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Capabilities/Limitations and Recommendations for Transporting TxDOT's Heavy-Duty Off-Road Construction and Maintenance Equipment Fleet

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16. Abstract: This research study reviewed TxDOT's off-road, heavy-duty construction and maintenance equipment transport requirements and assessed TxDOT's current equipment transport knowledge base and practices. We used web-based surveys to identify the load-trailer-truck combinations used in the Districts and to forecast the types of off-road equipment to remain in TxDOT's fleet over the next five years. We developed and submitted a survey questionnaire to a statistically-representative sample of TxDOT maintenance personnel to measure equipment transport knowledge. Results indicate that much is good within TxDOT relative to equipment transport. Employees ascribe importance to all aspects of the equipment transport process, and their overall knowledge of equipment transport is high. In particular, knowledge and capabilities relative to equipment transport practices and procedures, trailer hitches and hitching systems, load securement, chains and tie-downs, and equipment transport safety is very strong. However, equipment transport knowledge and capabilities relative to load distribution concepts and practices, training, and compliance with laws and regulations are not as strong. Follow-up interviews with Division and District maintenance personnel confirmed the themes identified in the questionnaire. By far, the one thing that field personnel stated would most improve equipment transport in TxDOT was training. They want *more* training, *better* training, and *refresher* training. Second to training, respondents stated that they needed newer, better equipment haul trailers and trucks.

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Implementation Statement

The primary objectives of this research have been to (1) review TxDOT's existing and future off-road equipment and transport requirements, and (2) assess TxDOT's current knowledge base and practices in transporting off-road equipment to determine capabilities and limitations. The researchers believe these objectives have been met, and the products developed will be used by TxDOT fleet managers and associated personnel to make informed purchasing and operational decisions regarding transport of TxDOT's heavy-duty off-road construction and maintenance equipment fleet. From an implementation perspective, in a very real sense, implementation for this project commenced when we began our program of visiting the TxDOT Districts during the data-gathering phase. These visits afforded an open invitation to key District maintenance personnel who routinely work with off-road equipment to become aware of and participate in the research process. This research study identified the need for *more* training, *better* training, and *refresher* training in the equipment transport area. By virtue of the revised Equipment Load and Tie Down curriculum, this research study satisfactorily achieved the "better" training requirement. Further, at least for the near term, the revised curriculum also satisfactorily meets the "refresher" training requirement. However, a stated need exists for "more" training. Our research shows that operations personnel strongly feel that everyone responsible for equipment transport – from the maintenance section supervisor to the technicians who load, tie down and transport equipment – need to be trained in a high-quality, uniform manner. The substantial investment to achieve this level of workforce training is, we think, warranted, and should be pursued with vigor.

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3.				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact)				
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate

(Revised September 1993)

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CHAPTER 1

INTRODUCTION

1.1 The Research Problem

This report documents a 2-year research study sponsored by the Texas Department of Transportation (TxDOT) which focuses on two areas: (1) review of TxDOT's existing and future off-road equipment and transport requirements, and (2) assessment of TxDOT's current knowledge base and practices in transporting off-road equipment to determine capabilities and limitations.

TxDOT transports heavy-duty off-road highway construction and maintenance equipment using various sizes and combinations of trucks (tractors) and trailers. Typically, most off-road equipment is transported on tag-a-long trailers towed by ten-yard dump trucks (Figure 1.1). While existing transport methods appear to be working, a concern exists that some off-road equipment may be better suited, and more safely transported, using combinations of larger tractors and trailers. Further, for a number of reasons the Department's off-road equipment has grown larger in recent years, and this larger equipment is putting a strain on TxDOT's equipment transport capabilities.

Figure 1.1 Common TxDOT Equipment Transport Practice: a Heavy Construction/ Maintenance Equipment Load (Front End Loader) Is Tied on a Tag-A-Long Trailer (Dovetail Style, Pintle Hitch) and Pulled by a 10 CY Dump Truck

When viewed over a span of years, this combination of factors suggests TxDOT's equipment hauling capabilities and practices may have reached a threshold, approaching the limit of their functionality. If so, leadership decisions must be made and proactive steps must be taken for TxDOT to continue to safely, effectively and efficiently transport heavy-duty off-road equipment. In particular, looking ahead for the next five years, transportation of off-road equipment to and from job sites represents a critical safety, operational, and resource issue for TxDOT.

The research findings summarized herein will help TxDOT fleet managers and associated personnel make informed purchasing and operational decisions regarding transport of TxDOT's heavy-duty off-road construction and maintenance equipment fleet. Further, the research provides for implementation of the research findings by developing training materials and offering a pilot training program to help increase the knowledge of District maintenance personnel so that they may continue to transport their off-road equipment in a safe, effective, and efficient manner.

1.2 The Research Approach

The research has been accomplished in seven tasks which were designed to achieve the two primary research goals: (1) review TxDOT's existing and future off-road equipment and transport requirements, and (2) assessment TxDOT's current knowledge base and practices in transporting off-road equipment to determine capabilities and limitations.

We began with a Database and Literature Review (Task 1), which provided a solid theoretical as well as practical basis for the assessment of TxDOT's off-road equipment transport procedures and requirements. We searched the transportation databases as well as databases of other public and private agencies such as those of major construction equipment manufacturers, major equipment haul trailer manufacturers, and federal agencies. We also contacted other State DOTs. Another key aspect of this task was to become completely familiar with TxDOT's Equipment Operations System (EOS) database.

Task 2, District Questionnaires, consisted of developing survey questionnaires to accomplish those research objectives in the Project Statement where the data are specific and well-defined. Our approach was to obtain the "objective" data up-front using questionnaires, and follow this up with the District site visits (Task 3) to clarify the data and to gain additional, more subjective data not amenable to questionnaire responses. The questionnaires and interviews therefore complemented each other and together formed a complete data-gathering process. Based on past TxDOT research experience in the maintenance area, we initially intended to visit all 25 TxDOT Districts; however, based on advice from the Project Monitoring Committee, we decided to visit a sample of the Districts (12 total) in order to spend additional time in the maintenance sections.

In Task 4, the results of the literature review and the District data-gathering effort (the research questionnaires and the on-site interviews) were tabulated, summarized, and synthesized. The outcome of this work was the first three products in the Deliverables Table.

Tasks 5 and 6, completed in the second year of the project, utilized the information gained in Tasks 1 through 4 to accomplish the implementation and training objectives. Task 5 entailed developing the training package including presentations, a workbook, and an instructor's manual. This training addresses the capabilities and limitations of towing equipment when transporting off-road equipment. After the instructional materials were developed, we delivered an initial pilot training session to TxDOT Subject Matter Experts (SMEs) who critiqued and commented on the

program with a view to improving its effectiveness. Any significant weaknesses were corrected and the training package was finalized. The training objectives were delivered as Products P4 through P8.

Task 7 has consisted of writing the final research report and project summary report.

1.3 Overview of this Report

This report is organized into seven chapters. This introductory first chapter is followed by a comprehensive discussion of the research method in Chapter 2. The remainder of the report presents our research findings.

In Chapter 3, we provide a summary of findings from the database and literature review. This includes information from the transportation databases as well as information obtained from other entities associated with equipment transport including major equipment rental companies, truck trailer associations, heavy equipment manufacturers, fleet owner/operators, federal agencies, and a sample of other State DOTs. The goal of this work was to obtain a broader, nationwide perspective on this issue.

Chapter 4 summarizes findings from the district questionnaires. This represents a shift in data gathering from breadth to depth. Our first questionnaire – a pencil/paper instrument focusing on equipment transport knowledge – was submitted to a representative, stratified sample of personnel in the TxDOT districts and divisions. We then designed and delivered two online surveys: one having to do with identifying load-trailer-truck combinations, and the other having to do with equipment inventory and procurement.

Equipment transport practices and procedures are the topic of Chapter 5. Here we summarize observations and findings based on field interviews with TxDOT personnel from the divisions and representative districts. Topics include equipment transport policy, trailer payload capacity issues, the “zone” concept for load distribution, use of tilt-deck trailers, issues with Texas Correctional Industries trailers, tie down systems, and training considerations. This is a summary of findings that were submitted and implemented during the course of the research project.

Chapter 6 briefly describes the training aspect of this research. We present our analysis of the former course on equipment load and tie-down as well as our recommendations for revision. We then summarize the curriculum and instructional materials we designed, developed, and delivered to TxDOT.

The report closes (Chapter 7) with a summary of key research findings and with recommendations both for additional research and for implementation.

CHAPTER 2

RESEARCH METHOD

2.1 Overview

Unlike a "typical" research project where the problem statement attempts to describe the relationship between selected independent and dependent variables; for example, the effect of binder content on aggregate adhesion, here the problem statement is *descriptive* and very open-ended. We focused on two areas: (1) review of TxDOT's existing and future off-road equipment and transport requirements, and (2) assessment of TxDOT's current knowledge base and practices in transporting off-road equipment to determine capabilities and limitations. This non-typical problem required a non-typical research method. As briefly stated in the introduction, we approached the problem as one of gathering, synthesizing, and reconstituting a tremendous volume of data. This work was accomplished in seven tasks for this two-year research project.

2.2 Research Tasks

2.2.1 Task 1. Database and Literature Review

We began the project with a comprehensive review of the literature on the problem of transporting off-road construction equipment. This was to provide a solid theoretical as well as practical basis for the assessment of TxDOT equipment transport procedures and requirements. We initially searched the transportation databases, including those represented by the TxDOT RTI Library at the Center for Transportation Research.

In addition to this "academic" literature on transporting off-road equipment, we searched databases of other public and private agencies such as those of major construction equipment manufacturers, major equipment haul trailer manufacturers, and federal agencies such as the Federal Highway Administration (FHWA), the Department of Defense, and the Forest Service. We also attempted to contact representatives of these groups to discuss their experiences and practices relative to equipment transport.

Another key aspect of this task was to become completely familiar with TxDOT's Equipment Operations System (EOS). This involved gaining a thorough understanding of all fleet management data currently available within the system, as well as the scope and limitations of these data. We focused on identifying and acquiring information not in the EOS but required for the project deliverables.

Finally, we contacted a sample of the other State DOT's (roughly 30 to 40 percent) to identify their typical equipment transport capabilities, procedures, and training practices. The phone and face-to-face interviews with subject matter experts outside TxDOT, nationwide, helped us broaden and deepen our understanding of equipment transport issues and provided a national perspective on the issues. This set the stage to conduct more in-depth, face-to-face interviews with knowledgeable persons in the TxDOT divisions and districts. We also used this opportunity to identify additional literature and printed resources.

From a reporting perspective, we have archived the handwritten notes of our conversations and interviews, as well as various manuals, photographs, reports, proceedings, and other materials we obtained as part of our inquiry. In selected cases – for example, interviews with representatives from other State DOTs – we prepared summary notes of our conversations. We maintain archived copies

of these notes in our files, but have also presented an electronic copy of these working notes (not edited for formal reporting) on a Data CD as described in Section 2.3 of this report.

Ultimately, the database and literature review helped identify and characterize off-road equipment transportation practices with a view to (1) synthesizing available information, (2) developing research questionnaires to gain further information, and (3) providing a context for interpreting data obtained in subsequent research tasks. We have reported the results of the literature review in Chapter 3 of this report.

2.2.2 Task 2. District Questionnaires

This task consisted of developing survey questionnaires to accomplish those research objectives in the Project Statement where the requested data were specific and well-defined. We ultimately developed three different research questionnaires, one traditional pencil/paper questionnaire and two web-based surveys.

The first questionnaire, a pencil/paper instrument, was designed to identify the essential areas of knowledge that must be understood by management, equipment operators, and maintenance staff for safely transporting off-road equipment. We also wanted to document current equipment transport knowledge levels of District personnel, as well as the practices actually being used in TxDOT Districts. Finally, we wanted to determine the level and scope of training provided in the Districts. This survey was submitted to a representative, stratified sample of personnel in the TxDOT districts and divisions in April-May 2004.

The second questionnaire, a web-based survey, was submitted to the full population of TxDOT Maintenance Section Supervisors in March 2005. The goal was to review TxDOT's current types of off-road equipment and determine their transport requirements. Our specific focus was to identify the actual load-trailer-truck combinations used in the districts. We also wanted to examine TxDOT's existing towing capabilities/limitations of its trailers and truck-trailer combinations. The web-based survey directly interacted with data in TxDOT's Equipment Operations System (EOS) database.

The third questionnaire, also a web-based survey that directly interacted with TxDOT's EOS database, was submitted to the full population of TxDOT Equipment Administrators in May-July 2005. The focus of this survey was to forecast the types of off-road equipment to remain in TxDOT's fleet over the next five years. We also requested a prediction of the off-road equipment that will be needed in the next five years.

We present the results of the first survey in Chapter 4 of this report. The results from web-based Survey 2 have already been reported as Product P1-Part 1. The results from web-based Survey 3 were reported as Product P1-Part 2 and Product P2. Chapter 4 also briefly summarizes the findings from these web-based surveys.

2.2.3 Task 3: Interviews/District Site Visits

Whereas Task 1 primarily was intended to yield *breadth* of information about equipment transport from available sources including non-TxDOT experts, Task 3 is about *depth* – as in deepening our understanding and knowledge of the issues. Specifically, our goal in Task 3 was to capture the wealth of institutional knowledge resident within the agency at both the Division and District levels.

2.2.3.1 Division-Level Interviews

At the Division level, we interviewed personnel in both Fleet Management and Heavy Equipment Purchasing. Both of these groups are part of the General Services Division: Fleet Management personnel are responsible for all aspects of fleet management policy and operations, and Heavy Equipment Purchasing personnel are responsible for writing specifications to procure TxDOT's trucks, trailers and heavy-duty off-road construction and maintenance equipment. We present a summary of the results of these Division-level interviews in Chapter 5 of this report.

2.2.3.2 District -Level Interviews

At the District level, based on past TxDOT research experience in the maintenance area, we initially proposed to contact equipment transport knowledge experts in all 25 TxDOT Districts to set up site visits/interviews. However, based on input from the Project Monitoring Committee, we elected to change our approach in order to increase our exposure to operations personnel. That is, we elected to visit fewer districts but to spend more time in the maintenance sections in these districts. Ultimately, this procedure resulted in site visits at 12 districts and 37 maintenance sections.

The goal of these site visits was to obtain a shared understanding of District/Maintenance Section perspectives on equipment transport during the interview, and then to physically observe and document illustrative examples of their practices and procedures in the field. This proved to be a very effective method for gathering information and yielded a large volume of data – over two linear feet of shelf space for documentation. These data are archived in our files and selected items are included in a Data CD (see Section 2.3 of this report).

2.2.4 Task 4: Data Analysis/Synthesis

The results from the literature review, the questionnaires, and the field interviews were tabulated, summarized, and synthesized. The outcome of this work has been the first three products in the Deliverables Table: Products P1, P2 and P3.

Product P1 [1] [2] is a current inventory (in electronic format) of:

- Trailers and tractor-trailer combinations, and their capabilities for transporting off-road equipment.
- Off-road equipment that is projected to remain in the TxDOT fleet over the next five years.

Product P2 is a listing of off-road equipment by category (e.g., motor grader, loader, etc.) that will likely be needed by TxDOT in the next five years [3]. The listing also addresses projected changes in sizes, weights, and transport requirements. Additionally, this product includes general specifications (size, payload capacity, etc.) of the required truck and trailer equipment needed to transport the "future" off-road equipment.

Product P3 is a series of recommendations regarding the safest means of transporting all types of TxDOT off-road equipment to include the combinations [4]. The recommendations take into account factors such as equipment weight and size, types of truck and trailer combinations, and trailer payload capacity.

The recommendations summarized in Product P3 essentially take the form of establishing "best practices" for transporting TxDOT's off-road equipment. This approach identifies what is best from local practices and shares this information with all the Districts, thereby strengthening TxDOT's entire program for transporting off-road equipment. Further, implementation was accomplished in real time. That is, when research findings emerged from our study and were communicated to TxDOT Fleet Management representatives, these were immediately addressed.

2.2.5 Task 5: Develop Training Materials

Implementation of the research was the focus for the second year of this project. This work consisted of developing training materials (Task 5) and conducting pilot training (Task 6). We initiated Task 5 by reviewing available training materials. We then attended and critiqued TxDOT's current "Equipment Load and Tie-Down" course. Based on this information and our research findings, we comprehensively revised and updated the Equipment Load and Tie-Down Course. The process consisted of the following steps:

- We identified learning objectives based on issues and needs identified during Tasks 1-4.
- For each learning objective, we created an appropriate set of tasks, conditions, and standards that map out the strategy to satisfy the objective.
- We identified the educational medium which most appropriately supported each objective and wrote lessons for delivery of the content.
- The collection of all lessons constitutes the new training program.

For example, we found that "trailer load distribution" for tag-a-long trailers was not well understood. Therefore, we created the learning objective of "determining the load distribution for properly loading tag-a-long trailers." That objective was broken down into individual tasks and appropriately illustrated through visual media, worked examples, and reference material.

We developed the training materials for delivery in a workshop-type setting with a strong hands-on component. Although we included in-process learning assessment, we did not introduce competency testing as part of the training event. However, we did provide in-class examples that appropriately illustrated the learning objectives.

The scope and format for the training materials is generally described in Products P4, P5, P6 and P7. The training materials were developed to improve knowledge and skill levels in the District Maintenance Sections and to address the capabilities and limitations of towing equipment when transporting off-road equipment. Training materials included a syllabus with learning objectives [5], MS PowerPoint slides [6], an Instructor Guide [7], and a Student Participation Workbook [8].

The sequence of activities for Task 5 consisted of (1) designing the training program, (2) developing the training materials, (3) obtaining review of these materials by the Project Director, Project Coordinator, and Project Monitoring Committee, and (4) finalizing the materials both prior to and during the initial pilot training in Task 6.

2.2.6 Task 6: Implementation/Pilot Training

In a very real sense, implementation commenced when we began our program of visiting the TxDOT Districts during the data-gathering phase. These visits offered an open invitation to key District maintenance personnel who routinely work with off-road equipment to become aware of and

participate in the research process, and sensitized us to the most effective style and manner by which we should present our findings.

Having set the stage for delivery as outlined above, we presented the fruits of our research through pilot training and instruction developed for employees at the TxDOT Maintenance Section level [9]. The training program consisted of an initial, full-day pilot workshop in Bryan, Texas where we invited selected maintenance and equipment personnel (Subject Matter Experts -- SMEs) from across the state to participate. The SMEs not only received the training but also were asked to critique and evaluate the training they received. The primary goal of this initial pilot workshop was to assess, refine, and finalize the training program and materials.

We also delivered a "research highlights" presentation to TxDOT equipment administrators, maintenance managers, fleet managers, and purchasing personnel at the October 2004 Logistics Management Conference in Austin, Texas [10]. We later delivered this same program to a national audience in January 2005 – the Maintenance Equipment Committee of the Transportation Research Board [11]. These meetings afforded an ideal opportunity to showcase the research findings and introduce the anticipated implementation/ training program to interested publics.

2.2.7 Task 7: Project Meetings, Products and Reports

Eight products and two reports have been/are being prepared for this project. The products have been identified already, as follows:

- Product P1 is a current inventory (in electronic format) of trailers and tractor-trailer combinations, and their capabilities for transporting off-road equipment.
- Product P2 is a listing of off-road equipment by category (e.g., motor grader, loader, etc.) that will likely be needed by TxDOT in the next five years.
- Product P3 is a series of recommendations regarding the safest means of transporting all types of TxDOT off-road equipment to include the combinations.
- Product P4 consists of the learning objectives for revised MNT172 Equipment Load and Tie Down course addressing the safe loading, tie-down, and transportation of construction equipment and materials over public roads and highways.
- Product P5 consists of the PowerPoint slides associated with this training.
- Product P6 consists of the Instructor Manual for this training.
- Product P7 consists of the Student Manual for this training.
- Product P8 consists of the Pilot Training workshop.

The reports include this Research Report presenting the findings of all research tasks, and TxDOT's 2-page Project Summary Report.

2.3 Archive/Publication of Research Data

2.3.1 Overview

As already noted, the research data gathered from the literature review, questionnaires, and site visits (Tasks 1, 2 and 3) has been cataloged, sorted, evaluated and organized, the goal being to distill recommended practices for transporting TxDOT's heavy-duty, off-road construction and maintenance equipment fleet. This research report presents those findings as a comprehensive stand-alone summary document.

2.3.2 Archive of Equipment Transport Research Data

We have taken an alternative approach toward archiving the hundreds of pages of supplementary materials – data gathered from interviews, site visits and the like. That paperwork is voluminous and there is a need to balance the desire for an archived copy of data versus the effort and cost associated with publishing it. With the approval of the Research Sponsor [12] and consistent with accepted research practice, we have proceeded as follows:

- TechMRT will maintain hard copies of the supplementary interview-related materials in our research files; these are archived working documents which are not in final report format.
- We have prepared selected data files for inclusion in this report as Appendices.
- We have scanned selected working documents, copied these files onto a Data CD, and provided the Data CD to TxDOT for archive purposes.

2.3.3 The Equipment Transport Data CD

The files on the Data CD primarily consist of notes, photographs, and other records – *not edited or formatted to the level necessary for publishing in this final report* – from our interviews and other data-gathering efforts. Specifically, the Data CD contains the following files:

Task 1: Database and Literature Review

- Interview Record, Travis Dunlap, New Mexico DOT
- Contact/Interview Record, State DOT Equipment Transport Survey
- Cargo Securement Regulation Fact Sheet

Task 2: District Questionnaires

- Questionnaire 1 – Pencil/Paper Survey Instrument
- Questionnaire 1 – Survey Results (raw numerical data)
- Questionnaire 1 – Survey Results (respondent comments)

- Online Survey 2 – Data previously reported as Product P1. Not included as part of this report.

- Online Survey 3 – Data previously reported as Product P2. Not included as part of this report.

Task 3: Interviews/ District Site Visits

- Interview records for conversations with representatives from Fleet Management, General Services Division, TxDOT.

- Interview records for conversations with representatives from Heavy Equipment Purchasing, General Services Division, TxDOT.

- Interview records for conversations with representatives from 37 Maintenance Sections from 12 of the 25 TxDOT Districts. These records summarize the results of the field interview and site visits. The typical interview record consists of a summary of the interview plus photographs and other documents provided by the District. The Data CD contains only the interview summary plus selected photographs.

Task 4: Data Analysis/Synthesis

- Data previously reported as Product P3. Not included as part of this report.

Task 5: Develop Training Materials

- Data previously reported as Product P4, P5, P6 and P7. Not included as part of this report.

Task 6: Implementation/Pilot Training

- Data previously reported as Product P8. Not included as part of this report.

The Data CD contains much of the data upon which the report findings are based. It is here the reader will find detailed, first-hand information about maintenance practices and procedures for transporting heavy-duty, off-road construction and maintenance equipment in various regions of Texas. In addition to the interview records, the data includes annotated photographs, contact names, and phone numbers for further information (current as of the date they were obtained). Again, we emphasize that the information on the Data CD represents working data files and these documents are not edited/formatted to the degree required for publishing in this final report.

