FEASIBILITY OF USING AUTOMATED DISTRESS DATA IN THE COUNTY NEED STUDY

FINAL REPORT

**Sponsored by the Project Development Division of the Iowa Department of Transportation and the Iowa Highway Research Board
Iowa DOT Project TR-418
CTRE Management Project 98-24**

DECEMBER 1998

Center for Transportation Research and Education

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Iowa Department of Transportation

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Feasibility of Using Automated Distress Data in the County Need Study

Final Report

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of the Iowa Department of Transportation
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Preparation of this report was financed in part
through funds provided by the Iowa Department of Transportation
through its research management agreement with the
Center for Transportation Research and Education.
CTRE Management Project 98-24

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December 1998

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

This research project was made possible through funding from the Iowa Highway Research Board (IHRB). We are grateful to the IHRB members for their support and cooperation in completing this project.

The researchers would also like to thank the members of the advisory committee for their input, participation, and assistance throughout the duration of the project. The advisory committee consisted of the Iowa County Engineers Association Functional Classification and Highway Needs Committee members.

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Our special thanks go to Stuart Anderson, Iowa Department of Transportation Office of Systems Planning, for serving as project monitor and for all of his help in providing the data and conducting the HWYNEEDS computer runs.

ABSTRACT

The quadrennial need study was developed to assist in identifying county highway financial needs and in the distribution of the road use tax funds (RUTF) among the counties in the state. During the period since the need study was first conducted using the HWYNEEDS software, between 1982 and 1994, there have been some large fluctuations in the level of funds distributed to individual counties. A recent study, which performed a sensitivity analysis of the software system used to support the need study found that one of the major factors effecting the volatility in the level of fluctuations is the quality of the pavement condition data collected and the currency of these data. The study reported in this document investigates the use of the automated distress data, that were collected for the Iowa Pavement Management Program (IPMP) for the paved county roads and input to the need study software, as a possibility for improving the quality and timeliness of pavement condition data. The underlying hypothesis for this study is that the IPMP data can be used to support the need study, improve its results, and possibly reduce the volatile fluctuations of money allocated to counties in consecutive need studies. The automatically collected data should alleviate the problems created by the inherent subjectivity and the lack of currency in the manually collected data.

This study identifies a procedure by which the automated distress data collected for the IPMP can be integrated into the quadrennial need study software program (HWYNEEDS).

IPMP condition data are used to replace the pavement surface ratings collected manually by the Iowa Department of Transportation (Iowa DOT) on a 10-year rotation (condition is collected for one-tenth of the entire county road network resulting in complete coverage every 10 years). A pilot study area was selected to demonstrate the use of the new distress data. The pilot study consisted of several corridors across several counties in a variety of areas in the state.

Recommendations are identified for the use of the automated distress data and also in terms of making some changes to the current process of the quadrennial need study. Future research areas are also identified.

INTRODUCTION

Iowa's quadrennial need study was first conducted in 1960, and the process used to conduct the need study was updated in 1982 to include the use of a computer program to project financial needs and to allocate financial resources among counties. Iowa's quadrennial need study serves two main purposes. The first is to determine the 20-year road needs in terms of construction, maintenance, administration, and engineering costs. The second purpose is to allocate road use tax funds (RUTF) to the counties in proportion to their relative needs.

The computer program, HWYNEEDS, developed by the Federal Highway Administration (FHWA), was adopted as the main programming tool for the need study. HWYNEEDS forecasts the condition of highways, automates the determination of financial needs, and provides a tool to help in the allocation of a percentage of the RUTF money to the counties. Since the implementation of HWYNEEDS, highway condition data have been collected manually, through visual surveys. Visual surveys are performed on one-tenth of the state's secondary highway network each year; thus data for the entire network are covered once every 10 years. This project examines the feasibility and the improvement in the results of HWYNEEDS by utilizing machine (automated) collected pavement condition data to serve as input to HWYNEEDS, instead of the current manually collected pavement condition data. It is hypothesized that automated data collection would have two advantages. The first is related to that fact that when condition data are collected by machine, there are fewer opportunities for biases and inconsistencies in the database. Secondly, once the automated collected data are applied to the quadrennial need study, the data are likely to be collected once every two years, thus improving the currency of the data used in the analysis.

Although the majority of highway needs focuses on the condition of the pavement, it is not the only feature considered in the HWYNEEDS program. The HWYNEEDS program considers all features of the highway network (paved and unpaved surfaces, structures, etc.) and project needs based on several key factors including the condition of paved surfaces, traffic, functional classification, and geometric characteristics.

In Iowa, automated pavement condition data are being collected for parts of the county network through a related program, the Iowa Pavement Management Program (IPMP). The IPMP is a statewide program to develop pavement condition databases to support the application of pavement management by the Iowa DOT and cities and counties for the federal-aid-eligible highways within their jurisdictions. Condition data for the IPMP are collected utilizing automated equipment. This equipment uses lasers and digital video to collect roughness, rutting, and cracking information. Automated distress data are objective and consistent and provide for a complete coverage of the pavement surface. By comparison, the current pavement condition data used to support the need study are collected through visual inspection. The current process may result in some bias through the inherent subjectivity of the manual data collection process.

Background

Quadrennial need studies conducted in the past have exhibited large changes (positive and negative) in the funds allocated to individual counties. The shifts in funding following each four-year study make it difficult for counties who experienced these shifts to plan for future highway improvement programs. In 1993, the Iowa Highway Research Board (IHRB) funded a project to clarify the quadrennial need study process and determine causes for the large shifts. The study, conducted by Cable, investigated the key factors that might result in large shifts in the allocation of resources to individual counties (1). One of the major factors was the sensitivity of the results to pavement condition. The study determined that a change of one to two points (on a 10-point scale) in the road condition rating resulted in a shift in needs that exceeded 30 percent (1). One of the recommendations that resulted from the Cable study was to improve the quality of the condition data by using automated equipment and by increasing the frequency of the inventory from once every 10 years to once every two years (1).

