type (Seperation)	Real	0
			Structure Orientation	Real	0
			Load Limit A to B	Real	0
			Load Limit B to A	Real	0
			Strut Height A to B	Real	0
			Strut Height B to A	Real	0
			Max Leng. Vehicle to make turn	Real	0
				Real	0

There are two types of nodes on the network beside the zone centroids, described above. They are “Intersections with Delay” and “Intersections without Delay”. First, Intersections with Delay are those that represent actual intersections or interchanges. Intersections without Delay are those that split links where there is no intersection, such as county lines.

It can be seen in the first line of the Link Format in table 5 that the Approach Code has a Categorical Variable with seven variables. The first variable is the “Through Traffic Code” which defines the direction of the approach link to the node (intersection). The first four variables in the Node Format in table 6 define the Adjustments that can be added to the time for passing through the intersection. By examining the direction coded into the various legs of the intersection, one can tell which movements are the straight through, right turn, and left turn movements. If any of these movements are restricted by lane geometry, structure height or weight limitations, an adjustment can be added to the respective movement to prohibit that movement in the assignment of a particular size load.

If the Approach Code is coded “zero” (0), the software automatically computes the left, right or straight through movements based on the coordinates of the legs on the intersection. However, because many of the roadway sections are not straight north-south and east-west, it has been found that the approach code must be coded by hand or by using a routine that inserts a “1” for the higher Functional Class and a “2” for the other approaches. If one were to allow the assignment of approach coded to be done automatically, figure 22 demonstrates that this configuration would produce unpredictable results.

Three of the legs are straight north-south or east-west but leg BC is more north-south than east-west, even though it is straight east-west at the junction at “B”. The approach codes for AB and BD should be the same to produce a straight through movement but by letting the software compute the approach code for BC, it would not be considered a through movement.

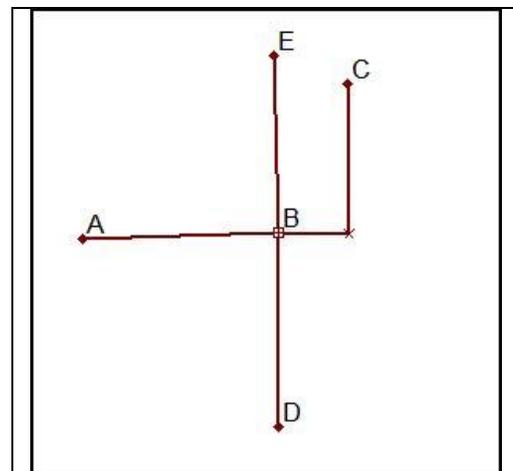


Figure 22. Use of approach codes.

It is necessary to correlate the values used for the approach codes and the value used for the Structure Orientation shown in table 8. If there is a grade separation or interchange at B, whether or not DB-BE is freeway, the “Structure Orientation” must be coded properly to assure that vertical clearance is applied to the correct movement. Assuming that DB-BE is the higher class

roadway, the Structure Orientation must be coded “1” if AB-BF goes over and “2” if the AB-BF goes under.

For at-grade intersections the problem is completely different. Vertical clearance is not an issue, but the approach width affects the ability for long loads to make turns. It can be seen near the bottom of the Revised OS/OW Link Format in table 5 that there are two blank rows (variables). Depending on the data that is obtained from the turning characteristics of over-length trucks, these blank variables can be used either for the maximum length trucks that can make a turn at that approach or the width of the approach.

As can be seen, there is considerable data that must be entered into the nodes and links by hand. It will require using the approach width data from CANSYS, vertical clearance data that KDOT has provided, Google Earth photography and considerable judgment.

In addition to revising the formats, two sets of criteria were established to define the Structure Type and Structure Orientation. Table 7 shows the intersection type that was developed for this research and table 8 shows the structure orientation.

Table 7. Structure type.

Code	Description
1	Rural and Urban intersections, No curbs, including painted channelization
2	Rural intersections, raised curbs and channelization
3	Urban intersections, curb and gutter and sidewalks
4	Roundabout
5	Diamond interchange
6	
7	Cloverleaf interchange
8	Folded Diamond interchange
9	Directional interchange
10	Partial Cloverleaf interchange
11	Grade Separation
12	

Table 8. Structure orientation.*

Code	Description
0	None
1	Cross Road Over
2	Mainline Over
*If all legs are of the same classification or importance, the road that is mostly east-west is considered the mainline	

It was previously indicated that the Permit Manager for ATS Specialized, Inc., said that I-70, particularly in Western Kansas, was a barrier for over-height loads moving north and south. Because of this, several locations along I-70 were identified for specific analysis to provide a

strategy for coding the assignment network for additional research. One of these was US-283 at Wakeeney, KS. Loads greater than 14 feet 4 inches cannot cross I-70 at the west junction at Wakeeney. Similarly, loads coming from the west on I-70 cannot get off of I-70 at the east junction (US-40 Business Route) because the clearance under I-70 at this location in 14 feet 3 inches.



Figure 23. I-70 Interchanges at Wakeeney.

Figure 23 shows the two interchanges at either side of Wakeeney. US-283 crosses under I-70 at the west end of Wakeeney, proceeds four blocks north, then turns east for one mile and then continues north. US-24 Business follows US-283 from the west interchange to where it turns north, then continues back to the south to the east interchange.

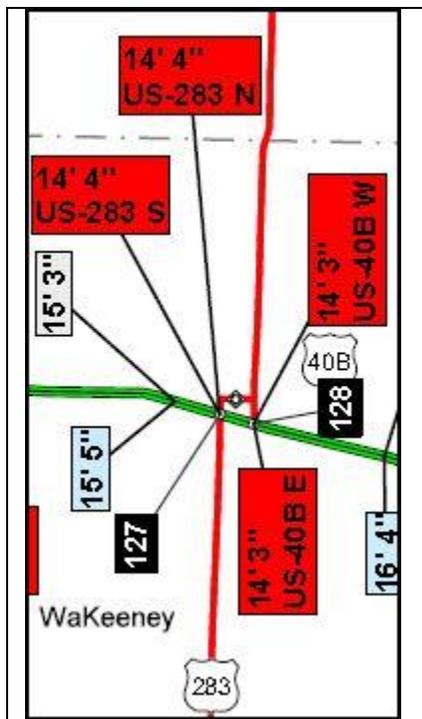
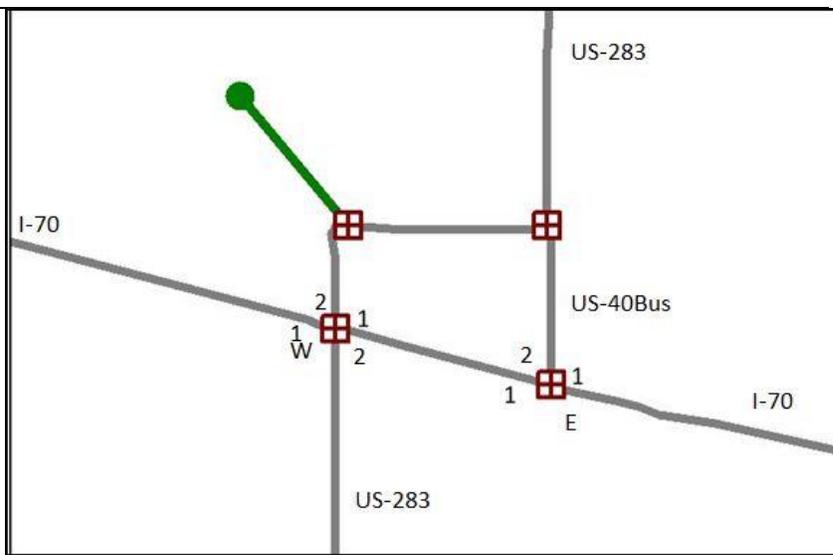


Figure 24. I-70 and US 283 copy from KDOT's vertical clearance map.