2.4 Research Focus and Limitations

Equipment transport represents a multi-faceted problem that can be explored from various perspectives. Therefore, it is appropriate to identify the boundaries and limitations of this research.

First, while we have attempted to listen to all of the stakeholders, we have intentionally focused our research from the TxDOT *maintenance* perspective. Our primary goal has been to help the maintenance employee who is responsible for transporting TxDOT's heavy-duty, off-road construction and maintenance equipment fleet on a daily basis.

Second, fleet management at TxDOT is tightly coupled to TxDOT's Equipment Operating System (EOS) database. The data and recommendations for this report rely on the EOS as the context for managing equipment data.

Third, it must be emphasized that equipment transport issues in TxDOT are dominated by the fact that most TxDOT equipment is transported on tag-a-long trailers pulled behind dump trucks. If low-boy trailers were the dominant equipment transport method, the issues would be different.

Fourth, and related to the above, the maintenance practices and procedures discussed herein are intended for use in Texas, for roads within the TxDOT system. The physiographic make-up of Texas includes mountains, beaches, deserts, high-rainfall areas, grasslands, and forests. This makes for a highly diverse range of conditions for which the practices and procedures discussed herein will apply. But Texas is obviously located in the southern part of the United States and thus does not experience severe winter weather like northern states do, so the equipment transport practices and procedures discussed herein do not heavily get into ice, snow and other cold-weather issues.

Fifth, we have taken the view that equipment transport is a functional activity at TxDOT, and the role of this research has been to inform decision-makers who seek continuous quality improvement to equipment transport policy, practices and procedures. Equipment transport by its very nature engages both safety and legality considerations, and it has been beyond the scope of this project to directly and comprehensively address the safety and legal issues. However, we have attempted to point out concerns when and where we encountered them. In certain cases we have identified needs and made recommendations which will impact equipment transport safety and legality. In such cases, we have articulated our findings as recommendations with full awareness that any changes will impact the overall fleet system and are therefore subject to practical, logistical, financial, and other implementation constraints.

CHAPTER 3

DATABASE AND LITERATURE REVIEW

3.1 Overview

We began the project with a comprehensive review of the literature on the problem of transporting off-road construction equipment. This was to provide a solid theoretical as well as practical basis for the assessment of TxDOT equipment transport procedures and requirements. We initially searched the transportation databases, including those represented by the TxDOT RTI Library at the Center for Transportation Research.

As noted below, the transportation databases contain very little information on the topics specific to this research. Therefore we directed most of our efforts toward identifying and contacting entities that might be able to provide useful perspectives and insight on equipment transport. Ultimately we contacted equipment rental companies, equipment trailer manufacturers, heavy construction equipment manufacturers, equipment fleet owner/operators, truck/trailer associations, and federal agencies such as the Forest Service. We also contacted a sample of the other State DOT's (roughly 40 percent) to identify their typical equipment transport capabilities, procedures, and training practices.

3.2 Transportation Databases

The traditional academic transportation databases yielded very little information on this research topic. No formal studies similar to the present study have been published. We did encounter a few brief articles of interest on topics such as trailer selection [13], how to make certain the hauling vehicle, trailer and its load fall within the legal limits of both federal and state guidelines and the trailer's load within the manufacturer's rated load capacity [14], the variables that impact handling, tire wear, and safety of towing rigs [15], and effective trailer utilization [16].

3.3 Major Equipment Rental Companies

The rental of heavy-duty off-road construction and maintenance equipment requires frequent deliveries and pick-ups to and from the rental customer's job sites. Based on this line of thinking, we identified and attempted to contact seven major equipment rental companies to gain an understanding of how this unique private industry conducts their equipment transport operations, and what types of policies, procedures and training programs are being implemented within their organizations.

Six of these companies are clearly the largest and most prevalent major equipment rental companies in the United States and include Hertz Equipment Rental Corporation, Rental Service Corporation, United Rentals, Inc., Sunbelt Rentals, Nations Rent, and The CAT Rental Store. Half of these companies responded that it is their corporate policy not to participate in research projects, and the other half did not respond at all.

The seventh rental company we contacted, Associated Supply Company, Inc. (ASCO), is a regional company that provides rental equipment to construction contractors in West Texas and

Eastern New Mexico. ASCO does a lot of equipment rental, sales and service business with TxDOT and TxDOT contractors and did agree to be interviewed.

In summary, ASCO uses Western Star truck-tractors (fifth-wheel) exclusively with a variety of trailers. They haul most of their equipment with lowboy type trailers, so load distribution is usually not a factor unless the equipment being transported is very heavy and trailer axle overloading becomes a concern. ASCO has a dedicated trailer for their track-type excavators and dozers. Most trailers have a dovetail (hydraulically controlled) rear ramping system. ASCO hauls a wide range of construction equipment including cranes, loaders, excavators, dozers, backhoes, compactors, rollers, motor graders, forklifts, aerial personnel devices and manlifts. Center of gravity markings are typically provided on most of the equipment they transport; however, load distribution markings are *not* typically provided on their trailers. All equipment transport operations are done with in-house personnel and equipment. They secure their loads with chains and ratchet-type boomers. ASCO only requires a commercial driver's license for their drivers, and the more challenging or difficult loads are transported by specific drivers who typically have the most experience. Training is limited to that provided by the equipment manufacturers. Regarding improvement of equipment transport operations, there is a need for better education on DOT regulations, trucks, and weight distribution issues. From ASCO's perspective, "too much guessing" goes on in the trucking industry when it comes to determining the weight of a piece of equipment to be transported.

3.4 Equipment Trailer Manufacturers

Trailers represent an integral component of heavy-duty, off-road construction and maintenance equipment transportation. Therefore, it seemed reasonable to obtain the perspective of the equipment trailer manufacturers on equipment transport policy, practice and procedures.

We attempted to identify a representative sample of equipment trailer manufacturers from the hundreds of trailer manufacturing companies. This was accomplished by using the internet to find a list of the top-volume sellers in the trailer manufacturer market. The list was then shortened by the companies that produce equipment hauling trailers. Out of the top-volume sellers, the following were contacted: Trail Boss, Big Tex Trailers, Overbilt Trailers, Globe Trailers, Superior Trailers, Lufkin Trailers, Trail King Industries, Featherlite Inc., Pitts Trailers, Talbert Manufacturing, Fontaine Trailer Company, Aspen Trailer, M.H. Eby Inc, Load King, and Ferree Trailer. A total of five of these companies replied to our questions.

The respondents indicate that trailer manufacturers have practically nothing to do with their trailers after they leave the manufacturing facility. Loading and hauling practices, training, and all other equipment transport aspects are left to the consumer. The manufacturers only provide a list of specifications and limitations for the trailers. As for trends in the equipment transport market, the trailer manufacturers almost unanimously replied that there has been an increase in the demand of tag-a-long trailers. The tag-a-long trailer is seen as a specialized trailer for certain types of machinery. With the increase in size of the equipment/machinery being hauled, the present trailers cannot withstand the larger size or weight. Therefore, changes to these trailers are pushed mainly by the changes of the equipment hauled by the trailer. We asked if the trailer manufacturing companies were doing anything new or innovative in the transport market. The replies again were almost the same. The manufacturers are trying very hard to stay up with the growth in the size of machinery that people are using. This is a very large task for the companies because a trailer that was used last year may not meet the specifications to haul a new piece of equipment of the same type.

3.5 Heavy Equipment Manufacturers

Major equipment companies manufacture the heavy-duty, off-road construction and maintenance equipment that is being used and purchased by TxDOT forces. We contacted several of these companies to gain an understanding of how the heavy equipment manufacturing industry conducts their equipment transport operations, and what sort of policies, procedures and training are implemented within their respective organizations.

Seven major equipment manufacturers were chosen for inclusion in this survey. We based our selection on information from TxDOT's Equipment Operating System (EOS) database. That is, we determined the number of units by manufacturer (make) for the most common and prevalent types of heavy-duty off-road construction and maintenance equipment in TxDOT's current fleet. This effort revealed that the predominant suppliers of equipment for TxDOT's current fleet are John Deere, Bobcat, Case, Ferguson, Volvo, Caterpillar, and Galion (Galion-Dresser). Although we initiated contact with all of these companies, only one – Caterpillar – responded to our questions. We attribute the relatively low response rate to the fact that the major equipment manufacturing business is highly competitive and extremely busy due to a very strong economy and a thriving construction industry. Further, corporate policy either prohibits or dissuades participation in research projects that could potentially compromise company secrets such as policies, procedures, training and operations that may give one company a business advantage over their competitors.

Caterpillar, however, did respond to our inquiry. Caterpillar is the world's largest manufacturer of construction and mining equipment, diesel and natural gas engines, and industrial gas turbines. Caterpillar's safety training focuses only on the use of the equipment after it is delivered to the job site. The safe loading and hauling of equipment is not taught by Caterpillar. On the other hand, Caterpillar does show buyers exactly where the equipment is to be tied down to a trailer for safe transportation. One main thing Caterpillar keeps in mind when designing a new model of equipment is current trailer hauling specifications. Caterpillar realizes that their customers will not necessarily buy a new trailer to haul their new equipment.

The size and weight of construction equipment has grown over time, making it harder to transport equipment because the payload capacity of existing trailers is being exceeded, and because of insufficient tie down locations. For the purposes of this research, we attempted to define how quickly the equipment is growing; *viz*, the rate of increase in size or weight. We specifically asked Caterpillar to help us define a trend line for the growth of equipment over time.

Caterpillar directed us to their *Performance Handbook* [17]. Section 19 in the *Performance Handbook* presents product data on former equipment models. That is, this book identifies the size, weight, horsepower and related information for a given type and model of equipment over time. We attempted to evaluate and plot these data for various types of equipment, one representative example being the D4 track-type dozer as depicted in Figure 3.1.

The trend line in this figure suggests that the weight of equipment has grown over the years. However, our analysis of the former equipment models and conversations with knowledgeable persons in Caterpillar's main offices suggest that while equipment is increasing in size and weight, it is not possible to project a valid and reliable trend line with respect to time. This is because many factors affect the sizes of the machines. For example, Caterpillar has restrictions to keep a model within a specification code, and some of these restrictions include engine horsepower and operating weight. The machine size increase or decrease fluctuates because Caterpillar tries to make their machines more user-friendly and efficient. Technology also changes, and Caterpillar works to keep

up with these new innovations and technology. Classifications of the machines also change within certain model numbers. For example, two different backhoe loader model numbers are 426B and 426C. These machines fit in the same model classification, but are not the same machines.

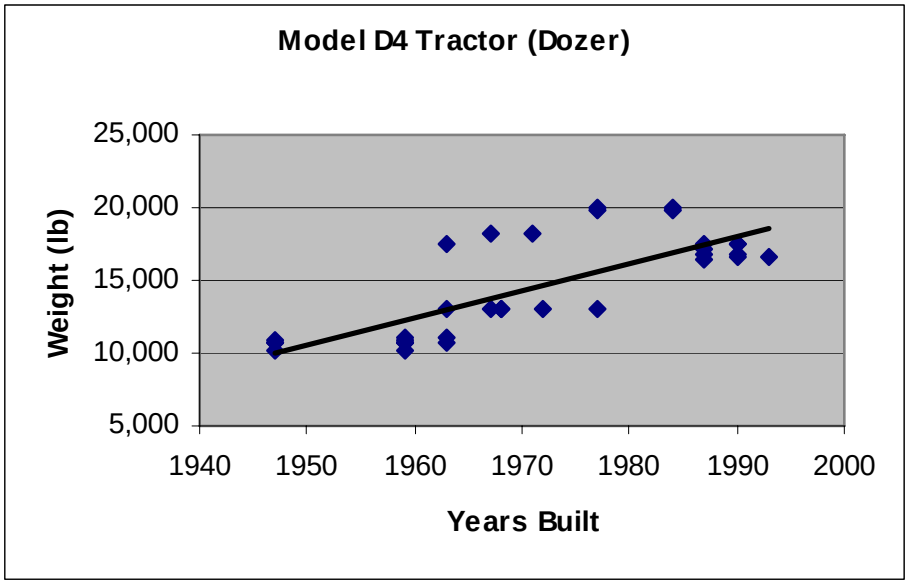

Figure 3.1 Increase in Weight in the Caterpillar Model D4 Tractor (Dozer) Over Time [17]

In sum, Caterpillar confirmed that equipment is growing over time, but could not definitively say how much or how fast.

3.6 Truck Trailer Associations

3.6.1 Truck Trailer Manufacturers Association

We contacted various professional associations and state and federal agencies having to do with trailer manufacturing, cargo securement, and other equipment transport issues. One of the key associations we contacted was:

Truck Trailer Manufacturers Association
1020 Princess Street
Alexandria, VA 22314
www.ttmanet.org

The Truck Trailer Manufacturers Association (TTMA) is an international association of trailer manufacturers and industry suppliers that exists to establish confidence between manufacturers of truck trailers and their suppliers to bring about a mutual understanding of the problems confronting all manufacturers. TTMA conducts programs and activities to further the interests of TTMA member companies and the truck trailer industry, and provides a means of cooperating with the various agencies of the U.S. Federal, U.S. state, and international governments on truck trailer issues.

TTMA provided helpful information and several publications [18] about equipment transport issues such as trailer nomenclature [19], loading and use of lowbed and industrial trailers [20], and recommended practice for determining GAWR and GVWR [21]. TTMA also provided a lowbed and heavy-duty platform trailer user's manual [22] and a trailer maintenance manual [23].

3.6.2 Other Transport Associations and Agencies

The dominant equipment transport issue that emerged from our conversations with TTMA was the new cargo securement regulations that took effect in January 2004. Promulgated by the Federal Motor Carrier Safety Administration (FMCSA) and entitled "Development of a North American Standard for Protection Against Shifting and Falling Cargo; Final Rule," [24] the new regulation concerns protection against shifting and falling cargo for commercial motor vehicles engaged in interstate commerce. To learn about the authority, development, implementation and training associated with these regulations, we contacted the following organizations:

Federal Motor Carrier Safety Administration
400 7th Street, S.W.
Washington, DC 20590
www.fmcsa.dot.gov

Canadian Council of Motor Transport Administrators
2323 St. Laurent Blvd.
Ottawa, Ontario
CANADA
www.ccmta.ca

Texas Highway Patrol
Commercial Vehicle Enforcement
455 "B" State Highway 195
Georgetown, TX 78628
www.txdps.state.tx.us

Commercial Vehicle Safety Alliance
1101 17th Street, N.W., Suite 803
Washington, DC 20036
www.cvsa.org

Specialized Carriers and Rigging Association
2750 Prosperity Avenue, Suite 620
Fairfax, VA 22031
www.scranet.org

The new cargo securement standards are based on the North American Cargo Securement Standard Model Regulations. They reflect the results of a multi-year comprehensive research program to evaluate current U.S. and Canadian cargo securement regulations; the motor carrier industry's best practices; and recommendations presented during a series of public meetings involving U.S. and Canadian industry experts, Federal, State and Provincial enforcement officials, and other interested parties. The intent of the regulation is to reduce the number of accidents caused by cargo shifting on or within, or falling from, commercial motor vehicles operating in interstate commerce, and to harmonize to the greatest extent practicable U.S., Canadian, and Mexican cargo

securement regulations. The regulation was issued September 27, 2002, and became effective December 26, 2002. Compliance was voluntary in 2003, but motor carriers had to ensure compliance by January 1, 2004.

3.6.3 Cargo Securement Regulations

The cargo securement regulations can be thought of as containing two interrelated sets of provisions: (a) general requirements on cargo securement for all carriers, and (b) specific securement requirements for certain commodity types including, among other things, "heavy vehicles, equipment, and machinery." The commodity-specific requirements control for that type of cargo.

Most of the research for these regulations was done by the Canadian Council of Motor Transport Administrators (CCMTA). The CCMTA issued a total of 17 reports over a 5 year period. The regulations were conceived and developed as a North American Cargo Securement Standard, this due to the large amount of truck traffic between the US and Canada and Mexico. Canada and the US were actively involved in development of the regulations; Mexico was interested but had limited representation in the process. The North American Cargo Securement Standard is very similar to, but in certain limited areas is stricter than, the US Regulations adopted by the FMCSA (CFR 49, Part 392 and 393).

The program under which the North American Cargo Securement Standards were developed included a comprehensive training component to facilitate compliance with the regulations. The investment in this training was substantial, $1.0 to $1.5M, so it is expertly done. The training program is laid out in modules corresponding to the different portions of the regulations and includes two general modules, as well as modules for each of the commodities (see Figure 3.2). All of the training would take about two days; the two general modules plus the heavy equipment module would take about one day.

Figure 3.2 North American Standard Cargo Securement Training Program [25]

The Cargo Securement Training Program [25] includes an instructor's manual, PowerPoint presentations, training videos, and more. The training package became available in December 2003 from the Commercial Vehicle Safety Alliance (CVSA) and other organizations. The Specialized Carriers and Rigging Association has produced a brief film [26] that gives an excellent overview of the new regulations and points out the differences between the new regulations (what is required now) and what used to be allowed.

As to TxDOT compliance with the regulations, TxDOT and other state DOTs are, as a general rule, ***exempt*** from FMCSA regulations per 49 CFR, Part 390, §390.3(f)(2) which says:

> "*Exceptions.* Unless otherwise specifically provided, the rules in this subchapter do not apply to… transportation performed by the Federal government, a State, or any political subdivision of a State, or an agency established under a compact between States that has been approved by the Congress of the United States…"

Despite the compliance exemption, TxDOT typically seeks to comply with these types of regulations simply because this promotes safety, it demonstrates a commitment by TxDOT to working diligently on behalf of the citizens of Texas, and it helps TxDOT manage its liability exposure in case of an accident.

The Texas Department of Public Safety (DPS) started enforcing the new federal regulations on January 1, 2004. State troopers were trained on the compliance issues associated with these regulations over the few months prior to this effective date. The Texas DPS developed training materials from an enforcement perspective (different than compliance), specifically focusing on out-of-service criteria and related issues.

3.7 Fleet Owner/Operators

We identified a representative sample of fleet owner/operators in three business sectors: major contractors, Texas municipalities, and public utilities in order to gain an understanding of how these fleet owner/operators conduct their equipment transport operations. Specifically, we attempted to determine the types of policies, procedures and training that are being implemented within their respective organizations.

3.7.1 Major Contractors

Major contractors do business with TxDOT on various construction and maintenance projects throughout the state, and that the nature of the construction business requires continual transportation of their heavy-duty off-road construction equipment fleet from project to project and job site location to location. We began with the Texas Top 120 Contractors List – 2003, which ranks contractors by total revenue in Texas.

From this list we selected eight major contractors, all of whom do business with TxDOT and who are prominent in the "Heavy/Highway" market sector: Austin Industries, J.D. Abrams LP, McCarthy Building Companies, Inc., L.H. Lacy Company Ltd., Traylor Brothers Inc., Archer Western Contractors Ltd., Granite Construction Company, Dean Word Company.

None of these major contractors responded to our query, probably because the construction contracting business is extremely busy due to a very strong economy and a thriving construction business.

3.7.2 Texas Municipalities

Texas municipalities must maintain streets and public utilities within the city limits along with many other tasks. With the need for the equipment to be transported quickly and effectively, an efficient fleet division is needed. We selected ten cities, aggregated by population. Houston, Dallas, and San Antonio, the three largest cities in Texas, were all chosen (1,000,000 +). These three make

up the first population group. Austin and Fort Worth (500,000 – 1,000,000) were chosen from the second category. Garland was chosen for third group (200,000 – 500,000). In the fourth grouping (100,000 – 200,000), Lubbock and Mesquite were chosen. The last group was represented by Lewisville and Midland (50,000 – 100,000). These cities were then researched and contacted. Out of the ten cities contacted, four responded including Midland, Garland, Austin, and San Antonio.

San Antonio personnel responded that they use an assortment of trailers, and these are used so frequently that it is hard to say whether one type is used more than another. They have over 4,500 pieces of equipment in their fleet, and it all gets moved quickly. Many of their trailers are specifically designed to carry a certain piece of equipment.

Austin personnel replied that they use a large amount of specialty trailers. These can be backhoe trailers where there are drop-ins for the tires or extra tie-downs in the required locations. These trailers are specifically designed for weight and size of the equipment they are meant to haul. City of Austin personnel determine the equipment-trailer combination by looking at the specifications for each combination, and determining which is adequate.

Garland personnel replied that almost all equipment in their city is hauled by a gooseneck trailer or tag-a-long trailer pulled by a dump truck. Training is accomplished by two methods: first the trainee is trained in-house (unspecified), and this is later supplemented with a driving course put on by the National Safety Council. However, the training is less than effective. People bring trailers into the shops that have been dropped because the latches are not connected properly, ostensibly because operators are only interested in getting the job done, not getting it finished correctly.

Midland personnel responded that they mostly use specialty trailers to haul their equipment. Backhoes are hauled on trailers that have drop-ins for the tires. They are pulled either by dump trucks or semi tractors, depending on the trailer chosen. On training, sometimes they send employees to external training courses. For very large equipment, a representative from the supplier will train personnel on how to secure the equipment for transport.

3.7.3 Public Utilities

Public utilities are constantly maintaining and repairing their transmission systems. Because of this, they must efficiently and effectively transport construction and maintenance equipment to and from their project sites. We began our query with a list of the largest public power utilities by way of the customers served. For those companies that serve 1,000,000+ customers, we selected the Los Angeles Department of Water and the Long Island Power Authority. For those companies that serve 500,000+ customers, we selected City of San Antonio Public Service. For those companies that serve 100,000+ customers, we selected the City of Tallahassee and Colorado Springs Utility. For those companies that serve 50,000+ customers, we selected the City of Lubbock. For those companies that serve 25,000+ customers, we selected Marietta Power and Cowlitz County Public Utility. Of these eight companies, four responded to our inquiry.

Respondents from the City of San Antonio stated that they most commonly use tag-a-long trailers pulled by a 6CY to 10CY dump truck to haul their equipment. They indicated they are trying to improve their operations by moving away from using what “is on the yard at the time” to using a trailer correctly sized for the load. They are also enhancing specification writing for their trailer procurement.

Respondents from the City of Lubbock stated that tag-a-long style ‘backhoe trailers’ in combination with a dump truck are what they use to transport their equipment. This has never

changed for the City. Lubbock is trying to write specifications for a universal trailer to haul all different makes of backhoes, and they are trying to make this universal trailer have adequate tie-downs for all the equipment.

Respondents from Marietta Power stated that the type of trailer used most often is a 20-foot, three axle tag-a-long trailer pulled by a dump truck. They have been doing everything the same for the last fifteen years. Respondents from the Cowlitz County Public Utility Division stated that Cowlitz County does not own heavy machinery or trailers to haul equipment. They hire everything out to subcontractors.

3.8 Federal Agencies

Relative to federal agencies, we were able to make contact with the United States Forest Service. The Forest Service has two options when it comes to equipment transport. One is subcontracting the task to some other company, and the other option is to transport the equipment themselves. About half of the transporting is subcontracted out, because the machinery can be too large for the trailers owned by the Forest Service. Also, because of the large geographical areas that the Forest Service works with, it would be hard to have a trailer accessible for every location. In-house equipment transport most commonly uses truck tractors and lowboy trailers. Reliability of machinery is a very strong point for the Forest Service.