Study Objectives

The main objective of this study is to determine the feasibility and benefits of using the automated distress data (roughness, rutting, and individual cracking measurements) in the HWYNEEDS program to replace the existing manually collected pavement condition ratings. The study will also investigate the impact of using the automated distress data on the overall needs and determine the sensitivity of the HWYNEEDS program to the use of the automated distress data.

PROPOSED WORK

The work described in this report addresses the feasibility and benefits of using automated distress data as input to the quadrennial need study program (HWYNEEDS) instead of the currently used subjective surface condition ratings collected for the Iowa DOT base record inventory.

The research conducted for this project only investigates the feasibility and benefits of using the IPMP automated distress data as input to HWYNEEDS. The research does not investigate the other parameters of the HWYNEEDS program. Issues which may be considered in future research include the rate at which the program forecasts future deterioration of pavements and other infrastructure features, the decision mechanisms used to select treatment strategies (decision trees), and the assessment of improved conditions following the application of a treatment. It is recommended that future research address the improvement and updating of HWYNEEDS parameters and potentially upgrading the entire HWYNEEDS system.

This study focuses on a pilot area to examine the sensitivity of the results to the use of IPMP distress data. The pilot area selected represents a group of highways indicative of the different environmental and traffic volume characteristics present in the counties around the state. For example, the selected highways will include highway segments from rural and urban counties, counties with flat and hilly terrain, and other variables felt to be important by the project steering committee. The results of the analysis using the IPMP data as input (the data collected by machine) are compared to the results of the computer program using the base record data (the manually collected data).

Project Tasks

The research project was accomplished by conducting five tasks. The following is a brief description for each task:

1. Pilot study area: This task involved the selection of pilot study pavement segments representing different characteristics of Iowa counties. The pilot study area was selected carefully and with the guidance of the project steering committee. The pilot study highways consist of routes in several counties. After determining the pilot study area, need study sections within that area were identified and located.

2. Data conversion: Develop a mechanism to convert the automated distress data from individual distress measurements to a composite score. The composite score was used as input to HWYNEEDS instead of the surface ratings visually collected by the Iowa Department of Transportation (DOT). The project steering committee members assisted CTRE researchers in developing the equations to convert individual distress ratings into a composite pavement condition rating.

3. Database: The need study section limits (begin and end) were loaded into the IPMP geographic information system (GIS) database. The section limits were determined using begin kilometer point and length. IPMP distress sections were located using global positioning system coordinates (GPS latitude and longitude coordinates). Dynamic segmentation was used to summarize the IPMP distress data (100 m test sections) to the need study sections selected for the pilot study.

4. HWYNEEDS program: The need study section information (identification information and the new and old surface ratings) was provided to the Iowa DOT Office of Systems Planning. The HWYNEEDS program was executed with both ratings based on IPMP and the Iowa DOT base record inventory surface ratings for the highway segments included in the pilot study. The results were reported back to CTRE for further analysis, investigation, and review.

5. Sensitivity analysis and evaluation: CTRE researchers analyzed and evaluated the results of several HWYNEEDS program runs to determine the sensitivity of the results to the use of automated distress data. The results were presented to the project steering committee, and based on comments and questions, more runs were requested.

REPORT ORGANIZATION

The first part of the report covers the research methodology, project tasks, and the implementation plan. The methodology section covers data conversion from the automated collection format to the format required by HWYNEEDS, the selected pilot study area, and the methodology used to forecast future deterioration of pavements as they age. The second part of the report is dedicated to the discussion of the sensitivity of HWYNEEDS to variation in the input parameters. The final part of the report discusses the conclusions and recommendations of the research project.

Throughout the entire project, a committee consisting of the county engineers serving on the Iowa County Engineers Association (ICEA) Functional Classification and Highway Needs

Committee (12 county engineers) supervised the research and provided input to the researchers. Also, a technical monitor from the Iowa DOT Office of Systems Planning provided advice and technical guidance to the committee and the researchers.

METHODOLOGY

This section describes the methodology followed to achieve the goals of the research project. This section is divided into three parts. The first part discusses the pilot study selection criteria and implementation. The second part contains the data conversion, and finally the third part describes the development of performance prediction parameters to conduct HWYNEEDS simulation runs.

Pilot Study Area

The pilot study consisted of routes (or multiple routes) in each county that comprised a corridor across regions of the state. The pilot study corridors were selected to take into account the different characteristics of the secondary road system across the state and between counties. Corridors in urban and rural counties were selected. Flat and hilly terrain areas were also included in the study. The pilot study corridors were about 1,100 km long and ran across 36 counties. In total, there were 21 corridors selected. Some of the corridors were further subdivided into small corridors resulting in a total of 36 corridors. Table 1 provides a listing of the corridors selected for the pilot study while Figure 1 provides a map of the sections' locations.

The Office of Systems Planning at the Iowa DOT provided the base record information for the needs sections included in the pilot study corridors. The information consisted of location, condition, and physical characteristics. The begin kilometer point (KMPoint) and length of each section were calculated and entered into the IPMP GIS database.

