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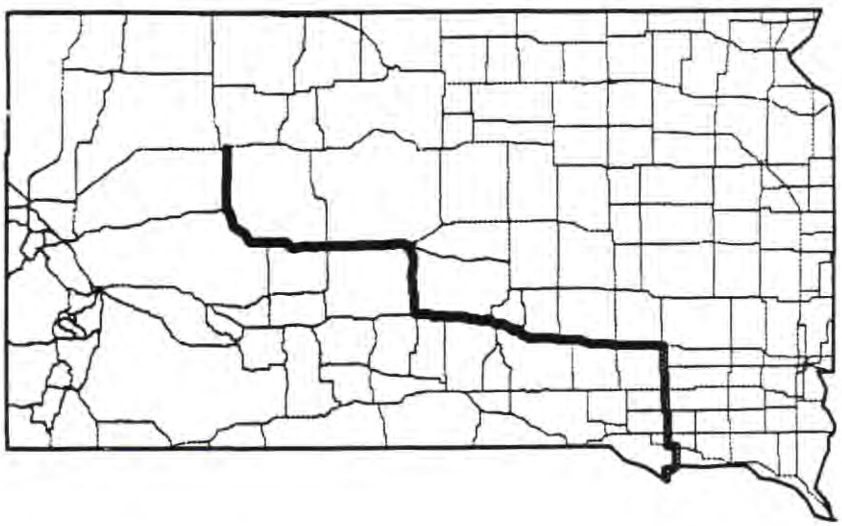
SD Department of Transportation
Office of Research



Feasibility of Automated Routing and Permitting of Oversize/Overweight Vehicles

Study SD96-07
Final Report

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August 1997

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16. Abstract

The consultant provided services to evaluate the feasibility of an automated permit and routing system for routing oversize/overweight vehicles. The objectives of the project were to determine the need and justification for automating South Dakota's vehicle permitting operation, to define functional and data requirements for automated routing and permitting and to evaluate existing software and hardware solutions meeting those requirements. In addition, organizational changes and procedures required to support the proposed system are proposed.

Approximately ten states have or are implementing automated permitting and/or routing permit systems. A review of highway and bridge features presently collected by the SDDOT indicated that the majority of data required to support an automated permit system is already collected by SDDOT. Several different organizations were considered to support the proposed system. An permit issuance organization located at a single site was recommended. Other sites would be connected to this site through call up modems and the Internet.

The proposed permit system should support the following features: spring thaw restrictions, construction zones, maintenance restraints, bridge and roadway restrictions, bridge capacity, etc. An "on the fly" bridge rating capacity would be very desirable.

One commercial system and one prototype system offering different solutions to automated permitting and routing were demonstrated. Both systems could be made to support the requirements of the proposed permit system. Implementation of an automated permit and routing system is financially viable and recommended.

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Executive Summary

The technology to automatically permit and route oversize and overweight vehicles is definitely available to South Dakota. From a survey conducted in Task 2, the project identified two commercially available systems which support automatic permitting and evaluation of potential routes. Only one of the commercial systems selects and evaluates a proposed route.

A survey and other contacts found approximately ten states doing, or developing, some type of computer assisted routing of oversize/overweight vehicles. The majority of the remaining states desire to have such functionality. The respondents were nearly unanimous that the key parameters in the routing process should include: truck configuration (axle loads and spacing), bridge horizontal, vertical clearances considering travel over and/or under the bridge, bridge strength, pavement width and number of lanes, horizontal clearance for obstructions, and shoulder width.

Based on interviews with South Dakota personnel, the project team found that South Dakota would be an easy state to implement an automated permit and routing system. For example, if all conditions were met, all agreed that a computer could automatically issue a permit. Presently, South Dakota Highway Patrol issues approximately 60,000 individual permits and 70,000 books of permits annually through a manual system. The main permitting operation is located at Sisseton. While the staff was described as being very professional, they also acknowledged that the present system is very stressful and the potential for errors exists.

Routing of oversize/overweight vehicles is now being accomplished using a bridge load capacity map, construction map, spring load restriction, bridge weight formula and historical records of past approvals. When the decision cannot be made by the permitting officer because the permit is for an overweight vehicle, the permit request is sent to the Office of Bridge Design for further analysis and approval.

A review of the highway and bridge features presently collected by the Department of Transportation indicates that the majority of the data required to support an automated permit issuance and routing system is already available. The data was described as being high quality and acceptable for supporting a routing function. No effort was made by the project team to verify the accuracy of these features.

The use of the SDDOT GIS highway map would be very beneficial for the routing function. The use of double lines for divided highways is especially beneficial. Inclusion of interchanges is necessary before this highway map could be used in a routing system. In addition, a strategy would need to be developed to show the functional features of each interchange.

Several approaches to management of a computerized permit office were considered during the project. The distributed approach to permit issuance has worked very well with a paper permit system, but it may be more difficult to implement with a computerized permit system. After careful consideration, it is recommended that the proposed computerized system be housed at a single location. Because of the experience available at the Sisseton facility, there is significant justification for keeping it there. However, support of the computerized permit office would probably be significantly easier if it were housed in Pierre. The telecommunications and database infrastructure appear to be better at Pierre than at Sisseton.

The single site location for permit issuance is recommended for two reasons. First, we have assumed that the computer support at the remote ports of entry is limited. Second, support of a computerized permit system will be required, and it would be more efficient if the system was located at one site.

To minimize the impact at the permit issuance office, the use of computerized input from the users (permit applicants, ports of entry, HP District 4 Headquarters, and mobile units) would be encouraged. This support would be available through modems and the Internet. Permits could be delivered locally through FAX or a local printer. Priorities could be established to make sure that these in house facilities are adequately supported.

The results of the cost benefit analysis indicate that the development of an automated permit and routing system would save the state considerable money each year. A benefit/cost ratio of approximately 1.58 was calculated.

Many benefits were identified that were difficult to quantify, but they may have significant potential savings for the state. The benefits include: better data for management to make staffing decisions, better service to the trucking industry through the use of technology, improved safety, development of alternative routing criteria such as "minimum damage", structural analysis of all state bridges for overweight vehicles, historical records of approved permits, an investment return for using the existing database and GIS investment, and support of alternative fee structures.

Of the two commercially available systems, only one supported automated routing of oversize/overweight vehicles. Based on this criteria, the system from GDS was recommended for additional study. A demonstration of the gdsPARS™ system was provided to the technical panel. It appears that this system meets all of the requirements identified during the study except it cannot perform bridge load ratings "on the fly". While the cost of implementing the system is rather high, the gdsPARS™ system has been successfully implemented in several other states. The organization behind the software is solid.

The principal investigator also demonstrated a prototype routing system, based on a routing application built for MapInfo, the leading desktop mapping system. This system supports one way and two way streets. A general discussion of the issues of building the highway map, including divided highways, interchanges, ramps, etc., was presented. The system supported construction zones, spring thaw restrictions, narrow lanes and shoulders, bridge clearances, etc., through the temporary barrier function. A bridge load rating program that could be integrated into the system to allow for bridge load rating "on the fly" was demonstrated. A map was generated that illustrated that the system would consider a route through an interchange and know that the vehicle would travel under and/or over a bridge on the selected route.

Based on the work conducted in this project, the following recommendations are presented for consideration by the South Dakota Department of Transportation and Highway Patrol:

1. It is recommended that an automated routing and permitting system for oversize/overweight vehicles be implemented in South Dakota. By implementing an automated system, the personnel involved in the present permitting system would be able to concentrate more on enforcement. It is clear that South Dakota would benefit from the implementation of an automated routing and permitting system since the benefit/cost ratio calculated in this study was 1.58. While numerous benefits were identified for the state, having the information in a database format would allow the state to manage the entire permit operation more efficiently.

2. It is recommended that the automated routing and permitting system be located in Pierre rather than in Sisseton. This would allow for improved system maintenance, telephone service and Internet access. Modern computer systems do not require large levels of support. When that support is required, it would be easier to obtain in Pierre than in Sisseton. The biggest disadvantage with this recommendation is that the expertise of existing staff may be lost. The challenge for South Dakota would be to transfer that experience from Sisseton to Pierre.

3. It is recommended that the automated routing and permitting system be accessible to the Ports of Entry through the Wide Area Network.. The trucking industry would have access to the system through modems or the Internet. This recommendation would reduce the effort required by the permitting staff and improve the service to the trucking industry.

4. The commercially available permit and routing system, gdsPARS™, is recommended because it meets the majority of South Dakota's needs as outlined in this report. When selection of the final system is made, the state may want to consider other systems presently under development.

Through the dedication of the present permit staff, the current hand system is working. However, it is recommended that the state proceed with the development of the proposed system and take advantage of the technology presently available.

Problem Statement

Today, the process of issuing truck permits by SDDOT and the SD Highway Patrol is essentially completed by hand. After collecting the permit information and working with a set of permit guidelines and highway information that includes bridge clearances and capacity, the route is approved and verified through a rather complex set of manual procedures. Due to the complexities of the route selection process, human errors have been known to occur. Also, the staff time required to complete this process is significant.

Many of the common errors could be eliminated through the use of an automated routing system. Major improvements in the efficiency of staff resources should be experienced by the SDDOT and SD Highway Patrol by computerizing the permit process. Most important, with data stored in an electronic format, South Dakota would be able to receive major improvements in analysis of permits granted and to provide better and more efficient services to the trucking industry.

Immediate benefits of this system would include:

1) Office personnel in the permit granting agencies would work more efficiently
2) The trucking industry would receive faster responses for truck permit requests and have the option to electronically transfer permits
3) Analyzing bridge capacities and verifying clearances by computer would reduce the workload in the Office of Bridge Design
4) Maps of the approved route and driving instructions would be provided
5) Bridge and highway damage due to miscalculations would be reduced
6) Safety for the traveling public would be improved.

Past experience in defining permit system requirements show that most states would not expect to issue all permits with the proposed system. Certain classifications of permits require the careful analysis of trained personnel before issuing the permit. However, it is the experience of the principal investigator that large classifications of permit requests would be covered by the proposed system. This would leave considerable time for the Office of Bridge Design to consider those permit classifications that require the careful attention of a bridge engineer.

Project Objectives

The objectives of this proposed project are:

1. Determine the need and justification for automating South Dakota's oversize/overweight vehicle permitting operation.

2. Define functional and data requirements for automated routing and permitting systems.

3. Evaluate existing software and hardware solutions meeting the functional objectives outlined in Objective 2. In addition, organizational changes and procedures required to support the proposed automated routing and permitting system shall be proposed. Present

and future financial, operations and information processing environments shall be considered in all recommendations.

This Final Report is organized by Tasks. The general format for each Task is an introduction, summary and conclusions. The body of the Task report follows. If appropriate, an appendix is included.

Task 1 Meet with Technical Panel to Review the Project Scope and Work Plan

1.1 Summary and Conclusions

A meeting with the Technical Panel was held in Pierre, SD in May 1996 to review the project scope and work plan. After a brief introduction, a general discussion of the current permit processing procedures, project expectations and scope was conducted. It was generally agreed that the work plan outlined in the proposal would be followed in this project.

Task 2 Conduct a literature review on automated routing and permit issuance systems. Include interviews with other states for information on systems in use or proposed

2.1 Summary and Conclusions

A NTIS literature search was conducted to survey the literature regarding automated routing and permit issuance systems. The only contact made through this search was to Dr. Jay Pucket, Department of Civil Engineering, University of Wyoming. Dr. Pucket has just initiated a study to develop an automated routing system within the Intergraph environment. He is using this approach because Wyoming is an Intergraph user. They plan to consider roadway parameters, bridge geometry, and structural capability in the routing process. While it is too early in the Wyoming project to evaluate the system being developed, the project team will be in contact with Dr. Pucket as the project progresses.

The survey located in Appendix 2.A was sent to all state DOT permit sections. The project team was very surprised to receive 34 responses to the survey. This is much better response than is normally experienced in surveys of this nature. A summary of the survey is presented in Appendix 2.B.

While the results are summarized in Appendix 2.B, the project team wishes to make a few observations with respect to the results and how they apply to the South Dakota project.

The annual number of permits requiring attention from the SD Highway Patrol is approximately 60,000. This permit volume lies in the lower quartile of the states responding.

Approximately 75% of the respondents had a computerized permit system. Most of these systems were developed with in house staff on mainframe computers using rather old development environments (COBOL, Assembler, etc.). Most of the permit systems were developed since 1984, but Pennsylvania started their permit system in 1965. Many agencies would not recommend developing a new system in the development environment originally selected. This indicates the changes in the computer industry and software during the past decade.

Approximately 50% of the respondents issued permits from a common site. Those states that had a computerized permit system also tended to issue those permits from a common site. Those states that do not have a computerized permit system were evenly split with regard to single or multiple permit issuance sites. System integration work is significantly higher when supporting multiple sites when compared to issuing permits from a single site. There was no trend between development costs and the number of sites issuing permits. However, the implementation time was higher for multiple site installations.

To reduce development costs, South Dakota may wish to consider issuing vehicle permits from a single site. This concept will be discussed in more detail in the Task 5 report.

The trends associated with development and total costs were not as apparent. Not all states provided cost data, and those that did were not always consistent. From the respondents, the resources required to develop the computerized permit system varied from $30,000 (1985) to $800,000 (1991).

There are so many variables associated with development costs it is probably not realistic to develop trends from the data. These variables would include number of sites supported, data transfer requirements, networking costs assigned to the project, data access requirements, etc.

One observed trend was that implementation time tended to increase for permit systems that supported multiple sites. Implementation time ranged from one weekend to several months. Some states had a 24 month implementation plan. Again, the results probably reflect the differences of computer resources available to the development teams.

The permit fee structure varied widely between states. One group of states charge a flat fee for each permit. Several charge an additional fee based on the overweight load to be permitted. Others charged a fee based on a ton-mile of overweight. A brief summary of permit fees are included in the Permit Survey Summary found in Appendix 2.B.

None of the respondents had a routing capability working with their computerized permit system. However, over 50% expressed a desire to have a routing function available. Three states (Florida, Kansas and Pennsylvania) are developing automated routing capability. One state reported that their automated routing system was not usable because of an incomplete database, and one state has proposed an automatic routing system for their system.

When asked what parameters should be included in the routing process, very few states responded. Those that did, checked all of the parameters listed in the survey. Those listed included:

Truck Parameters:
- Overall Height
- Overall Width
- Overall Length
- Overall Weight
- Truck Axle Configuration and Weights

Bridge Parameters:
- Vertical Clearance
- Horizontal Clearance
- Structural Capacity
- Posted Bridges

Highway Parameters:
- Lane Width
- Shoulder Width

Highway Classification
Construction Constraints.

The project team was somewhat surprised that no respondent added any feature in the "other" category. Since conducting this survey, two other parameters should be added to the above list. One is tire load per inch to minimize highway rutting and the other is spring thaw information.

During the survey and subsequent studies, two commercial computerized permit systems have been found. One vendor is GDS in Denver, CO., and the other is C.W. Beilfus & Associates in Chicago, IL.

GDS presently has six systems working or under development. They have versions that work in the DOS environment and Windows NT environment. After a site visit, system definition and integration is one of the strengths of this organization. They provide a full service permit and routing system. The support of the different permit requirements for each state was built into their system. This flexibility allows them to customize their application to meet the needs and requirements of each state.

The other permit system available is Superload from C. W. Beilfus & Associates. This system was written for the Windows NT environment. At present, this company has four systems installed or in the development stage. The Superload system manages permits and has a routing module. Based on a detailed electronic map and a defined truck configuration, Superload will evaluate a proposed route selected by the user. This routing module performs a complete structural analysis of each bridge along the proposed route. Superload provides the analysis results and stores company, truck, and route information for later use.

C. W. Beilfus & Associates, Inc. also provides a permit administration module that is customized for each state. This system is separate from the Superload module. The permit administration module provides the necessary permit data, permit types and accounting features required for permit management. A more complete description of both packages will be presented in the Task 5 report.

Task 2 Appendix A

Permit System Survey

QUESTIONNAIRE

Name ______________________ Organization ______________________

Address ______________________ City, State, ZIP ______________________

Title ______________________ Telephone Number ( ) ______________

I. **Present Permit System**

Approximate number of permits issued annually ______________________

Approximate maximum number of permits issued daily ______________________

Approximate maximum number of permits issued hourly ______________________

Are permits issued from a common Site? Yes _______ No _______

If No, How many sites issue permits? ______________

Is self permitting allowed in your state? Yes _________ No _________ Sometimes _____

II. **Do You have an Computerized Permit Issuance System?** Yes ______ No _____

If No, go to III.

What year was first system installed? ______________

What was its approximate original development cost? ______________

What is the total development costs including all updates and support? ___________

How long did it take to develop the original system? (months) ______________

How long did it take for full implementation of the original system? (months) __________

Who developed the system? In house __________ Vendor _________ Other _______

Who is providing permit system maintenance? In house _____ Vendor ____ Other ______

What hardware platform is required to support the system? ______________________

What computer language or database management system was used to develop your system?

