Implementation of HERS-ST in Iowa and Development/Refinement of a National Training Program

MTC
MIDWEST
TRANSPORTATION
CONSORTIUM

Final Report
August 2008

Sponsored by
University Transportation Centers Program,
U.S. Department of Transportation
(MTC Project 2004-01)

ctre
Center for Transportation
Research and Education

IOWA STATE
UNIVERSITY

About the MTC

The mission of the University Transportation Centers (UTC) program is to advance U.S. technology and expertise in the many disciplines comprising transportation through the mechanisms of education, research, and technology transfer at university-based centers of excellence. The Midwest Transportation Consortium (MTC) is the UTC program regional center for Iowa, Kansas, Missouri, and Nebraska. Iowa State University, through its Center for Transportation Research and Education (CTRE), is the MTC's lead institution.

Disclaimer Notice

Non-discrimination Statement

Technical Report Documentation Page

1. Report No. MTC Project 2004-01	**2. Government Accession No.**	**3. Recipient's Catalog No.**	
4. Title and Subtitle Implementation of HERS-ST in Iowa and Development/Refinement of a National Training Program		**5. Report Date** August 2008	
		6. Performing Organization Code	
7. Author(s) Thomas H. Maze, Omar G. Smadi, Neil A. Burke		**8. Performing Organization Report No.**	
9. Performing Organization Name and Address Midwest Transportation Consortium 2711 South Loop Drive, Suite 4700 Ames, IA 50010-8664		**10. Work Unit No. (TRAIS)**	
		11. Contract or Grant No.	
12. Sponsoring Organization Name and Address U.S. Department of Transportation Research and Special Programs Administration 400 7th Street SW Washington, DC 20590-0001		**13. Type of Report and Period Covered** Final Report	
		14. Sponsoring Agency Code	
15. Supplementary Notes Visit http://www.ctre.iastate.edu/mtc for color PDF files of this and other research reports.			
16. Abstract The Highway Economic Requirements System (HERS) is an economic model that uses highway performance monitoring system (HPMS) data to project future highway conditions and requirements. HERS is a highly complex model that, at the national level, uses samples of the highway network taken from the HPMS data. As a result, at the national level it is only used for aggregate network-level analysis (planning-level analysis). When the Federal Highway Administration's Office of Asset Management was established in 1999, the office began developing the state version of HERS, or HERS-ST. HERS-ST has since evolved into a model that is specifically crafted for states. A DOS version of HERS-ST was demonstrated at a workshop attended by representatives of several state transportation agencies in 2001. Since then, several improvements have been made to the software, including updates for a Windows environment and the addition of GIS capabilities. The current project will yield a HERS-ST specifically for Iowa, but one that can be used as a model for other states.			
17. Key Words asset management—GIS—HERS-ST—Highway Economic Requirements System—Highway Performance Monitoring System(HPMS)—network analysis		**18. Distribution Statement** No restrictions.	
19. Security Classification (of this report) Unclassified.	**20. Security Classification (of this page)** Unclassified.	**21. No. of Pages** 29	**22. Price** NA

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

IMPLEMENTATION OF HERS-ST IN IOWA AND DEVELOPMENT/REFINEMENT OF A NATIONAL TRAINING PROGRAM

Final Report
August 2008

Principal Investigator
Tom Maze
Professor of Transportation Engineering
Center for Transportation Research and Education, Iowa State University

Co-Principal Investigator
Omar Smadi
Research Scientist, Professor of Transportation Engineering
Center for Transportation Research and Education, Iowa State University

Research Assistant
Neil Burke

Authors
Thomas H. Maze, Omar G. Smadi, Neil A. Burke

Preparation of this report was financed in part
through funds provided by the U.S. Department of Transportation
through the Midwest Transportation Consortium,
Project 2004-01.

Project administered by
Midwest Transportation Consortium
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664
Phone: 515-294-8103
Fax: 515-294-0467
www.ctre.iastate.edu/mtc

TABLE OF CONTENTS

ACKNOWLEDGMENTS IX

EXECUTIVE SUMMARY XI

DEFINITION OF HERS-ST...1

DATA CUSTOMIZATION...3

- Highway Dataset 3
- Parameter Data Modification..3
- Control Data Modification...4

SAMPLE RUN ANALYSIS AND OUTPUT 5

HERS-ST TRAINING SEMINAR 9

CONCLUSION..10

REFERENCES 11

APPENDIX A. CHANGES MADE TO HERS-ST SAFETY PARAMETERS A-1

APPENDIX B. IOWA COST DATA USED IN HERS-ST ANALYSIS B-1

LIST OF FIGURES

Figure 1. Total improvement cost for Iowa interstate system by funding period for several annual constrained budget scenarios....6
Figure 2. Average IRI values for the Iowa interstate system for several annual constrained budgets....6
Figure 3. Total delay for Iowa interstate system for various funding scenarios....7
Figure 4. Improvement types in $130 million annual constrained budget for Iowa interstate system....8