Table 1. Pilot Study Corridors				
Corridor	**Route**	**County**	**County #**	**Description**
1	A034	Lyon	60	Highway 182 to Osceola county line
1	A034	Osceola	72	Lyon county line to Highway 60
1	A034	Osceola	72	L036 to Dickinson county line
1	A034	Dickinson	30	Osceola county line to N014
1	A034	Emmet	32	A048 to Highway 15
2	B040	Sioux	84	K018 to west city limits of Sioux Center
2	B040	O'Brien	71	L026 to Clay county line
3	A042	Kossuth	55	Highway 15 to Winnebago county line
3	A042	Winnebago	95	Kossuth county line to Forest City limits
4	A038	Winnebago	95	Leland city limits to R074
4	A038	Worth	98	Winnebago county line to Mitchell county line
4	A038	Mitchell	66	Worth county line to T026
5	B055	Hancock	41	Corwith east city limits to Cerro Gordo county line
5	B055	Cerro Gordo	17	Hancock county line to Highway 107
6	B060	Cerro Gordo	17	Highway 107 to Floyd county line
6	B060	Floyd	34	Cerro Gordo county line to Chickasaw county line
7	V056	Chickasaw	19	Howard county line to Bremer county line
7	V056	Bremer	9	Chickasaw county line to Highway 3
8	V062	Buchanan	10	Fairbank south city limits to D016
9	V065	Buchanan	10	Jesup south city limits to D048
10	Y031	Jackson	49	Dubuque county line to Highway 428
11	Y032	Clinton	23	E063 to Wheatland north city limits
12	Y04E	Clinton	23	Wheatland south city limits to Scott county line
12	Y04E	Scott	82	Clinton county line to Dixon north city limits
13	Y040	Scott	82	Dixon south city limits to Buffalo north city limits
14	H038	Henry	44	Mt. Pleasant east city limits to Des Moines county
14	H038	Des Moines	29	Henry county line to Highway 99
15	H017	Jefferson	51	Wapello county line to Pleasant Plain west city limits
16	V018	Tama	86	Highway 8 to E064
16	V018	Poweshiek	79	Tama county line to Highway 85
17	V013	Mahaska	62	G017 to Highway 63
18	K064	Plymouth	75	Sioux county line to Oyens north city limits
18	K064	Woodbury	97	Highway 20 to Monona county line
18	K064	Monona	67	Woodbury county line to K045
19	K045	Monona	67	Woodbury county line to Harrison county line
19	K045	Harrison	43	Monona county line to Mondale north city limits
20	L051	Cherokee	18	Highway 3 to Ida county line
20	L051	Ida	47	Cherokee county line to Crawford county line
20	L051	Crawford	24	Ida county line to Highway 37
21	M047	Crawford	24	Manilla south city limits to Shelby county line
21	M047	Shelby	83	Crawford county line to Pottawattamie county line
21	M047	Pottawattamie	78	Shelby county line to Montgomery county line

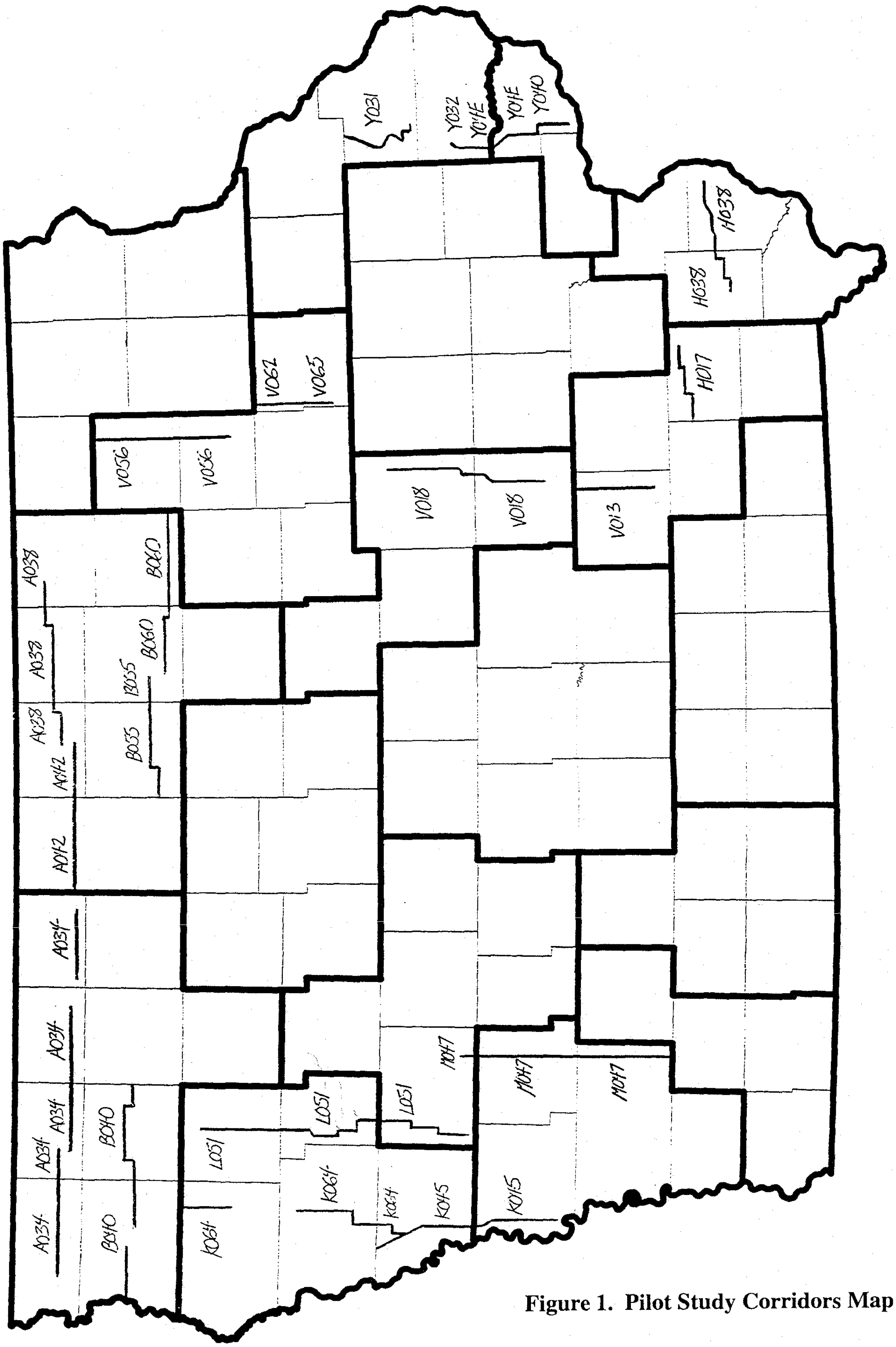

Figure 1. Pilot Study Corridors Map

The IPMP GIS database contains all of the history and condition information for the federal-aid-eligible secondary system for 15 out of 18 RPAs and all of the MPOs. The additional information on the needs sections included in the pilot study was added to the database, and dynamic segmentation was used to summarize the automated distress data (collected based on a 100m test section) for each need study section. The next section (data conversion) will provide more details on the automated distress data and the dynamic segmentation process.