“W”: I-70 and US-283 and “E”: I-70 and US-40 Bus Interchanges

**“1” : Approach Codes on I-70 Legs
“2” : Approach Codes on Other Legs**

Figure 25. I-70 and US-283 and I-70 and US-40 bus interchanges.

As can be seen in figure 24, the vertical clearance is on the north-south routes at both interchanges on I-70. Therefore, the Structure Orientation is “2”. This results in a Through Adjustment on I-70 (1 to 1) at both interchanges of zero because I-70 goes over the cross road. (see figure 25) At the west-interchange, the approach codes on US-283 are also a through movement but since this route goes under I-70, the Through Adjustment in 100, which prohibits the path building from using this route for any load over 14' 4". The right turn from the south to the east is controlled by the turning radius allowed by the intersection of US-283 onto eastbound on-ramp on I-70, which is dependent on the length of the load and independent of the height.

At the east interchange “E”, any height of load can get off of I-70 on the ramp, either from I-70 from the west or US-283 from the south, but the vertical clearance of the structure at this interchange (Structure Orientation “2”) prohibits any load over 14'3" from continuing north on US-283. If any load is to continue north on US-283 it must come from the east on I-70, subject to making the turn at the end of the off-ramp.

A second issue raised by ATS Specialized, Inc. was the intersections where turns must be made. KDOT routinely diverts loads away from US-83 at Garden City and back to US-83 at Scott City. Scott City has particularly wide streets in the downtown area so that turns from the east or west on K-96 can be made reasonably easily if traffic is stopped while the load is turning and parking near the intersection is restricted because it is necessary to use the entire intersection from curb to curb to make the turn. This is especially true if the load does not have steerable rear axles. At this point, the length of the load that can make the turn has not been determined.

ATS Specialized, Inc.'s staff identified the turn at K-25 and K-96 in Leoti, Kansas, as the most limiting for long loads. Although it is difficult to see in the overhead photo from Google Earth (figure 26), curbs have been added to shorten the crosswalk and to move through traffic away from the rear ends of parked vehicles.



Figure 26. Intersection of K-25 and K-96 in Leoti (Google Earth).

The restrictions can better be seen in ground level shots (figure 27a, b) taken at the south and west approaches. Not only do the curbs pose a considerable restriction, but notice how close the light posts and stop signs are to the edge of the curb. The yellow images in the pictures are a part of the Google's product and are not any marking in the street.



Figure 27a. South approach, looking north on K-25 at K-96 in Leoti (Google Earth).



Figure 27b. East approach, looking west on K-96 at K-25 in Leoti (Google Earth).

The network coding that is necessary to prohibit turns where the geometry is not adequate to accommodate long loads is show in figures 28 – 29.

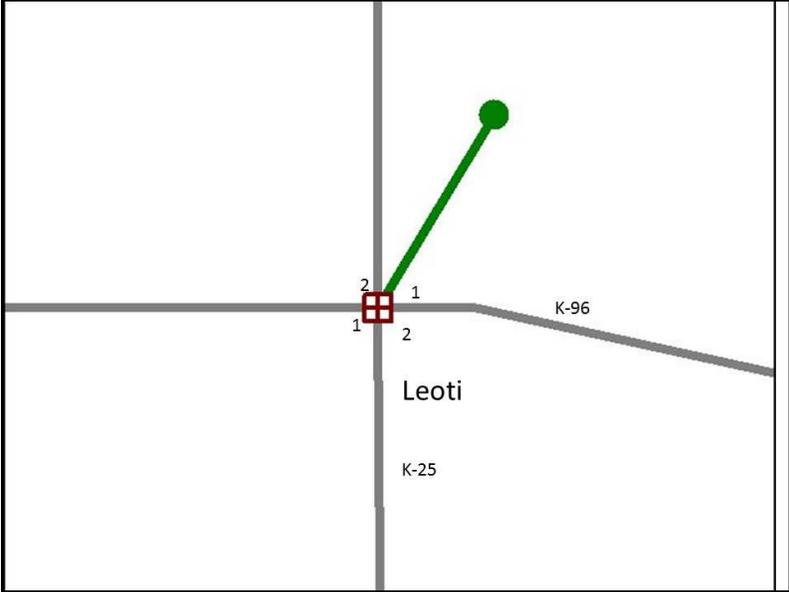


Figure 28. Leoti network node with approach codes.

Figure 28 shows the visual image of that portion of the state network at includes the links and node that represent Leoti, located at the intersection of K-25 & KI-96.

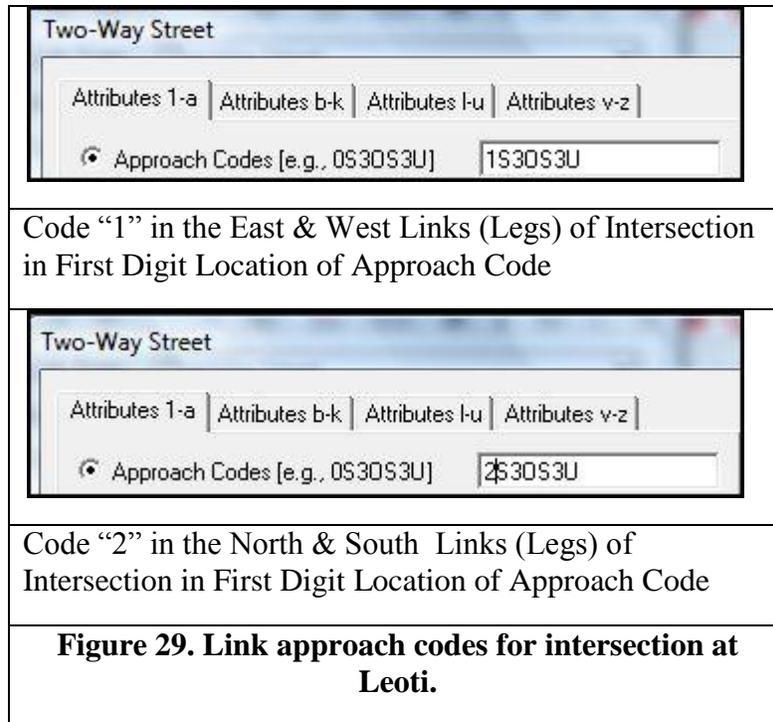


Figure 29 shows the Approach Code which is the first of 35 attributes that describe each link. The first digit of the Approach Code tell the computer which pair of legs make up the through movement through the node, the right turn and the left turn.