____

Would you recommend this language or DBMS? Yes _______ No ________

Is software located in a single office or distributed through several offices?

Single __________ Distributed ____________

Any other helpful comments describing your computerized permit issuance (tracking) system?

____

____

____

____

III. **Do you have a computer assisted method to automatically route oversize/overweight vehicles?**

Yes __________ No ____________ If Yes, Please continue

If No, would you like one? Yes ___________ No _____________ Go to IV.

What parameters are considered by the software to select an approved route:

Truck Parameters:

Overall Height _____ Overall Width _______

Overall Length _____ Overall Weight ______

Truck axle configuration and weights _____ Other Truck Parameters ______

Bridge Parameters:

Vertical Clearance ______ Horizontal Clearance _________

Structural Capacity ______ Posted Bridge ___________

Highway Parameters:

Lane Width ________ Shoulder Width ________

Highway Classification _______ Construction Constraints _______

How are electronic maps maintained? ______________________________

____

____

Does automatic routing function interface with computerized permit issuance system?

Yes ____ No _______

What is the criteria when the automated routing/permitting system is **NOT** allowed to issue a permit? ______________________________

____

____

IV. **Permit Fee Structure**

What is your permit fee structure? ______________________________

____

How is the fee collected? ______________________________

____

V. **We would appreciate any advise or comments regarding your system or the overall issue of automated routing of oversize/overweight vehicles** ______________________________

____

____

Please use the enclosed envelope to return questionnaire:

EnGraph
4840 W. 15th Street, Suite 1015
Lawrence, KS 66049

Task 2 Appendix B

Permit System Survey Summary

This survey was sent to all of the DOT offices throughout the United States inquiring about their present permitting and routing systems. These five areas were considered:

-- Volume and organization of permit operation;

-- Details of the computerized permit issuance system, if applicable;

-- Present fee structure for issued permits;

-- Proposed or present permit routing criteria; and

-- Details of the automated routing system, if applicable.

Volume and Organization of Permit Operation

Thirty-four states responded to this survey. Most of these states (twenty-four) have already implemented computerized permit issuance systems.

Key: na = no answer n/a = not applicable

State	Approx. Annual	Permits Issued Peak Daily	Peak Hourly	No. of Sites Issuing Permits	Self-Permitting Allowed?	Computerized Permit Issuance System?
Arkansas	140,000	650	54	1	Yes	No
California	135,000	600	70	2	No	Yes
Connecticut	65,000	400	50	1	No	Yes
Delaware	48,000	200	27	1	No	Yes
Florida	80,933	311	39	1	No	Yes
Georgia	175,000	1,200	110	1	No	Yes
Hawaii	7,200	50	12	4	No	No
Idaho	50,000	200	19	1	Sometimes	Yes
Illinois	225,000	1,200	200	1	Sometimes	Yes
Indiana	240,000	1,400	na	45	Sometimes	Yes
Kansas	60,000	325	30	35	Yes	In process
Kentucky	95,855	453	50	1	No	Yes
Maine	22,828	na	na	14	Yes	Yes
Maryland	103,680	500	63	1	No	No
Massachusetts	27,922	160	20	1	No	Yes
Michigan	145,000	600	67	4	No	In process
Mississippi	110,000	500	62	1	Sometimes	No
Nebraska	75,000	na	na	8	Yes	No
Nevada	33,000	112	na	1	No	No
New Hampshire	17,500	115	15	1	No	No
New Mexico	50,925	250	31	1	Yes	Yes
North Carolina	150,000	550	70	>1	No	Yes
North Dakota	25,583	99	12	19	Yes	No
South Dakota	60,000+	175	25	>18	Sometimes	No
Ohio	200,000+	1,100	150	1	Sometimes	Yes
Oklahoma	117,604	470	59	12	Yes	Yes
Pennsylvania	290,000	1,200	200	12	No	Yes
Tennessee	104,000	500	67	1	No	In process
Texas	443,000	2,000	167	1	No	Yes
Utah	75,000	300	30	9	No	Yes
Virginia	75,000	320	40	48	No	Yes
Washington	120,000	700	100	50	Sometimes	Yes
West Virginia	100,000	325	na	56	No	No
Wyoming	51,580	na	na	25	Sometimes	Yes

Computerized Permit Issuance Systems

Twenty-four of the thirty-four states that responded have implemented computerized permit issuance systems. Of those with computerized permit issuance systems, the majority (seventeen) were developed by and are maintained In House. Keep in mind, the "In House" software development costs, total costs and time are estimates because of differences in accounting procedures.

Key: na = no answer n/a = not applicable

State	Year Installed	Development Cost	Total Cost	Development Time	Implementation Time
California	1994	$400,000	$500,000	12 months	24 months
Connecticut	1996	na	na	36 months	2 months
Delaware	1985	$30,000	$100,000	6 - 12 months	12 months
Florida	1990	na	na	na	na
Georgia	1978	na	na	na	na
Idaho	1988	na	na	6 months	ongoing
Illinois	1984	$500,000	na	12 months	12 months
Indiana	1995	$70,000	$70,000	12 months	1 weekend
Kansas	1994	na	na	6 months	na
Kentucky	1988	na	na	na	na
Maine	1989	na	na	3 months	na
Massachusetts	1986	na	na	2 months	1 month
Michigan	1996	$500,000	na	na	na
New Mexico	1991	$800,000	$320,000	24 months	1 month
North Carolina	1987	na	na	na	na
Ohio	1991	$800,000	$1.6 million	12 months	1 month
Oklahoma	1995	$33,000 *	na	4 months	2 months
Pennsylvania	1965	na	> $2 million	na	na
Tennessee	na	na	na	na	na
Texas	1986	$500,000	> $1 million	15 months	1 week
Utah	1995	na	$1.5 million	na	22 months
Virginia	1993	>$100,000	na	7 - 10 months	4 months
Washington	1989	na	na	6 months	1 month
Wyoming	1994	$300,000	$500,000	18 months	24 months

. Key: na = no answer n/a = not applicable * = prototype

State	Year Installed	Development Cost	Total Cost	Development Time	Implementation Time
California	1994	$400,000	$500,000	12 months	24 months
Connecticut	1996	na	na	36 months	2 months
Delaware	1985	$30,000	$100,000	6 - 12 months	12 months
Florida	1990	na	na	na	na
Georgia	1978	na	na	na	na
Idaho	1988	na	na	6 months	ongoing
Illinois	1984	$500,000	na	12 months	12 months
Indiana	1995	$70,000	$70,000	12 months	1 weekend
Kansas	1994	na	na	6 months	na
Kentucky	1988	na	na	na	na
Maine	1989	na	na	3 months	na
Massachusetts	1986	na	na	2 months	1 month
Michigan	1996	$500,000	na	na	na
New Mexico	1991	$800,000	$320,000	24 months	1 month
North Carolina	1987	na	na	na	na
Ohio	1991	$800,000	$1.6 million	12 months	1 month
Oklahoma	1995	$33,000 *	na	4 months	2 months
Pennsylvania	1965	na	> $2 million	na	na
Tennessee	na	na	na	na	na
Texas	1986	$500,000	> $1 million	15 months	1 week
Utah	1995	na	$1.5 million	na	22 months
Virginia	1993	>$100,000	na	7 - 10 months	4 months
Washington	1989	na	na	6 months	1 month

State	System Developed By	System Maintained By	Hardware Platform	Language Written In	Hardware/Language Recommended?
California	In House	In House	PC Network	Access	Yes
Connecticut	In House	In House	Windows NT	Foxpro (DOS)	Yes
Delaware	In House	In House	Digital VAX	VAX Basic	No
Florida	In House	In House	LAN/PC	Cobol (XDB)	No
Georgia	In House	In House	VMS	Cobol	No!!
Idaho	In House	In House	Mainframe	CICS/GenROL	Yes
Illinois	In House	In House	Mainframe	na	na
Indiana	In House	In House	IBM 3090 170J	CA-IDMS/Cobol	No!!
Kansas	In House	In House	Mainframe	na	Yes
Kentucky	na	na	na	na	na
Maine	In House	In House	Mainframe	Cobol 68	No
Massachusetts	In House	In House	PC	R:Base	No
Michigan	GDS	In House	Novell	na	na
New Mexico	In House	In House	AS/400	Synon/Cobol	Yes
North Carolina	In House	In House	Mainframe	Assembler	No
Ohio	Vendor	In House/Vendor	Novell	XQL	Yes
Oklahoma	In House	In House	486/50	Foxpro	Yes
Pennsylvania	In House	In House	Mainframe	Cobol/C++	na
Tennessee	na	na	na	na	na
Texas	In House	In House	PC/LAN	Clipper PC	No
Utah	In House/Vendor	In House	Unix	Informix	Yes
Virginia	In House	In House	DOS	DOS based	na
Washington	In House	In House	IBM/Mac	Omnis	No
Wyoming	Vendor	In House	IBM 3270	Cobol	Yes

Additional Comments - Describing Computerized Permit Issuance Systems
(For contact names and numbers, refer to "Permit Fee Structure")

State	Comment
California	Developed a database with the ability to query by vehicle dimensions to provide a listing of route constraints.
Delaware	There are better tools available today, rather than using a Digital VAX platform written in VAX Basic.
Florida	The system partially computerized permits and permits issuance.
Idaho	Although there is only one office which runs the computerized permit issuance system, other offices have inquiry options to view the information. Also, the system is constantly being improved upon.
Indiana	Would not suggest using this environment. If we were doing this now, we would likely select PowerBuilder and an oracle RDBMS solutions running on an Alpha platform under Windows NT.
Michigan	Our companies on account and districts will be rejected first on their end, for errors. They can also track status of their applications.
North Carolina	Our current on-line permitting system is being rewritten. The programs will be rewritten from Assembler to Cobol and the current VSAM file will be reformatted to several DB2 tables.
Oklahoma	The present system is installed in the Oklahoma City office only as a primary testing system. A program is being written for a totally automated system.
Utah	Our system includes permits (oversize/overweight, trip and fuel), citations, warnings, and shift accounting. All locations are connected through a (frame relay) wide area network.
Washington	Our system is stand alone. We are currently exploring the development of a network system.

Permit Fee Structure

Every state has its own unique way of issuing permits as well as assessing charges, especially for oversize and overweight loads. The following is a brief summary of the fee structures throughout the United States. If further information is needed please contact the respective person from the state in question. (OW = overweight loads).

State	Fee Structure Summary	Contact	Phone Number
AR	$12 basic fee plus ton per mileage	Terry Nanney	501-569-2387
CA	$16 for 5 days; $90 annual	Bob Martin	916-654-3093
CT	$23 base fee; $3 wire fee (single trip permit)	Linda Ahl Hope	860-594-2880
DE	$5 extra for every 8000 lbs. over registered wgt.	Charles E. Johnson II	302-739-4374
FL	$5 base fee plus overweight mileage charge	William Albaugh	904-488-8814
GA	Multilayered by legislation	Jerry Gossett	404-656-7572
HI	$5, $10, $25 based on truck weight and width	Charles S. Yonamine	808-587-2183
ID	Base fee plus a ton mile tax for OW loads	Regina Phipps	208-334-8418
IL	Varies on mileage and weight	Joe Hill	217-782-2984
IN	$20 or $30 plus a mileage charge for OW	Ken Michael	317-232-5553
KS	$5 base fee, $125 annual oil permit	Steve Zimmerman	913-296-3618
KY	Overweight & oversized trucks, $60	Patricia A. Knoll	502-564-7150
ME	$3 - $15	Virginia M. Jewett	207-287-8632
MD	$30 for <45 tons;$5 per additional ton	Darlene Eide	410-582-5727
MA	$15, 5 days (1 trip); $300/yr. construction equip.	Steve Frymer	617-973-7345
MI	$7 single trip; $10 extended trip	Linda Taylor	Unavailable
MS	$10 for oversized; overweight mileage charge	Tommy Dorsey	601-944-9239
NE	Predefined fee structure per permit	Ron Kontus	402-479-4536
NV	$15 oversized (1 trip); $60 per 1000 lbs for OW	Jan Christopherson	702-888-7070
NH	$5 base fee; for OW, extra $2 per 5 tons	Kaye L. Hoyt	603-271-2691
NM	$15 single trip	Patricia Carshaw	505-827-0302
NC	$10 single trip	Tammy Denning	919-733-4740
ND	$10 base fee; large OW, extra $70 per ton	Dennis L. Erickson	701-328-4341
OH	$10 base fee; prorated by dimension and weight	Mike Barker	614-777-0244
OK	$20/$40 base fee plus $5 per 1000 lbs for OW	Ronald G. Knox	405-425-2210
PA	$15 for oversized plus OW mileage charge	Walter Knerr	717-783-6473
TN	$15 for oversized plus OW mileage charge	Carlos Downey	615-741-5196
TX	$30 base fee plus highway maintenance fee	Monty Chamberlain	512-465-3500
SD	Varies	Pat Rabenberg	605-698-3925
UT	$65 - $450 for oversized & overweight loads	Rick Chasby	801-965-4528
VA	$12 single trip	William Childress	804-225-3676
WA	$10 base fee (min) plus overweight charge	Barry Diseth	360-664-9497
WV	$20 base fee; overweight mileage charge	Courtney Joslin	304-558-3736
WY	$15 base fee; oversize and OW mileage charge	Bill Harris	307-777-4876

Present Automated Routing System

No state responded which had a fully operational automated routing system. A few respondents are in the process of developing such a system. Most states that do not have automated routing are very interested in obtaining an application of this type.

Key: na = no answer n/a = not applicable

State	Automated Routing?	Interested?
Arkansas	No	Yes
California	No	na
Connecticut	No	Yes
Delaware	No	na
Florida	In process	n/a
Georgia	No	Yes
Hawaii	No	No
Idaho	No	na
Illinois	No	Yes
Indiana	No	No
Kansas	In process	n/a
Kentucky	No	Yes
Maine	No	Yes
Maryland	No	na
Massachusetts	No	No
Michigan	Proposed	n/a
Mississippi	No	Yes
Nebraska	No	Yes
Nevada	No	Yes
New Hampshire	No	na
New Mexico	No	Yes
North Carolina	No	Yes
North Dakota	No	Yes
Ohio	Not usable	Yes
Oklahoma	No	Yes
Pennsylvania	In process	n/a
Tennessee	No	na
Texas	No	na
Utah	No	Yes
Virginia	No	na
Washington	No	na
West Virginia	No	Yes
Wyoming	No	na

Criteria Used for Permit Routing

Several states responded to the question related to the parameters that should be considered in an automated routing system. Most states responded that the following parameters should be considered in a routing routine:

Truck Parameters:

- Overall Height
- Overall Width
- Overall Length
- Overall Weight
- Truck Axle Configuration and Weights

Bridge Parameters:

- Vertical Clearance
- Horizontal Clearance
- Structural Capacity
- Posted Bridge

Highway Parameters:

- Lane Width
- Shoulder Width
- Highway Classification
- Construction Constraints

Two additional parameters not on the survey, but important:

- Tire Load per Inch
- Spring Thaw Data

Additional Comments - Automated Routing Proposals and Criteria

(For contact names and numbers, refer to "Permit Fee Structure")

State	Comment
California	Truck, bridge, and highway parameters are to be considered for software selection of automated routing systems. Our present database can be queried to list the parameters for route constraints. Electronic maps are maintained by creating "hard" maps which are exported to a GIS system.
Florida	Truck, bridge, and highway parameters are to be considered for software development which will begin in September 1996. Electronic maps will be maintained as a GIS application (currently being developed).
Georgia	Electronic maps will be maintained as a GIS application (currently being developed.)
North Dakota	Extremely heavy loads are approved through the NDDOT Bridge Division who utilizes a computer program.
Ohio	We currently have an automated routing system which cannot be used due to an incomplete database. Electronic maps are maintained through road and bridge inventory.
Oklahoma	We would like the automated routing to interface with computerized permit issuance system.
Pennsylvania	Are currently in the process of developing an automated routing system with truck, bridge and highway parameters taken into consideration. Electronic maps will be maintained under GIS and Autofax. The new automated routing system will also interface with the computerized permit system.
Utah	Willing to exchange current permitting system for one that includes routing. Planning to build an automated routing system using Intergraph or Arc/Info. This system should be allowed to interface with the permitting system. Currently, electronic maps are maintained through a CADD system.

Final Comments

At the end of the survey, the respondents were asked to provide any additional comments on the topic of automated routing or their current permit issuance system.

State	Comment
California	Keep it simple. Allow human interaction for logical decisions. (Regarding a new automated routing system.)
Idaho	Our system is fully automated except for vertical clearances and extremely heavy loads.
Illinois	We would like an automated routing system that would interface with our bridge database which would reduce time for bridge analysis.
Maine	The computerized permit issuance system works excellent. The monthly statements are also generated ready to mail from this system.
Michigan	We are very excited about our upcoming computerization.
Pennsylvania	We have been trying to automate routing for several years with full support by executive staff.
Texas	Texas is extremely interested in receiving information regarding automated routing.
West Virginia	We presently use Superload by Beilfus for anything over 110,000 lbs. It works great for superload analysis over bridges on route. It does not route for us. We are presently looking into automation. The structures department is not willing to accept present routing currently in the market. They want every bridge analyzed.