As for equipment transport training, the USFS only hires qualified personnel. Employees must have a commercial driver's license and must demonstrate that they can drive over the terrain required for the job. New hires will typically ride with seasoned employees for a designated time to demonstrate their ability. The Forest Service does not just drive on the roads. The machinery needs to be placed at the job site and this usually requires driving off-road over rugged terrain.

3.9 State DOTs

3.9.1 Sample and Response

We contacted a sample of the other State Departments of Transportation (DOTs) to identify their typical equipment transport capabilities, procedures and training practices. We selected a sample of 25 states, 11 of which were specifically designated by the Project Director and the remaining states selected based on land area and population. Figure 3.3 shows the State DOTs selected for this study (selected states are shaded; respondents are shaded in blue).

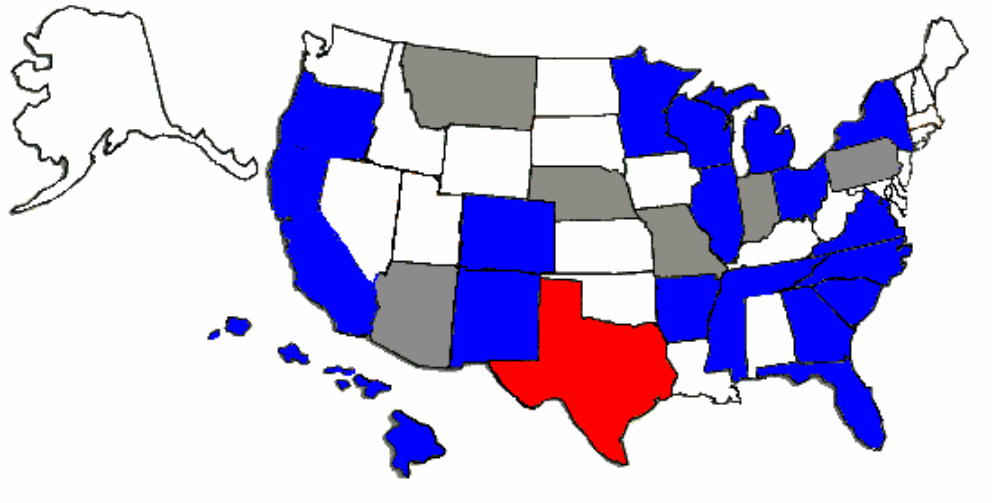

Figure 3.3 Sample of State DOTs Contacted for Equipment Transport Information

The initial personnel contacts for each state were made by telephone. After the appropriate contact was made, we conducted a telephone interview using a prescribed list of questions. In some of the State DOTs we interviewed more than one person as we were led to other individuals with more knowledge of the subject. The response rate was very good. We completed telephone interviews with 19 of the 25 DOTs contacted (76 percent), not including Texas.

The following sections summarize the State DOT responses. These include comments on equipment transport practice and procedure, policy, training, and issues and concerns. The Equipment Transport Data CD presents the detailed interview record for each State.

3.9.2 Equipment Transport Practice and Procedure

Equipment transport in the State DOTs is primarily done by "in house" maintenance personnel using a variety of trucks and trailers. One state does both in-house and contracted transport, and one state surveyed contracts out all of their equipment transport.

While specific practices vary from state to state, the larger and heavier equipment is typically transported on lowboy trailers pulled by truck-tractors. The more experienced drivers handle these truck-trailer-load combinations. Smaller equipment such as small front-end loaders and backhoes are transported on 10-ton and 20-ton tag-a-long trailers pulled by single and tandem axle dump trucks. Frequently these trailers are identified as the tilt-deck type, but fixed deck trailers are also used and ramp styles vary widely. Dedicated trailers are used for specialty equipment such as asphalt pavers and road planers. Haul distance typically is an issue. For long distances, lowboys will be used more frequently. For short distances, larger equipment such as motor graders will often be "roaded." A few states use lowboy-style trailers exclusively. A few states will pull smaller tag-a-long trailers with small trucks (not dump trucks). They do the best with what they have.

One state (Illinois) indicated their trailers are marked with a load distribution line that is designed to match up with the load's center-of-gravity marking.

3.9.3 Equipment Transport Policy

Of the 19 state DOTs that responded to our request for interviews, only three states (16 percent) indicated that they had any written equipment transport policies, procedures and guidelines. New Mexico DOT indicated that written policies and procedures are part of their "Loading and Securing" training class. CalTrans has written tie-down and chain procedures as well as other policies and guidelines. New York State DOT has various written policies, guidelines and procedures in their Safety and Equipment Manuals.

3.9.4 Equipment Transport Training

Of the 19 states that responded to our survey, five states (26 percent) have formal equipment transport training programs or a training academy, two states (11 percent) have training programs under development, one state (5 percent) contracts out training to a commercial vendor, and the remainder (58 percent) have no formal training program, courses or training materials specifically designed to address equipment transport issues.

Those state DOTs that do not have formal training programs typically use an *informal* on-the-job training process where the more experienced drivers/operators take the new, less-experienced personnel "under their wing." Also, equipment vendors sometimes provide limited load and tie-down training when they deliver a new piece of equipment. Union employees (e.g., Illinois) obtain certain types of training as well as designations/certifications for operating different types of equipment.

Training approaches and practices vary among the states with formal training programs. California (CalTrans) conducts equipment related training at the Motorized Equipment Training Academy in Sacramento, CA. They provide a two week training course (one week classroom/written, one week field) that addresses such topics as trailer backing, trailer loading, equipment loading and securement, tiedowns/binders, and driving. The training facility also provides training for truck driving, equipment operation, safety, and equipment maintenance and repair.

Colorado has a training academy in Golden, CO which employs a tiered training system where the main training focus is placed on entry level personnel. Most of the training is conducted by the more senior (experienced) personnel within the department.

New Mexico (NMDOT) has a training academy in Roswell, NM that has been in operation for 22 years. The academy is located on the old Air Force base and has a fleet of 160 pieces of training equipment worth $7 million. Every operator in NMDOT is required to attend the "101 Class." This class is a two week course which covers various topics related to equipment such as safety, preventive maintenance and equipment operation. The training academy also has a 2 week "Transport Class" that addresses such topics as equipment loading and securement and truck-trailer combinations. In addition to the classroom training, drivers are required to load and secure various pieces of equipment on various trailers, and are required to actually transport loads on the road for a distance of 750 to 1500 miles.

New York State (NYSDOT) has a variety of "training modules" that have been developed primarily for equipment operators. The equipment trainers recently updated the training modules for tractor-trailer drivers, and this training addresses issues related to equipment transport. The equipment transport training presentation uses visual media (photographs, images) and includes topics such as tie-downs, chains and binders, calculation of working loads, and more.

Ohio's training program for load securement has been implemented for several years. It is a stand alone training session within the truck and loader training. ODOT's courses are taught by a dedicated staff whose specific function is equipment training.

3.9.5 Equipment Transport Issues and Concerns

We identified several equipment transport issues and areas of concern among the State DOTs. These include:

- *Equipment Issues.* Compatibility issues exist related to braking systems and associated truck-trailer electrical and hydraulic connections/systems. Tire capacity on transport trailers is an issue because law enforcement officers typically check axle load limits and in the process determine that the tires are under capacity.

- *Policy:* Equipment transport policy is minimal to nonexistent in many states. Personnel should become familiar with applicable statutes such as Federal Motor Carrier Regulations, National Association of Chain Manufacturers, Texas Revised Code, etc. Equipment transport operators should be made aware of over-weight, over-height and axle weight problems associated with bridge laws.

- *Practices and Procedures:* The transport positioning of equipment with booms such as excavators, backhoes, cranes, and other "self-contained" equipment with hydraulic attachments is a challenge; the attachments can move if not tied down securely. Accidents due to over height loads can be a problem.

- *Preventive Maintenance:* A formal inspection procedure is needed to evaluate equipment trailer condition. Random inspections have found cracks in trailer support members. Also, equipment transport accidents should be investigated to identify any causes related to improper loading.

- *Purchasing.* Trailers are not always of sufficient size and capacity to haul the anticipated loads.

- *Training:* Training and special instruction in equipment load and tie-down is needed, especially for new (less experienced) personnel. More emphasis should be placed on properly training the workforce, especially in the area of safety training.

3.9.6 Recommendations for Improvement

One of our standard interview questions for the State DOTs was, "What one thing would you do to improve equipment transport operations in your state?" Responses were:

- Provide standard stickers on all trucks, trailers and equipment that include a visual drawing as well as an empty weight and loaded weight of the vehicle.

- Provide better "routing" information for the drivers involved in equipment transport. This would consist of a notebook that would be placed in each truck-trailer unit that would contain maps identifying the location of critical bridges along with their height and weight restrictions.

- Reinstate speed limits for certain types of trucks.

- Make sure operators use the correct chain (series 70) and only ratchet binders rated to the chain for load securement.

- Driver turnover is a constant problem, and when drivers leave, the training process has to begin over again. There is a need to hire smarter and better-trained operators and drivers.

These comments, together with the structured input about equipment transport practice and procedure, policy, training, issues, and concerns constitute a summary of our findings from the State DOTs.

CHAPTER 4

DISTRICT QUESTIONNAIRES

4.1 Overview

Our research included developing and administering a series of survey questionnaires to accomplish the research objectives in the Project Statement where the requested data were specific and well-defined. We ultimately developed three different research questionnaires: (1) a traditional pencil/paper questionnaire focusing on equipment transport knowledge, (2) a web-based survey to identify load-trailer-truck combinations used in the districts, and (3) a web-based survey to forecast the types of off-road equipment to remain in TxDOT's fleet over the next five years. The following sections discuss these surveys.

4.2 Equipment Transport Knowledge Questionnaire

4.2.1 Overview

The Equipment Transport Knowledge Questionnaire was designed to document the current equipment transport knowledge level and practices for those persons responsible for transporting TxDOT's off-road, heavy-duty construction and maintenance equipment. The survey items asked respondents about their experiences and opinion in relation to equipment transport knowledge, practices, training, safety, compliance with the law, and procurement. The survey was specifically designed for TxDOT maintenance section personnel; however, it was administered at both the district and division levels.

4.2.2 Subjects

The research subjects for this survey consisted of various personnel groups at both the district and division levels. The focal subject group at the district level consisted of maintenance technicians and equipment operators. These are the persons who actually perform the equipment transport job function. Another key subject group was section supervisors and their assistants. These persons have line authority for equipment transport in their respective maintenance sections. Other district-level respondent groups included district equipment administrators, directors of maintenance, maintenance engineers/administrators, and preventive maintenance coordinators. At the division level, respondent subjects included the purchasing unit and fleet management groups.

4.2.3 Sample Frame

We designed the sample frame to statistically represent all personnel groups responsible for equipment transport at TxDOT. We stratified the sample by group; that is, for some of the smaller groups – say, for example, equipment administrators – we sampled 100 percent of this group. For larger groups such as maintenance technicians/operators, we sampled only a percentage of the group. Table 4.1 identifies these groups and their sample size by job function.

For respondent groups where 100 percent of the population was sampled, we simply sent a survey to all persons in this group. For groups where only part of the population was sampled – that is, the maintenance technicians/operators and maintenance section supervisors/assistants – we used a random number generator to identify the selected fraction of respondents. This ensured a statistically random sample representative of the full population in these groups.

Table 4.1 Sample Frame for Equipment Transport Knowledge Questionnaire

Job Function	Respondent Population	Respondent Sample	Percentage of Population Sampled
Equipment Operator / Maintenance Tech	3000	648	22
Maintenance Supervisor / Assistant Supervisor	574	138	24
Preventive Maintenance Coordinator	25	25	100
District Equipment Administrator	25	25	100
Maintenance Administrator / Maintenance Engineer	25	25	100
Director of Maintenance / Director of Operations	25	25	100
GSD/Purchasing	4	4	100
GSD/ Fleet Management	6	6	100
Totals	**3684**	**896**	

4.2.4 Survey Design, Development, Pretest and Administration

We designed the survey questionnaire to cover specific equipment transport topic areas, the goal being to obtain respondent opinions on practices and procedures for transporting off-road, heavy-duty construction and maintenance equipment at TxDOT. Appendix A presents this 4-page survey questionnaire. The topic areas included in the questionnaire are:

- About You
- Equipment Transport Areas of Knowledge
- Equipment Transport Practices
- Equipment Transport Training
- Safe Operation
- Compliance with Law
- Equipment Transport Procurement
- Further Input

We developed the survey items based on information from the literature review and from communication with the project director and project monitoring committee. We pretested the items by submitting drafts to survey experts and to the project director and project monitoring committee for review. Any confusing or poorly-worded items were revised. We did not perform any numerical/statistical reliability testing on the survey items.

We designed and printed the survey in "scantron" format. That is, respondents would indicate their choices by penciling in small "bubbles" and the surveys could be read electronically. This minimized potential data entry error and other coding errors.

We administered the survey in May-June 2004. Respondents were initially notified by email in advance of the survey, and we sent out two reminders by email. As surveys were returned, they were preprocessed and scanned. We compiled the results in spreadsheets for data checking, summary and analysis.

4.2.5 Survey Response

Overall response to this traditional mailed survey was 586 surveys returned out of 896 surveys sent, for a 65 percent response rate. Of the returned surveys, 10 were blank and were excluded from subsequent analyses.

The survey included three demographic questions, one having to do with job function, one having to do with level of formal education, and one having to do with total years of work experience. Figure 4.1 identifies the respondent groups by job function and illustrates the percentage of respondents relative to the number of surveys returned.

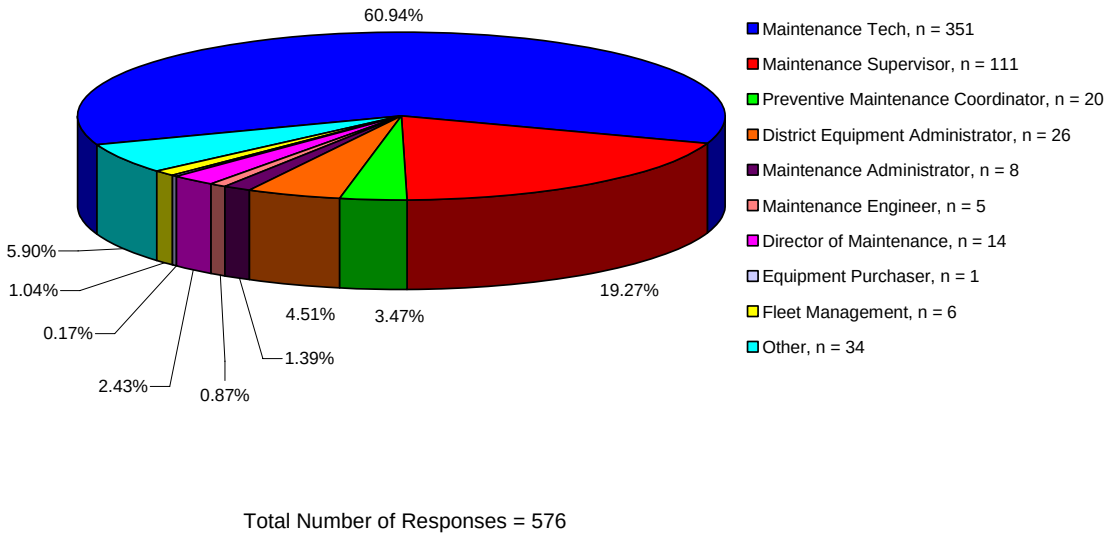

Figure 4.1 Survey Response by Job Function

Figure 4.2 presents these same data relative to the stratified nature of the sample. That is, Figure 4.2 identifies the percentages of respondents in each group who responded to the survey relative to the number of surveys administered to that particular group. This chart indicates that the group response in the divisions varied from 25 to 100 percent. The division-level respondents, GSD/Fleet Management and GSD/Purchasing, are very small respondent populations of 10 persons total. Group response in the districts ranged from 52 to 104 percent. The percentage response for PM Coordinators (104) is likely due to a coding error.

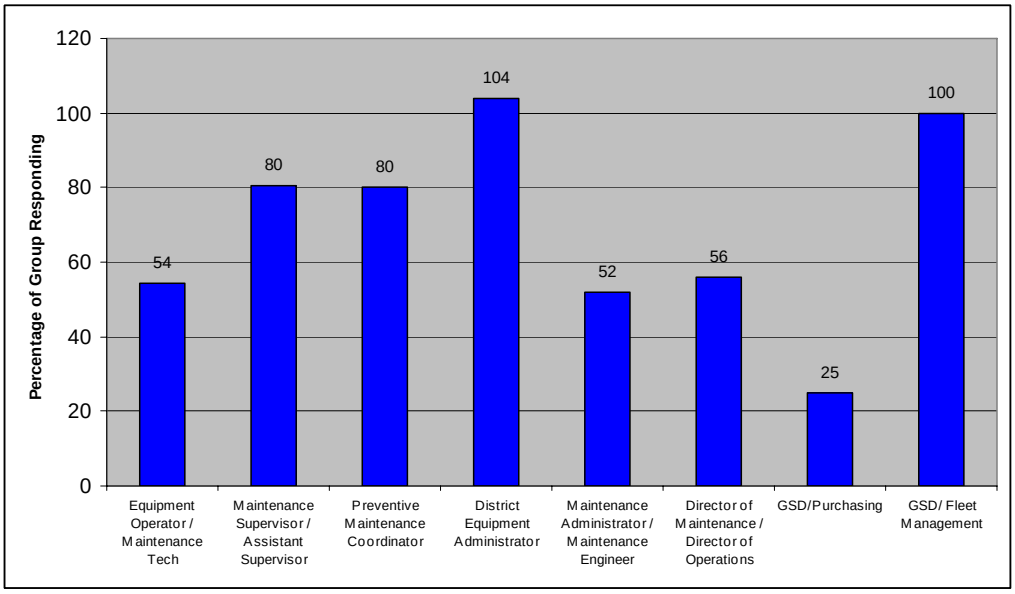

Figure 4.2 Group Response by Percentage of the Job Function Population Sampled

Figure 4.3 identifies the level of formal education for the survey respondents. The median level of education is a high school diploma, and this is consistent with job function for the TxDOT maintenance community.

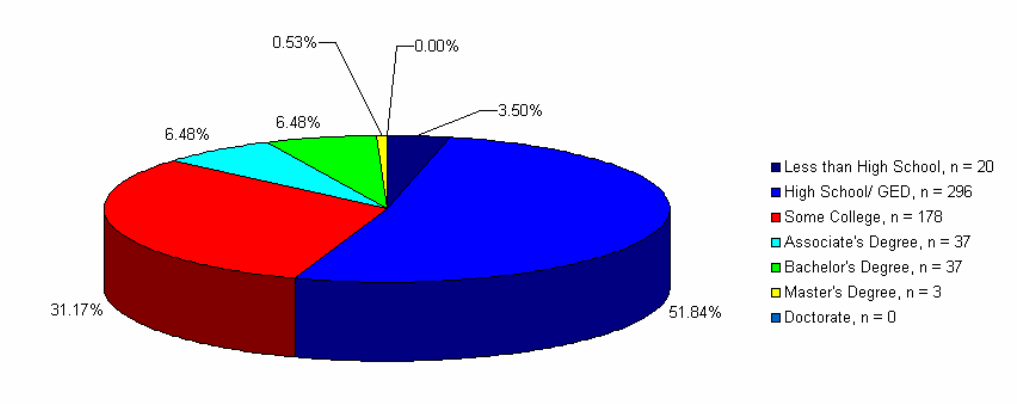

Figure 4.3 Survey Respondent Level of Formal Education

Figure 4.4 illustrates the total years of work experience for the survey respondents. This is a highly-experienced group with the median number of years of experience in the range of 16 to 20 years.

Taken as a whole, the survey response is very strong. Group response percentages suggest that the survey results are representative of the opinions of the various groups with the TxDOT equipment transport community. In turn, by virtue of our stratified random sample, the findings should be representative of the TxDOT maintenance forces in general and those persons who transport TxDOT's heavy-duty off-road construction and maintenance equipment fleet in particular.

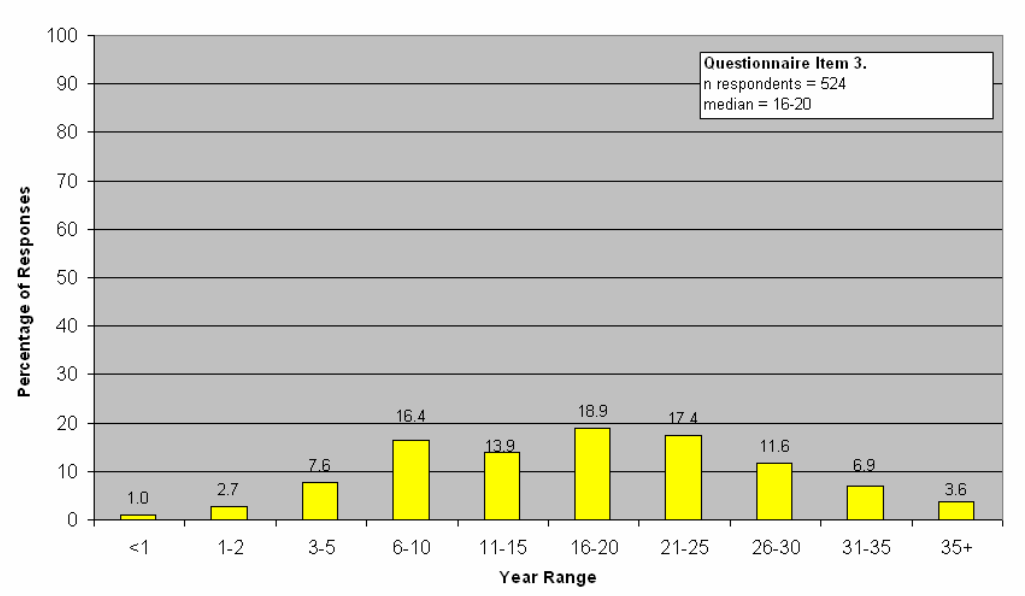

Figure 4.4 Survey Respondent Total Years Work Experience

4.2.6 Survey Results (All Respondents)

Tables 4.1 through 4.9 present the results for each section of the survey. Survey responses within a particular table represent percentages of respondents surveyed and are sorted by average, from highest to lowest. We did not attempt to perform group comparisons other than to note that the overall results closely mirror findings for the dominant group, maintenance technicians. We emphasize that these results represent a non-weighted summary of all survey responses. The following paragraphs present observations and comments on each table.

4.2.6.1 Degree of Importance of Equipment Transport Knowledge

The intent of the survey items in Table 4.1 was to discern the degree of importance that maintenance personnel place on various areas of equipment transport knowledge. Results indicate that all equipment transport knowledge areas identified are very important, with average scores above 6.0 in all categories. We observe that the top half of table 4.1 emphasizes knowledge of different types of equipment transport practices. These are the practical, hands-on, direct application knowledge areas needed to load, tie-down, and haul equipment. In contrast, the bottom of the table gets into knowledge of policies, laws, manuals, and other kinds of paperwork.