For Example, a “1” to “1” or “2” to “2” are through movements and a ”1” to “2” or “2” to “1” are left or right turning movements. A left turn is a movement between two links that do not share the same through traffic code, and which cuts across opposing traffic. QRS II must be aware of this opposing traffic. An immediate right turn occurs when the out link is immediately to the right of the in link and the through traffic code is different.

	North Leg Approach Code "2"	
West Leg Approach Code "1"		East Leg Approach Code "1"
	South Leg Approach Code "2"	
Figure 30. Node delay adjustment for intersection at Leoti.		

In the case of the intersection at Leoti, there is no added adjustment time for through movements as shown in the "Through Adjustment" in figure 30. Notice the last attribute for Intersection with Delay is "Max Leng. Vehicle to make a turn" with a default value of 125. This number is an assumed value to demonstrate when adjustments are added for left and right turns. This value can be accumulated after additional information is collected on the turning characteristics have been determined for various equipment configurations are determined from further research. If the lengths of the loads that are being analyzed exceed the length codes into this attribute, a Left and Right Adjustment (Attributes 2 & 3) must be coded. The values for these attributes are 100 minutes in the above figure.

In establishing a maximum length of a load that could successfully negotiate a turn in an intersection, the type of trailer needs to be known. It is most likely that the loads that will be carried on Kansas highways will be wind generator components. Since there is no way to design and construct highway that can accommodate every conceivable load, an assumption must be made that provides the most reasonable service within budget limitations.

As a baseline, the computer software will determine paths through the network following the minimum time path (i.e. fastest route) with no restriction between each pair of zone centroids

and the zone to zone time fill becomes the base times. Under ordinary circumstances the value of these attributes (turn adjustments) that are applied where restriction occur will cause the software to find a different path that is a few minutes longer than the minimum of the base network. If no path is available between a certain pair of zones, the path will remain the same but the time between those two zones will be 100 minutes or more greater than the base time. This will tell the user that there is no route available for a given load to get between those two zones. A larger adjustment may be used but an infinite value will cause the path building software to record an error.

It is important to remember that a separate network is needed for each size of OS/OW load tested. A set of restrictions based on a given weight will not be the same as the restrictions for a given height of load, a given length or a given width. Each network tested may contain only one dimension of the load (weight, height, length or width) or it may contain restriction based on a combination.

CHAPTER 5. SUMMARY AND CONCLUSIONS

5.1 SUMMARY

Background and Study Overview: As stated in Chapter 1 of this report: It should be noted that this project as initially proposed was not fully funded. The authors had requested \$50,000 of which half was to be from KDOT/ K-TRAN and half from the Kansas State University Transportation Center (KSUTC). The KSUTC portion was not approved; therefore the project as proposed was seriously underfunded. A decision was made to let the authors go ahead with the project to the extent possible. In regards to the tasks this basically meant that all were not completed to the extent originally proposed. The authors consider the effort that was accomplished with the funds available as a phase 1 or “pilot” study. A proposal to continue this, phase 2, was submitted in the 2012-2013 K-TRAN program. Should that funding become available, a more comprehensive study and report in regard to optimizing superload (OS/OW) corridors in Kansas could then be completed.

The information that was collected, albeit limited, is providing some excellent insight into the issues faced by trucking firms that move OS/OW shipments within and through the State and their relationship roadway features. Now that roundabouts are becoming more common throughout the state and the nation, many individuals, both in the public and private sectors, believe that the main concern for efficient movement of oversized loads are roundabouts that were being constructed. However, information that has been collected by the authors indicates that vertical clearance, diamond interchanges, curbs, non-removable signs, enhancements at pedestrian crosswalks all limit the ability for over-length loads to make turns to varying degrees. While it is not usually feasible to remove structures with limited vertical clearance, it is feasible to develop policies to better control their movement. However, the cost-benefit to sustain or enhance the current accessibility by constructing accommodating measures should be determined based on the product’s importance to the State’s economy.

What was lacking due to the limited funds was data to determine the highway routes that will provide, or can be upgraded to provide, the ability to transport OS/OW payloads of importance

to the state's economy to all or most locations in the state. Also, for those areas that cannot be accessed, research could be expanded to attempt to identify the limiting feature(s) of the route so that policy makers could determine if it would be economically feasible to build, remove or modify features to improve accessibility. It is clear to the authors, that, 1. a highway agency cannot design a system to accommodate any size and weight load and 2. there are many design elements that cause restrictions to OS/OW that should be considered in OS/OW routing and whether or not the cost of their construction, alteration or removal would result in benefits that would create a desirable cost/benefit ratio, is beyond the scope of any research being proposed by the authors. However, the authors believe, and will discuss more below and in the conclusions, that it would behoove all states to develop freight networks, (similar to what has been done in the states of Wisconsin and Minnesota and in Chapter 2 of this report) that would accommodate the sizes and weights expected and, on which portions decided by policy, law or economic study, to be necessary for specified OS/OW vehicles travel, have templates of the clearance and turning requirements of these specified OS/OW vehicles.

It should be noted that the duration of this study closely followed a pooled fund study, "Accommodating Oversize/Overweight vehicles at Roundabouts", that was being simultaneously conducted by the same authors and a number of issues of relevance to this study were of relevance to both studies. This situation enhanced the data that could be used in this study and this report, some of which is repeated from the pooled fund study interim report. (Russell et al., Interim Report, 2011)

One trivial but clarifying point that should be brought out is that in the beginning of this research the term "superload" was used indicating an oversize/ overweight, permitted load. It was soon determined that the term superload meant different things to different people in different states, but that oversize/overweight load signified a permitted vehicle that generally meant the same in the majority of states. Thus the term superload was superseded by oversize/overweight, with the acronym OS/OW which was used extensively in this report

5.1.1 Summary of Literature and Other Studies

In Chapter 2 the authors did a review of available, relevant material to this study. Very little published material was found; however, there is a great deal of information that can be found on the Internet, especially through FHWA and various state's sources. It was found that the FHWA is interested in having states develop statewide freight plans. They do not specifically address OS/OW; however, the authors of this report believe that states should take the initiative to do so. Most of freight networks include all or a portion of the National Highway Network. This is reviewed in detail in Chapter 2.

The FHWA has published a manual, "Statewide Freight Plan template" which was extensively reviewed in Chapter 2. It could provide the basis for a state economic study to better determine a cost-benefit ratio to help decide how far to go in accommodating OS/OW within a state. In summary, the template discusses the role that freight movements play in maintaining the vitality of a state's economy. Perhaps the most important section of the FHWA template will be repeated here for emphasis:

Establishing freight transportation performance objectives relative to system performance will provide a focus of action for a state DOT with respect to freight transportation. Performance measures should be implemented so a state can be determined if they are achieving their objectives and to quantify and assess the effects of current and future initiatives on system performance objectives to help determine the impact of investment choices. Performance measures can also serve as indicators of economic health and traffic congestion.