Conclusion:

The results of the survey show several similarities that are established throughout the United States, regarding individual permitting and routing systems. Five major areas of focus were considered in this survey: 1) the present permitting system used by the various DOT offices; 2) whether this permitting system was computerized and details of their current system; 3) the present fee structure used when assessing charges for permits; 4) the proposed and present criteria for an automated routing system; and 5) the details of the automated routing systems used. The responses for each focus area are summarized below.

Present Permitting System

The magnitude of permits issued varies greatly from state to state and shows no definite correlation between volume of permits per year and the use of a computerized permit issuance system. Five high volume states (issuing more than 75,000 permits per year) have not yet computerized their permitting system, while all other high volume states and several lower volume states are using a computerized permit issuance system. Also, there is no correlation between the number of sites issuing permits and the use of a computerized system or the allowance of self-permitting. However, one half of the states issue permits from a single site while approximately half of the states are currently allowing some sort of self-permitting.

Computerized Permit Issuance Systems

Twenty-four of thirty-four states are currently using a computerized permit issuance system, and almost all of these systems were developed since the late 80s. Total costs for the computerized permit issuance systems ranged from $70,000 to $2 million; but, also realize that almost all of these systems were developed "In House" which means these may be cost estimates and not actual figures.

Both development and implementation periods ranged from one month up to three years. Nearly all of the computerized permit issuance systems were developed and are maintained within the individual state's Department of Transportation. More than half of the states do not recommend the language or database management system used to develop their permitting system. Development languages on the mainframe included VAX Basic, COBOL, Assembler and others. For microcomputer based systems, development languages include C++, Clipper, Informix, Access, FoxPro and others. With today's technology, some of the development languages and platforms are becoming outdated, which leads to many states wishing their system was developed in a more modern computer environment.

Present Fee Structure

There are a wide variety of permit charges per state. The most common way for assessing permit charges include a base fee with an overweight and oversize ton-mileage charge. A more detailed list can be acquired by contacting each state through their respective contact person.

Present Automated Routing System

None of the thirty-four states responding have a fully operational automated routing system. However, all but three states were interested in implementing such a system. More notably, four states are currently in the process of developing an automated routing system application.

Criteria for Routing System

Since none of the respondents had a fully operational routing system, very few respondents answered this question. However, all of the respondents checked most of the truck, bridge and highway parameters listed on the survey. Some states would like a routing system to interface with their computerized permit issuance system and the electronic maps to be maintained in a Geographical Information System.

Summary

Most of the responding states are currently utilizing a computerized permit issuance system. None of the respondents have an operational automated routing system, four are developing one, and the majority of the remaining states are interested in developing one.

Task 3 Interview South Dakota Personnel involved in Permitting to Quantify and Outline the Existing Permit Process

3.1 Background

On June 25 - 26, 1996, Carl E. Kurt, Kyle J. Archer and Yanning Zhu from EnGraph interviewed personnel from the South Dakota Department of Transportation and Highway Patrol. These interviews were conducted with individuals or small groups. There was no formal format for the interviews. Personnel were encouraged to discuss any subject related to the project. However, comments regarding expectations and requirements of the proposed vehicle routing and permit system were encouraged. The availability of data required to support the proposed system was also discussed.

3.2 Summary and Conclusions from Interviews

All persons interviewed by the EnGraph team were very helpful and forth coming with information regarding the potential development of an automated permitting and routing system for overweight/overheight vehicles. Basically, the SD Highway Patrol and Department of Transportation currently have a paper system to issue approximately 60,000 permits in twenty two different categories and 70,000 books of permits annually. While the system is working due to the professionalism of the staff, there are many inefficiencies in the process. Tools and data required by management to implement more efficient policies are not easily available. Because of the heavy work load by the permitting team, the effort allocated to vehicle safety inspections in Sisseton has been significantly reduced. This is especially true during the daytime shift. This policy results in reduced safety for all persons traveling South Dakota highways and streets. Other issues such as the use of hand tools (maps, past approvals, etc.) for selection of approved routes were observed.

Several different configurations of the proposed computerized permit and routing system were considered in the study. A distributed approach to permit issuance, where several different sites issue permits, has worked very well with the existing paper system. As the state considers a computerized system, this approach to permit issuance may be significantly more difficult to implement with a computerized permit system. When every thing works, the distributed system would be great. Since Ports of Entry are generally located in isolated, rural areas, there is considerable concern for the availability of technical support for hardware, software and telecommunication systems.

After careful consideration, it is recommended that the proposed computerized system be housed at a single location. The single site location for permit issuance is recommended for two reasons. At most rural sites, computer and telecommunications support is rather limited. The state should plan on providing technical support of the proposed computerized permit system. This support would be more efficient if the entire system was located at one site. Access to the system from remote sites such as Ports of Entry, four Highway Patrol District Offices, mobile units, HP District 4 Headquarters and DOT's Central Office should be provided by modem and/or Internet. Efficiency of permit issuance staff and better support to the trucking industry should be improved with the dial up modems and the Internet access.

Because of the experience available at the Sisseton Port of Entry, there is significant justification for keeping it there. However, support of the facility would probably be significantly easier if it were housed in Pierre. The telecommunications and database infrastructure appear to be better at Pierre than at Sisseton.

The effort presently conducted by the DOT in developing a GIS map could be very useful in developing the database required to support the automated routing procedure. Since interstates and other divided highways are represented by two lines, it will be much easier to implement routing functions. One feature not included in the GIS database is highway interchange definitions and data. Since South Dakota is a relatively rural state, it would not be a major effort to add sufficient interchange information to the database to support the routing function at a later time.

Through the proposed system, data in existing databases could be added to the GIS map. This data includes pavement and bridge information. A more thorough discussion of this will be presented in the Task 4 Report.

South Dakota has relatively flexible rules for routing vehicles. All but six bridges have been included in a Bridge Analysis and Rating System (BARS) database, and influence line coefficients are readily available in electronic form. We would anticipate inclusion of bridge analysis "on the fly" not to be a significant barrier to the proposed routing system.

Several benefits of a computerized routing and permitting system were identified. While the improvement of services to the trucking industry through a more efficient and robust permitting process is a definite benefit, numerous other benefits for South Dakota were also identified. They include: safer approved routes by checking all bridges for a specific truck configuration rather than spot checking bridges as presently conducted; development of alternative routing strategies such as "least damage"; better and more efficient report generation; better management based on data contained in these reports; and the ability to study existing and alternative fee structures. Finally, an automated permit and routing system could relieve the existing staff of the burden of a manual system. Each benefit should result in a safer highway system for motorists in South Dakota.

At the conclusion of this Task, a document has been prepared to present the requirements for a proposed permit and routing system. This document is presented as a draft to be used by SDDOT and Highway Patrol as it develops its requirements document.

A summary of each of these interviews follows.

3.3 Interview Organization: Highway Patrol

Interviewees: Robert Miller and Pat Rabenberg

Historically, the South Dakota Highway Patrol has functional responsibility for issuing permits for overweight and overheight vehicles using a set of criteria developed by the South Dakota Department of Transportation. While there is an administration function located at Highway Patrol's District 4 Headquarters, the Sisseton Port of Entry has been the central office for issuing permits for overweight and overheight vehicles. However, permits are also issued from other Ports of Entry, Headquarters, and mobile units. Throughout the interview, there was no compelling issue identified that would recommend a change in the organizational structure if an automated permit routing system was implemented.

For the 1995-96 fiscal year, a total of 57,876 individual permits and 69,660 permit books were issued. Approximately 16,300 individual permits were issued through the Sisseton Port of Entry. Another 14,300 were issued by the Sisseton Port of Entry through the telecopier services such as ComData, Transceiver, EDS, etc. The other four Ports of Entry issued approximately 5,000 permits each. A summary of the permit effort for the Highway Patrol is presented in Figure 3.1.

South Dakota has nine mobile crews that do on site inspections and issue some permits. The total number of permits issued by these mobile crews varied from 117 to 534 annually. A total of 2,400 permits were issued by the mobile crews. Four individuals have responsibility to issue permits on a part time basis. The number of permits issued by these individuals is nominal (89 annually). Finally, general Highway Patrol officers also issue approximately 5,000 permits.

The Sisseton Port of Entry is the only Port of Entry that does permit routing.

In addition to those permits, the Highway Patrol also issues Books of Permits. These Permit Booklets are for the following permit types: over 80,000 pounds, telephonic, longer combination vehicles (LCVs) and commercial license trips. Approximately 70,000 permits are issued this way. The self permitting booklets are issued in books of ten permits. However, truckers must receive approval by calling the Sisseton Port of Entry before using individual permits.

The Sisseton Port of Entry is presently supported by 11 employees, open 24 hours per day and organized into three shifts. The 8 am to 5 pm shift work load is presently very heavy. The physical size of the existing building does not easily allow for the addition of additional personnel.

Approximately 50% of the site manager's time is spent issuing permits. In addition, approximately 80 - 90 % of the assistant manager's time is also spent issuing permits. All other people assigned to the day shift are involved in the permit issuing process on a full time basis. Despite the heavy work load, the morale in the Port of Entry was described as being very high.

ACTIVITY REPORT
FY 96 TO DATE
COLLECTIONS

6-1-95 TO 6-1-96

PRD BIJ	NO.	TON MILE	NO.	FUEL PERMITS	NO.	OVERSIZE PERMITS	NO.	HARVEST PERMITS	NO.	30 DAY COM LIC	NO.	MISC PERMITS	NO.	TOTAL COLLECTIONS
MCC	3,604	$54,030.00	1,208	$24,160.00	1,340	$33,515.77	1	$75.00	424	$12,657.00	94	$1,820.00	6,671	$126,257.77
SF	3,051	$45,765.00	1,070	$21,300.00	1,494	$42,495.40	18	$1,350.00	311	$12,202.00	50	$1,210.00	6,194	$124,402.40
SIS	4,975	$74,625.00	1,225	$24,500.00	9,539	$321,647.72	210	$15,750.00	330	$12,627.00	5	$105.00	16,284	$449,334.72
TLF	2,916	$43,745.00	800	$16,000.00	1,625	$44,161.33	29	$2,175.00	141	$6,191.00	146	$1,765.00	5,657	$114,037.33
YHK	422	$6,330.00	189	$3,780.00	410	$12,794.00	10	$750.00	88	$3,347.00	50	$697.00	1,169	$27,698.00
TLC	3,674	$55,115.00	1,158	$23,175.00	9,489	$525,232.86	0	$0.00	0	$0.00	2	$80.00	14,323	$603,602.86
PRT	18,642	$279,610.00	5,650	$112,995.00	24,097	$979,847.16	268	$20,100.00	1,294	$47,024.00	347	$5,757.00	50,298	$1,445,333.16
AUR	103	$1,545.00	49	$980.00	134	$4,872.64	31	$2,325.00	56	$2,083.00	4	$230.00	377	$13,035.64
BF	80	$1,200.00	21	$420.00	43	$1,200.00	6	$450.00	38	$1,262.00	10	$500.00	198	$5,032.00
HIT	80	$1,200.00	25	$500.00	67	$2,880.00	5	$375.00	33	$1,023.00	11	$530.00	225	$6,508.00
PRR	85	$1,275.00	31	$620.00	123	$4,820.80	25	$1,875.00	36	$682.00	2	$90.00	302	$9,362.80
RC	37	$555.00	13	$260.00	50	$1,350.00	5	$375.00	9	$250.00	1	$140.00	117	$2,930.00
VRM	79	$1,155.00	39	$780.00	44	$2,020.00	0	$0.00	14	$298.00	1	$5.00	177	$4,258.00
WIH	120	$1,800.00	54	$1,080.00	262	$11,077.00	6	$450.00	84	$2,517.00	8	$400.00	534	$17,324.00
H/F	123	$1,830.00	121	$2,400.00	144	$4,672.48	39	$2,925.00	31	$733.00	3	$100.00	459	$12,659.48
HWL	706	$10,560.00	353	$7,040.00	867	$32,892.92	117	$8,775.00	305	$8,847.00	41	$1,995.00	2,389	$70,109.92
HONDE	2	$30.00	2	$40.00	5	$100.00	0	$0.00	5	$138.00	0	$0.00	14	$308.00
WIPF	10	$150.00	3	$60.00	14	$720.00	0	$0.00	10	$272.00	0	$0.00	37	$1,202.00
STAUM	7	$105.00	4	$80.00	16	$740.00	0	$0.00	0	$0.00	0	$0.00	27	$925.00
ZENBE	6	$90.00	0	$0.00	2	$40.00	0	$0.00	3	$64.00	0	$0.00	11	$194.00
MCEO	25	$375.00	9	$180.00	37	$1,600.00	0	$0.00	18	$474.00	0	$0.00	89	$2,629.00
MC	19,373	$290,545.00	6,012	$120,215.00	25,001	$1,014,340.08	385	$28,875.00	1,617	$56,345.00	388	$7,752.00	53,742	$1,518,073.08
4SHQ	86	$1,125.00	14	$280.00	465	$20,160.00	235	$17,625.00	43	$1,378.00	123	$6,020.00	966	$46,588.00
PTRL	768	$11,640.00	130	$2,600.00	2087	$75,594.21	327	$24,525.00	505	$18,459.00	317	$9,536.00	4,134	$142,354.21
TOT	20,227	$303,310.00	6,156	$123,095.00	27,553	$1,110,094.31	947	$71,025.00	2,165	$76,182.00	828	$23,308.00	57,876	$1,707,014.31

ARRESTS & FINES

PRD BIJ	TRUCKS INSPECT	TRUCKS WEIGH	TRUCKS MEASRD	ARST SU	ARST OS	ARST TOTAL	FINES SU	FINES OS	FINES TOTAL
MCC	232,392	160,287	1,050	262	2227	2489	$40,173.00	$265,226.00	$305,397.00
SF	172,720	147,519	314	209	1381	1590	$40,969.00	$197,587.15	$238,556.15
SIS	73,500	65,877	264	47	760	807	$14,807.00	$112,816.00	$127,623.00
TLF	159,850	124,518	2,024	220	1553	1773	$39,577.50	$175,934.10	$215,511.60
YHK	56,929	39,779	281	151	247	398	$32,476.00	$39,623.00	$72,099.00
PRT	695,391	538,000	3,933	889	6,168	7,057	$168,002.50	$791,186.25	$959,186.75
AUR	10,197	5,707	244	217	339	556	$46,283.00	$40,368.15	$86,651.15
BF	11,635	7,339	260	136	157	293	$27,095.80	$31,003.65	$58,099.45
HIT	7,587	5,569	79	276	246	522	$37,942.65	$28,355.95	$66,298.60
PRR	6,059	3,687	189	220	211	431	$39,298.05	$27,255.95	$66,554.00
RC	11,875	9,030	131	109	171	280	$31,653.60	$26,093.87	$57,747.47
VRM	9,142	4,903	64	131	335	366	$24,670.75	$27,300.30	$51,770.05
WIH	8,097	3,731	288	266	469	744	$34,698.01	$46,350.00	$81,048.81
H/F	9,281	4,630	163	119	390	509	$19,392.35	$56,964.00	$76,356.35
HWL	73,683	46,618	1,818	1,455	2,252	3,707	$261,184.11	$285,700.37	$545,334.48
HONDE	433	323	5	10	23	33	$1,432.00	$2,418.10	$3,850.10
WIPF	755	402	9	22	38	60	$5,496.00	$5,904.75	$11,400.75
STAUM	402	165	7	5	20	25	$525.00	$3,995.75	$4,520.75
ZENBE	663	222	14	29	34	63	$5,623.60	$4,505.00	$10,128.60
MCEO	2,253	1,112	35	66	115	181	$13,076.60	$16,823.60	$29,900.20
MC	771,527	587,727	6,483	2410	8,535	10,945	$442,263.21	$1,093,710.22	$1,534,421.43

BOOKS OF PERMITS

OVER 80,000	47,570	$94,680.00
TELE[illegible]	7,920	$156,100.00
TWIN/TRIPLE	13,590	$135,900.00
COMMERCIAL	580	$8,700.00
TOTAL	69,660	$395,380.00

TOTAL COLLECTIONS PERMITS & BOOKS	$2,102,394.31

Figure 3.1 Summary of 1995-96 Annual Permits

Ways to improve the productivity of the Sisseton Port of Entry and services provided to the trucking industry were discussed. If the permit issuance system was computerized, improved productivity of the Port of Entry would be expected for all reporting functions. Other points of discussion involved permittees filling out their own permit application using computers and then accessing the system using the Internet or modems. Pursuit of these options was encouraged by the interviewees.