4.2.6.2 Level of Equipment Transport Knowledge

The data in Table 4.2 reflect the same knowledge areas as Table 4.1, but here the respondents were asked to assess *their own* level of knowledge in the various areas. The level of knowledge is lower in all areas than the degree of importance reported for that knowledge. As with Table 4.1, the top half of Table 4.2 indicates the highest levels of knowledge correspond to equipment transport practices – respondents seem to know most about what is important to them. However, only the top two items – knowledge of tie-down systems and knowledge of load securement and tie-down practices – exactly correspond to their importance ranking.

Table 4.2 Degree of Importance of Equipment Transport Knowledge

Item	Please indicate the *degree of importance* you place on each of the following areas of equipment transport knowledge.	n respondents (Note 1)	Degree of Importance, Percent (Note 2)						Average (Note 3)	Standard Deviation
			Not at All Important					Very Important		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
4.e	Tie-down systems (chains & boomers)	575	0	0	0	1	3	15	81	6.76	0.57
4.h	Load securement and tie-down practices	575	0	0	0	1	4	15	81	6.75	0.55
4.j	Equipment transport safety practices	574	0	0	0	1	4	15	79	6.73	0.60
4.g	Equipment loading/ unloading practices	573	0	0	0	1	3	17	78	6.72	0.60
4.i	Towing/ hauling practices	574	0	0	0	1	4	18	76	6.69	0.65
4.f	Trailer load limits/ size restrictions	574	0	0	0	2	5	15	78	6.68	0.67
4.k	Equipment transport daily preventive maintenance practices	572	0	0	0	2	6	18	74	6.65	0.67
4.d	Trailer hitch system	578	0	1	1	2	6	16	74	6.61	0.80
4.b	TxDOT equipment transport policy	579	0	0	0	2	8	16	73	6.60	0.75
4.a	State/ federal law	580	0	0	1	3	8	13	76	6.59	0.84
4.c	Equipment manuals (manufacturer-provided)	574	1	0	1	6	11	20	61	6.30	1.09

Note 1. "n" refers to the number of respondents for each question out of a total of 586 surveys returned.
Note 2. Percentages are based the number of respondents for each question. Values may not total 100 due to rounding.
Note 3. Average calculated based on a 1 to 7 weighting scale; anchors: 1-not at all important, 7-very important.

Table 4.3 Respondent Level of Equipment Transport Knowledge

Item	Please indicate *your own level of knowledge* on each of the following areas of equipment transport knowledge.	n respondents (Note 1)	Level of Knowledge, Percent (Note 2)							Average (Note 3)	Standard Deviation
			Not at All Knowledgeable						Very Knowledgeable		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
4.e	Tie-down systems (chains & boomers)	526	0	0	1	6	14	32	46	6.13	1.05
4.h	Load securement and tie-down practices	527	1	1	2	4	16	33	44	6.10	1.07
4.k	Equipment transport daily preventive maintenance practices	529	0	1	1	4	18	33	42	6.08	1.03
4.g	Equipment loading/ unloading practices	529	0	1	2	6	14	35	43	6.07	1.08
4.j	Equipment transport safety practices	526	0	1	1	6	19	35	37	5.98	1.06
4.i	Towing/ hauling practices	526	1	1	2	6	18	37	36	5.96	1.08
4.b	TxDOT equipment transport policy	528	1	1	3	7	19	35	35	5.89	1.14
4.d	Trailer hitch system	524	1	1	2	9	17	33	36	5.86	1.19
4.f	Trailer load limits/ size restrictions	530	1	1	3	10	21	33	31	5.70	1.27
4.c	Equipment manuals (manufacturer-provided)	526	3	2	4	16	26	25	25	5.35	1.43
4.a	State/ federal law	526	1	2	6	22	32	23	14	5.10	1.24

Note 1. "n" refers to the number of respondents for each question out of a total of 586 surveys returned.
Note 2. Percentages are based the number of respondents for each question. Values may not total 100 due to rounding.
Note 3. Average calculated based on a 1 to 7 weighting scale; anchors: 1-not at all knowledgeable, 7-very knowledgeable.

Table 4.4 Knowledge of Load Distribution Concepts and Practices

Item	Equipment Load & Tie-Down Information	n respondents (Note 1)	Intensity of Agreement, Percent (Note 2)							Average (Note 3)	Standard Deviation
			Strongly Disagree						Strongly Agree		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
6.	Each equipment trailer in my District/Section is clearly marked for load transfer (green line).	578	4	2	3	7	10	20	55	5.95	1.59
10.	The TxDOT system of lining up the green lines on trailers and equipment for proper load transfer makes sense to me.	578	4	2	4	6	10	23	52	5.90	1.60
8.	The center-of-gravity (green line) location is clearly marked on each piece of equipment I haul.	574	5	3	9	11	14	18	41	5.43	1.77
12.	The green line on our equipment trailers is correctly marked for proper load transfer.	577	5	2	6	12	16	23	35	5.42	1.67
11.	The TxDOT system of lining up the green lines on trailers and equipment for proper load transfer works almost all of the time.	576	4	4	5	11	17	27	31	5.38	1.65
9.	The trailer payload capacity is clearly marked on each trailer I use.	571	8	5	8	13	15	18	34	5.10	1.91
7.	The gross weight is clearly marked on each piece of equipment I haul.	575	9	7	7	13	12	18	35	5.06	1.99
5.	Written load & tie-down information is readily available for the equipment I haul.	568	6	5	10	21	22	17	18	4.72	1.71
13.	When new equipment is delivered, the equipment vendor provides instruction on how to safely/legally load and tie-down the equipment.	569	14	10	10	17	16	14	19	4.27	2.03

Note 1. "n" refers to the number of respondents for each question out of a total of 586 surveys returned.
Note 2. Percentages are based the number of respondents for each question. Values may not total 100 due to rounding.
Note 3. Average calculated based on a 1 to 7 weighting scale; anchors: 1-strongly disagree, 7-strongly agree.

Table 4.5 Equipment Transport Practices and Procedures

Item	Procedures	n respondents (Note 1)	Intensity of Agreement, Percent (Note 2)							Average (Note 3)	Standard Deviation
			Strongly Disagree						Strongly Agree		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
19.	I know how to do a daily preventive maintenance check on the trailers I use.	572	1	1	1	2	6	23	66	6.47	0.98
21.	I almost always do a daily preventive maintenance check on the trailer	567	4	2	2	3	9	20	60	6.15	1.48
18.	I know which trailers to use for each piece of equipment.	572	2	1	2	7	7	28	54	6.14	1.30
20.	I can almost always tell when the tie-down points (D-rings) on a trailer are damaged to the point that the trailer should be placed out-of-service.	575	3	2	3	8	11	24	50	5.92	1.49
23.	The way TxDOT transports their heavy equipment is a good system.	577	4	1	5	10	14	29	36	5.60	1.57
15.	When I load equipment, I almost always check to make sure that the weight of the equipment is less than the payload capacity of the trailer I haul it on.	570	5	3	7	12	14	23	35	5.37	1.74
22.	I have been told not to haul certain equipment on certain trailers, even though it will fit.	567	9	5	5	11	10	22	39	5.28	1.96
16.	I almost always haul other loads, materials or supplies on the same trailer I use to transport off-road equipment.	567	15	8	6	11	13	22	25	4.68	2.13
17.	I do not haul material in the dump bed of the truck at the same time that I am towing a trailer loaded with off-road equipment.	559	19	11	11	15	10	13	21	4.08	2.18
24.	The fact that TxDOT uses many different types of trailers to haul equipment is not a concern to me.	577	27	8	9	10	12	16	19	3.93	2.29
25.	TxDOT cannot safely transport all of its off-road equipment with its current fleet of trucks/ trailers.	572	28	12	8	11	8	11	22	3.83	2.35
14.	It is OK to haul a piece of equipment if I can load it on a trailer.	577	51	14	9	10	6	4	7	2.44	1.90

Note 1. "n" refers to the number of respondents for each question out of a total of 586 surveys returned.
Note 2. Percentages are based the number of respondents for each question. Values may not total 100 due to rounding.
Note 3. Average calculated based on a 1 to 7 weighting scale; anchors: 1-strongly disagree, 7-strongly agree.

Table 4.6 Knowledge of Trailer Hitches and Hitching Systems

Item	Trailer Hitches	n respondents (Note 1)	Intensity of Agreement, Percent (Note 2)							Average (Note 3)	Standard Deviation
			Strongly Disagree						Strongly Agree		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
30.	I know how to safely use the trailer hitch systems on the trucks and trailers I work with.	572	1	0	1	2	8	33	55	6.35	0.95
31.	I know how to do daily preventive maintenance for the trailer hitch systems I use.	574	1	1	1	4	11	28	55	6.24	1.11
28.	The hitching systems on TxDOT trucks and trailers are safe.	577	1	1	2	10	16	33	37	5.88	1.19
26.	The swivel pintle hitch works well for what TxDOT does.	574	7	3	3	11	14	22	41	5.50	1.78
29.	The hitching systems on TxDOT trucks and trailers are adequately maintained.	580	2	3	6	14	17	28	30	5.43	1.52
32.	I know the safe rated weight capacity of the hitches I use to pull equipment trailers.	574	6	5	8	14	21	20	26	5.00	1.78
27.	The fixed pintle hitch works well for what TxDOT does.	560	12	6	8	16	13	16	29	4.75	2.05

Note 1. "n" refers to the number of respondents for each question out of a total of 586 surveys returned.
Note 2. Percentages are based the number of respondents for each question. Values may not total 100 due to rounding.
Note 3. Average calculated based on a 1 to 7 weighting scale; anchors: 1-strongly disagree, 7-strongly agree.

Table 4.7 Knowledge of Chains and Tie-down Systems

Item	Chains & Tie-downs	n respondents (Note 1)	Intensity of Agreement, Percent (Note 2)							Average (Note 3)	Standard Deviation
			Strongly Disagree						Strongly Agree		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
34.	I know how many chains & boomers to use for tying down heavy-duty off-road equipment.	577	1	1	2	5	13	24	53	6.13	1.24
35.	I almost always can tell when a chain is damaged to the point that it should be put out of service.	577	2	2	2	7	11	29	47	6.00	1.35
36.	I almost always know the proper tie-down points for the equipment I haul.	572	3	2	2	6	18	29	40	5.82	1.39
38.	I can almost always tell when a boomer is damaged to the point that it should be put out of service.	575	3	2	4	10	13	27	42	5.77	1.50
39.	The epuipment trailers I use have a sufficient number of properly-placed tie-down points (D-rings).	573	5	5	5	9	14	24	38	5.48	1.75
33.	I can identify the proper grade of chain for tying down equipment.	576	3	4	6	13	18	23	34	5.43	1.61
37.	According to TxDOT policy, it is OK to use pull-over type boomers to tie down equipment.	571	75	9	3	5	1	2	5	1.72	1.57

Note 1. "n" refers to the number of respondents for each question out of a total of 586 surveys returned.
Note 2. Percentages are based the number of respondents for each question. Values may not total 100 due to rounding.
Note 3. Average calculated based on a 1 to 7 weighting scale; anchors: 1-strongly disagree, 7-strongly agree.

Table 4.8 Equipment Transport Training

Item	Equipment Transport Training	n respondents (Note 1)	Intensity of Agreement, Percent (Note 2)							Average (Note 3)	Standard Deviation
			Strongly Disagree						Strongly Agree		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
44.	Equipment vendors should explicitly cover how to properly load and transport equipment when it is delivered to TxDOT.	570	2	1	1	6	9	22	59	6.21	1.26
45.	I have the skills necessary to properly transport off-road equipment.	567	1	1	2	6	16	27	47	6.04	1.23
42.	The key to improving TxDOT's equipment transport practices is better quality training.	573	1	1	3	8	11	25	50	6.02	1.33
46.	Equipment transport skills are best learned by hands-on instruction.	572	3	2	3	6	13	25	48	5.93	1.44
47.	TxDOT should have an equipment transport annual refresher training course.	571	4	3	5	11	15	20	42	5.59	1.65
41.	Before I was trusted with hauling off-road equipment, my supervisor made sure I had sufficient training in how to do it properly.	558	7	9	6	12	13	20	33	5.09	1.94
43.	The TEEX equipment load & tie-down course does not cover all the equipment transport topics I need to know.	538	11	10	12	21	17	16	14	4.26	1.87
40.	For TxDOT drivers who transport equipment, the minimum job qualifications are not adequate.	563	12	11	10	21	19	13	14	4.18	1.88

Note 1. "n" refers to the number of respondents for each question out of a total of 586 surveys returned.
Note 2. Percentages are based the number of respondents for each question. Values may not total 100 due to rounding.
Note 3. Average calculated based on a 1 to 7 weighting scale; anchors: 1-strongly disagree, 7-strongly agree.

Table 4.9 Equipment Transport Safety Considerations

Item	Safe Operation	n respondents (Note 1)	Intensity of Agreement, Percent (Note 2)							Average (Note 3)	Standard Deviation
			Strongly Disagree						Strongly Agree		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
48.	It is my responsibility, as the person who loads the trailer and drives the truck, to make sure that heavy-duty, off-road equipment is safely transported.	561	1	0	1	1	2	13	83	6.75	0.71
51.	I follow the safe practices for transporting off-road equipment.	564	0	0	1	3	12	33	51	6.28	0.94
54.	I feel comfortable talking with my supervisor about any questions I may have regarding safe equipment transport practices.	566	3	2	2	4	8	23	59	6.17	1.38
50.	I know the safe practices for transporting off-road equipment.	568	1	1	1	5	17	33	43	6.10	1.05
53.	When I see unsafe equipment transport practices, I know what to do about it.	569	1	1	2	8	14	34	40	5.98	1.15
57.	My immediate supervisor takes appropriate action when I bring an equipment transport safety issue to his/ her attention.	561	3	2	3	8	10	25	49	5.92	1.48
52.	I can almost always recognize unsafe equipment transport practices.	570	1	1	2	6	19	34	37	5.91	1.17
58.	I know when an over-height load is not stable.	564	1	2	3	9	16	28	41	5.86	1.34
49.	Equipment in my District/ Section is always transported safely.	571	2	1	5	12	23	23	34	5.60	1.40
56.	Our District uses equipment transport accident/ incident reports to improve our safety practices.	568	5	2	4	14	15	25	35	5.47	1.65
55.	Adequate information exists on each trailer and piece of equipment so that I know which combinations are safe to haul.	565	6	5	8	17	19	25	21	4.97	1.70

Note 1. "n" refers to the number of respondents for each question out of a total of 586 surveys returned.
Note 2. Percentages are based the number of respondents for each question. Values may not total 100 due to rounding.
Note 3. Average calculated based on a 1 to 7 weighting scale; anchors: 1-strongly disagree, 7-strongly agree.

Table 4.10 Compliance with Equipment Transport Laws and Regulations

Item	Compliance with Law	n respondents (Note 1)	Intensity of Agreement, Percent (Note 2)							Average (Note 3)	Standard Deviation
			Strongly Disagree						Strongly Agree		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
63.	The truck/ trailer combinations used to transport off-road equipment in my District/ Section are almost always within the legal weight limits.	566	3	2	3	11	18	32	31	5.58	1.45
61.	I know what the regulatory limits are for the roads/ bridges where I haul equipment.	558	4	4	9	15	20	23	24	5.06	1.68
65.	As a general rule, off-road equipment of the same type is getting larger/ heavier over time.	564	7	4	7	19	16	21	27	5.05	1.78
59.	It is easy for me to tell if the equipment loads I haul comply with the Texas bridge law weight limits.	561	6	7	8	15	21	19	24	4.92	1.79
62.	The trucks used to transport equipment are sometimes loaded beyond their weight capacities.	565	25	14	10	15	13	11	12	3.58	2.10
60.	The trailers used to transport off-road equipment are often loaded beyond their payload capacities.	566	29	20	11	15	9	8	7	3.07	1.94
64.	Heavy-duty off-road equipment in my District/ Section is often transported illegally.	568	48	22	8	8	5	4	5	2.32	1.77

Note 1. "n" refers to the number of respondents for each question out of a total of 586 surveys returned.
Note 2. Percentages are based the number of respondents for each question. Values may not total 100 due to rounding.
Note 3. Average calculated based on a 1 to 7 weighting scale; anchors: 1-strongly disagree, 7-strongly agree.

Interestingly enough, respondents claim to know more about daily preventive maintenance practices than they think is necessary. Also, they claim to know less about trailer load limits and size restrictions than they need to – suggesting a fertile area for training. Consistent with the level of importance accorded to paperwork, knowledge of equipment manuals and state/federal law is low.

4.2.6.3 Knowledge of Load Distribution Concepts and Practices

Table 4.3 discusses knowledge of load distribution concepts and practices. First, we observe that average values are in the 5 to 4 range, or about one increment lower than for the previous tables. This suggests room for improvement relative to knowledge about load distribution and related concepts.

Respondents claim to know most about the green line markings on trailers, the green line concept for load distribution, and green line markings for equipment. This suggests that TxDOT personnel know that their system for achieving proper load distribution has to do with the "green line." However, the data cast some doubt about how well the green line system is working. Respondents suggest that in more than a few cases, the green lines are not correctly marked on trailers and thus the system does not always work. Further, respondents indicate a dearth of information about trailer payload capacity, gross equipment weight, and written load and tie-down information. These tangible expressions of proper load distribution rank lowest in this group.

4.2.6.4 Equipment Transport Practices and Procedures

Table 4.4 discusses general practices and procedures associated with equipment transport. Consistent with Tables 4.1 and 4.2, respondents indicate a strong grasp of preventive maintenance aspects of the equipment transport task. Respondents also indicate a high comfort level when it comes to knowing which trailer to use to haul equipment, and they claim to be able to identify when trailer tie-down points are damaged to the point that they should be taken out of service.

Overall, respondents generally feel that the way TxDOT hauls equipment is a good system, although some equivocation exists on this point.

Respondents do not always check to make sure that the weight of the equipment they load is less than the payload capacity of the trailer they haul it on. This might be because the payload capacity is not marked, or the weight of equipment is not marked, or these are not correct, or any combination of the above. However, respondents claim that, as a rule, they have been directed to consider the payload capacity of the trailer when they load equipment, and not just "haul it because they can load it."

Item 16, having to do with whether TxDOT personnel haul additional materials on the trailers when they transport equipment, yields unreliable results. Some respondents interpreted this question the way we intended, that is, as asking whether they haul additional material on the trailer when they transport equipment. For example, some maintenance personnel will transport a backhoe and for the same trip haul some bridge rail, posts, concrete, etc. on the trailer. However, other respondents interpreted this question as asking whether they use their trailers for multiple purposes; that is, for transporting equipment, or for hauling bridge rail, or for hauling posts, or cement, etc., but not at the same time. The vagueness of the item renders responses to this question as unreliable.

It appears that respondents are rather evenly distributed in their practice about hauling material in the dump bed of the trucks when they are towing equipment. Some always do, some never do, and most do something in between.

The fact that TxDOT uses many different types of trailers to haul their equipment is a concern to half of the respondents. Similarly, about half of the respondents feel that TxDOT cannot safely transport its off-road equipment with the current fleet of trucks and trailers.

4.2.6.5 Trailer Hitches and Hitching Systems

Table 4.5 discusses TxDOT's trailer hitches and hitching systems. Average values are in the 6 to 5 range, so knowledge about hitches can be considered relatively high. In particular, respondents claim that they know how to safely use the hitches and they know how to do preventive maintenance on these systems. Most feel that TxDOT's hitching systems are safe, and respondents express a significant preference for the swivel pintle hitch over the fixed pintle hitch. For the most part, respondents believe that the hitching systems are adequately maintained. Interestingly enough, respondents do not necessarily know the safe rated weight capacity of the hitches even though they generally believe they are safe and work well. Apparently, hitches are one component of the equipment transport system that maintenance personnel do not have concerns about.

4.2.6.6 Load Securement, Chains and Tie-downs

Load securement, chains, and tie-down systems are the topic of Table 4.6. Average values are in the 6 to 5 range, so knowledge about load securement, chains and tie-downs can be considered relatively high. Respondents claim that they know how many chains and binders to use for tying down heavy-duty, off-road equipment. This is a critical knowledge area, and it is significant to note that during the course of our research, TxDOT policy on this issue changed to align with the new cargo securement regulations. Prior to the new regulations, TxDOT guidance was relatively simple –four chains were used for most pieces of equipment. But the new regulations introduced significant complexity on this point, and it would not be safe to assume that all maintenance employees immediately grasped the new requirements. Respondents are confident in their ability to recognize when chains and binders (boomers) are damaged to the point that they must be placed out of service.

Most respondents claim to know the proper tie-down points for the equipment they haul. But this item is an issue where "most" may not be good enough. The reason is that when a maintenance technician does not know the proper tie-down points, this is tantamount to claiming that they do not know how to properly tie down – and transport – that piece of equipment. A little ambiguity would be sufficient to effectively shut down operations, or at a minimum, create ill feelings about the job, and possibly an unsafe or non-compliant transport situation. Looking at the data, 87 percent of respondents claim they almost always know the proper tie-down points. But 7 percent claim they do not know the tie-down points. The failure might be due to employee knowledge, but just as likely (if not more likely) has to do with uncertainty about the equipment itself. That is, the equipment might not have clearly-designated tie-down points. On the view that TxDOT operates some 4,000 pieces of equipment, seven percent "off" suggests that almost 300 pieces of equipment do not have adequate tie-down points, and this is not a small problem. Similar comments apply to the trailers not having adequate D-rings, only for D-rings on trailers, the problem is more severe.

Respondents acknowledge some ambiguity about being able to identify the proper grade of chain. In the era before the new cargo securement regulations (when this survey was administered), this would not have been much of an issue. However, the new cargo securement regulations specify that tie-down sets achieve a certain minimum working load limit, and this requires maintenance personnel to know the load rating for both the chains and binders.

Finally, most respondents (correctly) indicated that the use of pull-over type binders is not in accordance with TxDOT policy. TxDOT only allows the use of ratchet binders.

4.2.6.7 Equipment Transport Training

The items in Table 4.7 were designed to characterize the scope and adequacy of TxDOT's equipment transport training activities. Respondents strongly agreed that vendors ought to explicitly show how to load and tie down the new equipment they sell to TxDOT. However, per Item 13 (Table 4.3), this infrequently happens.

Respondents claim they have the skills to properly transport off-road equipment, but they also point out that better quality training is the key to improving TxDOT's equipment transport practices. "*Good to great*" comes to mind.

When it comes to equipment transport training, respondents feel hands-on instruction is the most effective method. They also feel annual refresher training would be a good idea. Most claim they were sufficiently trained before they were entrusted with transporting equipment, but a significant number (20 percent) did not feel adequately trained. Apparently, room for improvement exists in the training area.

The existing Equipment Load and Tie-down course provided by the Texas Engineering Extension Service (TEEX) got mixed reviews, with the balance of opinion being that the course does not adequately cover the equipment transport topics. Respondents expressed similar ambiguity about TxDOT's minimum job qualifications for equipment transport.