LIST OF TABLES

Table A.1. Injury reduction parameter modifications.... A-1
Table A.2. Injury/crash ratio by functional class (rural).... A-1
Table A.3. Injury/crash ratio by functional class (urban).... A-1
Table A.4. Fatality/crash ratio by functional class (rural).... A-1
Table A.5. Fatality/crash ratio by functional class (urban).... A-2
Table B.1. Rural right of way costs (in thousands of dollars) per lane mile....B-1
Table B.2. Urban right of way costs (in thousands of dollars) per lane mile....B-1
Table B.3. Improvement options in HERS-ST....B-2
Table B.4. Rural improvement costs (in thousands of dollars) per lane mile....B-2
Table B.5. Urban improvement costs (in thousands of dollars) per lane mile....B-3

ACKNOWLEDGMENTS

The authors would like to thank the Midwest Transportation Consortium for sponsoring this research.

EXECUTIVE SUMMARY

This report summarizes each task involved in the Midwest Transportation Consortium's Highway Economic Requirements System state version (HERS-ST) project. The initial goals of this project include customizing the HERS-ST software for the Iowa primary network, training Iowa Department of Transportation (Iowa DOT) employees to use the HERS-ST software, and holding a regional HERS-ST training seminar. The final task involves integrating the Iowa DOT training experience into Federal Highway Administration (FHWA) training materials and working with the FHWA Office of Asset Management to deliver HERS-ST training seminars to other states.

This document describes the steps used to customize the HERS-ST software, explains the run analyses performed using HERS-ST that would benefit the Iowa DOT, and summarizes the concepts that were included in the HERS-ST training seminar for the Iowa DOT.

DEFINITION OF HERS-ST

In 1987, the Federal Highway Administration (FHWA) began the work on an economic model that later became the Highway Economic Requirements System (HERS) (FHWA 2001). HERS was first used in 1995 to support the U.S. Department of Transportation's (USDOT's) condition and performance report. HERS is an economic model that uses Highway Performance Monitoring System (HPMS) data to project future highway conditions and requirements based on a comparison of the different potential projects. The model then selects improvement options that have benefits greater than their costs. Benefits include reducing user, agency maintenance, and societal costs over the life of the improvement (FHWA 2002a).

HERS-ST, the state-level version of HERS, is a highway investment and performance computer model that has been developed by the FHWA. This software is a Microsoft Access–driven database with a graphical user interface (GUI) that considers engineering and economic impacts and principles to determine the magnitude of alternative highway investment levels and program structures on highway condition, performance, and user impacts. Performance data is loaded from the HPMS data into the GUI. Parameter data provides cost data, deficiency levels, and other data to the HERS-ST analysis. The control data provides the settings for the modification of the HERS-ST analysis engine. The software is currently being utilized by the FHWA and state departments of transportation (DOTs) to estimate future investment requirements for pavement preservation and system expansion. The HERS-ST software has a twenty-year planning horizon, where the default settings analyze performance data for four funding periods of five years in length.

HERS-ST has several run analyses to examine a variety of funding situations. The full engineering analysis disregards a benefit-cost ratio to select projects and instead identifies all deficiencies on a highway system and calculates the funds necessary to fix them. The minimum benefit-cost ratio analysis implements all improvements with a benefit-cost ratio that is greater than the defined threshold value, which has a default value of 1.0. The Constraint by Funds run scenario maximizes the value of the improvements' benefits by selecting projects that are prioritized by deficiency but that are within the limits of the budget for each funding period. The Constraint by Performance run scenario optimizes the goals for the performance of the highway system for each funding period.

Every run scenario executed in HERS-ST produces a tabular output with roadway-related deficiencies, funding by improvement type, and changes between each funding period. Additionally, a "section conditions" spreadsheet file is created that contains performance metrics and improvement types for each segment that had been included in the HERS-ST analysis. The HERS-ST software includes a suite of report tools with chart, table, and report generation programs, as well as a rudimentary geographical information systems (GIS) function. The GIS function in HERS-ST is able to map deficiencies or improvements by section, but it is unable to perform sophisticated data analysis.

While HERS-ST can be a useful planning tool in forecasting performance and maintenance needs, the software has several limitations. HERS-ST is not a network model; thus, it does not consider the improvements of a parallel corridor in the project selection process of another corridor. HERS-ST is also not a spatial model. Therefore, traffic volumes cannot be assigned to specific links. Additionally, the structural costs involved in reconstructing or replacing bridges is not considered (FHWA 2004).