Each shift currently prepares a shift report that requires approximately one half hour per shift. With three shifts, this function requires three reports per day per Port of Entry. In addition, site management must prepare a daily report which requires approximately two hours per day of management time. Finally, Highway Patrol's District 4 Headquarters is spending three to four hours per week conducting billing reports and then two or three hours per month to cover billings from telephonic permits. Additional staff time is required at Headquarters to write checks (four hours per week) and to generate receipts (four to five hours per month).

The Highway Patrol offices use computers during the course of business. The Sisseton Port of Entry also uses computers to complete many functions. However, the level of usage and basic familiarity with computer principles is not particularly high.

A significant portion of the interview related to the discussion of the current routing process. While the present manual process works in the majority of instances, some critical situations do occur. For example, approval for some permits has been given when a more thorough review would have denied the request.

To assist the staff, the Department of Transportation provides a series of maps for use by the Sisseton Port of Entry. For example, a bridge load map is provided and updated annually. Also, construction zone (See Figure 3.2) and spring thaw (See Figure 3.3) maps are provided on a continual basis. Samples of these maps are attached.

The Sisseton Port of Entry is provided a series of truck configurations and approved routes. When a permit is requested for a new truck configuration, Sisseton personnel check this book of previously approved routes and make a decision on whether to issue the permit. In those cases where they are not comfortable with making this decision, the permit request is sent to the Bridge Design office at DOT Headquarters for further analysis. Approximately 50 percent of the permits for overweight trucks require assistance from the Office of Bridge Design. Thus, the support effort required by the Office of Bridge Design would be reduced accordingly if the proposed system were implemented.

Through the interviews, several issues were found that are causing operational problems in Sisseton. The most critical one is the lack of time to conduct vehicle safety inspections of vehicles entering South Dakota. Because so much time is spent issuing and managing the permit operation, very little time is left to conduct these inspections. Based on the inspections that are conducted, management is convinced that trucks with serious safety defects are not being found because of the lack of inspections. Thus, trucks with serious safety deficiencies are using South Dakota highways. While an incident could not be identified that was directly attributable to an

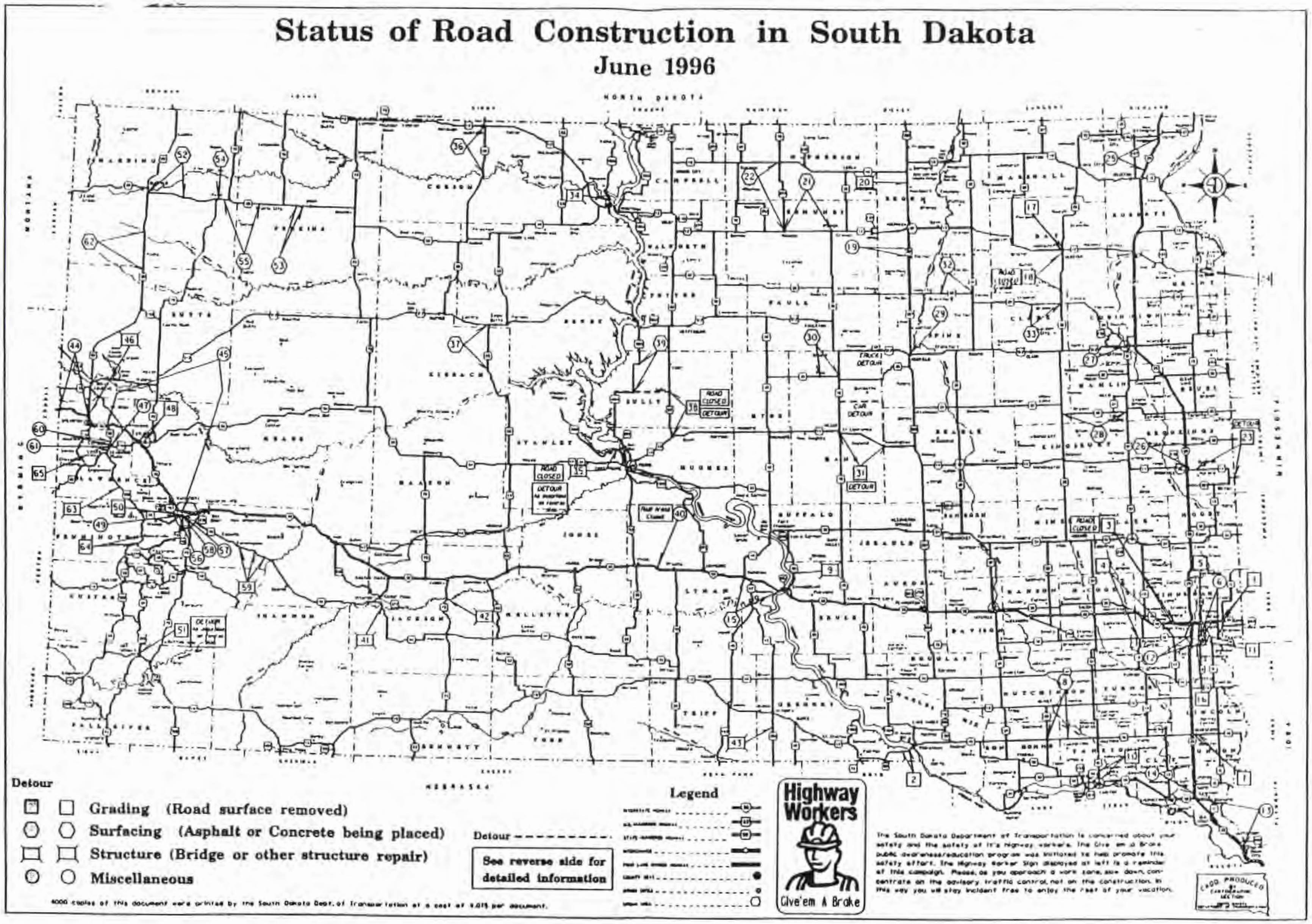

Figure 3.2 Construction Map

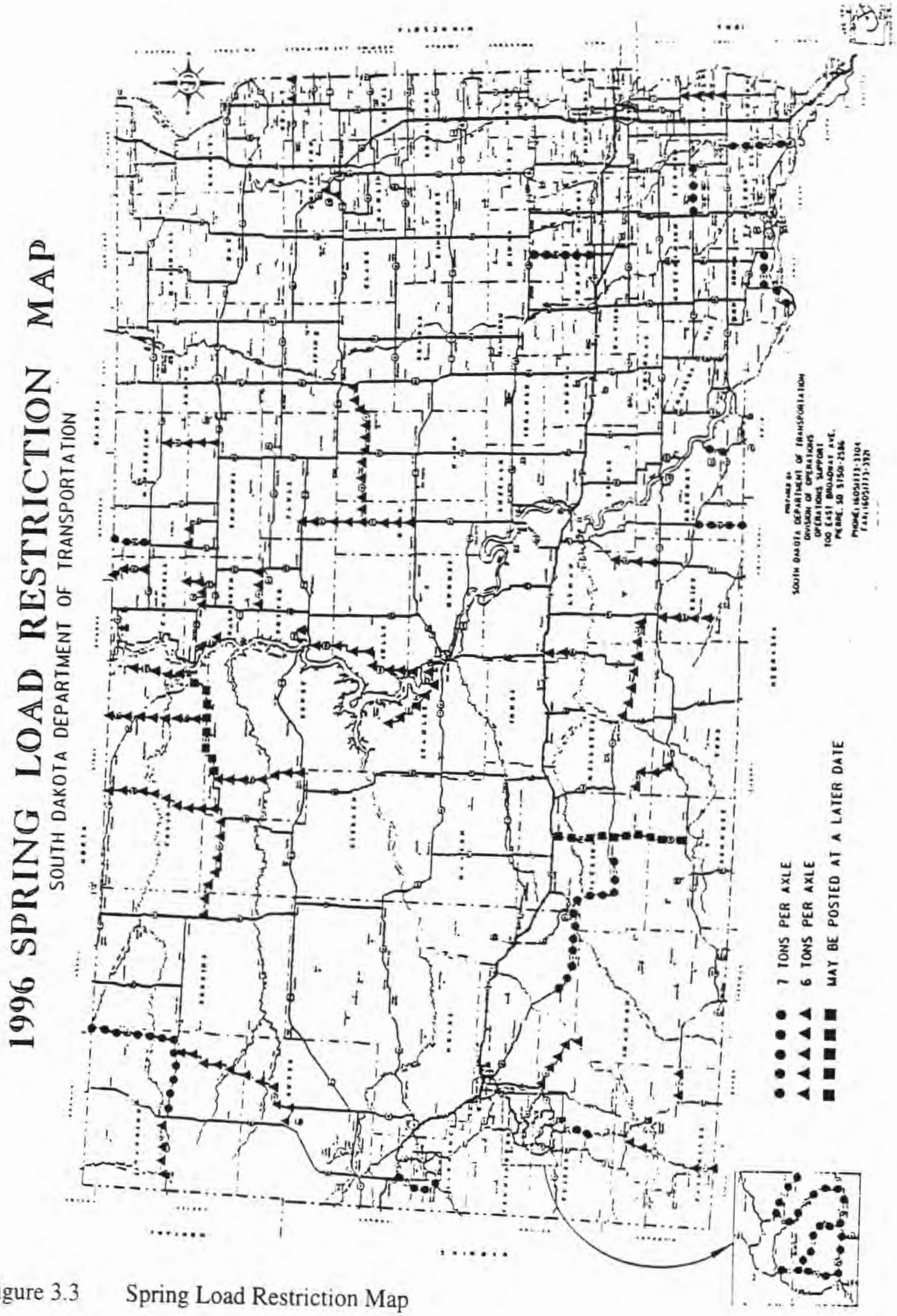

Figure 3.3 Spring Load Restriction Map

uninspected truck safety deficiency, it was agreed that a serious accident is likely to occur in the future.

A second issue involves the reporting functions required by site management. Since the present permit system is essentially a paper system, it is very difficult to collect the data required to support good management decisions. While the use of spreadsheets has made the reporting function somewhat easier, collection of the data for spreadsheets is a tedious manual operation. When asked if management could gage what time of day the most permits were issued, or what the maximum number of permits issued at peak times, management explained that while this information would be very valuable, there is no way to determine the answers to these questions at this time.

The time required to issue a permit using present procedures appeared very reasonable. One issue that does appear to be a major productivity hindrance is the approval cycle when payment of permit is made by credit card. In these cases, state personnel must make an 800 phone call to get approval from the approval agency (COMData). This process may require three to twenty minutes before approval is gained. In nearly 60 percent of the cases, personnel are put on hold for approximately 3 minutes. A call to the COMData account manager may help to eliminate this problem with or without an automated permit and routing system.

The present phone system within the Sisseton complex was described as "adequate". Phone lines into the site would support a computerized system with modems and Internet access. There may be a need to upgrade the phone system if a computerized permit system was installed at this site.

An analysis indicated that the present staffing for the Port of Entry appears to be very reasonable. While management of the Sisseton Port of Entry was very complimentary of the present staff, the stress of the present system has taken a toll on them. They realize that their job can have serious consequences if not done properly. Since they are using manual methods to route vehicles, they are very aware that they must make difficult judgment decisions everyday when routing overweight and overheight vehicles. Unfortunately, no one in the Port of Entry has a technical background to make these judgments. They are making these decisions based on experience and good judgment.

When asked if the staff would welcome the use of computers in the permit issuance procedure, we were assured that the staff is looking forward to the time when the Port of Entry is computerized. Since changing policies and methods can sometimes create dissension, it is refreshing to observe a staff that is looking forward to change and new challenges.

3.4 Interview Organization: GIS/Computer Information System

Interviewees: Frank Cooper, Willie Komes, Dennis Winters, Jerry Jacobson and Dan Houch

South Dakota is presently implementing a Geographical Information System (GIS) supported by two cartographers. While the GIS plan is to support decision mapping, the basics included in these maps will provide significant assistance while developing a permitting system which includes a vehicle routing option. Depending upon which approach a permit system vendor uses to develop an automated truck permit routing system, the base map and the associated data could be very useful in developing the routing system.

Each roadway segment was modeled as a single line except for divided highways, such as interstates, that were modeled as double lines. This approach has been found to be very useful when developing routing applications for oversize/overweight vehicles. The highway entities were digitized from 1:200,000 maps. This is more than adequate for routing purposes.

It would be very beneficial if the proposed permit system selected by South Dakota could take advantage of this electronic base map. That would allow South Dakota to gain additional use from its GIS investment and to help validate existing highway and bridge feature data.

The South Dakota map contains approximately 667 graphical elements (road segments) and approximately 364 routes. It also has approximately 15,820 control points at highway intersections and other key points. EnGraph asked that a sample of these points be exported with latitude and longitude data included. This data was geocoded with another GIS system, and the data overlayed very nicely with another state highway map. This is very good. See Figure 3.4 . However, only one name is currently supported for each segment. Eventually, each segment would need all highway names (subroutes) attached to the segment.

One important feature that is not in the SD GIS map is interchange data. Again, depending upon how the final routing application is built, the interchange data may be required. Tools are available to automatically drop the interchange information into a highway map. The existing interchange maps would be very beneficial to complete this task.

The location reference system used in the South Dakota databases is the Mileage Reference Marker (MRM). This makes the attachment of bridge and pavement data to a routing map relatively easy. A more complete discussion of the data required to support a routing function will be presented in Task 4.

South Dakota Department of Transportation is already collecting a wide variety of pavement and bridge information. Bridges are located relative to the MRM location reference system. Pavement information is also related to the MRM reference system. In

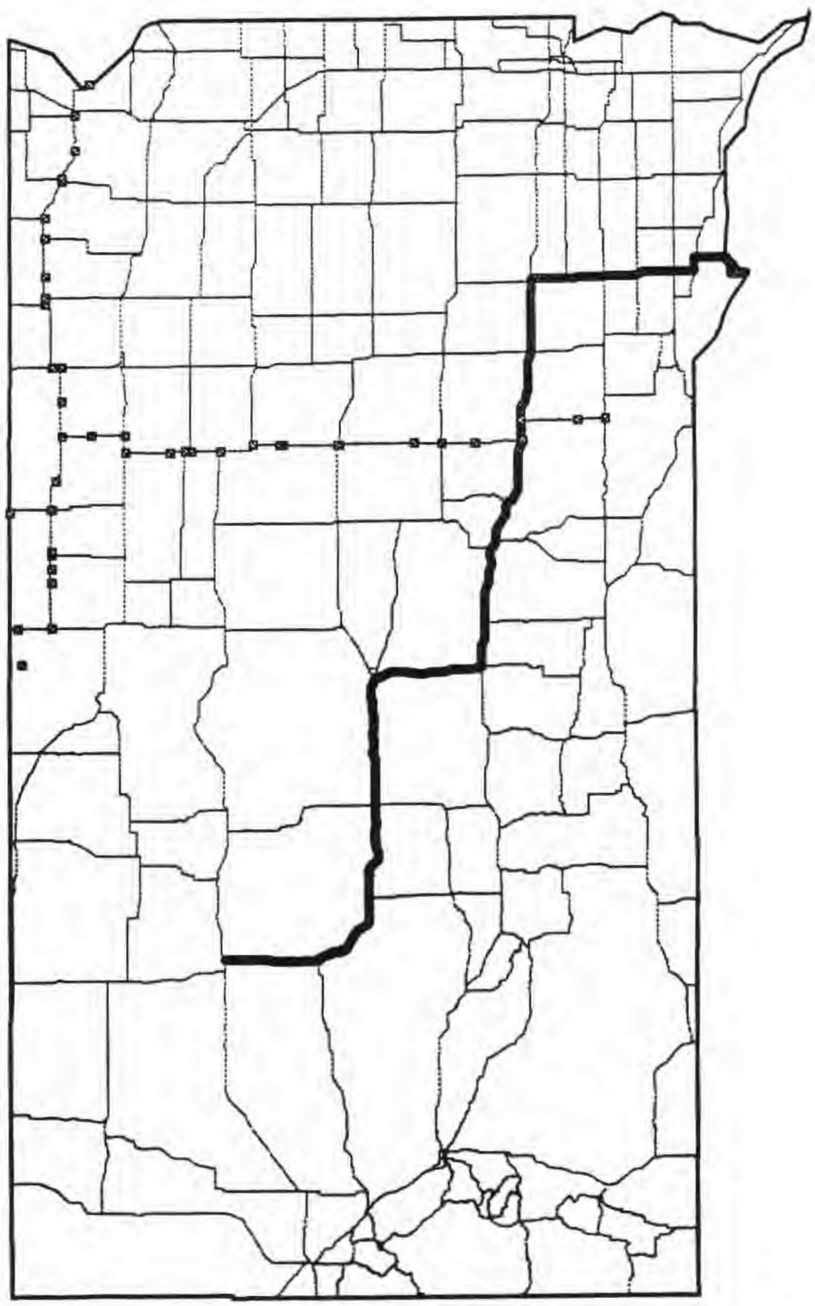

Figure 3.4 Overlay of Control Point Sample and State Highway Map

general, the data available in the SD database is thought to be accurate and of high quality. EnGraph has made no attempt to verify the accuracy of this data.