4.2.6.8 Equipment Transport Safety Considerations

Table 4.8 has to do with respondent opinions about equipment transport safety. Average values are in the 6 to 5 range, so overall knowledge about equipment transport safety can be considered relatively high.

First and foremost, respondents clearly understand that as the person who loads the trailer and drives the truck, they are responsible to make sure that equipment transport is done safely. Respondents claim they follow safe practices, and they talk with their supervisor when they are not sure about a safety issue. Knowledge about safe equipment transport practices is high, and if the respondent sees an unsafe practice, he/she knows what to do about it. In such cases, the supervisor will take appropriate action.

Respondents claim to have a good feel for recognizing unsafe practices or conditions. They also indicate that accident/incident reports are effectively used to improve safety. However, respondents express some ambiguity about the information provided to them so they can confirm that trailer and load combinations are safe to haul.

Arguably the survey responses on safety are very good, but the question remains: "Can you have too much safety?" Survey results suggest that as good as things are, opportunity exists to improve TxDOT's safety culture relative to equipment transport. Continual vigilance is always the key. A place to start would be to provide adequate information so that persons responsible for transporting equipment can know that the load-trailer-truck combinations are safe.

4.2.6.9 Equipment Transport Laws and Regulations

Table 4.9 has to do with respondent opinions about equipment transport laws and regulations. Whereas the previous table dealt with safety, this table covers the legal aspects of equipment transport at TxDOT. Average values are in the 5 to 4 range, so overall knowledge about equipment transport laws and regulations is a full increment lower than safety knowledge.

Respondents indicate that the truck/trailer combinations they use are mostly within legal weight limits. However, seven percent claim they are not legal. This gives rise to the question, is "most" good enough? Further, respondents show some ambiguity about regulatory limits and bridge law weight limits. Again, most claim they know what to do, but a significant group – 17 to 21 percent – is not sure.

The general belief is that off-road equipment is getting larger and heavier over time, and this is in fact correct as discussed in Section 3.5 of this report. Consistent with this view, about one out of three respondents (36 percent) feels trucks are *sometimes* overloaded. One out of four respondents (24 percent) feels trailers are *often* overloaded. And ultimately, about one out of seven respondents surveyed (14 percent) believes equipment is often transported illegally.

One the one hand, it should be remembered that all DOTs including TxDOT are, as a general rule, *exempt* from federal regulations. We discussed this in Section 3.6.3 of this report relative to the new cargo securement regulations. On the other hand, TxDOT typically seeks to comply with these types of regulations simply because this promotes safety, it demonstrates a commitment by TxDOT to working diligently on behalf of the citizens of Texas, and it helps TxDOT manage its liability exposure in case of an accident. The point is that inasmuch as TxDOT seeks voluntary compliance with laws and regulations, substantial opportunity for improvement exists in the equipment transport realm.

4.2.6.10 The Key to Improving Equipment Transport at TxDOT

The final item on the survey, Item 66, asked respondents to identify "the one thing" they would do to improve equipment transport at TxDOT. We received some 359 responses to this question which we sorted and analyzed into the following categories: training (42 percent), trailers (26 percent), trucks (8 percent) and 11 other categories comprising the remaining 24 percent of the responses.

By *far*, the one thing that respondents stated would most improve equipment transport in TxDOT was training. They want *more* training, *better* training, and *refresher* training. This is a key finding of this survey. Second to training, respondents stated that they needed newer, better trailers. In particular, they want more low-boy type trailers and they would like to do away with the tilt-deck trailers. Better trucks comprise the third category. Here respondents want more horsepower and they do not want to pull tag-a-long trailers with the 6CY dump trucks.

The "other" responses included comments such as the need for better load distribution information, more D-rings and tie-down points, personnel issues, purchasing issues, better preventive maintenance, better chains/binders, compliance with policy, use of a spotter, and a few miscellaneous observations. Some offered practical wisdom along the lines of "take your time" and "be safe." A few could only comment that there was no need for improvement: TxDOT does a good job with equipment transport.

4.2.7 Summary

The Equipment Transport Knowledge Questionnaire shows that much is good within TxDOT relative to equipment transport. Employees ascribe importance to all aspects of the equipment transport process, and their overall knowledge of equipment transport is high. In particular, knowledge and capabilities relative to equipment transport practices and procedures, trailer hitches and hitching systems, load securement, chains and tie-downs, and equipment transport safety is very strong. However, equipment transport knowledge and capabilities in other areas are not as strong. These include load distribution concepts and practices, training, and compliance with laws and regulations.

Opportunity for improvement exists in all areas, and one challenge to effecting change in this type of system is to identify specific goals for the different knowledge domains. In some cases – for example, safety – "good" is not good enough. In others – such as training – it is possible to readily distinguish areas for improvement. The findings summarized herein can guide implementation efforts toward quality improvement of equipment transport at TxDOT.

4.3 Load, Trailer and Truck Combinations Survey

The Load, Trailer and Truck Combinations Survey was an online "survey" administered to TxDOT Maintenance Section Supervisors during March 2005. The goal was to identify the load-trailer-truck combinations used in the districts and to analyze those combinations relative to equipment transport practices and procedures.

Survey responses were based on a February 5, 2005, data dump from TxDOT's Equipment Operating System inventory of trucks, trailers, and off-road equipment for selected class codes. Maintenance Section Supervisors representing all 25 TxDOT Districts and from 220 of the 324 Maintenance Sections surveyed responded to this survey, for a 68 percent response rate.

We reported the findings of this survey as Product P1, Part 1, and we direct the reader to the product report [1] for the results.

4.4 Equipment Inventory and Procurement Survey

The Equipment Inventory and Procurement Survey was an online "survey" administered to TxDOT Equipment Administrators during the period May 2005 through July 2005. The goals of this survey were to (a) obtain an inventory of existing heavy-duty off-road equipment projected to remain in the TxDOT fleet for the next five years, and (b) obtain a listing of *new* heavy-duty off-road equipment that TxDOT District Equipment Administrators predict will be needed by TxDOT in the next five years.

Survey responses were based on a February 5, 2005, data dump from TxDOT's Equipment Operating System inventory of trucks, trailers, and off-road equipment for selected class codes. Equipment administrators from 22 of the 25 TxDOT Districts responded to this survey, for an 88 percent response rate.

We reported the findings of this survey as Product P1, Part 2 and as Product P2, and we direct the reader to these product reports [2] [3] for the results.

CHAPTER 5

INTERVIEWS/ DISTRICT SITE VISITS

5.1 Overview

We conducted structured interviews of TxDOT personnel at both the Division and District levels in order to deepen our understanding and knowledge about equipment transport issues. Interviewees included the following:

Division Level:
- Fleet Management Personnel
- Purchasing Personnel

District Level
- Maintenance Section Personnel in 12 Districts

One of our goals in conducting these interviews was to identify and understand the different perspectives in the agency on equipment transport issues. Another key goal in conducting these interviews was to capture the wealth of institutional knowledge resident within the agency at both the Division and District levels. As noted in Chapter 2, all field data including the detailed interview records are archived in our files and selected items are included in a Data CD (see Section 2.3 of this report). The following sections summarize our findings.

5.2 Fleet Management Interviews

5.2.1 Overview

The Fleet Management interviews were conducted to obtain the unique perspective and recommendations of Fleet Management personnel relative to equipment transport issues. Prior to the interview, we provided a 44-item interview questionnaire which addressed the following topics:

- About Your Job…
- Training Considerations…
- Technical Questions About Equipment Transport Information…
- Technical Questions About Hitching and Connection Systems…
- Technical Questions About Tie-Down Systems…
- Technical Questions About Equipment Center-Of-Gravity & Load…
- Your Opinion Concerning Equipment Transport Legality & Safety…
- Closing Questions…

We conducted these interviews in February 2004. The following Fleet Management personnel participated in our interviews:

- Harry B. “Sandy” Sanders, Field Service Representative
- Curtis W. Reinert, Alternative Fuels Analyst

- Jerry A. Figures, Field Service Representative
- Frank Nieto, Alternative Fuels Analyst

5.2.2 Findings

The following briefly summarizes selected responses to questions posed within the context of the identified interview topics. Rather than present an exhaustive record of the interviews, we have streamlined this summary to only include responses that directly bear on the research objectives.

- Incident Reports Rarely Impact Policy: Fleet Management is notified about accidents/incidents involving equipment. In cases where an incident is attributed to equipment transport policy or procedure, Fleet Management is responsible for drafting recommendations and initiating any necessary changes to current policy/procedure and routing it through the TxDOT approval process. However, the view is that this process does not work well. Equipment transport policies and procedures are rarely changed as a result of findings from incident investigations.

- One Trailer Does *Not* Fit All: The tendency exists to try to purchase equipment so that "one size fits all" but this does not work. An example of this approach is where a certain district elected to get rid of all of its tag-a-long trailers and replace them with a truck-tractor low-boy haul trailer combination in each maintenance section. The challenge lies in the fact that this haul truck-trailer combination requires more full-time employees to man and transport all of the required equipment, coupled with the reality that TxDOT is trying to reduce its maintenance workforce. Given the current workforce trends, the typical option of using dump trucks with tag-a-long trailers might still be the most viable solution. Dump trucks are more versatile and require less manpower.

- Prison Trailers Are a Problem: TxDOT should buy trailers that are already commercially available. Problems exist with the Texas Correctional Industries (TCI) trailers, partly because TCI has no competition, and as a result, they have no motivation to get involved in trailer design and refinements. In particular, welding can be a concern at times as there is only one certified welder at the prison manufacturing facility. There appears to be no quality control to ensure that all work is done and meets specification or industry standards.

- The TEEX Equipment Load & Tie-Down Course is not of Consistent Quality: Fleet Management has been instrumental in the development of the "Load Distribution & Equipment Tiedown" manual for TEEX. However, the TEEX training is not adequate. Part of the weakness can be attributed to the instructors, and part to the districts. The Districts need to work with the trainers to provide appropriate equipment that is in good condition. Also, there needs to be better communication between TEEX and Fleet Management.

- Employees Are Not Always Adequately Trained: Maintenance employees are required to have a Commercial Driver's License. They should also have attended the TEEX course or have been trained on-the-job by an experienced driver. It is mandatory to have the proper license, but often drivers are assigned equipment transport duties without the proper training. Proper training should involve matching the truck and trailer to the equipment being transported, proper loading of all equipment, knowing the proper way and TxDOT policy on tie down of equipment, how to tie it down, where to tie it down,

what anchor points to use on the trailer and equipment, how to compute the number of tie down sets required, etc. Employees also need to be made aware of the handling changes when the truck is connected to a loaded trailer, in particular the handling effect from the equipment weight, height and width while making turns, going around curves, up and down a hill, etc.

- Equipment Transport Policy is Not Readily Available in the Field: Several TxDOT manuals are published on-line, but not all drivers have access to a PC. Hard copies of the current *Equipment Manual*, *Preventive Maintenance Manual*, and TEEX *Load and Tie Down* handout exist, but District equipment shops do not necessarily make these or other manuals available to maintenance section employees, nor do they keep them in the equipment. Thus, the maintenance section personnel responsible for the transport of equipment do not have *convenient* access to *user-friendly* manuals.

- Pintle Hitches are Not Always Adequately Maintained: The primary hitching system in TxDOT is the pintle hook system – either a swivel or fixed type. The swivel hitch is constantly overlooked in preventive maintenance and is therefore the most written-up item on TxDOT's PM checklist. The fixed pintle would be a better choice, because where TxDOT operates is not really off-road, so the swivel in not necessary.

- Center of Gravity Markings Do Not Exist on Loads: Equipment manufacturers are required by TxDOT purchasing specifications to mark the horizontal center of gravity on all equipment (loads). However, these markings do not always exist, and in some cases, they are not correctly located.

- Load Distribution Markings on Trailers are Incorrectly Located: TxDOT policy requires load distribution markings on trailers, however, the policy is not always executed. Fleet Management members have concerns regarding standardization in the method used to determine the "balance point" and load distribution point of a trailer. This is especially a concern regarding trailers manufactured by TCI. Even more fundamentally, it is not possible to have "one line fits all" for all trailer-load combinations on a given trailer. For a number of reasons, one mark does not transfer 17% on all equipment, and this has been proved in the field.

- Trailers are Sometimes Overloaded: Trailers are being overloaded some of the time (10 percent to 20 percent), not because of the trailer capacity, but because equipment is not positioned on the trailer to allow proper load distribution and load weight transfer.

- 6CY Trucks Should Not Be Used to Pull Heavy Equipment: Any procedure that allows an operator to haul a trailer loaded with equipment behind a six yard dump truck is a safety concern.

- The *One Thing* that would Most Improve Equipment Transport at TxDOT: (a) impress on the Maintenance Section Supervisors that their job is not to fix roads – that is their MISSION – their job is to manage their people, equipment, and resources, (b) provide proper training to drivers of on and off-road equipment and supervisor accountability when something goes wrong, (c) give the District Equipment Administrator authority to shut a job down when policy is not followed, and (d) training, refresher training, and documentation of that training.

5.3 Purchasing Interviews

5.3.1 Overview

The Purchasing interviews were conducted to obtain the unique perspective and recommendations of Purchasing personnel relative to equipment transport issues. Prior to the interview, we provided a 14-item interview questionnaire which addressed the following topics:

- About The Purchasing Process…
- Equipment Transport Issues and Purchase Specifications…
- Purchaser Training/ Knowledge About Equipment Transport Issues…
- How Can This Research Help You As A Purchaser?

We conducted these interviews in January 2004. The following Purchasing personnel participated in our interviews:

- Sandra Radosavljevic, CPPO, CTPM – Purchasing Supervisor
- Legay Imler, CPPB, CTP – Purchaser
- Johnie Muller, CTPM, CPPB – Purchaser
- Glenn Hagler, CPPO, CTPM – Purchasing Manager

5.3.2 Findings

The following sections summarize responses to questions posed within the context of the identified interview topics. Rather than present an exhaustive record of the interviews, we have only included responses that directly bear on the research objectives.

5.3.2.1 User Requests/Master User Requests

A request for a piece of major equipment is entered into the automated purchasing system in the form of a User Request. A User Request is typically developed from an existing Master User Request (MUR) which is associated with a TxDOT Standard Specification number. Standard specifications have been developed for most (95 percent) of the major equipment items being requested within TxDOT and are used whenever possible.

Included in the User Request is a complete description of the requested equipment with the selected options, TxDOT funding information, documentation of the need for the item requested, trade-in information (if applicable), an estimate of the anticipated cost, and a request for approval. The Purchasing group is now inserting questions, explanations, instructions and user prompts in the "Detail" section of the User Requests that requires the person inputting the request to *consider issues related to Equipment Transport*. Examples of this include:

- When making a request for a *trailer* that is involved in hauling major equipment, one must identify the make, model and description of the "heaviest/largest" equipment to be hauled on this trailer. Although it is not clear on the User Request forms, it appears that the weight and dimensions of the proposed equipment would be included in the blanks. If these details are

not provided in the User Request, a member of Purchasing or Fleet Managementwould be responsible for verifying compatibility during the approval process.

- When making a request for a piece of *heavy-duty maintenance equipment (load)* that would typically be transported on a trailer, Purchasing has included the weights associated with various equipment options and configurations. They have also provided information on a typical trailer that might be used to transport this particular piece of equipment within a District, including the "net carrying capacity" of the trailer, and have pointed out potential incompatibilities with the requested equipment (load). After these "cautionary" statements are made, the User Request prompts the requester to provide the make, model, and number of axles, and the net carrying capacity of the equipment trailer that would be used to haul the requested piece of equipment (load) in their respective District or Division. For example, blanks can be provided in the User Request Detail for the:
    - Base weight of the requested equipment
    - Total weight of all requested options
    - Total operating/haul weight including all options
    - Proposed haul trailer's net carrying capacity

The equipment transport aspect of the purchase specification development process could be improved by improving the Master User Requests. The objective is for Districts to deliberately consider if/how they can transport equipment being requested with their current fleet of trucks and trailers, and whether a new truck or trailer will be compatible with existing "sister" unit(s). Purchasing is in process of revising the existing MURs for trailers, and are adding more blanks to ensure they include equipment transport data. This will help prompt/remind Districts to provide the needed information at the time of request.

5.3.2.2 Trailer Specification Improvement

Fleet Management has been assigned a project to establish standards for trailed and towed equipment. Specifically, this consists of developing a section for the GSD manual to establish minimum requirements for trailed or towed equipment. Currently there is no consolidated, easy- to-access reference regarding what is required. Such a statement of policy would need to set forth the minimum requirements for trailed and towed equipment for both major and minor equipment, and for non-inventoried equipment; *e.g.*, safety chains, weight transfer, markings, etc. These requirements would need to apply regardless of the method of acquisition, purchased, transfer, donated, etc.

5.3.2.3 Better Communication for the Purchasing Process

Purchasing needs to know the *weight of the entire load* that a truck/trailer combo will need to transport, not simply the weight of one piece of equipment. For example, a District may request a trailer to transport a skid steer loader weighing 9,900 lbs. With 10 percent weight transfer to truck, the load would be 8,910 lbs., so we would normally buy a 10,000 lb. capacity trailer for that application. However, we then discover the District also intends to carry a planer attachment (1,500 lbs) and other supplies weighing an additional 1,100 lbs. With 10 percent weight transfer for the entire load, this District actually needs to transport is 11,250 lbs. Stated simply, Purchasing needs enough detailed information on the intended use, at time of request, to ensure the truck and trailer will safely and legally haul the maximum full load.

In addition, when requesting equipment that will be transported, Districts need to consider if they have an existing truck/trailer combo in the area where the unit will be assigned, to move it as needed. The size and weight of equipment continues to increase due to original equipment manufacturer design changes, so the ability to transport a new unit can and should be a critical factor in deciding what to request. More than one instance has occurred where a District has requested equipment and, upon delivery, realized they could not easily move from one job site to another. In several cases the District had to spend additional funds to purchase a truck and trailer to specifically accommodate the new equipment.

5.3.2.4 Equipment Manufacturer Limitations

TxDOT often encounters a challenge referred to as "product positioning" in the procurement of various classes of heavy duty construction equipment. This is because the construction equipment manufacturers, in an obvious effort to maximize their profits, produce very large, heavy, powerful, productive, and hence very expensive units that are directed toward the heavy construction industry. These manufacturers also place significant focus on the other end of the market, often supported by smaller contractors and home users. The problem that often arises is that a lot of TxDOT's needs for equipment fall somewhere in the middle. TxDOT needs equipment that is versatile; however, the extremes of the market are often looking for more specialized equipment. This situation creates problems related to lack of competition and availability of units at reasonable cost for certain classes of equipment.

5.3.2.5 Enhancements to the Purchasing Process

- Product Tabulation Sheet: Add requirement in the purchasing procedures to direct the purchaser(s) to include in the product tabulation sheet, the type of trailer the manufacturer recommends for hauling the unit of equipment where available and/or include the TxDOT trailer type that is required for hauling the unit. The product tabulation sheet is required when revising a specification or for developing a new specification.

- Standard Specification Folder: Add requirement in the purchasing procedures to direct the purchaser(s) to include in the information gained from the product tabulation sheet, in the standard specification folder. The standard specification folder is maintained/ retained on a permanent basis for reference, and is used by the purchaser when purchasing equipment.

- Master User Request (MUR): The MUR is used as an informational guide for districts when ordering equipment. MURs for trailers currently require the requestor to provide certain data elements that will allow the purchaser to validate the trailer is suitable for hauling the equipment identified in the MUR. Similar information could be developed for the heavy equipment MURs that would indicate the type of trailer required to accommodate the weight and size of the equipment.

5.3.2.6 Enhancements to the Fleet Management Process

- Help Desk Procedures – These procedures would be to assist the user in the field who may have questions/ complaints/ concerns and does not know who to approach for assistance. Draft procedures were developed to address this gap and are currently listed as Chapter 13 in the *Equipment Manual* (which is in draft status).

- Trailer selection guide/decision matrix – This type of matrix would be to assist the field user and/or manager in the selection of the proper tow vehicle/trailer combination. There is little in

the way of information available in this area. The guide could be used as a reference tool or a teaching aid to determine trailer to be used/tow vehicle and how to identify trailer towing problems that are exhibited when an unsuitable combination is selected or when improper loading is encountered.

5.4 District/Maintenance Section Interviews

5.4.1 Overview

At the District level, based on past TxDOT research experience in the maintenance area, we initially proposed to contact equipment transport knowledge experts in all 25 TxDOT Districts to set up site visits/interviews. However, based on input from the Project Monitoring Committee, we elected to change our approach in order to increase our exposure to operations personnel. That is, we elected to visit fewer districts but to spend more time in the maintenance sections in these districts. Ultimately, this procedure resulted in site visits at 12 districts and 37 maintenance sections (shaded in red, see Figure 5.1).

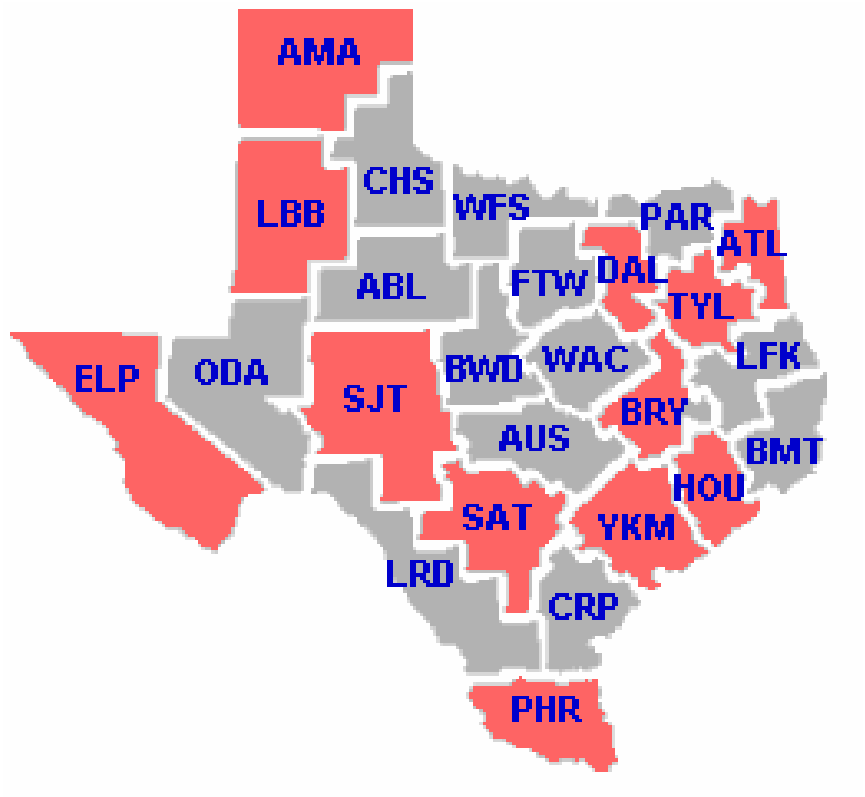

Figure 5.1 TxDOT Operational/Geographic Districts Visited as Part of the District Interviews (*Source:* TxDOT)

5.4.2 The Interview Questionnaire

Appendix B of this report presents our district site visit interview questionnaire. We developed a draft of this questionnaire and submitted it to our TxDOT Project Monitoring Committee for review and comment, and then finalized it for use in the research. We provided the questionnaire to District maintenance personnel at least one month in advance of our site visits, the idea being to help District personnel understand the type of information we wanted to talk about in the interview.