Data Conversion

This task involved developing a process to convert the individual automated distress data measurements collected for the IPMP into a single condition rating to be used in the HWYNEEDS program instead of the Iowa DOT base record inventory rating. The distresses collected for the IPMP are shown in Figure 2. Roughness (represented by the International Roughness Index, IRI), rutting, different types of cracking (depending on pavement type), and patching are collected. The proposed work suggested three different approaches to perform the data conversion.

1. The first approach is to have the steering committee drive over a number of sections and rate each section of pavement (sections with homogenous construction) on a scale from one to 100. Then the rating will be related to the extent and severity of individual distresses identified in the IPMP data through regression analysis. This approach was not selected because of its labor intensiveness, its emphasis on the ride (IRI), and its perceived subjectivity.

2. The second approach is to use the Pavement Condition Rating (PCR) index used by the Iowa DOT on the primary system and convert the scores from 100 scale to a scale compatible with the HWYNEEDS program. This approach was not selected because the PCR index was developed using only primary system pavements. The performance of those pavements differs to a great extent from the secondary system and thus was not deemed to provide an accurate measure for the HWYNEEDS program.

3. The third and final approach is to have the project steering committee rank the relative importance of each individual distress based on expert opinion and then develop a composite score for all of the distress data. This was the approach selected for the data conversion. This approach provides for maximum input from the county engineers and minimum subjectivity based on their input.

PCC Pavements		
Joints - D-Cracking and Spalling		
	Extent	*Number of joints with D-Cracking*
	Severity	*SHRP definition for MODERATE and HIGH*
Transverse Cracking		
	Extent	*Number of full width transverse cracks*
	Severity	*SHRP definition for MODERATE and HIGH*
Patching		
	Extent	*Area and number of patches*
	Severity	*Distress or no distress*
Ride (IRI)		
ACC Pavements:		
Transverse Cracking		
	Extent:	*Number of full width transverse cracks*
	Severity	*SHRP definition for LOW, MODERATE, and HIGH*
Longitudinal Cracking		
	Extent	*Length of longitudinal cracks*
	Severity	*SHRP definition for LOW, MODERATE, and HIGH*
Block and Alligator Cracking		
	Extent	*Area of block cracking*
	Severity	*SHRP definition for MODERATE and HIGH*
Pot Holes		
	Extent	*Number of pot holes*
Patching		
	Extent	*Area and number of patches*
	Severity	*Distress or no distress*
Ride(IRI) and Rutting		

Figure 2. Automated Distress Data Collected for the IPMP

Data Conversion Procedure

To convert the automated distress data (from individual distress measurements) to a format compatible with the HWYNEEDS program, a set of steps had to be completed. The following is a brief description of each step:

1. All of the needs sections in the pilot study corridors were added to the IPMP GIS database. The begin KMPoint and length of each section were calculated. All of the data from the Iowa DOT base record inventory were associated with each section. Those data included the surface condition rating.

2. Dynamic segmentation was performed to transform the automated distress data from the test sections to the need study sections. Each need study section consists of a multiple of automated test sections depending on the length. For example one kilometer need study section consists of 10 automated test sections). Transformation rules were used to summarize the data. The average value of rutting and roughness was used to determine a representative value of rutting and roughness for each section. The sum of the total cracking and patching was used to represent the degree of these distresses within the segment. Dynamic segmentation allows for easy data manipulation when data are stored in different formats and are located using different location referencing methods. Figure 3 shows a schematic of how dynamic segmentation works.