A brief discussion related to minimization of damage to pavement and bridges as a criteria for routing vehicles was conducted. One specific recommendation is to limit the load per tire inch to 500 pounds. Another suggested approach to minimizing damage was to select routes based on the Pavement Structure Number developed by the pavement management system.

Other issues discussed were construction zones and realignments. Construction zone information needs to be updated monthly In fact, bi-weekly updates may be necessary. A total of 12 to 14 reconstruction/realignments per year can be expected. We would suggest that the proposed system handle construction data separately from the basic highway map. That way, the proposed system could easily change the construction database without modifying the base map. However, vendors may have alternate approaches for handling this relatively short term data.

Three levels of highway data were identified. They are: 1) baseline data that, in general, does not change with time, 2) Planned program construction where long lead times are available, plans are made, etc., and 3) Temporary restrictions that occur on a shorter notice and for a short duration.

At present, this information is sent to the permit sites through a traffic control construction map developed in MicroStation.

Presently, South Dakota stores a wide variety of information regarding bridges and pavements on a mainframe database. It was quickly agreed that the proposed permit system should not be directly linked to this database. Many computer related and operational considerations would lead one to support a separate database to support the proposed permit system.

It was agreed that the recommended approach for handling permit system data would be to down-load the required data from the main frame database into a mutually agreed upon format and then upload it into the permit system. One would anticipate that this process would occur approximately every six months. However, there is no technical reason for the time interval to be for a longer or shorter time interval.

While it was premature to discuss the exact rules for routing vehicles, typical requests for data were found in the current database. Thus, EnGraph has not identified any additional data collection effort required to support a routing application.

All Ports of Entry are networked together with 56K lines. As outlined in the proposed systems document developed by EnGraph, we do not anticipate a large amount of data going between the different sites. Some of the emergency type data should be transmitted immediately. However, all of the other reporting functions could occur at slow usage times. It would be very advantageous if these standard data transmissions would be automated.

With an automated permit and routing system, a fair amount of data would be transmitted at the six month time frames when the base map route information is updated. Since this transfer could occur during non peak times, the impact on the network would be minimized.

It was agreed that Windows NT would be the preferred operating system. It would be anticipated that the proposed permit and routing management system would work on microcomputers.

A brief discussion was conducted regarding potential benefits of an automated permit and routing system. Since using data is one excellent way of finding and correcting errors in a database, this proposed system could be one use for the existing database. In addition, it would improve the reliability of the database. However, means would have to be built into the computerized permit system that would allow for immediate correction of any errors found in the data.

Another discussion point was service to the trucking industry. Service to this industry must improve for several reasons. For example, if Federal Aid was driven by usage, it would be to South Dakota's advantage to make South Dakota a desired route for truckers.

Another advantage of the proposed system is the advancement of management tools that would be available from this type of system. As already identified, management of the permit process based on historical records may allow more efficient management of the permitting process and a better driveway inspection program. Also, vehicles could be routed based on minimizing structural damage to pavements and bridges. Finally, historical records of approved routes and vehicle configurations for overload permitted vehicles could be useful to the pavement management system engineers.

3.5 Interview Organization: Office of Bridge Design

Interviewee: Todd Thompson

South Dakota is taking advantage of existing technology to rate bridges for overweight vehicles. Most South Dakota bridges have been analyzed with BARS and are available in its database for the analysis of unique vehicles. The state uses the load factor rating method for all bridges except timber and truss bridges. The department does not have any special restrictions or policies with respect to its rating procedures. There is no reluctance to approve a permit as long as the loads generated by the permit vehicle do not exceed the strength at an operating load level of the bridge.

Each year, approximately 1,000 permit requests are made that require the attention of the state Bridge Design Office. If the permit system could analyze all bridges "on the fly", it would be reasonable to assume that 90% of this effort would be saved. Each request takes approximately 30 minutes.

When an overweight permit application occurs, the issuing officer first determines whether the axle load configuration satisfies the Bridge Formula. In those cases where the axle load configuration satisfies the Bridge Formula, the permit is issued without additional analysis. In those cases where the axle load configuration does not meet the Bridge Formula, additional analysis, or a comparison with previous permits, must be conducted.

The Office of Bridge Design provides the Highway Patrol with the South Dakota Weight Limit Map as a basis of overweight permits. This map is color coded to represent the structural strength of bridges along each route. In this map, the red routes have the lowest capacity bridges and the black routes have the highest capacity bridges.

The Highway Patrol multiplies legal weights from the Bridge Formula by a load factor to determine the maximum axle weights, maximum axle group weights and maximum gross weight. These load factors are based on the route color. They vary between 1.00 and 1.33 for unrestricted movement and between 1.20 and 1.533 for restricted movement. Restricted movement requires that a restricted bridge must be crossed along the bridge centerline at five miles per hour and a front escort is required to handle approaching traffic. A note must be attached to the permit.

There are approximately 1,900 bridges in the state system. Influence line data is available for nearly all bridges in the South Dakota inventory. This data can be extracted from the mainframe database for analysis of a bridge. The department will eventually go to Virtis when that system becomes available.

A few bridges are not included in the BARS database, particularly trusses. However, influence lines exist for truss members. The developer of a permit system will need to develop a procedure for handling the structural restrictions for these special bridges.

Standard Distribution Factors, Impact Factors, and Multilane Reduction Factors are used in the bridge rating analysis. In some cases, a restricted speed limit and/or " Drive down the

Center Line" notes are used to take advantage of a reduced impact factor and/or a single lane rating analysis. If implemented, a note must be included on the permit. On interstates, South Dakota does not restrict speed or use the "Drive Down the Center Line" option.

South Dakota allows additional load carrying capacity (limited to a 15% increase) based on the width of the axle and a standard 8 foot axle width.

Local agency bridges are not rated by the South Dakota DOT. Therefore, the permit system needs to flag the permit applicant to make sure local agencies are notified before the trip commences. The placement of local agency contacts would be a convenient service provided by the state.

South Dakota does have flags on certain bridges that identify that the allowable loads for these bridges may not be increased. This policy will need to be considered in the implementation of the proposed permit system.

One operational problem that was identified is that the current system does not always make the permit entry and exit points clear. Thus, the Office of Bridge Design must make assumptions as to the proper entry and exit points. A computerized permit system could clarify the location of these points.

Overall, the existing policies and procedures of the Bridge Design Section make the inclusion of automated bridge ratings into the permit system relatively easy to implement.

Several benefits of the proposed system were identified. If an automated permit and routing system were implemented which included a rating module, approximately 90% of the time currently spent analyzing bridges for permit support would be saved. By automatically analyzing every bridge for overweight vehicles, improved highway safety and less damage to existing bridges would occur. This would result in a corresponding savings based on a reduction in bridge deterioration. Based on the experience of the bridge engineer and existing workload, not all bridges are always checked. This "skipping" of bridges for each vehicle rated would be eliminated and the corresponding "risk" would be minimized.

Another advantage of the proposed system would be the ability to develop histograms of historical data of overweight vehicles for fatigue analysis.

3.6 Interview Organization: Traffic Operations

Interviewees: Mike Young and Bernie Kambel

A discussion was held concerning the highway and bridge data requirements to support the proposed routing function. They included a base database of highway segments and associated data that would be updated every six months. This data would be down loaded from the GIS map and the main frame database operated by Computer Services.

Another level of data required to support the permit system would be Program Construction information which would be updated on a monthly basis. This data would include estimated times for the initiation and completion of projects. In addition, any restrictions (height, width or weight) would be included. These restrictions could be located, or referenced, using the MRM location reference system.

A third level of data would be Dynamic Restrictions associated with projects that may last approximately one week. Just like the Program Construction information, estimated time of project beginning and completion would be required. In addition, any restrictions (height, width or weight) would be included using the same location procedure developed for Program Construction.

The last level of data would be emergency restrictions. An example would be an accident that would close or restrict a highway segment for a relatively short period of time. For the proposed system, this data needs to be sent to the system immediately for inclusion in the database. This data would be collected by DOT Headquarters and then sent via the 56 K lines to the remote sites.

SDDOT uses the bridge weight formula to save time analyzing every bridge. There was also a general philosophy that material strengths are generally higher than expected.

A discussion of routing criteria was conducted. In general, the proposed system should be flexible enough so the criteria could be changed over time. For example, with the implementation of bridge and pavement management systems, new criteria could be used to minimize structural damage to pavements and bridges.

Another issue raised was the possibility of considering alternative methods for setting of permit fees. For example, the fee could be set based on the number of Equivalent Single Axle Loads (ESAL). That way, vehicles that cause less damage to bridges and pavements would have lower charges for permits.

Support of spring thaw load restrictions is critical. These conditions change on an annual basis. However, they may occur between February 15 and May 1. This information would require the estimated beginning and ending date, along with the beginning and ending MRM. Allowable pavement loads would include allowable axle load and load per unit tire width. While the proposed permit system must consider spring thaw information, physical signs on the highway in the field control Spring Thaw restrictions.

Implementation of temporary restrictions into a computerized routing system would depend upon the system selected. Generally, there are means to assign a flag or value to each segment, or link, with a temporary restriction. These flags would be updated daily. Since these temporary restrictions change frequently, there may be a need to add a disclaimer stating that the permit does not guarantee passage on the permitted route if an extenuating circumstance should occur.

Another restriction that needs to be considered is truck clearances between the bottom of the truck and the highway. The department has experienced some situations where vehicles get "hung up". This situation generally occurs at railroad grade crossings. In these cases where the criteria is not met, truckers must notify the railroad. How this data would be collected was not identified. There was a general consensus, that the state highway system roads all meet the clearance criteria.

A brief discussion of management issues was held. It was agreed that it would be recommended that management of the proposed system at DOT's Central Office would be housed in the Division of Operations. It was generally concluded that to support the proposed system, it would require one person working half time.

Finally, a discussion of potential benefits was held. They include:

1) Real time verification for a specific permit by field highway patrol officers.

2) Better and more efficient services to the trucking community. This would occur through more efficient processing of permit requests, but it would also allow new services. For example, routes could be pre-analyzed and saved in the system until a formal request was made.

3) Approved routes which minimize the structural damage to existing pavement and bridges. This could allow the integration of information gained from pavement and bridge management systems into the routing process. Rather than shortest or fastest path, the criteria could become the safest or least damage path. In addition, it would be hoped that more accurate approvals for the routes would occur.

4) With a computerized routing and permitting system, the possibility of new approaches for assigning permit fees would exist. With the permit data stored in a database, information would become available to assess the impact of these new fee structures.

5) An additional benefit would be the requirement that the flow of construction information be accurate and up to date. At present, the accuracy and timeliness of construction information has not been up to the highest standards.

6) A potential exists that legislative support would improve with a more rational routing criteria.

Task 3 Appendix

Proposed System Document For
South Dakota Permit and Routing System

Requirements of Proposed Automated Routing/Permitting System for South Dakota Highway Patrol and Department of Transportation

Background South Dakota Highway Patrol is responsible for issuing and enforcing all oversize/overweight vehicle permits for the state. The Highway Patrol issues most of these permits from five ports of entry. However, the majority of these permits are issued through the Sisseton Port of Entry. Permits are also issued by mobile unit personnel.

The criteria and support data (maps, etc.) are developed by the South Dakota Department of Transportation. This organization collects pavement and bridge data and establishes criteria for permitting. It also collects construction and spring thaw data.

At present, very little support of the permitting process is done with computers. In fact, computers are only used by management to compile and type up reports. Consequently, report generation and billings are taking up significant amounts of staff time. With built in standard reports, staff persons time could be used for more important tasks.

Based on the interviews with South Dakota personnel, EnGraph proposes that the fully implemented permit and routing system be located at a single site. Based on a historical perspective and experience of present staff, Sisseton Port of Entry would be a logical site. However, Pierre would be a very attractive alternative. Pierre has the distinct advantage of having better telecommunications and database support available. In addition, computer hardware and software support would be significantly better in Pierre.

The other Ports of Entry, Highway Patrol District 4 Headquarters and mobile units would have access to the system through modems and the 56k data network. In addition, qualified trucking industry and permitting services should have access to the system for data entry. Full permit and routing systems could be located at Highway Patrol and DOT Headquarters for purposes of backup and system maintenance.

This recommendation was not our original concept. Originally, it was proposed that full service systems be located at Sisseton, all other Ports of Entry and Highway Patrol, and DOT Headquarters, The mobile units would be supported with a data entry system which would issue a permit, but would not support any type of routing.

Our primary concern with the original concept dealt with support issues. The main one involves the support of the entire permit and routing system and its associated data at the remote Port of Entry sites. The chances for errors in data transferred between the sites would be enhanced. The challenge is not supporting the sites when everything works, but supporting the sites when it doesn't. Also, training expenses would be higher if the full system had to be supported at each port of entry. As learned in the survey, many states with an automated permit and routing system, issue permits from a common site.

Finally, integration of the automated permit system would be easier if only one site issued permits. The remote sites can be served with a computer calling into the central permit office, accessing the computer system and receiving a FAX or file for local printing.

Another concern for the Sisseton Port of Entry site is the lack of space. However, through improvements in productivity of present staff through software enhancements and by shifting much of the data entry workload to the permitee, it is our judgment that present staff will be much more productive. Thus, the need for additional staff at Sisseton should be minimized.

System Requirements: After reviewing the present system with representatives of the Highway Patrol and Department of Transportation officials, EnGraph proposes the following software system for the Highway Patrol and Department of Transportation:

The proposed automated permit and routing system would be located at a single site. This site would provide all administrative and routing functions. Each workstation would be connected to one another through a client/server environment. Similar systems would be located at Highway Patrol and Department of Transportation Central Office. However, these systems would be used as backup and support at the central permit issuance office.

This system would collect all permit information, route oversize/overweight vehicles by considering pavement, bridge, construction and temporary highway conditions, and then issue the permit. This system would also conduct all administrative functions of the system from a common database. This would include account management, receipt of fees, etc.

A second system, which is a subset of the primary system, would permit users to collect all permit information, issue a permit and transmit the data to the main system. This second system would have the functionality to reach the primary system through the 56k network, telephone lines and the Internet. While these local units would not have the capability to route vehicles, they could have the capability through access to the primary system. This second system would support the Mobile Highway Patrol units and nine mobile carrier inspectors. This system would allow the inspectors to automatically enter permit issuance information directly into the database. Since these inspectors will also have a printer available, they would efficiently offer a hard copy of the permit to the trucker.

Windows NT is the preferred operating system. Most developers are developing systems in this environment.

All Ports of Entry, Highway Patrol District 4 Headquarters and the Department of Transportation Headquarters are linked together with a 56K network system.

System Data Requirements

To support the primary permit systems, EnGraph recommends four types of required data. This data would be gathered and organized in the desired format by the Department of Transportation. This data would include:

1) **Graphical map giving a detailed description of the SD highway system**. The basis for this map has been developed by the SDDOT using the Intergraph GIS MGE system. This map contains approximate highway centerline objects which define the highway system. Interstates are included as double lines. Mileage Reference Markers (MRM) are defined along each highway segment and can be used to tie highway segment and bridge information to the map.

There are two major deficiencies associated with the present map when using it with an automated routing system. First, for most systems that support routing, highway segments must start and end at highway intersections. The SDDOT highway map was not developed that way. The other major deficiency is that highway interchanges were not included in the highway network.

EnGraph proposes that these two deficiencies be eliminated semi automatically with tools provided by Intergraph or third party software packages. This approach minimizes support requirements and provides the flexibility of allowing modification of the maps as future highway system changes are implemented.

EnGraph proposes that this data be updated every six months.

2) **Highway and Bridge Information.** The highway segment information is presently stored in a mainframe database supported by the Central Information Services Department at the State Level. The project team learned that this data can be downloaded for use by the truck permit system. Highway information would be attached to the graphical objects through the use of the MRM reference system.

South Dakota bridge data comes in two forms. The first set of data is associated with basic bridge geometry. This includes vertical clearances for traffic under and/or on the bridge, horizontal clearance, name(s) of route supported and name(s) of route under the bridge. The second set of data includes the structural information. This data includes positive and negative strengths at numerous predefined bridge stations, number of spans, span lengths, distribution factors, impact factors and influence line coefficients at tenth points for each span. With this data, each bridge is analyzed for the exact truck axle configuration.

EnGraph proposes that this data be updated every six months. It would be compiled by SDDOT.

3) **Programmed Construction Data.** This data would include restrictions(vertical and horizontal clearance), closed highway segments, and bridge load restrictions for programmed construction projects. For each restriction, a programmed start and end date would be provided. All projects would be identified with a beginning and ending MRM and/or bridge structure number.

EnGraph proposes that this data be updated every month. It will be compiled by SDDOT.

4) **Weekly Construction Updates.** SDDOT Regions and Areas work on local projects that are not a part of the programmed construction program. These projects are much shorter in duration and are much smaller. However, they do contain restrictions in vehicle height and width and/or bridge load limits. The form of the data would be identical to Programmed Construction Data previously discussed.