The final version of the questionnaire contains 33 questions with numerous sub-questions. This level of detail provided for a very fine-grained and structured conversation about equipment transport at the operations level. Ultimately, the interview questionnaire best served as advance notice to maintenance personnel about the topic for discussion, and as a guide for the conversation once we arrived on site. The three primary issues addressed in the questionnaire were:

- Equipment transport policy
- Equipment transport training
- Equipment transport practices and procedures

In sum, we felt we had accomplished our research objective if we left the district/maintenance section with an understanding of the level of familiarity personnel had with equipment transport policy, the extent to which they had received equipment transport training, and the types of practices and procedures personnel in that section used when transporting heavy-duty off-road construction and maintenance equipment.

5.4.3 District/Maintenance Section Site Visits

We made site visits to a total of 37 Maintenance Sections in 12 of TxDOT's operational/ geographic Districts. We scheduled the visits in February-March 2004, and made the site visits from April through August, 2004. The standard procedure for the site visits was as follows:

- Typically one or two members of the research team visited the respective TxDOT Districts to conduct the interview and observe equipment transport practices and procedures.
- The planned duration of the visit was two days at most Districts, the goal being to conduct interviews and field observations in two to four maintenance sections. The researchers documented equipment transport practices and procedures by means of notes, photographs, video, and audio recordings, as applicable.
- Each District convened appropriate representatives for the interview. We initiated contact through the District Equipment Administrator (DEA). In addition to the DEA, we specifically requested attendance at the interview by the Maintenance Supervisor, the Assistant Maintenance Supervisor, and one or two equipment operators. The interview typically took place at the Maintenance Section office but was arranged wherever it was most convenient and effective.
- In advance of our visit, we submitted the questions we intended to cover in the interview to the local District personnel. In this way, District personnel would be more prepared to discuss their own practices and procedures for addressing equipment transport issues. District personnel were encouraged to demonstrate any specialized equipment transport practices or procedures they use.

Table 5.1 summarizes the District demographics as they relate to our site visits and interviews. This table conveniently illustrates the site visit locations and the number of personnel who participated in our interview, along with their years of experience. It is significant to note that 258 TxDOT personnel with a combined total of 3,948 years of work experience participated in this research, offering us the benefit of their knowledge and expertise. The findings we gathered are theirs.

5.4.4 Synthesis of Findings from District/Maintenance Section Site Visits

5.4.4.1 Context for Recommendations

The goal of the District site visits was to obtain a shared understanding of District/ Maintenance Section perspectives on equipment transport during the interview, and then to physically observe and document illustrative examples of their practices and procedures in the field. This proved to be a very effective method for gathering information and yielded a large volume of data – hundreds of pages filling over two linear feet of shelf space for documentation. Of necessity, we are presenting a brief, highly-synthesized summary of findings from the site visits.

5.4.4.2 TxDOT's Equipment Transport System Works

One of the central findings to emerge from the site visits is that TxDOT's equipment transport practices, procedures and policy represent a functional system in which many things are being done well. For example, equipment transport knowledge among maintenance personnel is high, especially relative to practices. Preventive maintenance practices associated with equipment transport are strong. Safety awareness and practices associated with equipment transport are also strong. Further, we regularly encountered highly-talented, motivated, very competent people throughout the State as we discussed these issues. In sum, equipment transport is taken seriously at both the Division and District levels. Granted, equipment transport challenges exist, but it is important to realize that efforts to address these challenges amount to continuous quality improvement to a functional, working system. The following discussion is offered and should be understood within this context.

5.4.4.3 Policy Should be Simplified and Shared

Our research indicated that some maintenance personnel "don't know what is expected of them" relative to equipment transport policy. During our interviews, we asked maintenance personnel to "identify any policies, regulations, etc. you are aware of which describe how TxDOT personnel are supposed to transport heavy-duty off-road equipment." This question was frequently not answered. It is not that there is no policy. However, the policy exists within several different documents including the Equipment Manual, the Preventive Maintenance Manual, Preventive Maintenance Service Advisories, and the Equipment Load & Tie-Down Manual issued with the training course. Also, the persons who are the most knowledgeable and up to date on equipment transport policy are the Preventive Maintenance Coordinators (PMCs) and District Equipment Administrators (DEAs). Those who are most directly responsible for knowing and following equipment transport policy – maintenance personnel in the Sections – don't have direct access to the policy, and what they know they get from their PMC or DEA.

Table 5.1 District Demographics Summary, Equipment Transport Interview

District No./ Designation	District Name	Maintenance Section	No. of Personnel Interviewed	Years of Work Experience
04/ AMA	Amarillo	Claude	4	78
		Hereford	11	162
05/ LBB	Lubbock	Littlefield	8	84
		Lubbock Northeast	1	24
		Plainview	1	20
		Special Projects	10	109
07/ SJT	San Angelo	Sterling	10	166
		Tom Green	10	160
10/ TYL	Tyler	Mineola	6	128
		North Tyler	5	75
		Special Projects	5	113
12/ HOU	Houston	Special Projects	6	121
		Waller County	3	66
13/ YKM	Yoakum	Calhoun	10	133
		Lavaca	7	66
		Special Projects	7	120
		Victoria	6	112
15/ SAT	San Antonio	Bexar 410	12	202
		Bexar Northeast	11	124
		Seguin	9	101
		Special Projects	10	216
17/ BRY	Bryan	Brazos County	5	73
		Grimes County	7	74
		Special Projects	2	37
		Washington County	6	59
18/ DAL	Dallas	Dallas Northwest	12	145
		Dallas Southwest	8	98
		Special Projects	4	72
19/ ATL	Atlanta	Linden	9	189
		Texarkana	4	49
21/ PHR	Pharr	Mission	5	44
		Pharr	11	132
		Raymondville	5	131
		Special Projects	9	188
24/ ELP	El Paso	El Paso East	6	101
		El Paso West	6	76
		Van Horn	7	100
TOTALS			258	3948

Equipment transport policy that currently exists in several documents should be collected and published in one document – the Equipment Manual – which is the primary document at TxDOT for policy on equipment load and tie-down. This will require some editing to address inconsistencies and include any missing points. Interim policy updates should continue to be accomplished through monthly PM Service Advisories and through GSD Safety Notices. Further, the revised policy documents should be made readily available, either by hard copy or online, to personnel at the maintenance section level who are most directly responsible to know and implement equipment transport policy.

5.4.4.4 Payload Capacity is Not Well Understood

While it would be natural to think that a maintenance section person driving the truck, when asked to load a piece of equipment, could do a simple check and confirm whether the weight of the equipment is less than or equal to the payload capacity of the trailer, this is not currently the case.

We observed both inconsistency and inaccuracy in the payload capacity values identified for various trailers (Figure 5.2). One trailer might show a calculated payload capacity – identified as "maximum weight" (MW) – that is intended to take into account the fact that 17% of a properly-positioned load is transferred to the trailer drawbar. Other trailers might show a similar MW value, but not take into account the 17% load transfer. Others (incorrectly) determined payload capacity as GVWR minus Base Curb Weight. Still other trailers show a manufacturer's rating for payload capacity.

Figure 5.2 Payload Capacity is Frequently Incorrectly Marked, or Not Marked, on Trailers

Some of these payload capacity values are closer than others, but most are not correct. Safe payload capacity is not only a function of the trailer deck strength and stiffness, but also the axle capacity, and the tire capacity. Technically, it is the lowest capacity determined by the three methods. That is, a certain load might not overstress the deck but could overstress the axles, or perhaps the tires. Actual load transfer must also be taken into account.

Further, in addition to safe payload capacity – which is a function of the manufacturer's ratings for the deck, axles and tires – there is also a legal payload capacity. The legal payload capacity is a function of axle and tire load limits as per Federal and State road and bridge laws. A load might be within the safe payload capacity for a particular trailer, but overweight relative to the legal payload capacity. In the absence of an Overweight Permit, this could result in a citation by a Department of Public Safety trooper.

In sum, the research revealed confusion about the payload capacity concept, and we also observed non-valid payload capacity values identified on the trailers. Valid procedures for determining the safe and legal payload capacity for TxDOT equipment transport trailers should be developed and incorporated in both the Equipment Manual and the Equipment Load & Tie Down training course. Further, some type of "calculator" could be developed and distributed to the Districts to help implement this recommendation. The correct safe and legal payload capacity for all equipment transport trailers should be determined and clearly marked on the trailers.

5.4.4.5 The "ZONE" – A Revised Concept for Load Distribution

TxDOT's method for achieving correct distribution of load to the trailer drawbar (for tag-a-long trailers) or the fifth wheel (for low-boy trailers) has been "the green line." The basic idea behind the green line is that when a tag-a-long trailer is loaded such that the center of gravity of the load is aligned with the green line on the trailer, a 17% (+/-) load transfer to the drawbar occurs. That is the theory, based on static equilibrium of forces. This issue is significant to TxDOT primarily because of the widespread use of pintle-hitch trailers. These types of trailers require a minimum amount of load transfer to the drawbar for proper hauling and handling.

But our observations, conversations with maintenance personnel, and results from field tests lead us to conclude that the "green line" does not always provide an accurate alignment mark for proper load transfer on the trailers (Figure 5.3). That is, the green line might achieve correct load transfer for one piece of equipment on the trailer, but not for others. This finding coheres with results from the equipment transport opinion survey, where 5.4 / 7 was the average response when asked whether the green line is correctly marked.

Another point is that when proper load transfer to the drawbar is accomplished, this sometimes places the equipment on the trailer in such a way that adequate D-rings are not available for proper tie-down. Again, the load transfer issue is more significant for the pintle-hitch tag-a-long style trailers than for alternative trailer types such as low-boys.

Our findings indicate that the "green line" on trailers should be replaced with the "ZONE" for load distribution. The ZONE (also green) corresponds to "load distribution that achieves 15 to 20 percent load transfer of the payload to the drawbar for the heaviest load to be transported on a given tag-a-long trailer." The ZONE should be determined for all equipment transport tag-a-long trailers and clearly marked on the trailer. A related procedure should be implemented to facilitate the proper load distribution ZONE for low-boy trailers.

Figure 5.3 The "Green Line" on Trailers Does Not Always Provide an Accurate Alignment Mark for Proper Load Transfer

5.4.4.6 Tilt-Deck Trailers

Our equipment transport survey asked whether maintenance personnel felt that "as a general rule, off-road equipment of the same type is getting larger/heavier over time." The average response was 5.05/7 where 7 corresponds to "strongly agree." Anecdotal comments from maintenance personnel supported this finding. Inquiries to the heavy equipment manufacturers indicated that equipment does get larger over time, primarily because more features are being added to make equipment more versatile. TxDOT maintenance personnel further stated that they are purchasing larger equipment with more features because "they have to do more with it." In sum, while the rate of equipment size increase could not be established with a mathematical trend line, it seems clear that TxDOT maintenance forces are now purchasing larger, heavier equipment than in former times.

The question arises as to whether the tilt-deck trailers currently in the fleet are adequate for the larger loaders and other heavy equipment. On the positive side, maintenance personnel indicate that the tilt-deck is a "stout" trailer, it can be loaded quickly, and it is highly maneuverable since the trailer deck tends to be shorter. This makes the tilt-deck very handy for transporting lighter equipment such as the rotary broom, some pneumatic rollers, and the like.

However, with equipment getting larger and heavier, it is increasingly likely that the true – safe and legal – payload capacity of these trailers will be exceeded. The higher deck for the tilt-deck trailers causes vertical stability concerns for the larger loads. Also, with the trailer loaded to near capacity, the equipment fills up and in some cases exceeds the footprint of the trailer.

Maneuverability is more sensitive, and in certain districts, especially those with heavier traffic, some have viewed this as rising to the level of a safety concern (Figure 5.4).

Figure 5.4 Tilt Deck Trailers are Suitable for Hauling Smaller Loads Such as the Broom (left) But Not the Very Large Loads Such as the Wheel Loader (right)

This suggests that transport on larger, lower, more stable trailers is desirable, with the trend being away from having only a tilt-deck trailer for equipment transport. The addition of larger, lower, fixed-deck 2-axle and 3-axle trailers to the fleet, which has been occurring in the past few years, will help facilitate more stable transport. This type of adjustment to the trailer fleet will take both time and capital, recognizing that several maintenance sections only have tilt-deck trailers and use them to transport all their equipment except what they road or tow.

Further, most maintenance personnel indicated that they no longer pull heavy equipment with the 6CY trucks but instead use the 10CY trucks due to the increased stability. The 6CY trucks might be used to pull the very light loads, but *not* the heavy loaders, heavy rollers or similar large equipment. This is the recommended practice.

The use of tilt-deck trailers for hauling large loaders and other heavy equipment should be phased out and the maintenance sections should be provided with lower, heavier, more stable trailers appropriate for transporting the larger loads. Recognizing that implementation of this long-term recommendation will take some time, interim guidelines should be implemented to facilitate safe transport of large loaders and other heavy equipment in those maintenance sections that only have tilt-deck trailers. The interim guidance should remain in effect until replacement trailers can be provided.

5.4.4.7 Texas Correctional Industries (Prison) Trailers

In our research interviews, District maintenance personnel voiced various quality concerns relative to the Texas Correctional Industries (TCI) 2-axle and 3-axle fixed deck trailers. These concerns included: (a) actual payload capacity not matching the identified payload capacity, (b) improper location of the 17% load transfer point (green line), (c) broken welds – especially at the dovetail, the ramps, and sometimes D-rings, (d) excessive deflection of the ramps, (e) hydraulic system concerns, and various other things (Figure 5.5). This is not a comprehensive summary but an overview of the concerns reported to us in the field.

Figure 5.5 Quality Concerns Including Broken Welds, Excessive Deflection and Other Issues Were Identified on Texas Correctional Industries (Prison-Built) Trailers

The above findings were discussed relative to a design review of the 2-axle TCI trailer performed by Dr. Atila Ertas of Texas Tech University [27]. Among other things, it was observed that the trailer performance does not match what Dr. Ertas would have expected based on his design review, with the problem most likely being poor manufacturing quality at the TCI plant facility (prison).

Manufacturing/quality concerns associated with the TCI 2-axle and 3-axle fixed deck trailers should be evaluated and corrected. Relative to new/future trailers, manufacturing quality must be assured at the plant. Regarding existing trailers in the field, manufacturing problems should be addressed through inspection and correction as appropriate. TxDOT should procure trailers from non-prison sources until the TCI quality issues are addressed.

5.4.4.8 Tie Down Systems

This is a catch-all category to communicate various load and tie-down items we observed during our field interviews. For example:

- New federal Cargo Securement Regulations took effect in January 2004. These regulations were the subject of TxDOT *PM Service Advisory 285*, and discuss, among other things, the proper number of chains and binders required to secure a load against different types of forces (Figure 5.6). We observed various levels of incorporation of

these requirements in the different maintenance sections. More significantly, interpretation of the regulations changed after the regulations were issued, causing some confusion as to how many tie-down sets were actually required.

- Certain equipment load and tie down policies and procedures are not fully understood nor are they uniformly practiced in the maintenance sections.

- The new cargo securement regulations coupled with efforts to achieve proper load distribution has resulted in a need for more D-rings on trailers.

- More tie-down points are also required on equipment. New equipment is being designed in awareness of the regulations and is being delivered with more and better-marked tie-down points. But certain types of existing, older equipment are very unusual and it is difficult to find points for proper tie-down. Attention should be directed to achieve the required number of tie-downs.

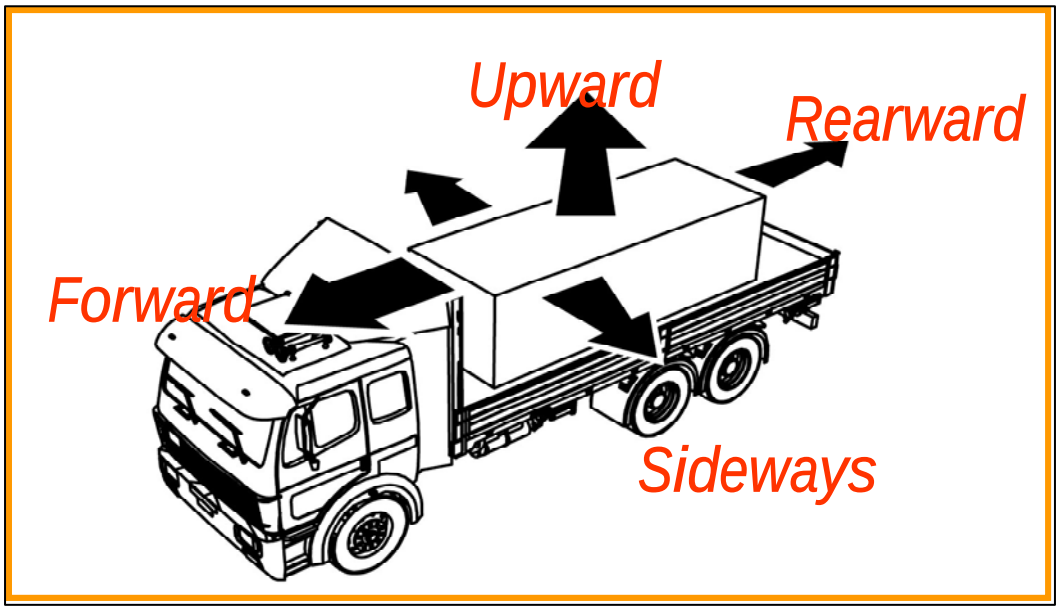

Figure 5.6 The New Cargo Securement Regulations Require Adequate Tie Down Sets to Resist Forward, Rearward, Sideways and Upward Forces

Maintenance personnel are working to implementing policy relative to equipment transport markings on trailers and equipment. However, such markings are not yet fully and uniformly in place across the state. Various equipment transport issues associated with equipment load and tie down should be addressed as follows:

- Continue to implement the new Federal cargo securement regulations as per the latest interpretation of the regulations. Resolve confusion regarding the required number of chains for cargo securement.

- Clear up confusion regarding TxDOT equipment load and tie down policy and procedure on certain load and tie-down issues; for example, whether it is acceptable to cross chains, whether it is acceptable to transport equipment when the dump truck bed is fully or

partially ballasted, whether it is acceptable to transport a backhoe with the bucket in the dump truck bed, etc.

- Add D-rings to equipment transport trailers as necessary to accomplish cargo securement per the new Federal regulations.

- Add tie-down points to equipment as necessary to accomplish cargo securement per the new Federal regulations; clarify tie-down point locations and add as appropriate.

- Continue implementation of a uniform marking system for trailers and loads with valid equipment load and tie-down information.

5.4.4.9 Equipment Transport Training

The Equipment Load & Tie-Down course was developed by the Texas Engineering Extension Service (TEEX) and for several years was provided to TxDOT employees by TEEX instructors under contract with the Training, Quality & Development group of the TxDOT Human Resources Division (HRD/TQD). However, TEEX lost their training contract in FY04.

The TEEX course had some good points. For example, it introduced the idea of load distribution, transfer of load, the green line, etc. The combination of class and field study – both book-learning and hands on – is an effective approach. Further, this is information that maintenance employees do not receive anywhere else – not from other courses, and not from the equipment vendors when they deliver equipment.

Numerous aspects of the course need improvement, however. Of critical significance is that the course content became outdated based on information developed during this research project. The instructional design could also be more effectively done. Relative to training delivery, at times the instructors taught equipment transport practices not consistent with TxDOT policy. Also, regarding the field instruction, the instructor frequently had to make do with the equipment available on site and this can dramatically limit the effectiveness of what can be taught.

The existing TxDOT training course, *MNT172, Equipment Load and Tie-Down*, should be extensively revised/updated. The new version of the course should: (a) improve/ build on the existing course design, (b) use new content to supplement the existing material, (c) focus on the hands-on aspect, and (d) provide for uniform implementation in the maintenance sections. Given the scope of the revisions, all maintenance personnel should attend, not just new personnel. Also, a bi-annual refresher course should be added to the curriculum.

5.4.4.10 Hydraulic Hoses on Tag-a-Long Trailers

Some tag-a-long trailers – including certain models of prison trailers – use self-contained hydraulic systems powered by electrically controlled (12 volt) motors on their trailers. These motors drive the hydraulics that fold and unfold the trailer loading ramps. This is the preferred system.

However, other trailers use a pure hydraulically-controlled ramp system that is driven by the power take-off/hydraulics from the truck. This latter system requires hydraulic lines to be connected from the trailer to the truck to operate the ramps. Crews then must disconnect the hydraulic lines from the trailer to the truck when moving down the road, as sharp turns can cause the hydraulic lines to come loose, or the hydraulic connections can be broken off the truck. Connecting/disconnecting

the hydraulic lines is very time consuming for the crews, and is messy (Figure 5.7). This presents various problems including potential for leaky hoses and oily/slick dangerous surfaces – a safety hazard. It also requires special configuration and type of hydraulic connectors on the truck.

Figure 5.7 Hydraulically-Controlled Trailer Ramp Systems Driven by the Power Take-Off/ Hydraulics from the Truck are Messy and Time-Consuming to Use

The preferred system is to use self-contained electrically controlled hydraulics on the trailer. This only requires an electrical connection to the truck which is already in place for trailer lights and brakes.

5.4.4.11 Miscellaneous

In addition to the above items, we identified certain "best practices" associated with equipment transport. One best practice is the use of a ladder or some form of steps on equipment trailers for safety when the workers have to climb down off of the equipment while it is on the trailer (Figure 5.8). These are particularly helpful in wet/inclement weather. Another best practice is the use of low clearance signs at the maintenance yard for those sections where low-clearance bridges exist (Figure 5.9). These signs serve as a reminder to maintenance personnel to be vigilant when loading high-profile equipment such as backhoes or wheel loaders.

Figure 5.8 Storable Ladders on Trailers Help Provide for Worker Safety

Figure 5.9. Low Clearance Signs Remind Employees to Think About the Height of their Load

5.4.5 Implementation of Findings

Implementation of the information obtained from the interviews and site visits has been accomplished in various ways. Many of our findings were implemented in real time. That is, when research findings emerged from our study and were communicated to TxDOT, these were immediately addressed. Examples include changes to the TxDOT *Equipment Manual*, Fleet Management policy initiatives about the Cargo Securement Regulations, and quality issues about the TCI (prison) trailers.

Other aspects of our findings were incorporated into the revised Equipment Load and Tie Down training course curriculum, which is described in Chapter 6 of this report. Examples include clarification about how to determine safe and legal trailer payload capacity, the ZONE concept for load distribution, and various best practices observed in the Districts.