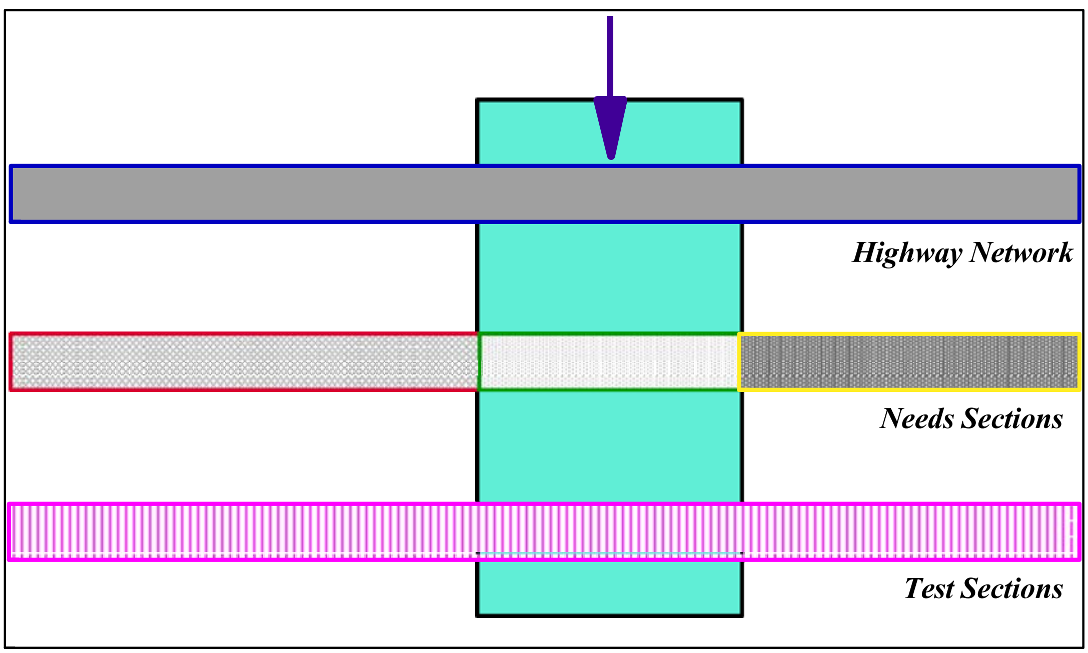

Figure 3. IPMP Dynamic Segmentation Process

3. The project supervisory committee met two times with CTRE researchers to discuss which distresses to use in the composite measure and the weight for each distress. The committee decided to divide the needs sections into three pavement types: asphalt, rigid, and composite. Using the committee members' expert opinions, a weight for each individual distress item was determined. The weights for each pavement type should add up to 100. Distress weights did not consider the different distress severity levels. Figures 4 though 6 show the distresses considered for each pavement type and their associated weights.

4. To work with different distress severity levels, each severity level was assigned a weighting factor. For example, high severity alligator cracking was given more weight than moderate severity alligator cracking because it affects the pavement condition in a more severe manner. Figures 4 through 6 show the weighting factors for each severity level.

5. Based on the weighting factors, pavement type, and the automated distress measurements, a composite score (0-100) was calculated for each need study section. The composite index was calculated by subtracting the weight for each individual distress from a total of 100. One hundred represents a section in excellent condition, while zero represents a section in poor condition.

6. The calculated composite scores were then divided by 20 to transform the scores from a 100-point scale to a five-point scale. The HWYNEEDS program uses a five-point scale for the surface rating. The base record inventory surface rating is on a 10-point scale, and that is divided in half to get it to a five-point scale to be used in the HWYNEEDS program. Also, the lowest score the HWYNEEDS program utilizes is one (the worst possible condition), so anything between zero and 20 in the automated distress composite scores was transformed to a rating of one. When the base record inventory is used, ratings between zero and two are transformed to a rating of one.

Data Preparation

Once the data conversion was completed, the data were formatted for HWYNEEDS and delivered to the Office of Systems Planning at the Iowa DOT to perform the HWYNEEDS program runs. The data included all of the necessary base record data and the new surface ratings developed from the automated distress measurements.

The results from the different HWYNEEDS program runs are presented in the results section in this report. Rating comparisons between the automated distress and the base record inventory ratings are also presented.

ASPHALT PAVEMENT					
DISTRESS	SEVERITY			GROUP WEIGHT (%)	TOTAL WEIGHT (%)
	LOW	MODERATE	HIGH		
IRI (ride)				35	35
BLOCK CRACKING		1x	1.5x	40	10
ALLIGATOR CRACKING		1x	2x		10
RUTTING					20
TRANSVERSE CRACKING	1x	1.5x	2x	25	10
LONGITUDINAL CRACKING (non wheel path)	1x	1.5x	2x		15
LONGITUDINAL CRACKING (wheel path)	1x	1.5x	2x		

Figure 4. Asphalt Pavement-Weighting Factors

CONCRETE PAVEMENT					
DISTRESS	SEVERITY			GROUP WEIGHT (%)	TOTAL WEIGHT (%)
	LOW	MODERATE	HIGH		
IRI (ride)				35	35
"D" CRACKING		1x	1x	40	25
JOINT SPALLING		1x	1x		15
TRANSVERSE CRACKING	1x	1.5x	2x	25	25

Figure 5. Concrete Pavement-Weighting Factors

COMPOSITE PAVEMENT					
DISTRESS	SEVERITY			GROUP WEIGHT (%)	TOTAL WEIGHT (%)
	LOW	MODERATE	HIGH		
IRI (ride)				35	35
TRANSVERSE CRACKING	1x	1.5x	2x	50	20
LONGITUDINAL CRACKING (non wheel path)	1x	1.5x	2x		15
LONGITUDINAL CRACKING (wheel path)	1x	1.5x	2x		15
ALLIGATOR CRACKING		1x	2x	15	5
PATCHING	1x	1x	1x		5
POTHOLES					5

Figure 6. Composite Pavement-Weighting Factors

Performance Prediction

This part of the methodology dealt with the development of a set of performance models for the surface ratings from the automated distress data. Different models were developed for the three pavement types (asphalt, rigid, and composite pavements). The models forecast the deterioration in future condition of the pavement surface rating. These models were used to forecast the condition of pavement sections in the future. The forecasts of pavement conditions were made for the years when the need study would be conducted in the future (1998, 2002, and 2006). The forecasted conditions were then assumed to be the conditions that would be measured in the future through automated distress measurement. These future conditions were input into the HWYNEEDS software to simulate future runs of the model. The simulations were assumed to be representative of future outcomes of the model if the automated data were used as input to the model in the future. The simulated future runs of the model were used to evaluate the volatility of the variation through time of resources allocated to individual corridors. The results section includes a detailed discussion of the results of the simulation runs.

The performance models are also used to compare the resulting surface ratings with those in the base record inventory ratings. The performance models used in the HWYNEEDS program deteriorate the base record surface ratings. In other words, imbedded in the HWYNEEDS model is a performance model that is used to deteriorate the condition of the pavements over time. The two sets of performance models (automated and HWYNEEDS) are compared by analyzing the surface ratings resulting from each model. The report's results section presents the comparison in detail.

To develop the automated distress data performance models, a set of needs sections with age, pavement type, and surface rating information had to be compiled. The data necessary to support the development of a performance was not always available for every need study section in each of the pilot corridors. There were about 77 asphalt pavement sections, 64 rigid pavement sections, and 17 composite pavement sections with complete data sets. The surface ratings were regressed against age for the three pavement types, and three performance models were developed. Figures 7 through 9 show the data and the three models (2).