A second area of data that may change weekly is spring thaw information. While state law sets a beginning and ending time for spring thaw, SDDOT has the flexibility to set restrictions within the state law parameters. The type of data required to support spring thaw information is similar to the construction data. Data would include beginning and ending MRM for the affected area, start and ending date for the restriction and axle load limits for the section. It is anticipated that there would be one record for each spring thaw restriction.

EnGraph proposes that this data be updated weekly. It would be compiled by SDDOT.

5) **Emergency Restrictions.** Emergency situations occur that impact routing decisions. To get this information into the system as fast as possible, all full service sites will have the capability to add data to the system. When added, this data will automatically be sent to all other full service sites. The data would include MRM start and/or end, type of restriction, time restriction begins and time restriction ends. The time for these types of restrictions would be limited.

This data could be added anytime by DOT Central office, Highway Patrol District 4 Headquarters or Permit Issuance Center.

System Operation

A brief explanation follows that describes the operation of the full system automated oversize/overweight vehicle permit system. The first step is to collect administrative information about the permit. A brief description of this information follows:

a) Administrative Data Module

A database containing all client information would be developed and supported. This database would include client ID, address and billing information, contacts, permit type, etc. In addition, data such as permit origination and destination site, time and date of permit application, system operator, etc. would be automatically added to the record. An automatic permit ID would be assigned.

The main administrative database would be stored at the central permit office location. After collecting the administrative information, the system will go either to the Oversize or the Overweight Permit section, or both sections. Each section is defined in detail:

b1) Oversize Permits

For permits that are oversize, the operator would be asked to provide the permit vertical height and/or horizontal width.

b2) Overweight Permits

For overweight permits, the system would provide the operator the opportunity to define the following information:

Number of axles
Spacing of all axles
Axle load for each axle
Width of each tire on each axle
Axle width.

b3) Proposed Route Designation

The system would have the flexibility of selecting a proposed route or to evaluate a route proposed by the permittee. If it evaluates a proposed route, the system shall accept commands such as I90 to SH 53 to SH XX, etc.

When data from either b1) or b2) and b3) are gathered, the system would automatically go to the Routing Module.

c) Routing Module

The routing module would integrate the information obtained in the earlier modules and all of the data previously described. From the graphics objects, a network would be built and analyzed with network analysis tools. From the administrative data module, the system would determine the date range, origin and destination points, and the characteristics of the permit vehicle, i.e. oversize and/or overweight. At this point, the system will check the following databases:

i) Bridge Vertical and Horizontal Clearance Table
ii) Calculate allowable rating factor for the proposed permit vehicle for each bridge
iii) Adjust allowable rating factor for impact and one lane options if required
iv) Programmed Construction Table
v) Weekly Construction Table and Spring Thaw Table
vi) Emergency Restriction Table.
vii) Highway Segment Table (Criteria yet to be determined.)

After all databases are checked, this module would select the desired route and prepare the required routing maps and drive tables.

d) Input/Output Options

Obviously, permit issuance staff would enter all required data from computer keyboards. However, alternate methods should be considered for getting permit data into the system. These alternative modes would include:

i) 800 Telephone Line support (Inputted by a central permit office staff member)

ii) PC Modem (Permittee enters data at their site and the data is transferred electronically to the permit granting location.

iii) Internet/CGI

The actual permit could be given to the permitee in the following modes:

i) Printed locally on a laser printer

ii) FAX/Modem

iii) Internet

e) Output Reports

The system would have the capability of supporting reports of permit information during any time period. However, standard time periods of weekly, monthly and annual would be supported. A Structured Query Language (SQL) would be very beneficial to support access and analysis of the database for customized reports. Standard reports would be developed to support repetitive reporting functions.

Task 4 Determine Required Data Input for Support of an Automated System and Compare These Needs with Existing South Dakota Databases. Identify Which Data Elements will be Needed, Where They are Located and What is Missing.

4.1 Summary and Conclusions

When compared to the results of the Task 2 Questionnaire, the data requirements to support the needs of an automated routing system are rather minimal. That does not mean the accuracy requirements for the required data are trivial. In fact, it is the opposite. All data required by the proposed permit system must be included and be the highest quality.

At present, the South Dakota DOT stores its features inventory in a database maintained in a mainframe database management system. How this data would be integrated into a permit and routing system would depend upon the software vendor. If a GIS environment were used, one would build the highway network with MRM data attached to each segment. Then, one would write a short data attachment application to attach all of the desired features (pavement and bridges) to the links and symbols through the MRM reference system. Other systems may require a hand approach for attaching this data to highway segments.

SDDOT has developed an electronic map of the state highway system. This map is complete with the exception that the major interchange information is missing. Also, if a GIS environment were selected for the proposed routing system, one would need to break the segments in the SD GIS map at all intersections.

The pavement data required to support the permit routing operation would depend upon the criteria developed by SDDOT. For example, if it were desired to route wide vehicles on highways with relatively wide shoulders, then shoulder width would be an important criterion.

Some data features required for bridges include: vertical clearances for truck traffic on and/or under the bridge, clear deck width, under bridge clear widths when the roadway is under a bridge, etc. For pavements, one may want to consider AADT, number of lanes, lane width, shoulder width, any vertical or horizontal obstructions.

As stated, this data is currently being collected, updated, and stored in a mainframe database management system. It is recommended that this data be downloaded at regular intervals.

To support an automated permitting and routing system, the reliability of data must be very high. If not, the permit system will issue permits based on inaccurate data.

The data required to support the permit and routing system will depend upon which vendor is selected for the system. However, there are several similarities between all systems. If a GIS based system is used, the validation of highway and bridge data could be very valuable.

In conclusion, EnGraph did not find any feature data elements that need to be collected to support the proposed routing and permit system. The only additional information required is the geometry data for major interchanges.

4.2 Highway and Bridge Data Available

As stated previously, South Dakota is presently collecting and storing highway feature information in a Roadway Environment System (RES) File. Fortunately, each data item is located based on a Mileage Reference Marker (MRM). Thus, it would be relatively easy to attach this data to a map for use in an automated routing application. Again, how this data will be attached to the proposed routing application would be very dependent upon the eventual vendor selected.

The project team has selected a list of fields in the RES files that could be used to support an automated routing system. These roadway fields are found in Table 4.1 and the bridge fields are found in Table 4.2. These fields were selected based on previous experience. They can be modified depending on the routing criteria used. Some fields have been included because the data may be very useful when building the proposed system database.

There are some fields in the Intersection Inventory Master File that may be very useful when building the highway network database. How this information would be used would be dependent upon the method used to build this highway network database.

Table 4.1 Roadway Data Field Items Identified to Support Proposed Automated Routing System

Data Item Name	Description
HWY-NUMBER	Highway Number
HWY-SUFFIX	Suffix Designation Code for Road Type
MRM	Mileage Reference Marker
DISP	Displacement
TRA-LOAD-CLASS	Code for Load Class
TRA-CUR-ADT	Current Year ADT
DATA-CLASS	State, County, City or Federal
FEA - 16	Rural-Urban Code
FEA - 30	Surface Width to Nearest Foot
FEA - 33	Right Shoulder Width to Nearest Foot
FEA - 40	One Way - Two Way Code
FEA - 41	Divided - Undivided Code
FEA - 45	Federal -Aid Route
FEA - 46	Highway Category
FEA - 47 A & B	First Coincident Highway Number and Suffix
FEA - 48	First Coincident Highway Category
FEA - 49 A & B	Second Coincident Highway Number and Suffix
FEA - 50	Second Coincident Highway Category

Table 4.2 Bridge Data Field Items Identified to Support Proposed Automated Routing System

Data Item Name	Description
STR-NO	Structure Number
HIGHWAY-CARRIED CODE	Code for Type of Highway Carried
NUMBER	Number of Highway Carried by Structure
DATA-CLASS	State, County, City or Federal
MRM	Highway Carried Mileage Reference Marker
ADT	Average Daily Traffic
ADT-TRUCK	Average Daily Truck Traffic
FEATURE-INTERSECTED FEA.	Feature(s) Crossed by Structure
LANES	Number of Lanes on Structure
LOAD-DESIGN	Design Type and Load Type Codes
OPER-TYPE	Operating Load Type Code
OPER-TON	Maximum Load
INV-TYPE	Inventory Load Type Code
INV-TON	Inventory Maximum Load
APPR-ROADWAY-WIDTH	Approach Roadway Width
MAX-V-CLR-R	
MAX-V-CLR-FT-R	Maximum Vertical Clearance (FT)
MAX-V-CLR-IN-R	Maximum Vertical Clearance (IN)
BENEATH BRIDGE DATA	
HIGWAY-BENEATH	
B-CODE	Highway Beneath Code
B-NUMBER	Highway Beneath Number
B-MAX-V-CLR-R	Rt Highway Beneath Maximum Vertical Clearance
B-MAX-V-CLR-FT-R	Rt Maximum Vertical Clearance (FT)
B-MAX-V-CLR-IN-R	Rt Maximum Vertical Clearance (IN)
B-MAX-V-CLR-L	Left Highway Beneath Maximum Vertical Clearance
B-MAX-V-CLR-FT-L	Left Maximum Vertical Clearance (FT)
B-MAX-V-CLR-IN-L	Left Maximum Vertical Clearance (IN)
B-HORIZ-CLR-R	HWY Beneath Horizontal Clearance
B-HORIZ-CLR-L	Left HWY Beneath Horizontal Clearance
B-MAX-V-UNDCLR-R	Rt Highway Min Vertical Underclearance
B-MAX-V-UNDCLR-FT-R	Rt Min Vertical Underclearance (FT)
B-MAX-V-UNDCLR-IN-R	Rt Min Vertical Underclearance (IN)
B-MAX-V-UNLCLR-L	Left Highway Min Vertical Underclearance
B-MAX-V-UNDCLR-FT-L	Left Min Vertical Underclearance (FT)
B-MAX-V-UNDCLR-IN-L	Left Min Vertical Underclearance (IN)
OUTSIDE-UNDCLR-R	Outside Lateral Underclearance
OUTSIDE-UNDCLR-L	Outside Lateral Underclearance - Left Rdwy
MEDIAN-UNDCLR-R	Median Lateral Underclearance
MEDIAN-UNDCLR-L	Median Lateral Underclearance - Left Rdwy
BRIDGE-WIDTH	Clear Distance Between Curbs

Each vendor would need to estimate the effort to attach this data to their routing application. If this is done in a GIS environment, once the roadway elements, interchanges, and MRM data is attached, the attachment of this data to individual segments would not be difficult.

Task 5 Identify and Evaluate Applicable Software Solutions Considering Costs and Implementation Requirements

5.1 Introduction

Through the survey conducted in Task 2, EnGraph found two commercially available routing systems and one under development. The first system was developed by GDS in Denver, Colorado. The other commercially available system is SuperLoad developed by C. W. Beilfus & Associates, Inc., in Illinois. Both systems have their advantages and disadvantages. A prototype system is under development for the Kansas Department of Transportation by the Principle Investigator and his research assistant (Carl E. Kurt and Kyle J. Archer, respectively). A brief description of this prototype system is presented in the Appendix of this Task Report.

The project team conducted a site visit to GDS. A phone call was made to C. W. Beilfuss & Associates, Inc. to learn about the capabilities of their permit routing system.

5.2 Summary and Conclusions

Only one of the two commercial systems identified has the capability to automatically route oversize and overweight vehicles. The Permit and Routing Solutions (gdsPARS™) system from GDS is the commercially available system recommended for South Dakota. The database portion of the permit system appears to be very well organized. The user interface of the Windows NT version is very well done. While the company was reluctant to disclose how it does its network routing, it has supported routing for a very long time. Because of this experience in routing, the process appears to be very stable.

Since most permit systems are customized to meet state needs, it was difficult to determine how much customization would be required to meet South Dakota's needs. GDS appears to be using the most current technology, and they could certainly deliver a system suitable for South Dakota's requirements. The only component that is not presently supported is "on the fly" bridge rating. However, there was nothing identified in the system evaluation that would not allow GDS to include this feature for South Dakota.

5.3 GDS Interview

INTERVIEWEES: Johnathan Tarr and Jerry Blesser

GDS is a software developer that has expertise in many areas of government operations. Typical projects include utility planning for local governments, the largest GIS project related to wastewater management in Columbus, Ohio, and a similar project in Maine. They have developed and implemented the advanced public transportation system plan for the Olympic Games in Atlanta. They have several mass transit transportation projects throughout the world. Finally, they have developed a Permitting and Routing Solutions (gdsPARS™) system to support permitting and routing of oversize/overweight vehicles. Approximately eight states are currently using or planning to use their system.

One of the first observations made is that the system is generally customized for each state. It appears that each state has a distinct set of criteria. For example, consider payment of permit fees. Two states, Texas and Washington, only accept credit cards for their permits and therefore wanted that functionality built into their systems. They also wanted electronic funds transfer, but some legal issues were caused by this request.

The present version of gdsPARS™ is being developed for Windows NT. Basically, gdsPARS™ has three main modules. They are: 1) Permit Accounting, 2) Permit Issuance, and 3) Routing Module. Since it is built in modules, gdsPARS™ can be updated as required by the user.

Several different configuration issues were discussed for the proposed South Dakota Project. For example, one option would be to have all permitting issued out of a central permit office. In this option, all ports would "dial in" to the central office. The system could be built so the data collection module would be at each remote site, and the data would be transferred to the central office. The remote site could also be another user for the central office. After the permit was approved, the system could FAX the permit to the remote user or send a file to be printed locally. The main advantage of this approach is that the support required at the remote sites may be reduced.

A second issue would be the improved security associated with having the permit issuance system physically located at one site. The chief reason this issue was raised was that auditors would have all of the data available at one location. All other accounting functions could be located at this site or Highway Patrol Headquarters. The data required to support the routing function would also be located in one area.

As we learned from talking to the vendors, it is very difficult at this stage of the project to get specific numbers associated with using either commercial system. In fairness to the vendors, there are just too many variables at this time.

A base license for the gdsPARS™ system is $150,000. That system will support the Permit Issuance and Routing Modules previously described. It would not include development of the database required to support the system or the Permit Accounting Module. These costs vary widely.

When asked what other systems cost, including systems integration, we were told that Michigan's system cost approximately $500,000 and West Virginia's system was approximately $800,000. The West Virginia system also included a complete customized financial/accounting system and hardware to support the system. Maintenance agreements are extra and seperate agreements.

For GDS, system costs include the following services:

User Interface
Systems Integration
Criteria Development
Data Acquisition and Verification
Network Analysis
E-mail Server when required
Testing and Training
Security and Standards Development
SetUp and Installation
Development of Customized Reports.

Obviously, this would be a complete turnkey solution.

GDS proposed a phased approach to further develop this project. If selected, they would investigate the South Dakota approach to permit issuance and determine how South Dakota's approach to routing would fit into their system. They would also begin a study to evaluate the quality of the data provided by the state.

The gdsPARS™ system has the capability of routing oversize and overweight vehicles. GDS has successfully translated highway data from an Intergraph environment to their system. However, they do not support a GIS approach to network routing. As previously discussed, they were very reluctant to discuss their core routing engine with the project team. While we were disappointed, it was certainly understandable. They stated they have a GIS system developed in house that could provide maps of the selected routes if desired. Since this is not a part of their basic routing module, it exists to display routing results and not to calculate routes.

Criteria for routing vehicles is generally "fine tuned" for each system. Changing the criteria is relatively easy with the GDS system. Data required to support the system is generally inside the DOT somewhere, but the data usually needs verification before it can be used for routing vehicles.

Data required from the permittee is the typical information required for permits. For example, administrative information, such as date(s) of travel, start and destination locations as well as vehicle axle loads, axle spacing and tire widths are supported. Also, users may add other restrictions such as daylight hours only, restrict access to certain highways during peak traffic conditions, etc. When this data has been collected, the system will provide a route to the user considering system based restrictions and the above mentioned criteria.

The gdsPARS™ system routinely handles construction restrictions and spring thaw restrictions. Construction restrictions can have a start date, end date or until further notice.

The system has a wide range of reports built into it. However, customized reports are also available.

When discussing benefits to states using their system, the GDS representatives responded that "We provide data that these bridge and road people would kill to get their hands on, like what types of trucks are using their roads and what they are carrying".

The overall feeling of the project team was that this firm has considerable experience and is very competent to deliver a total solution for South Dakota. Considering the fact that South Dakota is not a populated state with a lot of rules, we would consider the implementation of this system to be relatively easy. If the data quality is as good as it was described to the project team during the interview, verification of data would be minimized.

The one area which GDS does not support at present is "on the fly" structural analysis of bridges for a specific rating vehicle. Nothing in their system was implied that would make this impossible to do, it just has not been requested.

Two clients of GDS were approached for comments about working with the company. While the systems were rather old, both references were pleased with the performance of their GDS system and enjoyed working with the company.