This report will summarize the completed tasks for the Midwest Transportation Consortium's (MTC) HERS-ST project. Customization of the default data was necessary to properly represent the highway infrastructure that the Iowa DOT is responsible for maintaining. Manipulation of the data to prepare a presentable output was an issue. These tasks were completed, and the researchers held a one-day HERS-ST training seminar for Iowa DOT and FHWA employees on Monday, June 27, 2005.

DATA CUSTOMIZATION

Customization of the data used in the HERS-ST analysis was imperative to meet several specific needs. The Iowa DOT was aiming to use HERS-ST to prioritize projects and designate funds appropriately in the fields of asset management, highway safety, and highway maintenance. Because every state transportation agency manages and collects data about its highway network differently, changes need to be made to the default control and parameter HERS data to reflect these differences. Additionally, reconstruction and improvement costs vary by state, so modifications to the default cost information need to be made. Ultimately, the default parameter and control data values reflect nationwide averages, and the HERS-ST analysis could be optimized when values are used that directly reflect conditions on the Iowa primary system.

Highway Dataset

The highway dataset provides the dimensions and operating characteristics of the network to HERS-ST. Similar to the HPMS reporting standards, HERS-ST has 98 attribute fields for every record within a dataset. Several data modification tasks were needed to conduct accurate run analyses in HERS-ST with Iowa HPMS data. Loading errors with the Iowa HPMS dataset were an initial issue. The first dataset obtained from the Iowa DOT Office of Systems Planning was a series of 37,000 sample sections of less than one mile in length throughout the state. This dataset was not well refined, contained numerous data errors, and produced spurious results when a HERS-ST run analysis was executed.

As an alternative, the HPMS sample dataset was replaced by a 100% sample that contained only 5,031 records. The complete sample dataset contained 8,800 miles of highway segments, which represents the entire primary system throughout the state. From the complete dataset, meaningful run analyses in HERS-ST could be performed. Using the query tool in HERS-ST, analyses were run on the entire interstate system throughout the state, the urban interstate system, and the primary system excluding the interstate system.

To obtain a higher level of accuracy in the analysis of pavement deterioration on the Iowa primary system, modifications to the international roughness index (IRI) values were made. The Iowa DOT collects IRI data for each test segment, then aggregates these averages to finite Geographic Information Management System (GIMS) segments of significant length. This method loses the local impact of IRI data. As an alternative, 10 m distress IRI data collected by Roadware Group, Inc., was substituted for the IRI data provided by the Iowa DOT. The IRI data was averaged for each wheel path and assigned to test sections throughout the primary system.

Parameter Data Modification

The parameter data provides significant information to the HERS-ST analysis regarding pavement specifications, improvement costs, and deficiency thresholds. A workset may have multiple sets of parameter data, although only one is active at a given time. The customization of the parameter values in HERS-ST involved modifications to the safety parameters, deficiency thresholds, and cost parameters.

The safety parameters estimate the future safety of the highway system given the crash rates for different highway functional classes and the length of the analysis period. Specifically, the value of life was adjusted from the HERS-ST default of $3,000,000 to the Iowa DOT fatality cost of $1,200,000. The Iowa DOT Office of Traffic Safety provided values for the injury-crash ratio and fatality-crash ratio by functional class. The actual changes that were made to the safety parameters are listed in Appendix A.

The deficiency thresholds are used to determine whether a highway segment requires an improvement. These settings in HERS-ST also determine the best improvement type based on the deficiency threshold. The pavement deterioration rate has a default value of 0.3. A sensitivity analysis was conducted with several different rates before 0.15 was selected because this value provided a reasonable time period for resurfacing projects on interstate segments. In addition, eight modifications were made to the present serviceability rating (PSR) and the maximum PSR after resurfacing based on the pavement type for urban and rural sections.

The cost parameters measure the expense of an improvement on a highway segment. One of the modifications made to the cost parameters involved changing the state cost factor from 0.745 to 1.0 to provide more weight for each improvement. The state cost factor affects how the improvement costs are viewed in the interface and used in the HERS-ST analysis. A state cost factor is derived for each state by the state's Office of Infrastructure and is calculated from price trends as a three-year rolling average that is applied to all capital costs associated with the improvement (FHWA 2002b). The following cost parameter data was changed relative to the default cost data that the Iowa DOT uses to price transportation projects:

- Improvement cost (by functional class)
- Right of way cost (by functional class and terrain)
- Pavement cost (by pavement thickness)
- Pavement cost for unreinforced rigid slabs

Appendix B lists the cost data used in the HERS-ST analyses prepared for the Iowa DOT.

Control Data Modification

Modifying the control data allows the user to specify the analysis objective, method, cost units, output information, and other settings to control the analysis. Like the parameter data, a workset can have several sets of control data, although only one set can be active at a time. The discount rate used in reducing benefits was modified from 7% to 4% to reflect the discount rate used by the Iowa DOT. The maximum speed limit for the interstate scenario was changed from 75 mph to 65 mph to reflect the state of Iowa's maximum speed limit on rural interstate segments at the time.