5.1.2 Western Minnesota Freight Network

The FHWA mentioned that Minnesota, New Jersey, and Southern California are good examples of states that had developed a freight network. Also, that Minnesota included OS/OW as part of their network. Note although not part of this FHWA report, Wisconsin later also did this, which has been discussed in detail in this report and will be briefly summarized below.

As pointed out in the Western Minnesota Freight Network study, they followed the guidelines defined at the federal level by Congress and the FHWA who have defined a primary network from a policy standpoint for encouraging interstate commerce and heavy truck travel. This national network of highways includes 1. The interstate highway system and, 2. Other highways designated by the states in response to the surface transportation assistance act of 1982, sometimes referred to as the national truck network which consists of highways submitted to FHWA as being capable of safely handling larger commercial motor vehicles.

The Minnesota study expanded use of the existing designated transportation networks as a base to designate a specific Minnesota truck network. The routes were selected because of their designation for existing truck use and for the specific purpose each serves in the overall transport network. It included :

- Interstate/National Highway System/Strategic Highway Network
- National Network and Minnesota Twin Trailer Network
- Interregional Corridor (IRC) System
- 10-Ton Roadways
- Local Roadways (less than 10 tons)
- Minnesota Tiered Roadway Network (Designated State Trunk Network)

5.1.3 Wisconsin's Freight Network

The state of Wisconsin, with pooled funds from Minnesota and Wisconsin took the above ideas of a freight network a step further. They decided that their developed freight network should accommodate a WB 67 design vehicle throughout the network. In addition, they had a consultant check the turning clearance requirements of about 30 typical OS/OW vehicles prevalent on Wisconsin roads and the consultant developed six templates (in addition to the AASHTO designated WB 67) which they considered check vehicles. All portions of their freight network did not need to be capable of accommodating these check vehicles. However they did designate certain portions of their freight network as OS/OW routes and these sections had to accommodate the six OS/OW check vehicles in addition to the WB67.

Further, since a number of the OS/OW loads were long loads of either 65 or 75 feet, they developed routes and maps of Wisconsin's long truck operators. Details are found in Chapter 2.

5.1.4 Legal Issues

Although an in-depth study of legal issues is beyond the scope of this project it was clear that they are important. Probably the most important issue deals with trucks staying in their lanes at roundabouts. The authors believe it should not be any more of an issue than at traditional intersections. Trucks take wide turns at most any intersection and hardly stay in their lanes. There are signs on most large trucks warning other drivers that truck makes wide turns. However, talking to people in the trucking industry they say it becomes a legal issue. If there is a crash between a large truck and the vehicle and the truck is even a few inches out of their lane they claim they lose in court. The Oregon Trucking Association (OTA) fought hard to change the law so that it would not be illegal for a truck to be out of its lane at a roundabout. They would also like to see laws that prohibit other drivers from driving alongside of them and/or road signs indicating that they should not.

Another issue is in regard to escort services. Most or all OS/OW are escorted. It is not clear, and the authors feel there is no universality among states, whether they need to be escorted by police or, if private, or by their own escort services, would have the authority to direct traffic when needed. The authors conclude that these issues need to be studied in detail.

5.1.5 The Oregon Moratorium on Roundabouts

Details of the trucking industry's opposition to roundabouts, which they believe are detrimental to large truck transport, is documented in detail in Chapter 2. Oregon has a law which states that the transportation commission cannot permanently reduce the vehicle carrying capacity of an identified freight route when altering, relocating, changing or realigning a state highway. Such projects need the approval of a Motor Carrier Advisory Committee (MCAC), otherwise approval of the Oregon Transportation Commission. Identified freight routes in Oregon are now

interpreted as not only the Oregon Highway plan freight route designation, but in addition, any nationally recognized truck routes like NHS routes and possibly local jurisdiction truck routes as well.

Opposition by one or more truckers in Oregon led to a state representative introducing legislation with severe limitations on the use of roundabouts in the state. The state DOT then put a moratorium on the planning and building roundabouts in the state of Oregon until they could work with the trucking industry to work out their concerns. To work out these concerns, a roundabout steering committee was formed within the Oregon Motor Carrier Advisory Committee (MCAC). They are working toward a process of inclusion of freight representatives into their roundabout design criteria as well as having review capability at specific locations where roundabout designs would occur.

5.1.6 Surveys from Accommodating Oversize/Overweight Vehicles at Roundabouts

While this study was going on, the authors were also conducting another pooled fund study, Accommodating Oversize Overweight Vehicles (OS/OW) at Roundabouts. Data for this pooled fund study was obtained by four surveys. The first survey dealt mostly with permits for OS/OW vehicles and some of the data was relevant to this study. Only a few key points will be made here.

In regard to a question regarding restrictions to OS/OW loads, the following is a summary of the reported restrictions with the percentage of respondents reporting that the restriction is a known problem to OS/OW:

- Bridges 100%
- Curbs 18.9%
- Interchanges 56.8%
- Intersections 64.86%.
- Overhead structures 89.2%
- Overhead wires 40.5%
- Rail- highway grade crossings, 48.6%

- Raised channelization 18.9%
- Roundabouts 35.1%
- Signs and signals 70.3%
- Utilities 48.6%

Some of the solutions to the restrictions provided by the respondents are:

- Utilize automated routing and analysis system to ensure none of the items listed above are involved in a specific route of an oversize vehicle.
- Reroute the vehicle/load to a highway that will accommodate the load.
- Raising overhead wires and on rare occasions use "jumper" bridges.
- Stop use of fixed cross arms for signal lights or have them able to swing out for high loads.
- Requires all utility lines to be higher.
- Design roundabouts to accommodate longer loads at least on major routes.
- Design intersections with more shoulder width for better turning radius.

5.1.7 Kansas Data Study

The presence of OS/OW loads is becoming more common on Kansas highway in the last few years. It appeared to slow down some in 2010 but KDOT staff believed this to be attributed to a slow-down in the economy. During the past year (2011), the number of application received by KDOT for OS/OW showed an increase over the previous year. While the Kansas Trucking Connection (KTC), a cooperative effort between the Kansas Department of Transportation (KDOT), the Kansas Corporation Commission (KCC) and the Kansas Department of Revenue (KDOR), receives many more applications, only those exceeding 150,000 gross weight are sent to KDOT for analysis and routing, KDOT staff analyzes each load's axle spacing and proposed load against the bridge characteristics for each bridge over which the load is directed to use. While other characteristics of the load and the elements of the route over which the load is directed is considered, the review is mostly based on the experience of the staff. This includes the height, width and length of load. It is primarily the responsibility of the applicant to

determine if they can successfully travel over the suggested route. The applicant is supposed to report any deviations they must make, but this is seldom done.

Based on the comments of selected transportation companies, an analysis was made of a traffic assignment package that had been previously used for statewide truck studies. It was necessary to make adjustments in the parameters and attributes of the data used to describe the state network to recognize the restriction that are encountered by the OS/OW loads. While normally trips are routed over the fastest route between origin and destination, these modifications in the attributes prevented the assignment of trips over segments or through intersections that would be a restriction to a given OS/OW load.