CHAPTER 6

TRAINING MATERIALS

6.1 Overview

Implementation of the research was the focus of the second year of this project. This work essentially consisted of developing training materials and conducting pilot training for equipment transport. Much of the training needs assessment was addressed in year one as part of our data gathering effort. As noted from both the Equipment Transport Knowledge Questionnaire and the Interviews/District Site Visits, by *far*, the one thing that respondents consistently stated would most improve equipment transport in TxDOT was training. They wanted *more* training, *better* training, and *refresher* training. This chapter summarizes the training/implementation aspects of our research.

6.2 Instructional Design

6.2.1 Evaluation of the Existing Equipment Load and Tie Down Course

The Equipment Load & Tie-Down course was developed by the Texas Engineering Extension Service (TEEX) and the course training manual is periodically updated by staff members from the Fleet Management group. We attended one of the TEEX training workshops in March 2005, and carefully reviewed both the curriculum design and the instruction [28]. The following comments and recommendations summarize key points gleaned from observation of the training event:

- The training needs to be presented in terms of learning objectives with measurable outcomes. Some of the existing learning objectives need to be revised.
- Visual aids, graphics, and other supplementary instructional materials, other than the TxDOT *Load Distribution and Equipment Tie Down Handbook*, are vital for achieving effective, interesting instruction.
- Portions of the *Handbook* require revision, and in some cases this will require policy decisions by Fleet Management.
- Training should recognize that an interim period exists at present where achieving the ideal in equipment transport will not be possible under certain circumstances. Clear guidance that recognizes the importance of continuing maintenance operations within a context of safe practice and procedures should be articulated.
- The instructor should specify, ahead of time and in detail, the equipment needed for training, and this equipment should be there, on site, at the start of the course. The instructor should not have to wonder whether the equipment will be provided. This is too important an item and doesn't need to be left to chance.
- Classroom and hands-on instruction should be alternated throughout the day, with the hands-on aspects used to illustrate key points.
- Each learning objective should be assessed with some type of quiz that will provide learners an opportunity to demonstrate that they know the material.
- Scales used for weighing equipment to establish load transfer should be familiar to the instructor and should yield reliable and valid results.
- Careful thought needs to be given to evaluating and confirming instructor qualifications.

Based on review of the existing course and the findings from our research questionnaires and interviews, it was clear that the TEEX course had some good points. At the same time, numerous aspects of the course needed dramatic updating. Ultimately, we recommended that the existing course be kept, but that it be extensively revised.

6.2.2 Learning Objectives and Curriculum Development

Our goal in updating the TxDOT training course, MNT172, Equipment Load & Tie Down, was to improve/ build on the existing course design, but to use new content from this research to supplement the existing material. In particular, we sought to focus on the hands-on aspect, and to provide for uniform implementation in the maintenance sections.

To this end, we developed and articulated 16 course objectives. Upon completion of the new course, learners should be able to:

1. Identify applicable policy guidance and regulations for proper loading and tie-down of equipment for transport.

2. Define the criteria for safe and legal over-the-road transportation/ equipment selection which pertain to vehicle weight, height, width and length.

3. Explain the concept of proper load weight transfer for equipment transport for tag-a-long and other trailers.

4. Demonstrate the idea of center-of-gravity relative to the center-of-gravity markings on equipment.

5. Position equipment on trailers using TxDOT's standard load weight transfer procedure – "the zone."

6. Identify conditions that justify the use of alternate load weight transfer criteria.

7. Recognize unsafe loading and transport practices.

8. Explain the concept of proper tie down of equipment for transport on tag-a-long and other trailers.

9. Calculate the proper number of tie-down sets (chains and load binders) necessary to safely and legally contain a specified payload/ piece of equipment.

10. Recognize unsafe tie down practices and out-of-service tie down components (chains, load binders and grab hooks).

11. Identify conditions that justify the use of alternate tie-down criteria.

12. Demonstrate the proper use of safety chains for equipment transport for tag-a-long and other trailers.

13. Explain how to make sure that trailer hitches are not overloaded.

14. Demonstrate proper preventive maintenance for various types of trailer hitches; especially pintle and fifth wheel hitches.

15. Demonstrate the ability to identify and competently address non-typical transport situations.

16. Identify published resources and personnel (district & division) who can provide support/answer questions about equipment load and tie-down.

Upon approval of the learning objectives, curriculum design followed a prescribed sequence of steps: (1) designing training program modules to satisfy the learning objectives, (2) developing the training materials for those modules, (3) obtaining review by the Project Monitoring Committee, and (4) finalizing the materials during the pilot training workshop. We approached our work with the belief that for the training to be effective, our instruction would need to target our key audience – maintenance employees who are directly responsible for transporting TxDOT's heavy-duty, off-road maintenance and construction equipment fleet. The training materials developed for this project are research Products P4, P5, P6, and P7 and include a syllabus with learning objectives [5], MS PowerPoint slides [6], an Instructor Guide [7], and a Student Participation Workbook [8].

6.3 Pilot Course

We conducted a full-day pilot workshop in August 2005 for maintenance personnel and subject matter experts strategically-selected from throughout the state. These personnel critiqued and evaluated the training they received, and we used comments from the pilot workshop to refine and improve the training into final form. The training consisted of eight modules as follows:

Module 1.	Introduction
Module 2.	Equipment Selection
Module 3.	Load Weight Transfer
Module 4.	Tie-down of Equipment
Module 5.	Trailer Safety Chains
Module 6.	Trailer Hitches
Module 7.	Non-typical Transport Conditions
Module 8.	Support Documents

The curriculum is highly visual and incorporates numerous photos, drawings, illustrations, and some video. We incorporated active learning exercises consisting of hands-on demonstrations, in-process quizzes, discussion and other activities intended to promote learner interaction.

6.4 Curriculum and Training Assessment

Part of the pilot workshop consisted of evaluation of the training by the subject matter experts in attendance. Table 6.1 summarizes the numerical data collected from the course evaluations on three topics: content, emphasis, and clarity. The data in Table 6.1 indicate that the course content was highly relevant and valuable with average scores ranging from 4.2 to 4.5 out of 5.0. The content was also clearly presented, understandable, and not confusing. In particular, learners indicated that they appreciated the pictures, the discussion, the questions and exercises, and the feedback.

Table 6.1 Subject Matter Expert Evaluations of the Revised Equipment Load & Tie Down Pilot Course

Course Evaluation	Average Score	Target Score
A. Course Content (The material is relevant and valuable for my work…)		
1. Introduction	4.2	5
2. Equipment Selection	4.2	5
3. Load Weight Transfer	4.3	5
4. Tie Down of Equipment	4.4	5
5. Trailer Safety Chains	4.4	5
6. Trailer Hitches	4.3	5
7. Non-Typical Transport Situations	4.2	5
8. Resources for further information	4.3	5
B. Emphasis (The presentations gave appropriate emphasis (time) to the topics…)		
1. Introduction	3.3	3
2. Equipment Selection	3.3	3
3. Load Weight Transfer	3.4	3
4. Tie Down of Equipment	3.4	3
5. Trailer Safety Chains	3.2	3
6. Trailer Hitches	3.2	3
7. Non-Typical Transport Situations	3.2	3
8. Resources for further information	3.3	3
C. Clarity (The presentations were understandable…)		
1. Introduction	4.4	5
2. Equipment Selection	4.4	5
3. Load Weight Transfer	4.1	5
4. Tie Down of Equipment	4.4	5
5. Trailer Safety Chains	4.4	5
6. Trailer Hitches	4.4	5
7. Non-Typical Transport Situations	4.3	5
8. Resources for further information	4.4	5

Learners thought the module presentations were slightly long but generally gave appropriate emphasis to the topics. However, some comments noted that this 8-hour course was crammed with content and could easily have been expanded to fill 12 hours or even two days – and most would have liked that. Also, the hands-on field demonstration exercises were not done due to inclement weather, and these would clearly be a necessary aspect of the course.

6.5 Acceptance/Implementation

This research study identified the need for *more* training, *better* training, and *refresher* training in the equipment transport area. Comments and assessment from subject matter experts suggest that the revised course satisfactorily meets the "better" training requirement. The quality is superior and achieves the stated learning objectives both in content and method of delivery. We submitted the revised curriculum to TxDOT's Training, Quality and Development personnel, the intent being that they would begin using this new curriculum as they teach the course in the Districts.

Further, we feel that at least for the near term, the revised curriculum also satisfactorily meets the "refresher" training requirement. A substantial amount of new content was introduced into the revised curriculum, so much so that the old and new courses are simply not the same. Any learner attending the new course would see a lot of material not covered in previous version of the course. Having said that, the newness will eventually wear off, and we interpret our research findings to suggest that employees do need a true refresher course of some sort. This refresher course has not been designed or developed.

While the new curriculum is both better and fresher, it is not clear that it satisfies the stated need for "more" training. Our research shows that operations personnel strongly feel that everyone responsible for equipment transport – from the maintenance section supervisor to the technicians who load, tie down and transport equipment – need to be trained in a high-quality, uniform manner. The substantial investment to achieve this level of workforce training is, we think, warranted. Implementation will be a function of priorities, resource allocation, and funding.

CHAPTER 7

SUMMARY AND RECOMMENDATIONS

7.1 Summary of Findings

This report documents a 2-year research study sponsored by the Texas Department of Transportation (TxDOT) which focused on two areas: (1) review of TxDOT's existing and future off-road equipment and transport requirements, and (2) assessment of TxDOT's current knowledge base and practices in transporting off-road equipment to determine capabilities and limitations.

7.1.1 Research Approach

The work associated with this research project was accomplished in seven tasks. Task 1 consisted of a database and literature review of equipment transport knowledge sources, including contacts with public and private agencies such as those of major construction equipment manufacturers, equipment haul trailer manufacturers, federal agencies, and a sample of other State DOTs. This work provided a solid theoretical as well as practical basis for the assessment of TxDOT's off-road equipment transport procedures and requirements. Task 2, District Questionnaires, consisted of developing survey questionnaires to accomplish those research objectives in the Project Statement where the data are specific and well-defined. Our approach was to obtain the "objective" data up-front using questionnaires, and follow this up with the District site visits (Task 3) to clarify the data and to gain additional, more subjective data not amenable to questionnaire responses. More than 250 TxDOT personnel participated in the District site visits, allowing us to capture some 3,900 years of construction/maintenance experience and institutional knowledge. In Task 4, the results of the literature review and the District data-gathering effort were tabulated, summarized, and synthesized. Tasks 5 and 6, completed in Year 2, addressed the communication and implementation objectives. Here we developed training materials for equipment operators, managers, and other maintenance personnel to help them better understand and deal with transporting off-road equipment. We then conducted a full-day pilot training workshop, the goal being to finalize an effective training program. Task 7 comprised submittal of final project reports.

7.1.2 Database and Literature Review

The transportation databases contained very little information on the topics specific to this research – no formal studies similar to the present study had been published. So, we directed most of our efforts toward identifying and contacting entities that might be able to provide useful perspectives and insight on equipment transport. Equipment rental companies haul most of their equipment with lowboy type trailers, so load distribution is usually not a factor. Haul trailer manufacturers have practically nothing to do with their trailers after they leave the manufacturing facility. Instead, loading and hauling practices, training, and all other equipment transport aspects are left to the consumer. Caterpillar, the world's largest manufacturer of construction and mining equipment, was able to confirm that equipment size and weight are, in fact, growing over time. The dominant equipment transport issue that emerged from our conversations with professional associations and federal agencies was the new cargo securement regulations that took effect in January 2004.

Cities and public utilities with fleets typically transport their heavy-duty off-road equipment on tag-a-long trailers pulled by a dump truck, similar to TxDOT. Procedures and practices vary among the other State DOTs, with certain challenges being common to all. Equipment issues; the fact that equipment transport policy is minimal to nonexistent in many states; transport practices and procedures are sometimes unworkable; the need for trailer preventive maintenance; the need for better

purchasing practices; and inadequate training programs for equipment load and tie-down are common themes in transportation maintenance departments throughout the United States.

7.1.3 Equipment Transport Knowledge Questionnaire

We developed three different research questionnaires which we administered to TxDOT personnel: (1) a traditional pencil/paper questionnaire focusing on equipment transport knowledge, (2) a web-based survey to identify load-trailer-truck combinations used in the districts, and (3) a web-based survey to forecast the types of off-road equipment to remain in TxDOT's fleet over the next five years. This report summarizes findings from the pencil/paper questionnaire; results from the web-based questionnaires were previously published as products.

We designed the equipment transport knowledge questionnaire to obtain respondent opinions on practices and procedures for transporting off-road, heavy-duty construction and maintenance equipment at TxDOT. Overall response was 586 surveys returned out of 896 surveys sent, for a 65 percent response rate. Results indicate that respondents view all equipment transport knowledge areas as very important, with average scores above 6.0 (out of 7.0) in all categories. When the respondents were asked to assess *their own* level of knowledge in the various areas, the actual level of knowledge was lower than the importance accorded to the topic.

Knowledge of load distribution concepts and practices show that respondents know about the green line markings on trailers, the green line concept for load distribution, and green line markings for equipment. However, the data cast some doubt about how well the green line system is working. Relative to general practices and procedures associated with equipment transport, respondents indicate a strong grasp of preventive maintenance aspects of the equipment transport task. Respondents also indicate a high comfort level when it comes to knowing which trailer to use to haul equipment, and they claim to be able to identify when trailer tie-down points are damaged to the point that they should be taken out of service. Overall, respondents generally feel that the way TxDOT hauls equipment is a good system, although some equivocation exists on this point. Knowledge about trailer hitches and hitching systems can be considered relatively high. Most feel that TxDOT's hitching systems are safe and are adequately maintained. Knowledge about load securement, chains and tie-downs can also be considered relatively high. In particular, respondents claim that they know how many chains and binders to use for tying down heavy-duty, off-road equipment, and they claim to know the proper tie-down points for most of the equipment they haul.

Overall knowledge about equipment transport safety can be considered relatively high. For example, respondents clearly understand that as the person who loads the trailer and drives the truck, they are responsible to make sure that equipment transport is done safely. Respondents claim they follow safe practices, and they talk with their supervisor when they are not sure about a safety issue. Respondents also claim to have a good feel for recognizing unsafe practices or conditions. Compared to safety knowledge, overall knowledge about equipment transport laws and regulations is a full increment lower. Respondents indicate that the truck/trailer combinations they use are mostly within legal weight limits. However, respondents show some ambiguity about regulatory limits and bridge law weight limits. About one out of three respondents feels that trucks are *sometimes* overloaded. One out of four respondents feels that trailers are *often* overloaded. And ultimately, about one out of seven respondents surveyed believes that equipment is often transported illegally.

The final survey question asked respondents to identify "the one thing" they would do to improve equipment transport at TxDOT. By *far*, the one thing that respondents stated would most improve equipment transport in TxDOT was training. When it comes to training, respondents claim that they have the skills to properly transport off-road equipment, but they also point out that better

quality training is the key to improving TxDOT's equipment transport practices. They want *more* training, *better* training, and *refresher* training. Second to training, respondents stated that they needed newer, better trailers. In particular, they want more low-boy type trailers and they would like to do away with the tilt-deck trailers. Better trucks comprise the third category.

7.1.4 Interviews/District Site Visits

We conducted structured interviews of TxDOT personnel at both the Division and District levels in order to deepen our understanding and knowledge about equipment transport issues. These included interviews with representatives from Fleet Management, Purchasing, and a sample of Maintenance Sections throughout the State.

The Fleet Management interviews were conducted to obtain the unique perspective and recommendations of Fleet Management personnel relative to equipment transport issues. The interviews identified several equipment transport problems/challenges, including: incident reports rarely impact policy, one trailer does *not* fit all, some problems exist with the prison trailers, the TEEX equipment load & tie-down course is not of consistent quality, employees are not always adequately trained, equipment transport policy is not readily available in the field, pintle hitches are not always adequately maintained, center-of-gravity markings do not exist on all loads, load distribution markings on trailers are often incorrectly located, trailers are sometimes overloaded, and 6 CY trucks should not be used to pull heavy equipment. According to Fleet Management, the *one thing* that would most improve equipment transport at TxDOT is to impress on the Maintenance Section Supervisors that their job is not to fix roads – that is their MISSION. Their job is to manage their people, equipment, and resources, and proper training and supervisor accountability will go a long way toward accomplishing this objective.

The Purchasing interviews were conducted to obtain the unique perspective and recommendations of Purchasing personnel relative to equipment transport issues. These interviews suggested various areas for attention. For example, the equipment transport aspect of the purchase specification development process could be improved by improving the Master User Requests. The objective should be for Districts to deliberately consider if/how they can transport equipment being requested with their current fleet of trucks and trailers. Establishment of standards for trailered and towed equipment would create a consolidated, easy- to-access reference regarding what is required. Better communication with the Districts is a must – Purchasing needs to know the *weight of the entire load* that a truck/trailer combination will need to transport, not simply the weight of one piece of equipment. Specific enhancements to both the purchasing process and the fleet management process would also help to improve equipment transport at TxDOT.

We made site visits to a total of 37 Maintenance Sections in 12 of TxDOT's operational/ geographic Districts. The goal was to obtain a shared understanding of District/ Maintenance Section perspectives on equipment transport through an interview, and then to physically observe and document illustrative examples of their practices and procedures in the field. The three primary issues addressed in these site visits were equipment transport policy, equipment transport training, and equipment transport practices and procedures. Results indicate that, as a general rule, TxDOT's equipment transport practices, procedures and policy represent a functional system in which many things are being done well. Granted, equipment transport challenges exist, but it is important to realize that efforts to address these challenges amount to continuous quality improvement to a functional, working system.

Relative to equipment transport policy, it should be simplified and shared. Our research indicated that some maintenance personnel "don't know what is expected of them" relative to equipment transport policy, and don't know how to get this information.

Trailer payload capacity is not well understood. We encountered confusion about the payload capacity concept, and we also observed non-valid payload capacity values identified on the trailers. Further, the "green line" does not always provide an accurate alignment mark for proper load transfer on the trailers. Our findings indicate that the "green line" on trailers should be replaced with the "ZONE" for load distribution. The ZONE (also green) corresponds to "load distribution that achieves 15 to 20 percent load transfer of the payload to the drawbar for the heaviest load to be transported on a given tag-a-long trailer."

Despite better maneuverability and other positive aspects, our research suggests that the use of tilt-deck trailers for hauling large loaders and other heavy equipment should be phased out and the maintenance sections should be provided with lower, heavier, more stable trailers appropriate for transporting the larger loads. Further, maintenance personnel voiced various quality concerns relative to the Texas Correctional Industries 2-axle and 3-axle fixed deck trailers.

Hydraulics for the trailer ramps were identified as an issue. Some tag-a-long trailers use self-contained hydraulic systems powered by electrically controlled motors on their trailers to fold and unfold the trailer loading ramps. This is the preferred system. However, other trailers use hydraulically-controlled ramp systems that are driven by the power take-off/hydraulics from the truck. These latter systems are time-consuming to operate, are messy to use, and should be avoided.

Various load and tie-down items observed during our field interviews require attention. These included, among other things, the need for uniform implementation of the new cargo securement regulations, the need for more D-rings on trailers, and more tie-down points on equipment.

Finally, our interviews indicated that the existing TxDOT training course, *MNT172, Equipment Load and Tie-Down,* should be extensively revised/updated.

7.1.5 Curriculum Development and Pilot Training

Implementation of the research was the focus of the second year of this project. This work essentially consisted of developing training materials and conducting pilot training for equipment transport. Our goal in updating the TxDOT training course, MNT172, Equipment Load & Tie Down, was to improve/ build on the existing course design, but to use new content from this research to supplement the existing material. In particular, we sought to focus on the hands-on aspect, and to provide for uniform implementation in the maintenance sections. To this end, we developed and articulated 16 course objectives.

Curriculum design consisted of designing training program modules to satisfy the learning objectives. We then developed the training materials for the modules, and obtained initial review by the Project Monitoring Committee. Finally, we conducted a full-day pilot workshop in August 2005 for maintenance personnel and subject matter experts strategically-selected from throughout the state. These personnel critiqued and evaluated the training they received, and we used comments from the pilot workshop to refine and improve the training into final form.

7.1.6 Products and Reports

This research yielded eight products and two reports. The first two products interact heavily with TxDOT's Equipment Operating System (EOS) and were reported separately. Product P1 is a current inventory of trailers and tractor-trailer combinations, and their capabilities for transporting off-road equipment. Product P2 is listing of off-road equipment by category that will likely be needed by TxDOT in the next five years.

Product P3 is a series of recommendations regarding the safest means of transporting all types of TxDOT off-road equipment to include the combinations. These and other recommendations appear throughout this research report.

Products P4 through P8 have to do with the training development objectives. Product P4 consists of the learning objectives for revised *MNT172 Equipment Load and Tie Down* course. Product P5 consists of the PowerPoint slides associated with this training, Product P6 consists of the Instructor's Manual, and Product P7 consists of the Student Manual. Product P8 is the Pilot Training workshop.

The reports include this Research Report presenting the findings of all research tasks, and TxDOT's 2-page Project Summary Report.

7.2 Recommendations for Implementation/Further Research

The research findings suggest certain promising areas for implementation/further research relative to improving equipment transport at TxDOT. These include: (a) more training, (b) development of payload capacity/equipment selection calculators, and (c) enhancements to TxDOT's Equipment Operating System.

7.2.1 Implementation/Training

In a very real sense, implementation for this project commenced when we began our program of visiting the TxDOT Districts during the data-gathering phase. These visits afforded an open invitation to key District maintenance personnel who routinely work with off-road equipment to become aware of and participate in the research process.

This research study identified the need for *more* training, *better* training, and *refresher* training in the equipment transport area. By virtue of the revised Equipment Load and Tie Down curriculum, this researched study satisfactorily achieved the "better" training requirement. Further, at least for the near term, the revised curriculum also satisfactorily meets the "refresher" training requirement.

However, a stated need exists for "more" training. Our research shows that operations personnel strongly feel that everyone responsible for equipment transport – from the maintenance section supervisor to the technicians who load, tie down and transport equipment – need to be trained in a high-quality, uniform manner. The substantial investment to achieve this level of workforce training is, we think, warranted, and should be pursued with vigor.

Eventually, the newness of the revised curriculum will wear off, and we interpret our research findings to suggest that employees do need a true refresher course of some sort. This refresher course has not been designed or developed, but it should be.

7.2.2 Payload Capacity/Equipment Selection Calculators

Our research revealed confusion about the payload capacity concept, and we also observed non-valid payload capacity values identified on the trailers. Safe payload capacity is not only a function of the trailer deck strength and stiffness, but also the axle capacity, and the tire capacity. Technically, it is the lowest capacity determined by the three methods. Further, in addition to safe payload capacity – which is a function of the manufacturer's ratings for the deck, axles and tires – there is also a legal payload capacity. The legal payload capacity is a function of axle and tire load limits as per Federal and State road and bridge laws.

We developed and presented valid procedures for determining the safe and legal payload capacity for TxDOT equipment transport trailers as an exercise for the Equipment Load & Tie Down training course (Session 2, Exercise 1.1). Given the repeatability of this type of calculation, it is reasonable to suggest that some type of "calculator" could be developed, programmed, and distributed to the Districts to help share this knowledge.