SAMPLE RUN ANALYSIS AND OUTPUT

A sample run analysis was created in HERS-ST to test the validity of the analysis engine as well as the output functions. The 20-year analysis consisted of four funding periods with 5-year durations. The analysis identified the deficiencies and improvements on Iowa's interstate highway network. All of the interstate sections were selected in HERS-ST by using the query tool. All sections of the I-235 corridor through Des Moines were excluded because the entire reconstruction of this highway is ongoing and expected to be completed in 2008. A "constrained by funds" scenario was chosen to determine the amount of funding necessary to achieve the desired average performance metrics on the interstate system. A sensitivity analysis was conducted in which the HERS-ST analysis was constrained by the following funding scenarios:

- $550 million per funding period
- $600 million per funding period
- $650 million per funding period
- $700 million per funding period
- $750 million per funding period

HERS-ST offers chart, table, GIS, and report functions as ways to display outputs. For this project, the GIS and chart functions were used extensively, but HERS-ST was used to calculate the values while the final maps and charts were created outside of the software. HERS-ST is a powerful economic and engineering model, but its graphical output options are limited. Therefore Arcview GIS 9.0 was utilized to create maps, and Microsoft Excel was used to create charts.

The chart report function was used in HERS-ST to display the funding distribution for the five scenarios and to depict the effect of different funding mechanisms on the performance of the Iowa interstate system. Figure 1 depicts the total improvement cost for each funding period for the Iowa interstate system.

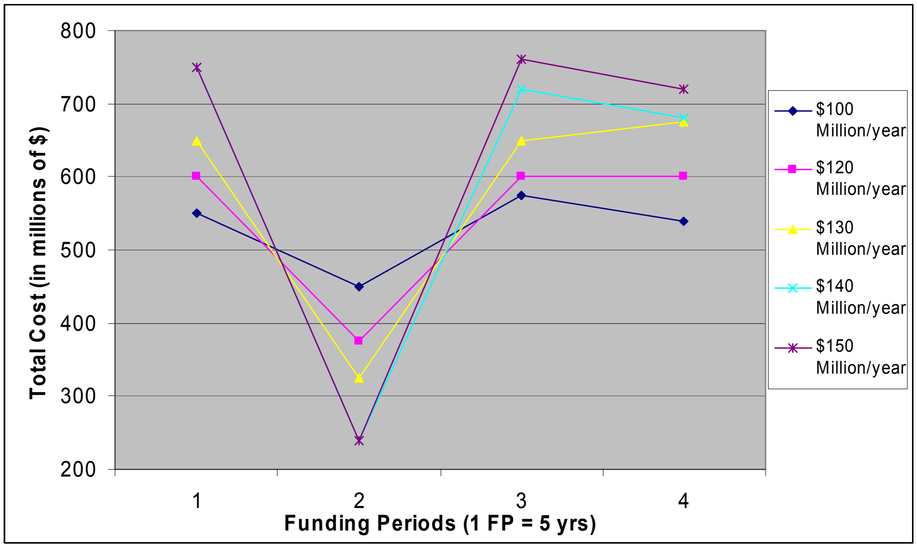

Figure 1. Total improvement cost for Iowa interstate system by funding period for several annual constrained budget scenarios

It is evident from Figure 1 that HERS-ST can overfund a particular funding period in a constrained budget scenario if a specific highway segment meets the deficiency level requirements. HERS-ST offers extensive output options for the performance metrics calculated for each funding period in a run scenario. Figure 2 displays the average IRI values for pavements on the Iowa interstate system.

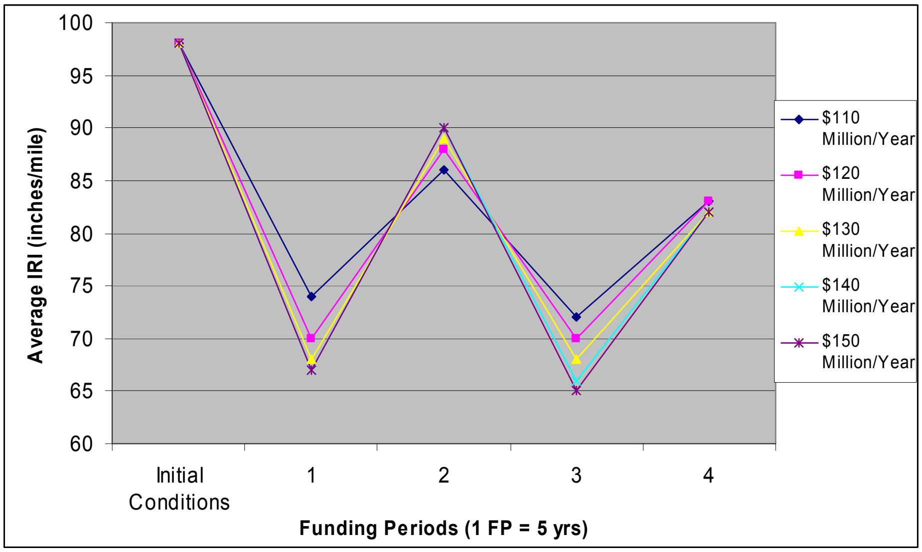

Figure 2. Average IRI values for the Iowa interstate system for several annual constrained budgets