The KTC office is responsible for receiving and processing of all appropriate applications and was previously located in the offices of the Kansas Corporation Commission (KCC) at the time this research was initiated. Because of their paper filing system at the time, overall data of the types of industries shipping OS/OW loads was too labor intensive to be collected. KDOT staff provided the researchers with data about all OS/OW that they had processed in the last ten years. With the exception of wind energy components, there were very limited patterns that could be found in the data. If bridge beams were delivered to a specific location, it was unlikely to be repeated again for many years. This was also true for buildings, beams of building such as the soccer stadium in Wyandotte, or nuclear reactors. It was assumed at the beginning that once a wind farm is developed there will be little need for more access to that wind farm. However, it was later discovered that lightning and hail can do considerable damage to the blades of a wind generator so that they will have to be replaced.

It has been found that the transportation firms that haul wind generator components have adapted their equipment to deal with some of the restrictions that they encounter. One of the major adjustments is the steerable rear axle. This has allowed them to make turns with long loads at intersections or at ramps of interchanges that were previously a barrier. The vertical height restriction of low clearance structure is not easily solved. It is mentioned that crossing the Interstate is a major concern for firms hauling wind energy components.

It has been observed that it may be cheaper for some large load components to be manufactured and assembled at a central location and shipped to its final destination, or perhaps manufactured and/or assembled at their final destination. As a result, there seems to be no limit to the size of weight of the load that shippers would like to transport on the highways of Kansas or any other state. No transportation agency can be expected to accommodate every load that might conceivably be assembled. Therefore, there will always have to be a trade-off between what shippers might want to move and what the agencies responsible for the design of the highway/street system can provide. This leads to the question, beyond the scope of this study, whether the responsibility lies with the state to accommodate haulers' equipment or if the haulers should be responsible for improvements or innovations to their equipment, and to what extent. The issue should be studied.

5.2 CONCLUSIONS

As stated on page 2, *Caveat regarding work plan*, the project was underfunded which limited the ability for the researchers to fulfill all the original research objectives. It is expected that a phase II following project will enhance the final conclusions.

The authors' main conclusion from this phase I effort is that Kansas should consider developing a freight network which includes segments where selected OS/OW vehicles can be accommodated. The "selected" OS/OW vehicles should be developed in conjunction with input from industry that requires OS/OW shipments and truckers who do the shipping. This could be balanced with economic value to the state or specified regions and interstate commerce laws. It is suggested that something like the Super-Haul corridor that was proposed for Minnesota by the Wilbur Smith study be considered

It has become evident that additional study is desirable to determine how restrictions of all types can be eliminated or managed to allow access via freight and OS/OW networks to all parts of the state where important for efficient movement across and within the state for OS/OW loads.

Bridge load and clearance restrictions, horizontal and vertical clearance from structures, wires, signs and signals, utilities, etc. are easy to see and consider in routing and/or freight networks,

but maneuvering at intersections of all kinds can be just as formidable and not as clear cut to find and account for. Ground vertical clearance can also be a problem and often associated with intersections, e.g. where there are curbs, rail grade crossings and roundabouts. Ground vertical clearance at roundabouts has not been well studied.

While an initial assumption of the pooled fund study, reviewed in this report, was that roundabouts were the most serious restriction, others intersection types have been also identified as problems. On freight and/or OS/OW routes where intersections of any type may be the concern, a set of templates of a series of check vehicles that would cover known configurations, clearance and turning requirements of know OS/OW requirements should be developed and applied.

Further research should be pursued to develop criteria and policy to address size, height and weight restrictions that effect areas or industries important to the state's economy. Also, further research should be pursued to determine the cost/benefit of altering various, restrictive intersection types to accommodate OS/OW versus using alternative routes.

In the case of roundabouts on OS/OW routes, accommodating OS/OW should be balanced against the challenge of maintaining a safe design for all other vehicles and the cost of doing so versus the benefits to the areas' economy. Also in the case of roundabouts, sometimes OS/OW can be accommodated by allowing counter-flow or segment of wrong way travel. This requires traffic control, and the authors believe laws are not clear as to legality of such measures, or to who should have the authority to control traffic, nor laws or policy as to who would pay for such required services.

Finally, a study of policy regarding what degree of responsibility lies with the state to accommodate haulers' OS/OW equipment and to what degree should the OS/OW haulers be responsible for improvements or innovations to their equipment to transport should be considered. This should include both economics and existing state and federal laws.

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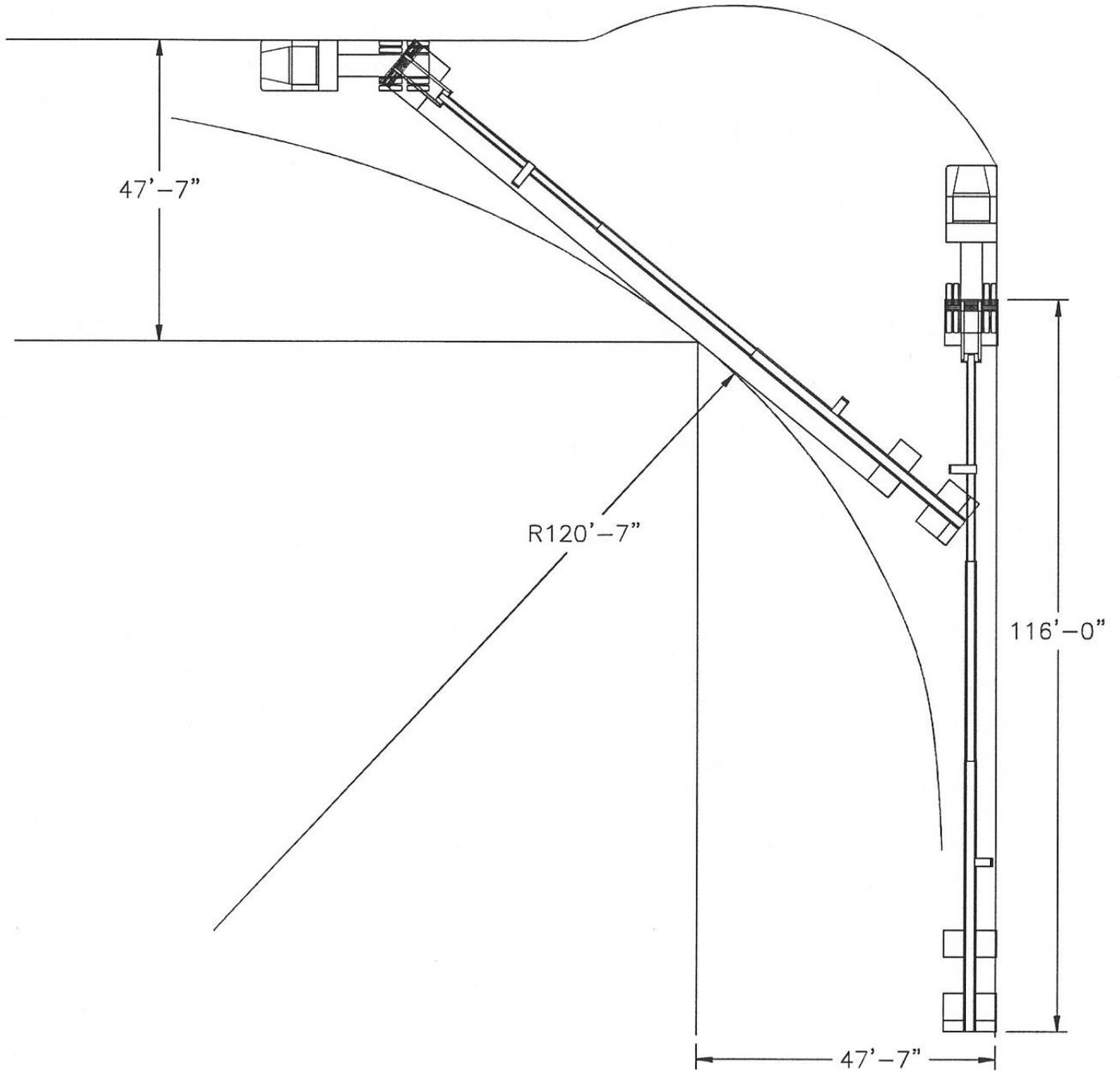
The US National Network