In its simplest form, the calculator might be a spreadsheet. A more powerful, menu-driven version could incorporate a simplified user interface, ranges of variables, printed output, and other features. Ultimately, the calculator might also serve as a training tool. Instructors could require learners to work through simple hand solutions, and then demonstrate the "Payload Capacity Calculator" as a way to check their work and do other, more tedious, daily checks.

In addition to the "Payload Capacity Calculator," additional equipment transport calculators could be developed to assist with proper equipment selection. For example, a similar type of calculator could be developed to evaluate the safety and legality of truck/trailer/load combinations.

7.2.3 Enhancements to TxDOT's Equipment Operating System

The payload capacity and equipment selection calculators described above represent tools that will help maintenance section personnel ensure that they are safely and legally transporting TxDOT's heavy-duty, off-road construction and maintenance equipment. These calculators are amenable to field use but would require reliable, valid input data such as weights, dimensions, deck heights, etc. for trucks, trailers and equipment. During the course of the research, we suggested that the need for reliable, valid weight and dimension information might warrant additional research work. We repeat that suggestion here as a possible follow-on research project.

Specifically, TxDOT's Equipment Operating System (EOS) database contains over 200 fields and over 17,000 records, with a record containing data for an individual piece of major equipment. In relation to equipment transport issues, it is clear that the data in certain key fields, for example, trailer capacities, are either missing or incorrect. Further, no EOS data fields (or data) exist for pertinent information that would enable meaningful safety/legality checks for equipment transport, such as dimensional information, center of gravity, transport height, etc. The "database enhancement" modification would consist of defining key fields relative to equipment transport for addition to the TxDOT EOS, and then populating these, and other appropriate fields, with reliable and valid data.

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0-4575-1
Appendix A
Equipment Transport Knowledge Questionnaire

SURVEY INSTRUCTIONS

TxDOT 0-4575, EQUIPMENT TRANSPORT SURVEY QUESTIONNAIRE

This survey questionnaire is to obtain your opinion on practices and procedures for transporting off-road, heavy-duty construction and maintenance equipment at TxDOT.

Confidentiality Statement

Your responses will be COMPLETELY CONFIDENTIAL and ANONYMOUS in that responses are mailed directly to Texas Tech University and individual names are never linked to responses. We will report the results in the form of grouped statistical data.

Instructions for Participating in this Survey

The questions we are asking you to answer request opinions about your own experiences with equipment transport at TxDOT. While we appreciate accuracy, it will not be necessary anywhere on this questionnaire to refer to your records. There are no right or wrong answers; just use your memory as best you can. If you do not understand the meaning of a particular word or phrase, feel free to call the researcher (see below). Also, note the following:

1. **Please read each question *carefully*.**
2. Be sure to fill in the answer bubbles carefully and completely.
3. Please mark only one answer per question, using a number 2 pencil.
4. The questions are worded to *directly apply* to TxDOT personnel who are responsible for hauling TxDOT's off-road, heavy-duty construction and maintenance equipment fleet. Mostly this will be operators in the Maintenance Sections, Shop and Special Projects crews.
5. TxDOT personnel who do not personally haul equipment but who nevertheless are involved with equipment transport should also answer the questions. For example, a Maintenance Supervisor may not haul equipment himself, but he will direct employees to do so. These supervisors should answer the questions from their own experience based on how they instruct their employees. The same applies to other District maintenance and shop personnel.
6. Please attempt to answer *every question*. If a question just does not apply to you, leave it blank.

Survey Content

The questionnaire covers several topic areas, and we estimate that you can complete the survey in about 20 minutes. The topics are:

- About You
- Equipment Transport Areas of Knowledge
- Equipment Transport Awareness, Compliance, and Knowledge of Procedures
- Equipment Transport Training
- Safe Operation
- Compliance with Law
- Further Input

When you Finish...

When you finish the survey, please mail it back to us (Texas Tech University) in the envelope provided. TxDOT will pay the return postage. If you have questions, please contact the Research Supervisor, Bill Lawson, by phone at (806)742-3521, or by email at Bill.Lawson@coe.ttu.edu.

THANK YOU FOR YOUR HELP WITH THIS RESEARCH!

TxDOT 0-4575, EQUIPMENT TRANSPORT SURVEY QUESTIONNAIRE

ABOUT YOU

1. Please indicate which of the following best describes your present job function:

① Equipment Operator/ Maintenance Tech
② Maintenance Supervisor/ Assistant Supervisor
③ Preventive Maintenance Coordinator
④ District Equipment Administrator
⑤ Maintenance Administrator
⑥ Maintenance Engineer
⑦ Director of Maintenance/ Director of Operations
⑧ Equipment Purchaser
⑨ Fleet Management
⑩ Other

2. Please identify your level of formal education:

① Less than High School
② High School/ GED
③ Some College
④ Associate's Degree
⑤ Bachelor's Degree
⑥ Master's Degree
⑦ Doctorate

3. Total years of work experience:

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
<1	1-2	3-5	6-10	11-15	16-20	21-25	26-30	31-35	35+

EQUIPMENT TRANSPORT AREAS OF KNOWLEDGE

4. Please indicate the *degree of importance* you place on each of the following areas of equipment transport knowledge. Also, please indicate *your own level of knowledge* for each:

	NOT AT ALL IMPORTANT ▼	VERY IMPORTANT ▼	NOT AT ALL KNOWLEDGEABLE ▼	VERY KNOWLEDGEABLE ▼
a. State/federal law		6		7
b. TxDOT equipment transport policy		6		7
c. Equipment manuals (manufacturer-provided)		6		7
d. Trailer hitch systems		6		6
e. Tie-down systems (chains & boomers)		6		6
f. Trailer load limits/ size restrictions		6		7
g. Equipment loading/unloading practices		5		6
h. Load securement and tie-down practices		5		6
i. Towing/ hauling practices		6		7
j. Equipment transport safety practices		6		6
k. Equipment transport daily preventive maintenance practices		6		7

EQUIPMENT TRANSPORT AWARENESS, COMPLIANCE, AND KNOWLEDGE OF PROCEDURES

Equipment Load & Tie-Down Information

	STRONGLY DISAGREE ▼	STRONGLY AGREE ▼
5. Written load & tie-down information is readily available for the equipment I haul.		6
6. Each equipment trailer in my District/ Section is clearly marked for load transfer (green line).		4
7. The gross weight is clearly marked on each piece of equipment I haul.	1	
8. The center-of-gravity (green line) location is clearly marked on each piece of equipment I haul.		4
9. The trailer payload capacity is clearly marked on each trailer I use.	1	
10. The TxDOT system of lining up the green lines on trailers and equipment for proper load transfer makes sense to me.		7
11. The TxDOT system of lining up the green lines on trailers and equipment for proper load transfer works almost all of the time.		6
12. The green line on our equipment trailers is correctly marked for proper load transfer.		4
13. When new equipment is delivered, the equipment vendor provides instruction on how to safely/ legally load and tie down the equipment.	1	

EQUIPMENT TRANSPORT AWARENESS, COMPLIANCE, AND KNOWLEDGE OF PROCEDURES continued

Procedures

	STRONGLY DISAGREE ▼						STRONGLY AGREE ▼
14. It is OK to haul a piece of equipment if I can load it on a trailer.	1	2	●	4	5	6	7
15. When I load equipment, I almost always check to make sure that the weight of the equipment is less than the payload capacity of the trailer I haul it on.	1	2	3	4	5	●	7
16. I almost always haul other loads, materials or supplies on the same trailer I use to transport off-road equipment.	1	2	3	4	5	6	●
17. I do not haul material in the dump bed of the truck at the same time that I am towing a trailer loaded with off-road equipment.	1	2	3	4	●	6	7
18. I know which trailers to use for each piece of equipment.	1	2	●	4	5	6	7
19. I know how to do a daily preventive maintenance check on the trailers I use.	1	2	3	4	●	6	7
20. I can almost always tell when the tie-down points (D-rings) on a trailer are damaged to the point that the trailer should be placed out-of-service.	1	2	3	●	5	6	7
21. I almost always do a daily preventive maintenance check on the trailer before I haul a load.	1	2	3	4	5	●	7
22. I have been told not to haul certain equipment on certain trailers, even though it will fit.	1	2	3	4	5	●	7
23. The way TxDOT transports their heavy equipment is a good system.	1	2	3	●	5	6	7
24. The fact that TxDOT uses many different types of trailers to haul equipment is not a concern to me.	1	2	3	4	●	6	7
25. TxDOT cannot safely transport all of its off-road equipment with its current fleet of trucks/ trailers.	1	2	3	4	5	6	●

Trailer Hitches

	STRONGLY DISAGREE ▼						STRONGLY AGREE ▼
26. The swivel pintle hitch works well for what TxDOT does.	1	2	3	4	●	6	7
27. The fixed pintle hitch works well for what TxDOT does.	1	2	3	4	5	●	7
28. The hitching systems on TxDOT trucks and trailers are safe.	1	2	●	4	5	6	7
29. The hitching systems on TxDOT trucks and trailers are adequately maintained.	1	2	3	4	●	6	7
30. I know how to safely use the trailer hitch systems on the trucks and trailers I work with.	1	2	3	4	5	●	7
31. I know how to do daily preventive maintenance for the trailer hitch systems I use.	1	2	3	4	●	6	7
32. I know the safe rated weight capacity of the hitches I use to pull equipment trailers.	1	2	3	●	5	6	7

Chains & Tie-downs

	STRONGLY DISAGREE ▼						STRONGLY AGREE ▼
33. I can identify the proper grade of chain for tying down equipment.	1	2	3	4	5	●	7
34. I know how many chains & boomers to use for tying down heavy-duty off-road equipment.	1	2	3	4	5	●	7
35. I almost always can tell when a chain is damaged to the point that it should be put out of service.	1	2	●	4	5	6	7
36. I almost always know the proper tie-down points for the equipment I haul.	1	2	3	●	5	6	7
37. According to TxDOT policy, it is OK to use pull-over type boomers to tie down equipment.	1	●	3	4	5	6	7
38. I can almost always tell when a boomer is damaged to the point that it should be put out of service.	1	2	3	●	5	6	7
39. The equipment trailers I use have a sufficient number of properly-placed tie-down points (D-rings).	1	●	3	4	5	6	7

EQUIPMENT TRANSPORT TRAINING

	STRONGLY DISAGREE ▼						STRONGLY AGREE ▼
40. For TxDOT drivers who transport equipment, the minimum job qualifications are <u>not adequate</u>.	1	2	3	**4**	5	6	7
41. Before I was trusted with hauling off-road equipment, my supervisor made sure I had sufficient training in how to do it properly.	1	2	3	4	5	**6**	7
42. The key to improving TxDOT's equipment transport practices is better quality training.	1	2	3	4	5	6	**7**
43. The TEEX equipment load & tie-down course does not cover all the equipment transport topics I need to know.	1	2	3	4	5	**6**	7
44. Equipment vendors should explicitly cover how to properly load and transport equipment when it is delivered to TxDOT.	1	2	3	4	5	6	**7**
45. I have the skills necessary to properly transport off-road equipment.	1	2	3	4	5	**6**	7
46. Equipment transport skills are best learned by hands-on instruction.	1	2	3	4	5	6	**7**
47. TxDOT should have an equipment transport annual refresher training course.	1	2	3	4	5	6	**7**

SAFE OPERATION

	STRONGLY DISAGREE ▼						STRONGLY AGREE ▼
48. It is my responsibility, as the person who loads the trailer and drives the truck, to make sure that heavy-duty, off-road equipment is safely transported.	1	2	3	4	5	6	**7**
49. Equipment in my District/ Section is always transported safely.	1	2	3	**4**	5	6	7
50. I *know* the safe practices for transporting off-road equipment.	1	2	3	4	5	**6**	7
51. I *follow* the safe practices for transporting off-road equipment.	1	2	3	4	5	**6**	7
52. I can almost always recognize unsafe equipment transport practices.	1	2	3	4	5	**6**	7
53. When I see unsafe equipment transport practices, I know what to do about it.	1	2	3	4	5	**6**	7
54. I feel comfortable talking with my supervisor about any questions I may have regarding safe equipment transport practices.	1	2	3	4	5	**6**	7
55. Adequate information exists on each trailer and piece of equipment so that I know which combinations are safe to haul.	1	2	**3**	4	5	6	7
56. Our District uses equipment transport accident/ incident reports to improve our safety practices.	1	2	3	4	**5**	6	7
57. My immediate supervisor takes appropriate action when I bring an equipment transport safety issue to his/her attention.	1	2	3	4	5	6	**7**
58. I know when an over-height load is not stable.	1	2	3	4	**5**	6	7

COMPLIANCE WITH LAW

	STRONGLY DISAGREE ▼						STRONGLY AGREE ▼
59. It is easy for me to tell if the equipment loads I haul comply with the Texas bridge law weight limits.	1	**2**	3	4	5	6	7
60. The trailers used to transport off-road equipment are often loaded beyond their payload capacities.	1	**2**	3	4	5	6	7
61. I know what the regulatory limits are for the roads/ bridges where I haul equipment.	1	2	3	4	5	**6**	7
62. The trucks used to transport equipment are sometimes loaded beyond their weight capacities.	1	**2**	3	4	5	6	7
63. The truck/ trailer combinations used to transport off-road equipment in my District/ Section are almost always within the legal weight limits.	1	2	3	4	5	**6**	7
64. Heavy-duty off-road equipment in my District/ Section is often transported illegally.	1	**2**	3	4	5	6	7
65. As a general rule, off-road equipment of the same type is getting larger/ heavier over time.	1	2	3	4	**5**	6	7

FURTHER INPUT

66. If I could do one thing to improve equipment transport at TxDOT, it would be (brief answer):

GET THE NECESSARY EQUIPMENT NEEDED TO HAUL THE CONSTRUCTION EQUIPMENT (Trucks / TRAILERS)

THANK YOU FOR YOUR PARTICIPATION IN THIS SURVEY.

0-4575-1
Appendix B
District Interview Questionnaire

District Site Visits
Equipment Transport (ET) Project
TxDOT Project Number 0-4575

RESEARCH STATEMENT

TechMRT: Center for Multidisciplinary Research in Transportation at Texas Tech University, Lubbock, Texas is conducting a research project on Equipment Transport (**ET**) for the TxDOT General Services Division (GSD) in Austin. The research Project Director for TxDOT is Mr. Don Lewis. Don is the manager of the FM group in Austin.

The purpose of this research is to evaluate TxDOT's current practices and procedures for the transportation of their heavy-duty off-road construction and maintenance equipment fleet. Based on the results of our evaluation, we will provide recommendations that will enable TxDOT personnel to safely, effectively and efficiently transport their existing and future equipment fleet.

We will accomplish the research objectives, in part, by conducting 3 survey questionnaires and 12 District site visits. The first of the surveys will be a "pencil and paper" opinion questionnaire and will be mailed out to various District, Division and Maintenance Section personnel in late April. The other two survey questionnaires will be computer-based and are expected to be rolled-out in May-June 2004. The web-based surveys will address truck-trailer-equipment (load) (TTL) combinations (for the Maintenance supervisors) and current and future equipment needs (for the equipment administrators).

But our purpose today is the **site visits**.

RESEARCH OBJECTIVES

The objectives of the District site visits are to:

- Document current ET knowledge levels in District personnel (Task 2.b)
- Document ET practices actually being used in TxDOT Districts (Task 2.b)
- Document the level and scope of training provided in the Districts (Tasks 2.b, 2.d and 2.e)
- Obtain input from District personnel that will enable us to:
    - Develop recommendations on the safest means of transporting off-road equipment to the jobsite (Task 1.d)
    - Develop recommendations for truck, trailer and equipment (load) procurement specifications to meet the demand of off-road transport in the next five years (Task 1.e)
    - Develop information/training needs for TxDOT personnel who are involved in the ET process (Task 2.d)

Our order of business for the District Site Visits (DSV's) is:

- Interview selected field and supervisory personnel (as appropriate) who are involved in ET operations
- Observe and photograph actual ET loading, positioning, tiedown, and unloading operations at selected District, Section, or jobsite locations
- Listen to and document any comments and suggestions provided by TxDOT personnel
- Obtain copies of any ET documentation or training materials that may be beneficial to TxDOT personnel

TXDOT 0-4575 EQUIPMENT TRANSPORT PROJECT
SITE VISIT INTERVIEW QUESTIONNAIRE

ABOUT YOUR MAINTENANCE SECTION PERSONNEL:

1. Sign-in sheet (personnel present for interview)
2. List of section maintenance personnel involved in equipment operation & hauling, including:
    a. Name
    b. Work experience (years)
    c. Job function title
    d. TEEX equipment load & tiedown course (year taken?)
3. Which personnel are responsible for which aspects of transporting equipment? For example, supervisory, scheduling, TTL combination selection, operations, training, safety, PM, etc?

ABOUT YOUR HEAVY-DUTY, OFF-ROAD EQUIPMENT INVENTORY

Identify the "equipment." State if loads are hauled by the section, hauled by the District, "roaded," etc.

4. Trucks?
    a. 10 CY Dump Trucks _____
    b. 6 CY Dump Trucks _____
    c. _____
    d. _____
    e. _____
5. Trailers (heavy-duty equipment & dedicated)?
    a. _____
    b. _____
    c. _____
    d. _____
6. Loads?
    a. Motor grader (maintainer) _____
    b. Rubber tire loaders _____
    c. Pneumatic roller _____
    d. Steel wheel roller _____
    e. Rotary broom _____
    f. Backhoe _____
    g. Skid steer loader _____
    h. _____
    i. _____
    j. _____

EQUIPMENT TRANSPORT POLICY

7. Please identify any policies, regulations, etc. you are aware of which describe how TxDOT personnel are supposed to transport heavy-duty off-road equipment?

8. Which policies do you rely on most?

9. How do you stay up-to-date on equipment transport policy?

10. Have you heard about the new Federal "Cargo Securement" regulations that went into effect January 1, 2004? [P.M Service Advisory 285?] If so, how are you addressing these requirements?

EQUIPMENT TRANSPORT TRAINING

11. In your maintenance section, what are the minimum qualifications for personnel who transport equipment?

12. What **areas of knowledge** do you think are the most important for equipment transport?

13. What training is *available* for your personnel who transport equipment? (TEEX? Other?)

14. Are you aware of other training that you think might be helpful, but which is not offered at TxDOT?

15. Questions about the TEEX **Load Distribution & Tiedown** course:

    a. Do you think the TEEX training is effective (helps you personnel do their job)?

b. What did you find most helpful about it?

c. What did you like least about it?

d. How could the course be improved?

e. If you were to add more equipment transport training, what topics (not now covered in the TEEX course) do you think should be covered?

16. Should equipment transport training be done "in class," "on the job," or in combination?

17. Do you think that equipment transport refresher training would be worthwhile? If so, how frequently? How long (Full day? Half day, etc.)?

EQUIPMENT TRANSPORT PRACTICES & PROCEDURES

18. Truck-Trailer-Load (TTL) **combination selection**

a. Who in your Section makes the call on which TTLs are used?

b. How many persons do you use to load equipment?

19. Talk about the **trucks.**

a. Comparison of 10CY versus 6CY for hauling equipment loads?

b. Can heavy-duty, off-road equipment be safely hauled with a 6CY truck?

c. Any concerns about power? Braking? Handling?

20. Talk about the **trailers.**

a. Discuss the trailer types you use (advantages and disadvantages)

b. Any problems with load positioning on trailers?

c. Do you know the payload capacity?

d. Is the ET information (green line, weight, height) clearly marked? On ALL trailers? Is the information accurate?

e. Sufficient tiedown points? In the appropriate locations?

f. Is your trailer fleet adequate? What type of trailer do you prefer? Why?

21. Talk about the **loads**.

a. Any problems with load positioning for each load?

b. Do you know the operating weight for each load?

c. Is the ET information (green line, weight, height) clearly marked? On ALL equipment? Is it accurate? Would a **placard** with this information be helpful?

d. Sufficient tiedown points on ALL your equipment? In the appropriate locations? How to best retrofit older equipment?

e. What equipment is the most difficult to load? Why?

22. Equipment transport **practice issues & concerns**

a. Do you have any problems with handling (fishtailing, etc.) when hauling equipment?

b. Do you think the green line on the trailer & load is marked in the right location?

c. How carefully do you follow the green line alignment guidance?

d. Do you have any concerns about vertical stability, trailer deck too high, overturning, top-heavy load, etc. (high loads)?

e. Do you have any concerns about the trailer footprint being too small for the load?

23. Trailer **hitch** systems

a. Which hitch systems do you use?

b. Do you think the hitches you use are adequate?

c. Do you prefer the swivel pintle or fixed pintle hitch? Why?

d. Are the hitches being adequately maintained?

24. **Tiedown system** components & configuration (chain, hooks and boomers)

a. What size & grade of chain, hooks & boomers are you using?

b. How do you know if these are safe? Legal? Meet policy? Etc.

c. Does older equipment have adequate tiedown points? If not, is this a problem?

d. The new regulations discuss "out-of-service criteria" for chains, boomers, and hooks. Out-of-service means failure to comply with the regulations. Do you know the out-of-service criteria for the tiedown system components? Do you know proper tiedown configurations?

25. Hauling and securement of **additional loads**, materials, equipment and supplies

a. How frequently do you haul additional loads or supplies, etc. *on the trailer* at the same time you are hauling heavy-duty off-road equipment?

b. How frequently do you haul material *in the truck* when you are pulling a trailer loaded with a piece of heavy-duty off-road equipment?

c. How frequently do you haul ON-ROAD equipment that would normally be driven to a site under its own power?

26. Equipment transport **safety**

a. What, if anything, could be done to help improve the level of safety with respect to equipment transport in your Section?

b. Is safety adequately covered in the equipment transport training?

27. Equipment transport **law/regulation**

a. What, if anything, would help you ensure that equipment in your Section is transported in accordance with the law?

b. Are legal issues adequately covered in the equipment transport training?

28. **Preventive maintenance** (PM) for equipment transport systems (trucks, trailers, loads, hitches, tiedown systems)

a. How could you improve the PM checklists for TTLs in relation to equipment transport?

b. Would it be helpful to have a pre-transport PM checklist specifically for ET?

WRAP UP

29. From the standpoint of the TxDOT equipment transport process, what do you think is the weakest link?

a. **Policy** … we don't know what is expected of us
b. **Purchasing** … we don't have what we need to do the job
c. **Management** … not responsive to problems
d. **Trailers**… haven't kept up with equipment we haul
e. **Training**… we have not been adequately prepared to do our job
f. **Other** (specify) … _____

30. If TxDOT could do just one thing to help you more safely, effectively, and efficiently haul your heavy-duty, off-road equipment, what would it be?

31. Do you feel you are doing anything innovative in the equipment transport area?

32. Do you have any suggestions, comments, or recommendations for improvements?

33. How are ET drivers informed of bridges with low clearances, bridges with weight restrictions and low hanging overhead lines in the District or territory in which they operate? Are maps available that identify these potentially problematic routes?