Figure 2 indicates that the $150 million annual funding scenario for the Iowa interstate system will provide a lower average IRI value than the lower funding scenarios. Figure 3 depicts the total delay for the Iowa interstate system given the five annual funding scenarios.

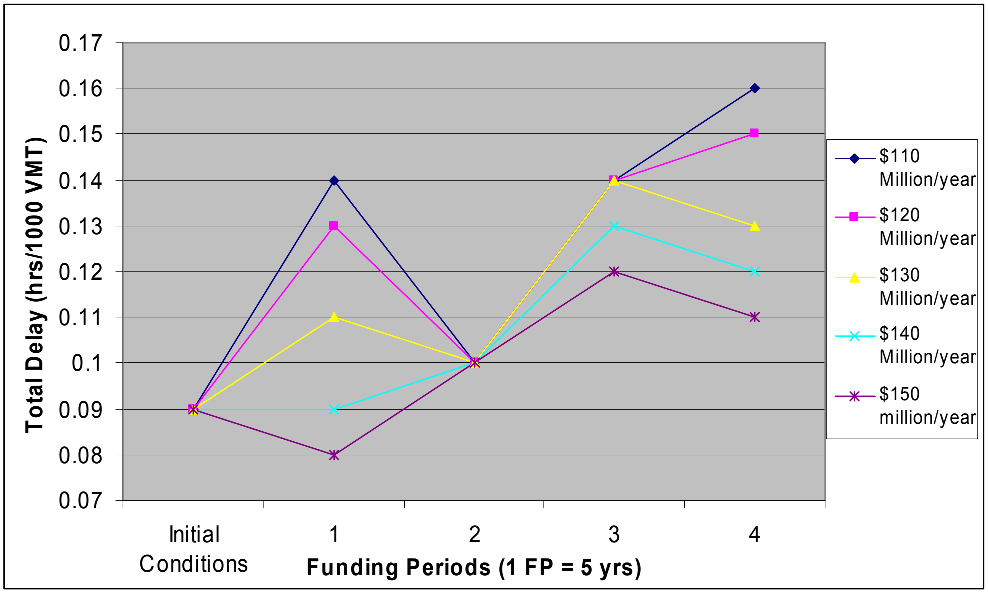

Figure 3. Total delay for Iowa interstate system for various funding scenarios

Figure 3 indicates that delay levels are reduced when additional amounts of funding are dedicated to the Iowa interstate system. The chart function in HERS-ST is useful for determining the distribution of funds across funding periods, as well as how various funding scenarios affect the performance metrics on the Iowa interstate system.

A series of maps were generated in Arcview GIS 9.0 based on the improvement data generated from HERS-ST analyses. HERS-ST has a GUI driven by a Microsoft Access database. Therefore, the improvement types were extracted from the database in Microsoft Access, brought into Arcview GIS 9.0 as a shapefile, and symbolized by the improvement types that HERS-ST designated for each segment.

The purpose of these maps was to determine the locations and types of improvements that HERS-ST recommended on the Iowa interstate system over a 20-year analysis period. A sensitivity analysis was conducted for the pavement deterioration rates because HERS-ST recommended resurfacing the same segments of interstate every three years when the normal lifespan of pavements is seven years. The improvement types that HERS-ST can recommend include resurfacing, resurfacing and adding lanes, and reconstruction.

Figure 4 depicts the improvement types identified in HERS-ST for a constrained annual budget of $130 million for the Iowa interstate system. The sections that are colored green indicate resurfacing, blue indicates a capacity improvement, and orange indicates that a reconstruction is necessary for the selected segments.