(http://www.ops.fhwa.dot.gov/freight/freight_analysis/freight_story/major.htm)

APPENDIX

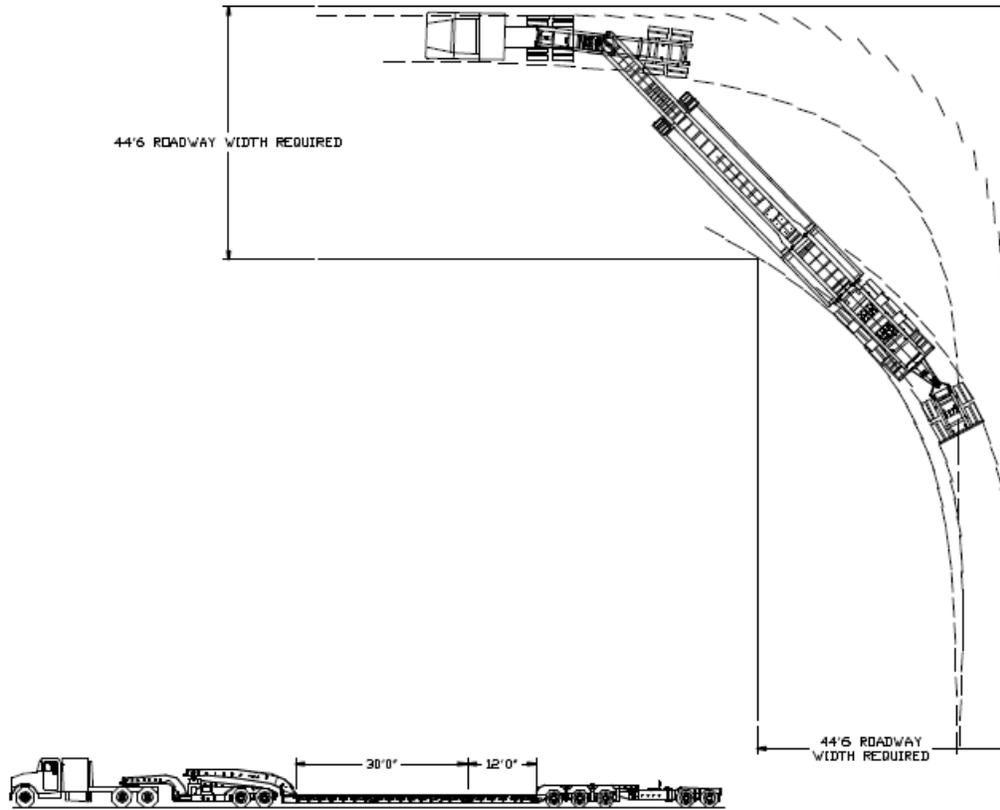
Appendix A. Turning requirements for various ATS Specialty, Inc.

Wind tower Blade -

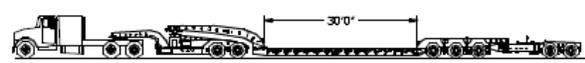
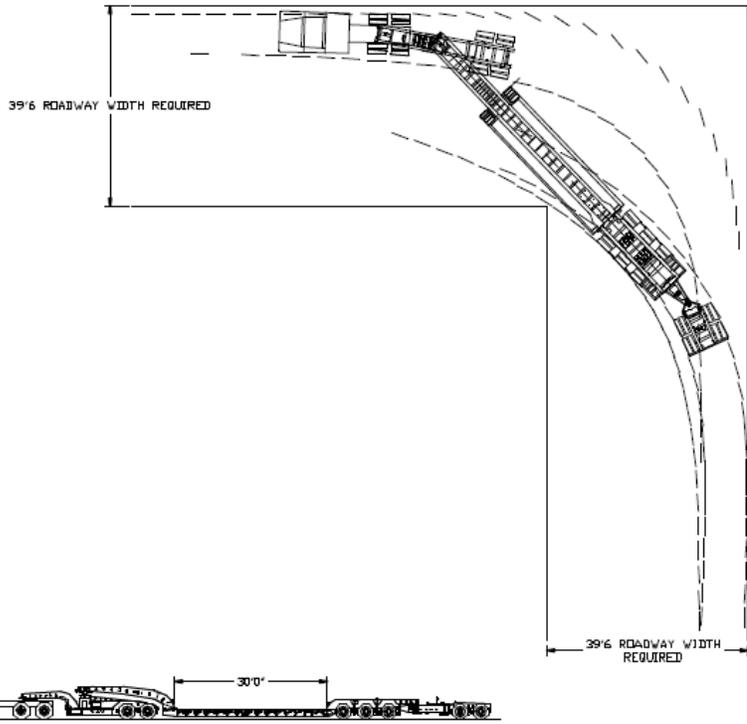


This depicts a Shorter Blade and the main turning path, keep in mind the trailers can have an inner trailer bridge of 110' and then a 6' to 10' axle spacings with the remainder of the blade having a "Tail Swing" that can vary in height by model

Low Deck Trailer (2ax Jeep, 3ax Trlr, 2ax Bstr)