5.4 C. W. Beilfus and Associates, Inc. Interview

INTERVIEWEE: John Bennet

C. W. Beilfus and Associates, Inc. is the developer of SuperLoad. This system is an outgrowth of a project developed twenty years ago, called BARS. BARS is a bridge analysis program that among other things has the capability of rating existing bridges. This is the same BARS program that the South Dakota Department of Transportation uses to rate existing bridges.

SuperLoad interfaces with the BARS database through a preprocessor. This system allows a new BARS analysis to automatically update the SuperLoad database. It is anticipated that SuperLoad will also interface with the new bridge program, VIRTIS, when it becomes available.

C. W. Beilfus and Associates, Inc. incorporated the BARS rating approach into SuperLoad. When SuperLoad was developed, no GIS software packages were available that would work with their system. In effect, they built their own display system to display routes. West Virginia has the oldest system but Ohio, Indiana, and Iowa are also users of SuperLoad. Originally, SuperLoad was developed for a RISC 6000 computer system, but it has been ported down to a 200 MHz Pentium Pro for Ohio.

SuperLoad is currently working in the Windows NT and Windows 95 environment. The Windows NT environment is the preferred one. The system works in multiple sites and in the client/server environment. SuperLoad is also working in an environment where remote sites enter data locally and then transmit the request, via zipped files, over the telephone line. It also will FAX back a solution for issuance of the permit. Finally, SuperLoad works on the Internet.

SuperLoad has the ability to handle a wide range of administrative functions. Before conducting an analysis, it will quickly check all highway and bridge parameters before actually conducting an analysis on the remaining parameters. With a map of the highway system, the user is able to click on the highway segments to be checked for a specific permit vehicle.

To define the permit vehicle, one is prompted for the axle spacing and weight, and/or vertical and horizontal clearances before beginning the analysis.

SuperLoad does NOT do automatic routing. When asked the reason for this lack of capability, the response was that there was a certain amount of liability assumed by the state when the state selected the route. The developer could develop an automated route selection module, but it has not been asked to automate the routing process due to liability issues.

When asked about Construction Restrictions and Spring Thaw Restrictions, the response was that SuperLoad supported these types of restrictions. However, while they integrate well with Intergraph maps, they also would need the interchange information included in the map database.

When asked about pricing for SuperLoad, the discussion became rather fuzzy. Again, the project team heard that there were too many variables for a definite figure. When asked how they would implement a project, they stated that they preferred to do a two phase implementation project. In the first phase, (approximately $15,000), they would like to investigate the format of existing data, system requirements, etc. At the conclusion of the first phase, they would be in a better position to estimate the total cost of the project.

We were able to determine that the first license for SuperLoad is $50k, the second is $20k, the third is $15k and the remaining licenses are approximately $10k each. For support, which includes free software upgrades, the fee is 20% of the base license fee annually. Typically, there is an approximately $150,000 consulting fee that goes to set up the database and other services.

Task 6 Perform Cost-Benefit Analysis for Adoption of Automated Systems Considering the Benefit of Improved Public Services, Efficiency, Reduction of South Dakota's Liability due to Increased Accuracy in Routing and other Pertinent Benefits and Recommendation on Appropriate System.

6.1 Summary and Conclusions

While it was difficult to quantify many of the benefits and costs associated with implementing an automated permit and routing system, it was relatively easy to demonstrate that the benefits of the proposed system would greatly exceed the costs of the proposed system.

One of the most difficult costs to quantify was the cost of implementing a system. Software vendors were very reluctant to discuss fees because of the wide range of variables and options available. A software cost of $600,000 was allocated based on costs of implementing systems in other states, inflation, and factoring in the complexity of the South Dakota permit system. A one time $20,000 cost was included for additional training of support and operations personnel to get the system operating.

Annual costs considered included initial investment, software license support, half time administrator, and network/hardware upgrades. Annual benefits assigned values include improved reporting functions, permit staff productivity, billing and receipt functions and reduced requirements for structural analysis in the Office of Bridge Design. An additional $100,000 benefit was identified to account for improved routing and safety inspections. This is based on the fact that one serious accident would not occur annually.

Based on this analysis, implementation of this system would have a benefit cost ratio of approximately 1.58. As the system requirements are more closely defined, a better estimate of this ratio will be available.

Other advantages and benefits of the proposed system were also identified. Some of these benefits could potentially pay for the system by themselves. These benefits include: support of alternate routing criteria (e.g. least damage), improved service to the trucking industry, better and more efficient bridge analysis, a historical record for evaluation of overweight vehicles, support of alternative fee structures and others.

Overall, the implementation of the proposed permit and routing system would have a very positive impact for South Dakota and on the service provided to the trucking industry using South Dakota highways.

6.2 Basic Assumptions

In the development of the cost benefit analysis, certain assumptions were made. All support functions associated with the permit system were cost out at an average salary of $11.00 per hour. Management of the permit operation was cost out at an average salary of $14.00 per hour. The requirements for a half time administrator to provide internal support for the system and to collect all of the data required to support the system were identified. An annual direct cost of $35,000 was assigned to this administrator. Structural analysis effort in the Bridge Section was charged at an annual salary of $45,000 per year. In all analysis, an indirect cost of 44.3% was added to all salaries.

6.3 Overview of Costs

An initial license and implementation fee of $600,000 was assigned to the project. As stated in previous chapters, it was difficult to get a firm number from software vendors to implement a system for South Dakota. While one could get basic license fee information, all the other variables also drive the total cost of the system. Part of this is the structure, reliability and consistency of the highway features data. Based on historical costs to implement systems in other states, reliable feature data, and the fact that South Dakota is a rural state, the $600,000 fee was allocated.

Another cost includes the annual fee for the software license and updates. A $30,000 fee was assigned for this cost. A half time administrator was recommended in DOT Headquarters to support the system. This administrator would be responsible for placing the data required to support the permit system in the proper format.

In the cost benefit analysis, $33,000 was allocated for 6 high performance microcomputers at the central office to support the proposed system. Support of this system will require a high level of performance and numerical calculations. Therefore, one should specify fast processors, large amounts of memory and large hard drives for these computers. Saving a few dollars on computer hardware is not a wise savings. No costs were assigned to the other support sites because their computer utilization would not be as high. It was assumed that since they will be part of the state wide network that they would have computers at the site.

A $5,000 annual cost was identified to help support the network that links the Ports of Entry to the central office. In addition, these costs would help cover upgrades to hardware, telecommunication equipment and software development tools.

6.4 Overview of Benefits

Benefits were broken into two categories. Those benefits that could be quantified were included in the analysis. However, throughout the project, other benefits listed in the following sections, were identified that could have major impact on the economy of South Dakota, operation of the transportation system, and service to the trucking industry. While discussing potential benefits with South Dakota personnel, the conclusion was rapidly made that many of these benefits that are not quantified could have a major impact on the entire system.

6.5 Quantified Benefits

Many of the quantified benefits were identified at the Sisseton Port of Entry or the centeral permit issuance office. For example, the present reporting functions required approximately 30 minutes per site per shift per day. While computers are used in some of these reporting functions, the present system is a manual operation. This function would be handled entirely by the computer through a shift report output option.

Also, there should be a significant improvement of staff productivity when issuing permits. For example, one should not need address information for repeat customers. That data should be entered once and then stored in a database. Permits that require routing should be done more efficiently with the assistance of the proposed system. For analysis purposes, a 25% reduction of permit time was assigned to each permit.

The billing and receipt functions at Highway Patrol Headquarters should have an improved efficiency when using a computerized system. All bills could be developed automatically with the proposed permit system. Additional savings should be realized in reconciling the receipts. A savings of 6 hours per week was estimated for automating the billing system and 2 hours per week for the improved receipt process.

The department is spending approximately 1000 hours per year analyzing bridges to support the current permit operation. If an analysis function is included in the permit and routing system, the majority of that time could be saved. For analysis purposes, a savings of 900 hours was identified.

As previously discussed, there was general agreement that one accident per year would be avoided using the proposed system. This reduction would be for two reasons. First, better routing decisions would be made when converting a manual system to a computer based system. Second, there were reports of approximately ten accidents per year in construction zones. If better services were offered, some of the construction zone accidents would not occur because trucks would be routed around those zones. A savings of $100,000 per year was assigned to this reduction of accidents category.

The results of the cost-benefit analysis are included in Table 6.1. A detailed explanation of each cost and benefit is shown in Appendix 6.A.

While these quantified costs and benefits are very important, the project team also identified many benefits that could not be quantified if an automated permit and routing system were developed. A brief discussion of these benefits will now be presented.

6.6 Additional Vehicle Safety Inspections

Because of the extremely high work load at the Sisseton Port of Entry, management recognizes that one important function that has been relegated to a lesser priority is conducting driveway inspections. Management knows from past experience that when these inspections are conducted, serious safety deficiencies are found. While no one could directly relate an accident to a specific deficiency, everyone recognized that the risk of a potentially serious accident was much higher with the safety deficiencies noted.

There is an opportunity to increase driveway inspections without additional staff by improving the efficiency of the permit team and reducing hand based reporting functions.

6.7 Better Management of Existing Staff

The Sisseton management was asked how many permits were issued at peak hours and when did these peaks occur? While this data would be very helpful, it is not available unless an even greater burden was to be placed on the staff. One potential report from the system could be a statistical analysis of staff productivity during the day, but also on a seasonal basis. This could potentially lead to improved management and scheduling of present staff.

6.8 Service to the Trucking Industry

From those organizations that have a computerized permit and routing system, there was general agreement that the efficiency of the permitting group, and service to the trucking industry improved. We recommend that selected trucking firms and permitting services be allowed to electronically "call in" their permit requests. This would save the state from entering all input data, and it could allow the permit to be issued without any, or reduced, effort by state staff.

The truck permitting services seem to appreciate this service. Some states do not want the permit to be issued without review from a staff person. Others issue the permit if a given set of criteria are met. Even when permit applications are reviewed, staff time is saved because the customer is entering the permit information. When permits are issued without personnel review, the service to the trucking industry is obviously improved.

Other benefits to the industry could be the option to furnish maps of the approved route. While this would be a service to the truck driver not familiar with South Dakota, it would also encourage compliance with the permit. A drive table, with map, outlining the approved route could be provided.

The trucking industry could also confirm the permit based on local or current conditions. For example, construction and spring thaw data could be included in the confirmation process.

6.9 Additional Bridge Analysis

EnGraph believes that it is possible to analyze all bridges along a selected route for all overweight vehicles "on the fly". Thus, every bridge along the selected route would be analyzed for the specific axle configuration (weight and spacing). Presently, only the most critical bridges are selected for analysis.

6.10 Historical Records

In the evaluation of pavements and bridges, it is often desirable to determine the affect of design and maintenance decisions based on the extreme loads placed on that highway feature. If historical records are kept, a record of permits issued would be invaluable in the analysis.

6.11 Alternate Routing Criteria

With the advent of pavement management systems, it may be possible to consider alternate criteria for routing overweight vehicles. For example, a route may be determined based on the "least damage" to pavements and bridges. This alternate routing approach would have the potential of providing significant benefits to the state. While this is beyond the scope of this project, it is a very interesting concept for additional consideration.

6.12 Alternate Fee Structure

While it was not the intent to evaluate alternate fee structure, the use of a computerized permit system would allow the mechanics of using a more sophisticated fee structure for permits to be implemented. For example, an administrative fee could be assigned each permit and then a mileage fee could be implemented. There are certainly other alternatives. Under the present hand permit system, it would be an additional administrative burden to consider alternate fee structures. If routes were assigned based on the "least damage" concept described earlier, fees could also be assigned based on the same criteria.

6.13 Return on GIS and Features Database Development Investment

Because automated routing is a new concept for South Dakota, it provides an additional benefit for projects already being undertaken by the state. The GIS map will be very beneficial for the initial installation of the proposed system and for its maintenance. As outlined in Task 5, data required to support the proposed computerized routing system is a very necessary component. It has been our experience, that when data is used for a critical function, such as routing, the overall quality of the data is improved. Thus, the other applications and policy decisions based on this data would benefit from increased data reliability.

Table 6.1 Annual Cost Benefit Analysis

One Time Costs	
License Fee and Development of Associated Database	$ 600,000
Computer Hardware	$ 33,000
Training	$ 20,000
Total Startup Costs	$ 653,000
Annual Costs	
Initial Investment (5 Year Payout)	$ 130,600
Annual Support License	$ 30,000
Network /Hardware Upgrade Costs	$ 5,000
Half Time Administrator	$ 25,253
Total Annual Costs	$ 190,853
Annual Benefits	
Reduced Reporting Functions	$ 55,263
Improved Permit Issuance Efficiency	$ 111,111
Improved Billing Efficiency	$ 4,952
Improved Receipt Management Efficiency	$ 1,651
Reduced Structural Analysis	$ 29,221
Direct Benefits Subtotal	$ 202,198
Increased Safety Through Reduced Accidents	$ 100,000
Total Quantified Annual Benefits	$ 302,198
Benefit/Cost Ratio	1.58

Appendix 6 A

Worksheet for Cost-Benefit Analysis

Table 6.2 Cost Benefit Analysis Work Sheet

	Base Salary	Units	Indirect Costs	Total Costs
Half Time Administrator	$ 35,000.00	0.5	0.443	25253
Reduced Reporting Functions	$ 14.00	2735.5	0.443	55263
Improved Permit Issuance Efficiency	$ 11.00	7000	0.443	111111
Improved Billing Efficiency	$ 11.00	312	0.443	4952
Improved Receipt Management Efficiency	$ 11.00	104	0.443	1651
Reduced Structural Analysis	$ 45,000.00	0.45	0.443	29221

Justification of Units

Reduced Reporting Functions	30 minutes per shift * 3 Shifts * 52 weeks * 5 sites
Improved Staff Productivity	14 persons * 2000 hrs/yr * 25% Improved Efficiency
Improved Billing Efficiency	6 hrs/wk * 52 weeks
Improved Receipt Management Efficiency	2 hrs/wk * 52 weeks
Reduced Structural Analysis	$45,000 per year * 50 % * 90% Improved Efficiency

Task 7 Submit Interim Report

An interim report was submitted in March 1997. Upon review by the Technical Panel, a list of issues was presented to the principal investigator. Those comments have been addressed in this Final Report.

Task 8 Based on Recommendations of the Technical Panel, Conduct a Demonstration and Critique of the Recommended System with the Technical Panel.

Based on input from the Technical Panel, arrangements were made for Jerry Bleser, from GDS to present a demonstration of their Permit Management and Routing System. Following this demonstration, a second presentation was conducted on the prototype system developed by the principal investigator for the Kansas Department of Transportation.

8.1 gdsPARS™ System Demo

The current GDS Permitting and Routing System (gdsPARS™) application is a 32 bit application developed to work with Windows NT. This application works in a client/server environment with a similar look and feel between modules and screens. ORACLE is the database management engine, and most of the remaining code is written in C++.

The system consists of several modules which include a permit module, accounting module and maintenance, and a routing module. The basis of the system is a series of rules developed for each state during implementation and put into the system by a Rule Maker tool built into the system. As an example, Minnesota has approximately 485 rules, and Maryland has approximately 85 rules.

As part of the demonstration, the Rule Maker Editor was demonstrated. These rules guide the operator to determine if a permit is required or if the permittee request is allowed. In addition to standard rules, special rules governing highway segments and bridge utilization are supported. The system allows the operator to override these rules based on the authority level of the system operator. This authority is given by the system administrator.

For the operator, the system collects a variety of input information from the permittee through a series of screens or tabs. The system contains seven screens for the operator to select. These screens include:

Permittee
Loading
Weight
Route
Summary
Restrictions
Instructions.

The Permittee screen allows the user to complete information regarding the data associated with the permittee organization. This screen includes information regarding permittee name, billing information, type and date of permit requested, etc. As with all screens in the system, this screen was organized in a very logical manner which made it very easy for the operator to enter the data. It was obvious that a database of information for existing customers supported this screen. This way, key strokes required by the operator were minimized.

The Loading screen contained information regarding the vehicle and load to be permitted. Typical required data in this module would include vehicle length(s), height, width, etc. Information gained by this module was very useful as the system applied this information to the rules previously discussed.

Definition of tire configuration and all axle loads and spacing was included in the Weight screen. As with all modules, the system permits the use of metric and English units. Obviously, English units are the preferred set of units now but when looking toward the future, it would be important that metric units be supported. One example of dual set of units is tire width descriptions. For example, to determine the axle load per unit tire width, the metric designation P215 permits the system to calculate the axle load per unit tire width by recognizing that the P215 tire is approximately 215 mm wide. Since other truck tires are designated with an English based standard, the support of dual units is very beneficial.

The Route screen documents the route desired by the permittee. An easy to use approach was demonstrated which allows the user to request a proposed route-by-route basis or simply enter the entry and exit points and have the system determine the best route of travel. For example, if a city name was designated, the system looks up the city, determines what highways intersect the city, and then allows the user to select a specific highway, direction and location. All of this information was developed on a single screen. After this information was entered, this module tries to complete a route between the entry and exit points using the highway and bridge database stored with the system and the rules previously discussed.