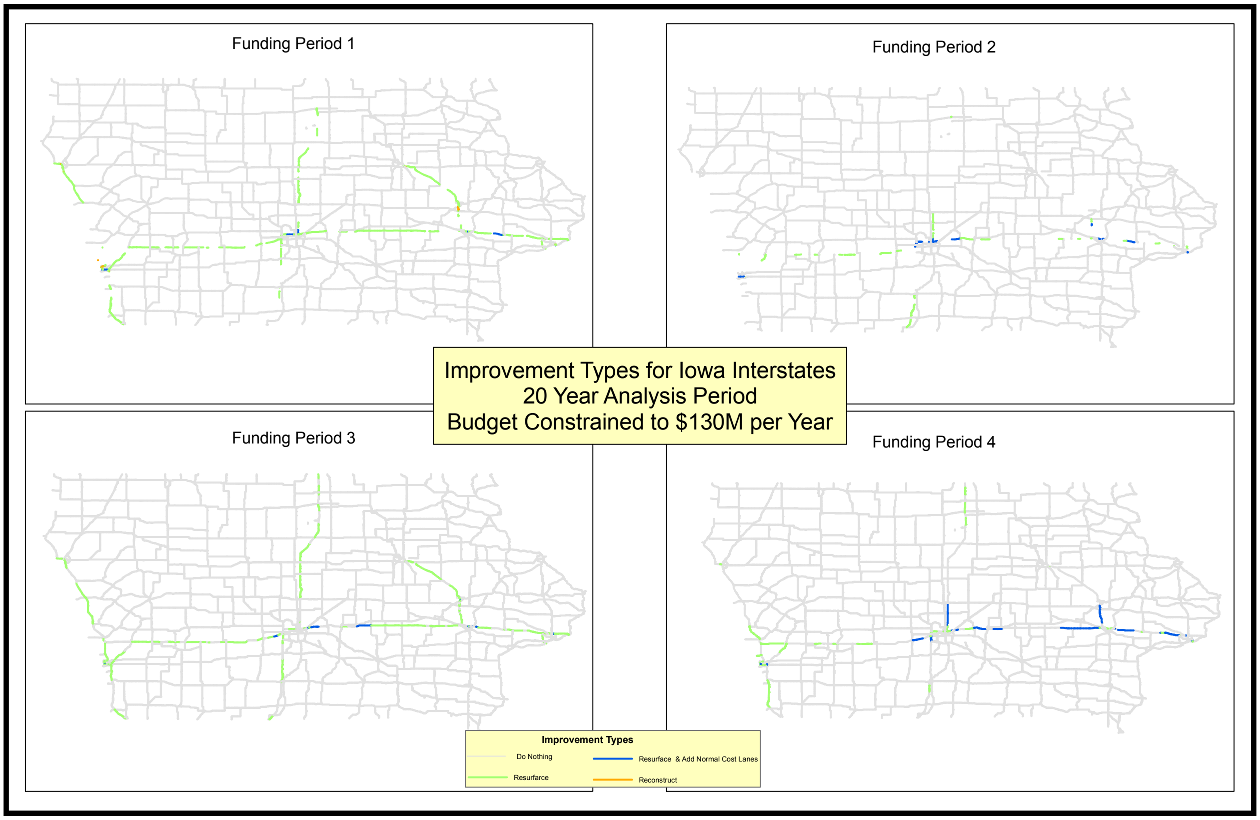

Figure 4. Improvement types in $130 million annual constrained budget for Iowa interstate system

It is evident from Figure 4 that the majority of the Iowa interstate system will be resurfaced in the 20-year planning period. HERS-ST also recommends capacity improvements on the I-80 corridor between Des Moines and the Illinois border, the I-35 corridor between Des Moines and Ames, and the I-380 corridor between Iowa City and Cedar Rapids.

By using HERS-ST, a user is able to derive a scenario, run an analysis, and generate maps and charts that characterize the nature of the improvements and the effect that they may have on the performance metrics of the affected corridors.

HERS-ST TRAINING SEMINAR

A HERS-ST training seminar was held on Monday, June 27, 2005. Ten employees from the Iowa DOT and the FHWA Iowa Division attended this day-long training seminar, which was organized and administered by the principal investigator, co-principal investigator, and research assistant of the MTC HERS-ST project. The seminar was held at the Center for Transportation Research and Education at the Iowa State University Research Park in Ames, Iowa.

The training seminar began by defining the capabilities and limitations of HERS-ST, as well as the applications that are possible. Along with this introduction to HERS-ST, the presenters gave the audience insight into the ways several state DOTs are currently using the software. The second presentation introduced the technical attributes of the HERS-ST model. Specifically, the presentation explained how economic models, engineering models, and decision support tools comprise the analytical engine of HERS-ST. The third presentation provided an overview of the customization of the parameter and control data in HERS-ST that was performed to accurately depict the pavement specifications, improvement costs, and deficiency thresholds that represent the primary system throughout the state of Iowa. The fourth presentation explained how to run analyses with HERS-ST and view the results. In addition, this presentation included instructions on creating reports using the outputs of run analyses in HERS-ST.

Following lunch, the seminar attendees participated in a three-hour hands-on training seminar. Each seminar participant was given a laptop computer with the HERS-ST software installed, the Iowa primary roads dataset, and the modified control and parameter data. The hands-on session began by instructing the seminar participants to query specific segments from the Iowa primary roads dataset. Afterwards, the participants executed a constrained budget run analysis and opened the tabular output to view the results. From the results of this analysis, the participants generated charts and used GIS to create maps of the segments that were selected. At the end of the training seminar, all participants had a basic understanding of what HERS-ST is and how the software can be utilized in the long-term planning process at a state DOT.