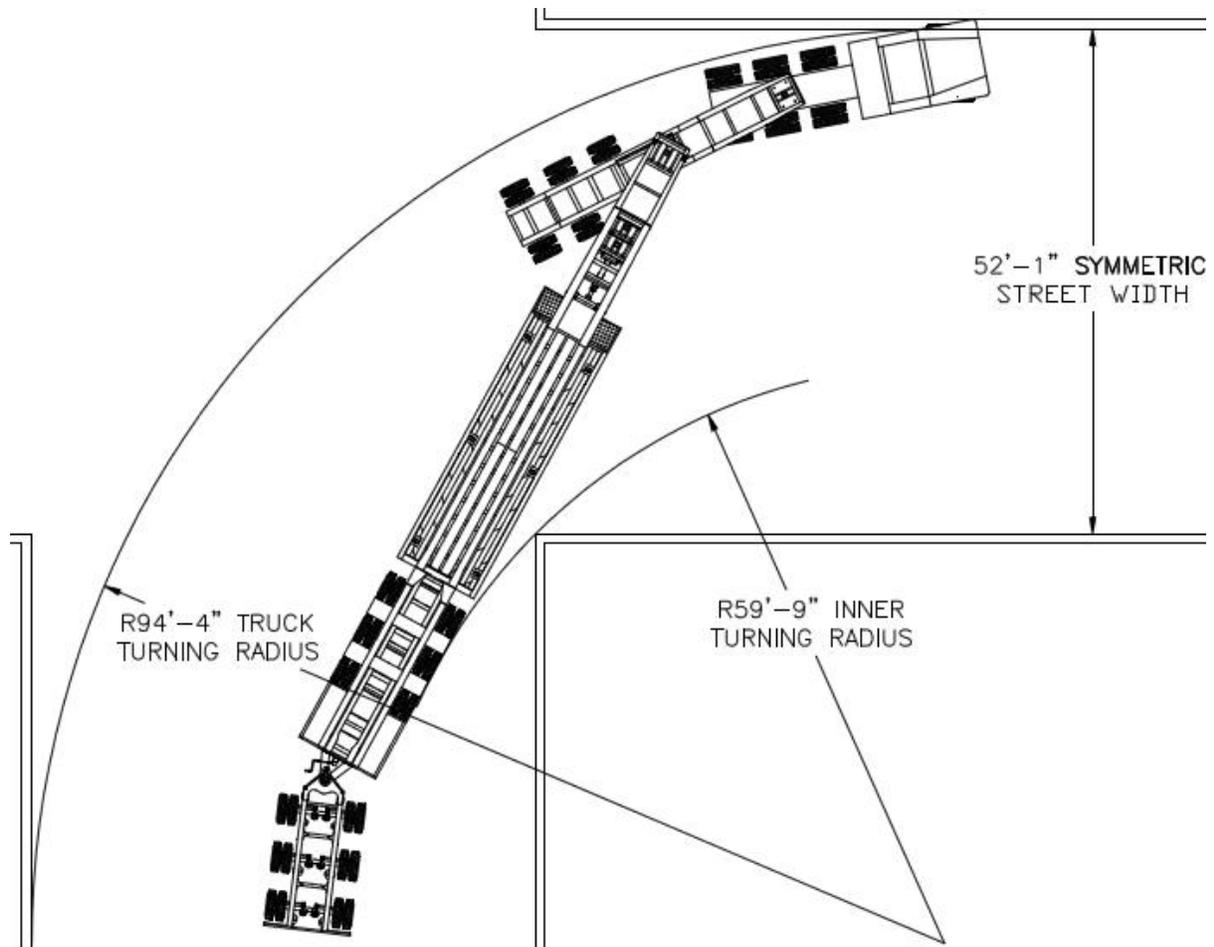


Note this trailer has an additional 12' Deck Insert added to the normal Trailer Deck. This trailer is a non-steerable unit.



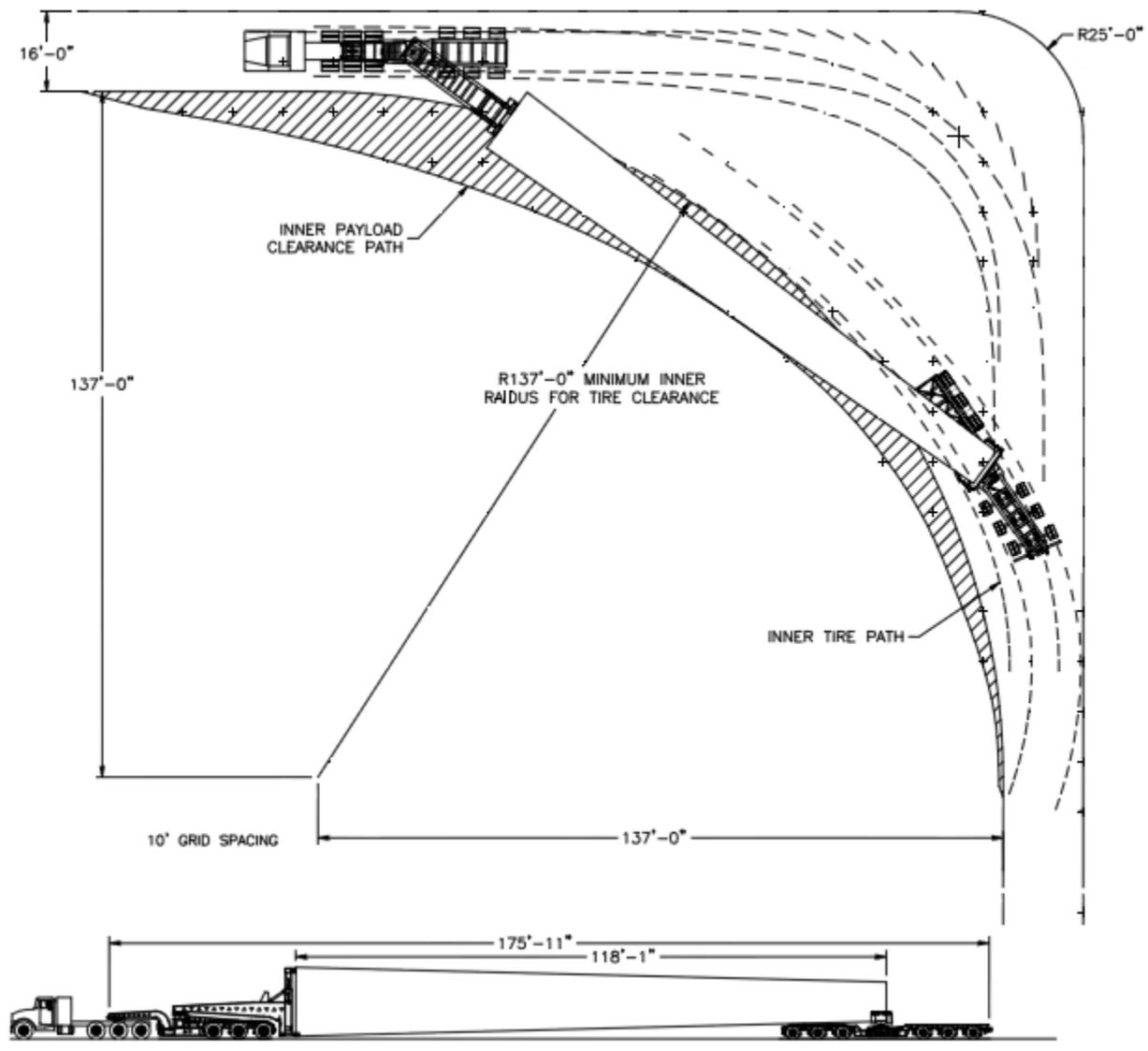
Same Truck but without a 12' Deck Insert

Low Deck Trailer (3ax Jeep, 3ax Trlr, 3ax Bstr)



This Unit Above is a non-steer sample.