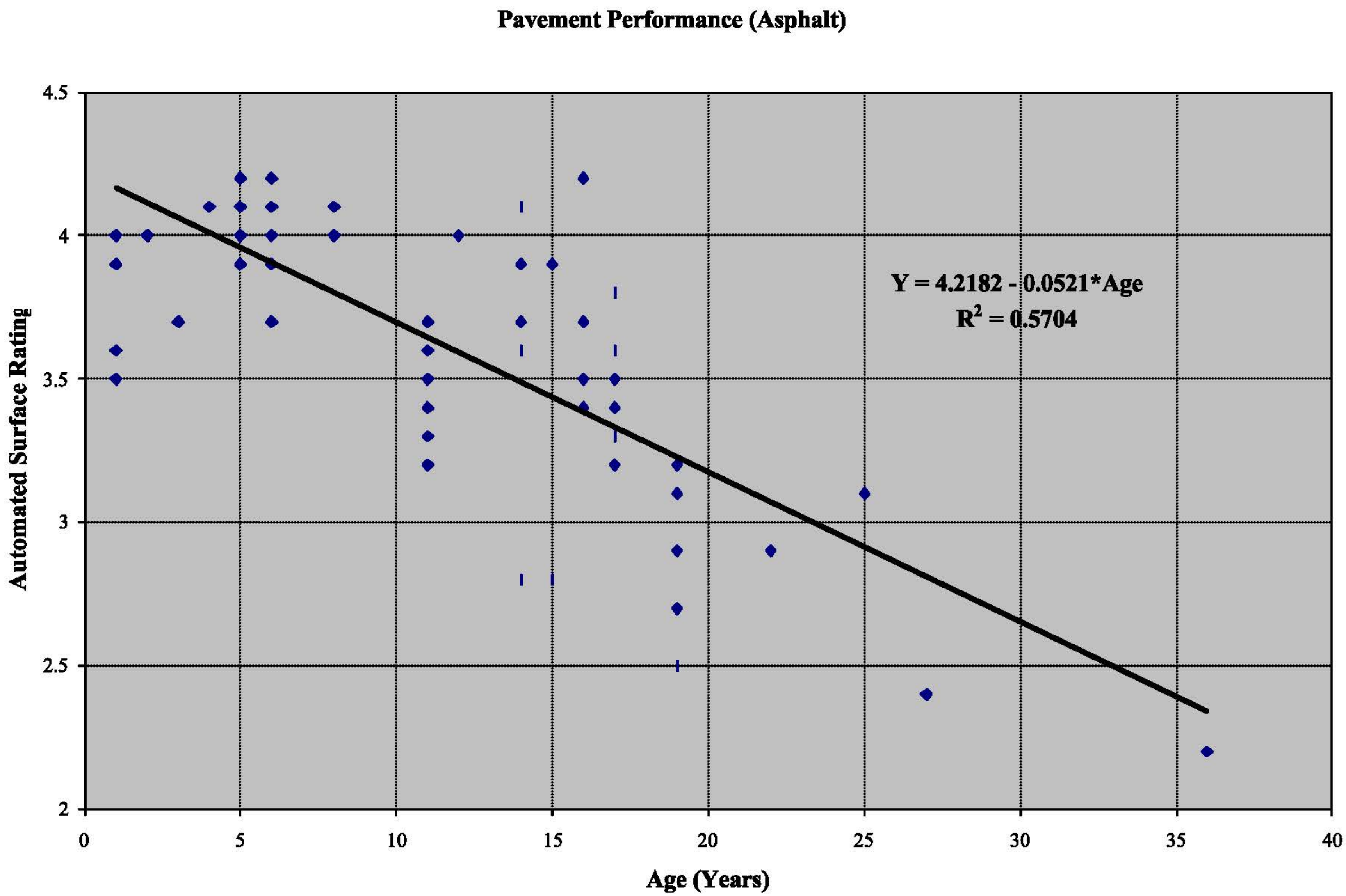

Figure 7. Asphalt Pavement Surface Rating Performance Model

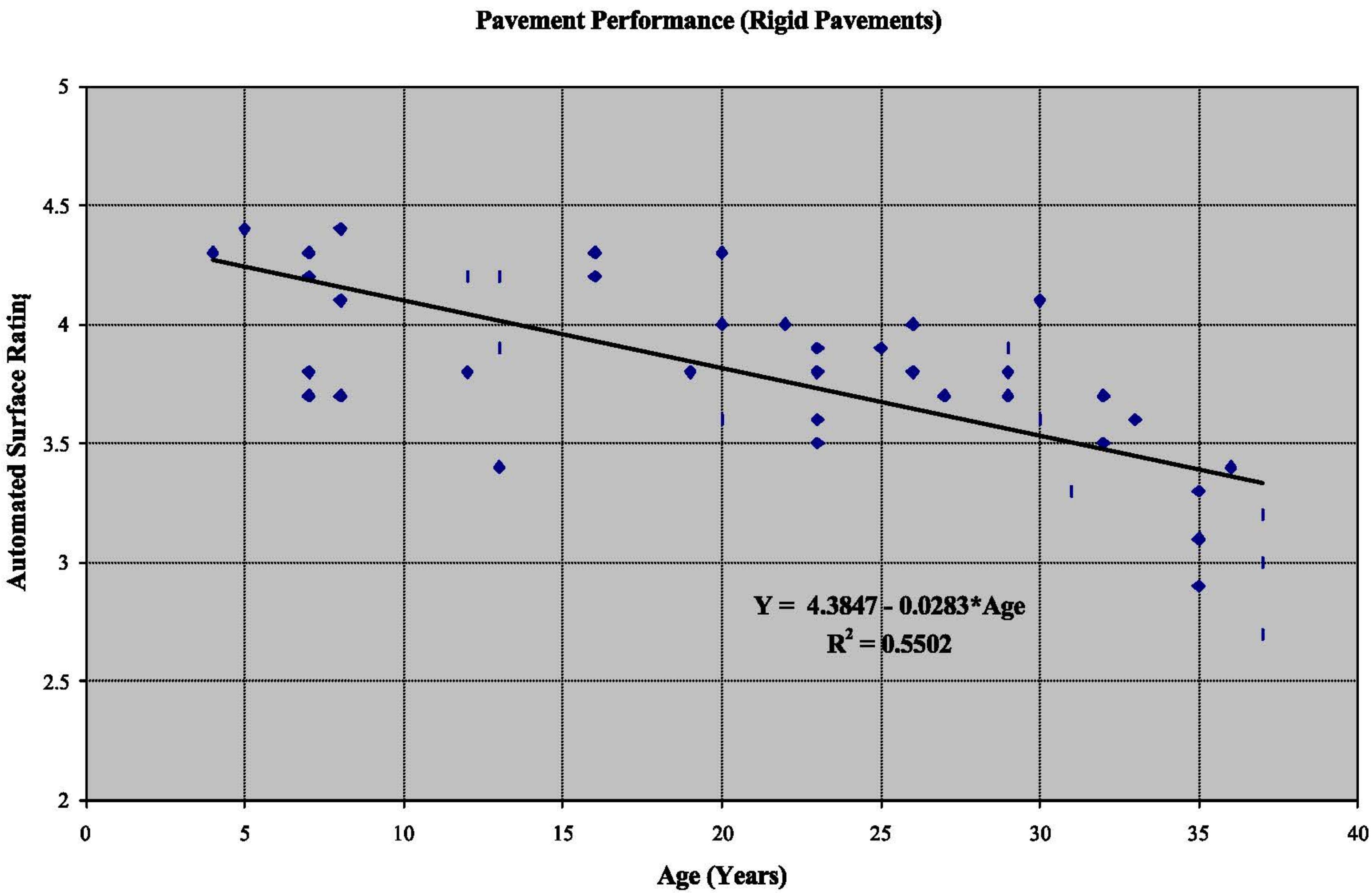

Figure 8. Rigid Pavement Surface Rating Performance Model

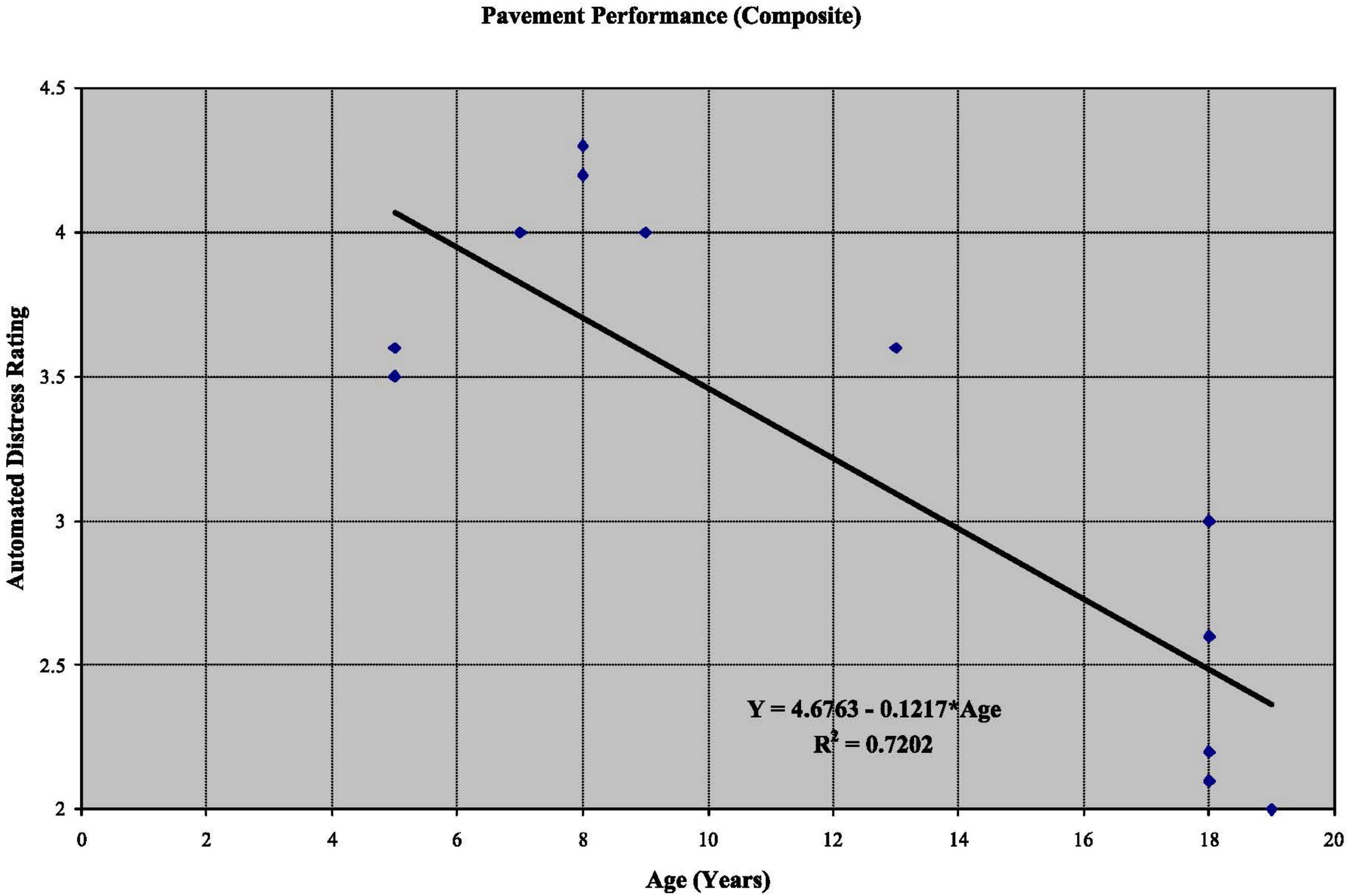

Figure 9. Composite Pavement Surface Rating Performance Model

RESULTS

This section presents the results from the HWYNEEDS program and analyzes its sensitivity to changes in the input data. Each run simulates the road portion of the quadrennial need study conducted on the pilot corridors. The HWYNEEDS program uses all of the information originally found in the base record inventory in addition to the automated surface ratings generated through this project. Six different runs of the HWYNEEDS program were performed by Stuart Anderson of the Iowa DOT office of Systems Planning. The runs were conducted to achieve the following goals:

1. To test the feasibility and benefits of using the automated distress data for the surface ratings instead of the base record inventory.