In the upcoming months, the principal investigators will collaborate with the FHWA Office of Asset Management to develop a HERS-ST regional training seminar to be held at a location central to the Midwestern states (e.g., Kansas City). Representatives from neighboring state DOTs will be invited to attend this seminar (i.e., Minnesota, Missouri, Nebraska, Kansas, and Illinois).

CONCLUSION

The objective of this project was to become familiar with HERS-ST, customize the software for the Iowa DOT, and train employees to integrate this software into their planning, safety, and maintenance processes. Through a series of trial runs, the researchers found that more accurate analyses could be executed when the 100% Iowa primary road dataset, as opposed to the HPMS sample dataset for Iowa, was used in the HERS-ST analysis.

The report functions in HERS-ST are useful for identifying the distribution of capital between funding periods or quantifying the changes in the performance metrics when programmed improvements have been implemented. The training seminar proved to be successful in introducing Iowa DOT employees to HERS-ST and explaining to the participants how this software can be integrated into the long-range planning process. A regional HERS-ST training seminar is being planned by the principal investigators and the FHWA Office of Asset Management.

REFERENCES

FHWA. 2001. *Highway Infrastructure: FHWA's Model for Estimating Highway Needs Has Been Modified for State-Level Planning*. Prepared for Congress by the General Accounting Office. GAO-01-299. Washington, DC: General Accounting Office.

FHWA. 2002a. *HERS-ST: Highway Economic Requirements Systems: State Version, Pilot Program 2002*. Washington, DC: Federal Highway Administration.

FHWA. 2002b. *Highway Economic Requirements System-State Edition Version 2.0 Technical Report*. Washington, DC: Federal Highway Administration.

FHWA. 2004. *Highway Economic Requirements System-State Version Users Guide*. Draft Copy, Software Version 3.X. Washington, DC: Federal Highway Administration.

APPENDIX A. CHANGES MADE TO HERS-ST SAFETY PARAMETERS

The tables in this appendix describe the modifications made to the safety parameters data.

Table A.1. Injury reduction parameter modifications

Name	Definition	Default HERS-ST Value	Iowa DOT Value
APDFPC	Annual percentage decline in fatalities per crash	0	0.012
APDIPC	Annual percentage decline in injuries per crash	0	-0.017
APDCR	Annual percentage decline in crash rates	0	-0.007

Table A.2. Injury/crash ratio by functional class (rural)

Rural	Default HERS Data	Iowa DOT
Inj/Cr Rural Freeway	0.45	0.32
Inj/Cr Rural Expressway*	n/a	
Inj/Cr Rural Principal Arterial	0.63	0.69
Inj/Cr Rural Minor Arterial	0.56	
Inj/Cr Rural Major Collector	0.63	

In Table A.2., the default HERS-ST values were used when the values were not provided by the Iowa DOT.

Table A.3. Injury/crash ratio by functional class (urban)

Urban	Default HERS Data	Iowa DOT
Inj/Cr Urban Freeway	0.49	0.41
Inj/Cr Urban Expressway	0.36	
Inj/Cr Urban Principal Arterial	0.41	0.40
Inj/Cr Urban Minor Arterial	0.34	0.34
Inj/Cr Urban Major Collector	0.35	

In Table A.3, the default HERS-ST values were used when the values were not provided by the Iowa DOT.

Table A.4. Fatality/crash ratio by functional class (rural)

	Default HERS -ST Data	Iowa DOT
Freeway	0.01	0.01
Principal Arterial	0.02	0.02
Minor Arterial	0.01	0.01
Major Collector	0.01	

The fatality/crash ratio values provided by the Iowa DOT were the same as the default values in HERS-ST.

Table A.5. Fatality/crash ratio by functional class (urban)

	Default HERS-ST Data	Iowa DOT
Freeway	0.0038	0.0044
Expressway	0.004	0.003
Principal Arterial	0.0027	0.0027
Minor Arterial	0.0024	0.0018
Major Collector	0.0026	

In Table A.5, all of the values supplied by the Iowa DOT were utilized. The Iowa DOT does not collect data on major collectors, and therefore the default HERS-ST value was used.

APPENDIX B. IOWA COST DATA USED IN HERS-ST ANALYSIS

The tables in this appendix depict the default HERS-ST cost data values and the modified values that were obtained from the Iowa DOT.

Table B.1 depicts the default cost values in HERS-ST for rural right of way and the cost values supplied by the Iowa DOT. The Iowa DOT values were used in the analysis.