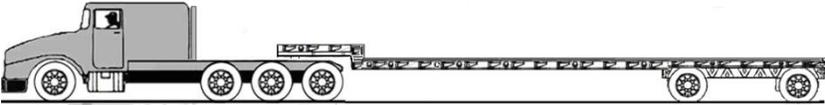
3ax Schnable Jeep with 6ax Dolly



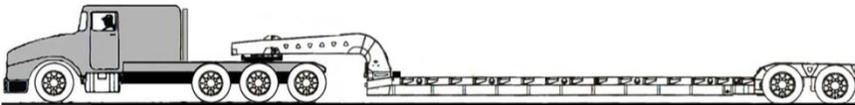
A Longer sample of Tower Section



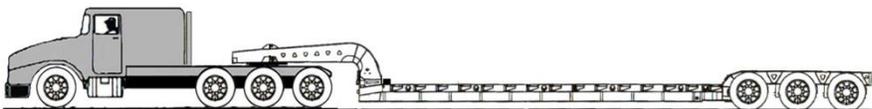
2 Axle Flatbed



2 Axle StepDeck



2 Axle DD/RGN



3 Axle DD/RGN



(2x2) 2 Axle Deck / 2 Axle Booster



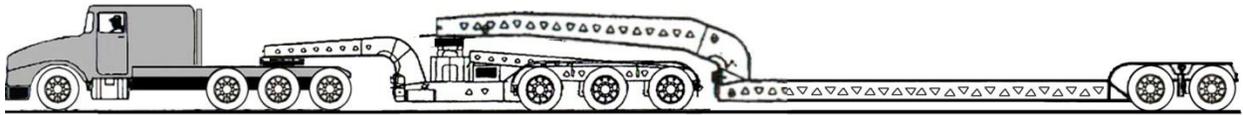
(2x2x2) 2 Axle Jeep / 2 Axle Deck / 2 Axle Booster



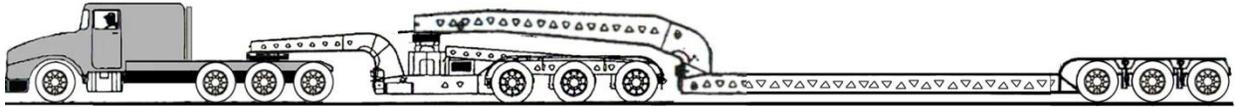
(2x3x2) 2 Axle Jeep / 3 Axle Deck / 2 Axle Booster



(2x3x3) 2 Axle Jeep / 3 Axle Deck / 3 Axle Booster



(3x2) 3 Axle Jeep / 2 Axle Deck



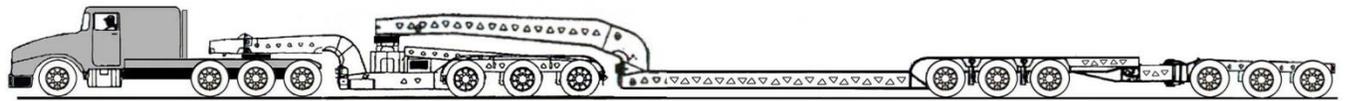
(3x3) 3 Axle Jeep / 3 Axle Deck



(3x2x2) 3 Axle Jeep / 2 Axle Deck / 2 Axle Booster



(3x3x2) 3 Axle Jeep / 3 Axle Deck / 2 Axle Booster



(3x3x3) 3 Axle Jeep / 3 Axle Deck / 3 Axle Booster (Non Steerable)



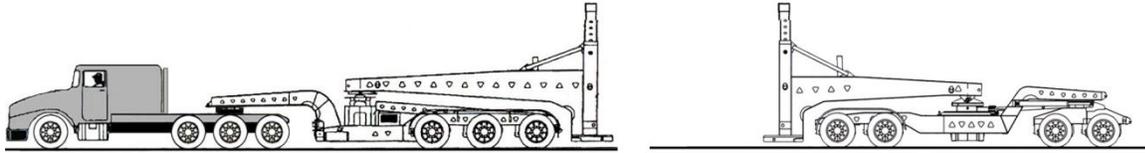
(3x3x3) 3 Axle Jeep / Neck with 6 Axle Dolly (Steerable)



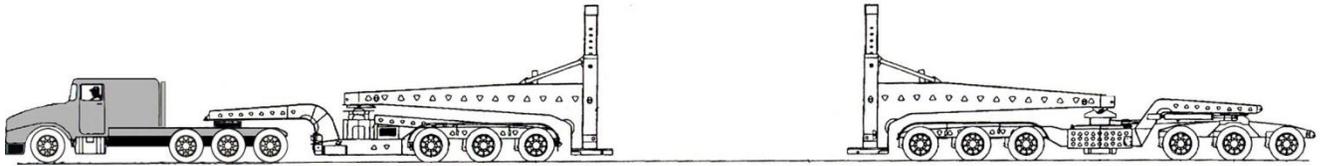
2x2x2 Double Schnable



2x3x3 Double Schnable



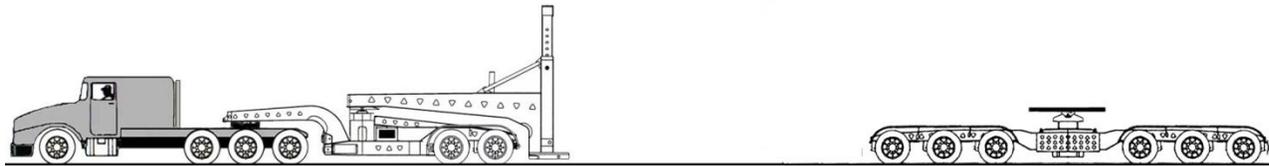
3x2x2 Double Schnable



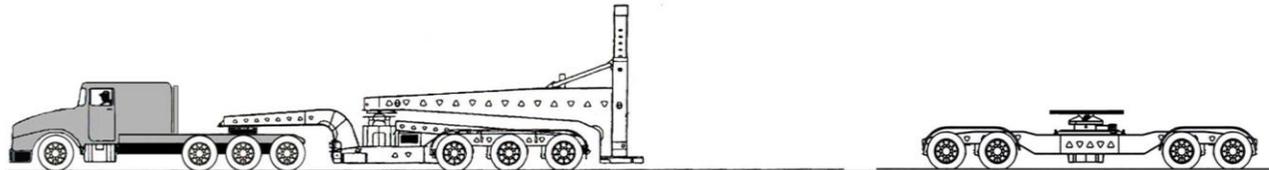
3x3x3 Double Schnable



2x2x2 Schnable Dolly



2x3x3 Schnable Dolly



3x2x2 Schnable Dolly



3x3x3 Schnable Dolly



2x3x1 2 Axle Jeep / 3 Axle Deck / 1 Axle Booster



3x1 3 Axle Deck / 1 Axle Booster



19 Axle

6 Axle Jeep / 9 Axle Dolly

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