A summary of the permit application was displayed in the Summary screen.

The Restriction screen allowed the operator to review the restrictions built into the system through the rules. In addition, the system provided the flexibility for the operator to add special restrictions to the permit as required.

Finally, special instructions can be attached to the permit application through the Instruction screen.

After all of the information required to support an application request was provided, the route selected, etc., the system either issues a permit or holds the application for issuance at a later time. The hold feature would be very beneficial because permit information is not reentered if the permit was requested at a later date.

This concludes the overview of the system based on the perspective of a system operator. Some of the operational experiences of existing GDS clients confirmed that the improvements in productivity of the permit issuance office that were assigned in Task 6, Cost Benefit Analysis, were very reasonable.

The single permit site concept was also discussed. Overall, it was agreed that a single site supporting the system would be much simpler to implement and support. A Pierre location would probably be easier than the Sisseton site.

The gdsPARS™ system currently supports a wide variety of options to attach to the system. For example, the system supports dial up modems from outside clients. In this case, software is provided to approved clients so client staff can enter the permit information previously discussed. If all data is correct, a permit could be issued by the system without any activity of the permit issuance office staff. Access to the system is also provided through the Internet. In all cases, fire walls must be provided to minimize the possibility of unauthorized use of computers and data. To guarantee access to the system by South Dakota personnel, a system with reserved lines for certain South Dakota offices was suggested. That way, access to the system by key South Dakota offices could be assured.

To support the permit system, several important issues were demonstrated. For example, screens were developed so system administrators could update construction and maintenance information. These screens would reflect the restrictions placed on bridges and highway segments. Easy access and modification of this information was provided.

The Rule Editor previously discussed was also a very important support tool. Initially, GDS enters the rules based on a state's statutes and/or procedures governing issuance of permits. Routine maintenance as laws change is usually completed by the client. The development of the rules governing the issuance of permits are based on these laws. The format of these rules follows:

If Observation1 *.and.* Observation2 . *and* . Observation3 *.and.* .... *Then* Result.

Any number of observations can be utilized in the development of these rules. A typical rule may be that *if* the permittee has an oil rig that does not exceed 120k GVW nor 75 feet in length or 14' 6" in height *then* no permit would be required.

Similar rules can also be developed for highway segments and bridges. The rule editor was very easy to use and very well organized. The secret for its success is the development of the rules to accurately reflect the laws of South Dakota.

Another important support tool is a Utilities Module. In this module, customized reports are developed for the client. The number of standard reports can vary for each installation. Based on the interviews conducted in Task 3, a considerable amount of effort is expended during the work day collecting data associated with management reporting functions. This effort should consist of picking a standard report and evaluating the information contained in the reports.

Another tool provided in the Utilities Module provides the capability of editing and updating the database required to support the system.

The databases required to support the routing and permitting modules are updated in the following manner. The first step is to create a series of 9 ASCII text files, called State Data Format (SDF). These nine files are listed in Table 8.1

SDF File Name	Purpose
Bridge	Locates bridge and inputs bridge clearances and structural strength
County	ID and Name of County
Route_ID	Contains Route ID, travel information, feature location along route and by state plane coordinates
Instruct	Descriptive message template for routing instructions
Ramp	Physical characteristics of ramps, loops and connectors
Restrict	Descriptive message template for routing restrictions
Route	Route data
Segment	Contains segment data including direction of travel, width of road surface, shoulders and number of lanes
Town	Town ID, name and county

Table 8.1 gdsPARS™ SDF Files

In addition to the information required by each SDF file, each state has the option to add state specific attributes. Each SDF file has a very straight forward set of formatting rules such as one record per line, comma delimited, variable character strings enclosed by double quotes and all white space outside pairs of double quotes ignored. Once the SDF files are complete, GDS provides software to convert the SDF formatted data into the gdsPARS™ Binary Database.

The cost of implementing the system in South Dakota were discussed. The costs associated with implementing the gdsPARS™ system in a state has five components. They would include: a) license fee for the software, b) customization fee for special features, c) service time for developing permit rules, the collection of data and building the SDF files, d) training and e) annual maintenance and upgrades. South Dakota could save considerable service contract fees by collecting and building the SDF files in house. Typical costs for implementing permit systems in other states generally fall in the $600,000 to $650,000 category.

It has been GDS's experience that it takes approximately 18 months to fully implement a permit and routing system. One could implement the permit module first, and then add the routing module at a later time. With regard to support required by South Dakota, the half time effort of one person is reasonable to support the system.

Finally, the stability of the company and its management was discussed. The panel was assured that while changes in the ownership of GDS were imminent, the future of the organization and the permitting system was stable. NOTE: The GDS Transportation Business Unit was acquired by Bentley Systems, developer of Microstation® desktop products and its strategic affiliate GEOPAK on June 4, 1997. The two companies have incorporated the existing

GDS software technology, and sixteen employees in a new joint venture, GEOPAK Transportation Management Systems, Inc. (GEOPAK-TMS), focusing on providing intelligent transportation applications including Permit and Routing Solution (gdsPARS).

The overall assessment by the Technical Panel of the gdsPARS™ permitting and routing system was very positive. The one disappointing area was the structural evaluation of bridges. gdsPARS™ uses a system of categorizing bridge strengths in three or four different categories based on vehicle axle configuration weights and Federal Bridge Formula B. Also, gdsPARS™ interfaces with custom or standard, BARS or VIRTIS, bridge rating programs. However, it does not have the capability to conduct the rating on individual bridges within the system. Thus, the savings for the structural engineering identified in the Benefit/Cost Task may not be possible.

8.2 EnGraph's Routing Solution Demo

The principal investigator made a presentation of a prototype system developed for the Kansas Department of Transportation (KDOT). This solution is based on a routing algorithm, MAP-TN™, that was built in C++ and MapBasic™, using MapInfo, the leading desktop mapping system.

To use the existing routing functions built for MapInfo by EnGraph, one had to build a very sophisticated map of the Kansas highway system. This map was developed using data from KDOT's CANSYS highway and bridge database. While the data and data structure of KDOT and SDDOT are different, there are many similarities between the two approaches to database management.

Since KDOT wanted the highway map to be compatible with the TIGER92 files, the interstate, US and state highway objects were extracted for the entire state. Because of the inherent inaccuracies in TIGER data, some clean up of the maps was required.

Once this was complete, a map of the Kansas highway system was developed. However, because of the structure of the TIGER files, there were many duplicate objects and identical objects with different attribute names. Also, these objects were very short, which required a large number of objects (approximately 55,000) to develop the map.

MapInfo has a development language called MapBasic that allows users to develop customized applications. A small MapBasic application was developed to merge the TIGER based highway objects and to eliminate the duplicate objects. To facilitate support of the vehicle routing application, attributes such as the main route name, and appropriate subroute names were retained.

There were several rules developed for merging the objects. First, objects would break at all intersections, county/state lines or at city limits. Second, highway names would follow the KDOT hierarchy. This ordered hierarchy was Interstate, US and State highways. Then, a lower highway number would have preference over a higher highway number. If a route contained I-70, US 40 and K 7, I-70 is the main route designation and US 40 and K 7 would be the subroutes. At the conclusion of this exercise, the map contained approximately 2,500 objects.

Once this task was completed, a second MapBasic application was built to connect sub section data to the objects. A number of objectives were accomplished during this step. As part of the database, one could determine if the highway was divided or undivided. If the highway was divided, two segments would be created and were designated as one way streets. If the highway was not divided, a single segment would be created and the segment was designated as a two way street.

Since KDOT uses a county logpoint as its primary location reference system, all highway segments had a beginning and ending county logpoint. All logpoints started at the southern or western county border. The application would determine the exact location for the object. It built an object that was graphically correct and had the appropriate data, subsection ID, route names, a set of logpoints for each highway name, etc. Accuracy of the map and database were paramount to the project. If the lengths of the segment objects and the database were different by more than one percent, data would not be attached to the segments until the discrepancy was identified and corrected.

At the conclusion of this step, a map was developed containing approximately 5,500 map objects that were correctly located on a map. Each segment had a subsection ID, route name information, logpoint information, one way street information and other information that is used in the routing criteria to be discussed later.

Once the map was created, a third MapBasic application was developed to attach all bridges to the map. This was very easy since the bridge database contained the county name, highway and county logpoint data. With this information, each bridge was accurately located on the map and assigned to a segment.

The last step in making the map was the attachment of interchanges to the map. KDOT provided two large binders of intersection maps. The philosophy of the project was to develop an automated process to handle the majority of the interchanges and to use the MapInfo drawing tools to handle the remainder of the interchanges. In reality, approximately 98% of the interchanges were handled using the procedure developed. A dialog box would appear that breaks every interchange into four quadrants. In each quadrant, the user may identify a cloverleaf, ramp, both or none. Once this is done, the system determines whether the traffic goes over, or under each bridge, draws the interchange, designates one way segments, if appropriate, etc.

With these tools, it has taken between 30 minutes and 3 hours to complete the highway system for a county. An average county is taking approximately one hour to complete. When this task is completed, approximately 25,000 to 30,000 segments are expected in the map.

When this highway map is completed, a MapInfo based routing system, MAP-TN, converts this highway map into a MAP-TN database. As previously discussed, MAP-TN is a routing system working within MapInfo to route vehicles from an entry point to an exit point. MAP-TN supports one way streets, temporary point and line barriers, user defined cost function, turn restrictions, and other important features. MAP-TN is routinely being used with 100,000 link networks. It takes less than one second to analyze the network for a given entry point and approximately seven seconds to draw a detailed map.

Conceptually, once the permit vehicle was defined, all bridges and highway segments are checked and compared to the criteria developed with KDOT. If a bridge or highway segment could not pass this criteria, a point or line barrier, respectively, is automatically created. A route is never selected that would require a vehicle to pass over a barrier. If spring thaw or construction information were entered into the system, additional barriers would be created as appropriate.

Finally, it was demonstrated that an entry and exit points could be selected by a variety of means and the shortest path selected. If a "least damage" criteria were developed, the route could be selected based upon the least damage criteria. Then, a map, drive table, and other information would be available to the user.

There was some discussion as to whether a map was really required. Since the real advantage of this approach is to identify the potential barriers that exist for a specific vehicle, presentation of the map is an option. As demonstrated to the panel, one could see that the route would go under certain bridges and over others. Thus, the detailed configuration of the interchange was considered in the routing process.

One feature was discussed but not demonstrated. That was how to conduct bridge rating for each bridge in the system for the permit vehicle as part of the routing process. Since the demonstration, a C++ application was developed under the direction of the principal investigator to load rate highway bridges. On a Pentium Pro, 200 MhZ computer, the bridges of South Dakota were load rated in less than 10 seconds. Since each bridge could be rated for every permit vehicle, the savings identified for the Office of Bridge Design could be realized.

In conclusion, routing of oversize and overweight vehicles in a GIS environment was demonstrated. Because of the flexibility built into the MAP-TN routing system, the routing features discussed during this project are supported all by the system. Bridges that could not carry the permit vehicle load or meet clearance requirements became point barriers. Highway segments that did not meet construction, spring thaw restrictions, etc. became line barriers. Then, the system would select the most feasible route that would not pass through any barrier.

8.3 Demonstration Conclusions

Two very different routing systems were presented to the technical panel. The gdsPARS™ system has a proven track record with an established track record of providing permitting and routing services to states. Included in this experience is a proven record of permitting issues, software development, hardware integration issues, database integration and management and other consideration.

There are two drawbacks to the gdsPARS™ system demonstrated. First, it lacks a bridge load rating system. The second is its cost.

The principal investigator believes that GDS may be interested in considering the addition of bridge load rating into the gdsPARS™ system. On another project, the principal investigator has demonstrated that a bridge load rating function would require approximately 1 second per thousand bridges load rated per permit vehicle axle. Since South Dakota has less than 2,000 bridges on the state system, the time required to load rate each bridge for a five axle permit vehicle would be approximately 10 seconds. If the load rating function were added to gdsPARS™, this system would certainly meet the permitting and routing needs of the state.

While the cost of gdsPARS™ is rather high, there is a certain lack of risk for South Dakota. This company has systems operating in numerous states and each state is generally pleased with the product.

The system under development by the principal investigator was presented as another approach to permit routing. The system developed has the flexibility so South Dakota highway and bridge data could be easily integrated into the system. Bridge load rating features could easily be included in the system. The results of this bridge load rating would be incorporated into the routing system through the temporary barrier tables. Once alternative routing criteria were developed, it could be integrated into the system through the built in user defined cost function feature.

Database management of permit issuance was not a criteria for the prototype system development effort. Based on our experience, the requirements for the database and its engine are rather simple. The key will be to build a user interface that assures the increased productivity and ease of use. Also, the system must have high reliability because the state and trucking industry will be reliant upon the system.

Based on the demonstrations presented to the technical panel, EnGraph recommends that the state consider moving forward on implementing a computerized permitting and routing system for South Dakota. The technology is there and the time is now.

Task 9 Prepare a final report, including Findings, Methods, Conclusions and Recommendations.

This document composes the final report for this project. The findings and methods have been described in the discussion of each task. The remainder of the discussion will focus on the conclusions and recommendations at the project level.

9.1 Summary and Conclusions

Based on the results of the interviews, the project team found that the South Dakota Highway Patrol has primary vehicle permit issuance responsibility. The primary office responsible for this operation is located at the Sisseton Port of Entry. However, permits are also issued by other Ports of Entry, Mobile Carriers, HP District 4 Headquarters, and others.

The present permit issuance system is a paper process. Permits are hand written. Routes for overweight/oversized vehicles are determined by hand. This system works for two reasons. One is the dedicated service of the personnel at the Sisseton Port of Entry. The other is that the number of permits issued is not overwhelming. However, because of the improvements in technology, it should be evident that South Dakota must improve the current permit system by embracing technology for its permitting operation. Significant improvement of productivity of office personnel and improved routing procedures should result from the implementation of an automated permit and routing system.

The present permit issuance system considers bridge rating information, spring thaw restrictions, construction restrictions and type of vehicle permit requested. However, all of these factors are considered by personnel using hand methods. While the professionalism and dedication of the staff is very high, unfortunately mistakes are made because of the system currently supported. When the staff does not feel comfortable with making a permit decision for an overweight vehicle, the permit application is forwarded to the Office of Bridge Design for further evaluation. While the Office of Bridge Design responds rapidly to these requests, this process delays the issuance of the permit.

Based on a review of the data stored in the Roadway Environment System (RES) databases, South Dakota has sufficient data to support an automated routing system. The project team was assured that the accuracy of this data was high. EnGraph recommends that this data be down loaded into an agreeable format for inclusion into the proposed automated routing system. Depending upon the approach selected for routing, the GIS map presently under development by the department may be very useful when defining the South Dakota highway system. With any routing system, the data in the RES databases will be critical to support this functionality.

Two commercially available permitting and routing systems were identified. Based on the work completed during this project, the gdsPARS™ system has been recommended as the commercially available system best suited for South Dakota. The Technical Panel was given a demonstration of this system. It provides a comprehensive solution to the issuance, management, and routing of permit requests.

From the benefit/cost analysis, South Dakota could expect a benefit/cost ratio of approximately 1.58 if an automate permit system were adopted. In addition to the direct benefits identified in this study, numerous other benefits were identified that were not quantifiable.

Based on the work conducted in this project, the following recommendations are presented for consideration by the South Dakota Department of Transportation and Highway Patrol:

1. It is recommended that an automated routing and permitting system for oversize/overweight vehicles be implemented in South Dakota. By implementing an automated system, the personnel involved in the present permitting system would be able to concentrate more on enforcement. It is clear that South Dakota would benefit from the implementation of an automated routing and permitting system since the benefit/cost ratio calculated in this study is 1.58. While numerous benefits were identified for the state, having the information in a database format would allow the state to manage the entire permit operation more efficiently.

2. It is recommended that the automated routing and permitting system be located in Pierre rather than in Sisseton. This would allow for improved system maintenance, telephone service and Internet access. Modern computer systems do not require large levels of support. When that support is required, it would be easier to obtain in Pierre than in Sisseton. The biggest disadvantage with this recommendation is that the expertise of existing staff may be lost. The challenge for South Dakota would be to transfer that experience from Sisseton to Pierre.

3. It is recommended that the automated routing and permitting system be accessible to the Ports of Entry through the Wide Area Network.. The trucking industry would have access to the system through modems or the Internet. This recommendation would reduce the effort required by the permitting staff and improve the service to the trucking industry.

4. The commercially available permit and routing system, gdsPARS™, is recommended because it meets the majority of South Dakota's needs as outlined in this report. When selection of the final system is made, the state may want to consider other systems presently under development.

Glossary and Acronym List

BARS	Bridge Analysis and Rating System
gdsPARS™	gds Permitting and Routing Solutions
MAP-TN	EnGraph's Routing Application
MRM	Mileage Reference Marker
RES	Roadway Environment System
SDF	gds State Data Format