Table B.1. Rural right of way costs (in thousands of dollars) per lane mile

		Default HERS-ST Value	Iowa DOT Value
Interstate	Flat	103	208
	Rolling	92	208
	Mountainous	82	208
Principal Arterial	Flat	92	158
	Rolling	82	158
	Mountainous	73	158
Minor Arterial	Flat	85	143
	Rolling	73	143
	Mountainous	63	143
Major Collector	Flat	82	120
	Rolling	71	120
	Mountainous	63	120

Table B.2 lists the default cost values in HERS-ST for urban right of way and the cost values supplied by the Iowa DOT. The Iowa DOT values were used in the analysis.

Table B.2. Urban right of way costs (in thousands of dollars) per lane mile

	Default HERS-ST Value	Iowa DOT Value
Freeways/Expressways	304	484
Other Divided	305	484
Other Undivided	242	234

Table B.3 shows the improvement options in HERS-ST and the abbreviations associated with these improvements.

Table B.3. Improvement options in HERS-ST

RCHC	Pavement reconstruction and add high-cost lanes
RCNC	Pavement reconstruction and add normal-cost lanes
RCWL	Pavement reconstruction with wider lanes
RC	Pavement reconstruction
MWHC	Resurface and add high-cost lanes
MWNC	Resurface and add normal-cost lanes
MinW	Resurface and widen lanes
RsSh	Resurface and improve shoulders
RS	Resurface
CCNF	Cost of constructing new facilities

Tables B.4 and B.5 show the default cost values for urban and rural improvement options. The abbreviations shown in Table B.3 are used to describe the improvements in Tables B.4 and B.5.

Table B.4. Rural improvement costs (in thousands of dollars) per lane mile

		Default HERS-ST Values									
		RCHC	**RCNC**	**RCWL**	**RC**	**MWHC**	**MWNC**	**MinW**	**RsSh**	**RS**	**CCNF**
Interstate	Flat	1565	633	714	595	1143	398	323	221	125	2801
	Rolling	1590	741	788	612	1232	424	346	233	120	3068
	Mountainous	2507	854	1044	870	1677	599	475	286	155	3732
Principal Arterial	Flat	1199	799	609	520	1143	408	315	153	78	2521
	Rolling	1380	826	684	588	1232	456	348	167	78	2761
	Mountainous	1786	1175	897	735	1489	851	495	228	115	3358
Minor Arterial	Flat	1041	694	469	370	1028	403	262	155	66	1145
	Rolling	1261	755	590	503	1030	557	275	157	71	1243
	Mountainous	1551	1021	920	661	1309	708	364	195	110	1644
Major Collector	Flat	1143	611	534	379	805	383	212	108	37	1040
	Rolling	1117	669	648	468	975	381	223	118	43	1128
	Mountainous	1361	896	829	646	1017	651	296	151	54	1488

		Iowa DOT Values									
		RCHC	**RCNC**	**RCWL**	**RC**	**MWHC**	**MWNC**	**MinW**	**RsSh**	**RS**	**CCNF**
Interstate	Flat	2250	1250	100	950	1500	750	550	275	250	3000
	Rolling	2250	1250	100	950	1500	750	550	275	250	3000
	Mountainous	2250	1250	100	950	1500	750	550	275	250	3000
Principal Arterial	Flat	1750	1100	900	850	1250	650	400	200	175	2750
	Rolling	1750	1100	900	850	1250	650	400	200	175	2750
	Mountainous	1750	1100	900	850	1250	650	400	200	175	2750
Minor Arterial	Flat	1750	950	800	600	1250	500	375	190	125	1750
	Rolling	1750	950	800	600	1250	500	375	190	125	1750
	Mountainous	1750	950	800	600	1250	500	375	190	125	1750
Major Collector	Flat	1500	850	750	600	1100	425	275	150	100	1750
	Rolling	1500	850	750	600	1100	425	275	150	100	1750
	Mountainous	1500	850	750	600	1100	425	275	150	100	1750

Table B.5. Urban improvement costs (in thousands of dollars) per lane mile

Default HERS-ST Values

	RCHC	RCNC	RCWL	RC	MWHC	MWNC	MinW	RsSh	RS	CCNF
Freeways	9160	3939	2889	1769	9298	4076	1716	513	238	6340
Other Divided	5447	2176	1779	1008	5825	2554	946	351	160	5707
Other Undivided	3848	1407	1546	922	4347	1905	1001	306	181	1533

Iowa DOT Values

	RCHC	RCNC	RCWL	RC	MWHC	MWNC	MinW	RsSh	RS	CCNF
Freeways	10000	4000	2000	1500	5500	3500	1300	400	300	5000
Other Divided	7000	3000	1500	1250	4000	2000	1000	300	250	4000
Other Undivided	4000	2000	1250	1000	3000	1500	900	250	200	2500