2. To compare the difference in needs between the individual corridors using both the automated distress ratings and the base record inventory ratings.

3. To test the consistency of county level needs from one study to the next when automated distress ratings are used as input to the quadrennial need study.

4. To compare the difference in needs between individual corridors in the pilot study between the original base record ratings and the deteriorated base record ratings.

This section is divided into two parts. The first part discusses the needs results and the second part will present the condition performance results.

Needs Results and Comparison

To compare the differences in needs between the different HWYNEEDS program runs, only the surface ratings data have been changed. All of the other parameters of the HWYNEEDS program were maintained the same for all runs. This results in need changes due only to changes in the pavement surface ratings. Figures 10 through 16 on the next pages show the results and comparisons of the different HWYNEEDS runs. The first four figures (Figures 10 through 13) show the needs differences, while the last three figures (Figures 14 through 16) illustrate the simulated runs using forecasted automated distress data in the quadrennial need study.

Six HWYNEEDS program runs were performed for this project. The first two HWYNEEDS runs compared the difference in need between using the base record inventory rating (collected between 1988 and 1997) and the automated distress ratings (collected between 1996 and 1997). The only change between these two runs was the pavement surface ratings. Figure 10 shows the difference in need of funds for each corridor considered in the pilot study. All but one of the corridors experienced either an increase or the same amount of funds when compared to the base record data. The total needs using the surface ratings from the base record are about $156 million while the automated distress ratings resulted in total needs of about $189 million for the 36 corridors. That is about a 20 percent increase in total needs. Individual corridors experienced increases ranging between 10 percent and 200 percent. When the average surface ratings of the automated and base record data are compared, there was a difference of about one point (on a five-point scale). The ratings using the automated collected data were usually lower than those of the base record ratings. So, the 20 percent increase in needs is a result of the difference in the average condition.

The third run of the HWYNEEDS program was performed using the deteriorated base record inventory surface ratings, taking into account the date when the inventory was done. The original data could have been collected any time between 1988 and 1997. Using the deterioration curves in the HWYNEEDS program, the surface ratings were deteriorated to reflect the number of years that have passed since the data were collected. Even though the deterioration rates used were not developed based on historical data, this should result in more total needs. Figure 11 shows the difference in need between the original base record ratings (BR) and the 1998 deteriorated base record ratings (BR_98). The total needs have increased from about $156 million to $170 million. That is an increase of almost 10 percent. All the corridors except two experienced either an increase or stayed the same. The two corridors that decreased required further study and are discussed later in this report.

The last three runs of the HWYNEEDS program were performed using the deteriorated automated distress data. The original automated distress data were collected in 1996 and 1997. The performance models developed for the three pavement types were used to simulate deterioration, and the surface ratings were calculated for a simulated 1998, 2002, and 2006. Each one of those simulated years resulted in a HWYNEEDS run.

Figure 12 shows the difference in need between the original automated ratings (AUTO) and the 1998 deteriorated automated distress ratings (AUTO_98). The total needs using AUTO_98 have increased from $189 million to $193 million. That is an increase of about two percent. When compared to the difference between BR and BR_98 of 10 percent, the importance of using up-to-date condition data in the HWYNEEDS program is illustrated. The difference in time between AUTO and AUTO_98 is either one or two years, while the difference between BR and BR_98 is between one and 10 years. Thus more current data help to diminish the volatility of the resulting need to individual counties between needs studies.

Figure 13 shows the difference in need between the BR_98 and AUTO_98. The total needs for BR_98 of $170 million compare to total needs for AUTO_98 of about $193 million. This results in a difference in total needs of about 13 percent. The first two runs of the HWYNEEDS program (original BR and AUTO ratings) produced a 20 percent difference. The decrease in the difference is attributed to deteriorating the base record inventory ratings, which should result in more needs due to the fact that BR_98 should more accurately reflect the condition of the pavement surface.

Figure 14 shows the difference between the three simulated runs of the automated distress ratings (AUTO_98, AUTO_2002, and AUTO_2006). The resulted total needs of $193 million, $197 million, and $204 million for AUTO_98, AUTO_2002, and AUTO_2006 respectively were determined. All the individual corridors, except two, experienced an increase in needs or stayed the same. Again, the two corridors that experienced decreased needs were studied further and are described later in this report. Deteriorating the surface ratings for the three simulated runs resulted in increases of two percent between AUTO_1998 and AUTO_2002, and 3.5 percent between AUTO_2002 and AUTO_2006.

Figure 15 shows the six HWYNEEDS runs and their total needs. The figure shows that the changes in total needs between the three simulated runs using the automated distress data are more stable (two percent to 3.5 percent - Figure 16) when compared to a change of 10 percent between the runs using the manually collected base record data BR and BR_98. Finally, Figure 16 shows a comparison between the percentage change of the past HWYNEEDS runs and the new simulated runs. Even though the simulated runs were conducted on a pilot study area, they provide insight into the likely volatility of changes in total needs when the automated distress data are used as input to HWYNEEDS. The change between the 1986 quadrennial need study total road needs (QNS_86) and QNS_90 was about one percent, while the change between QNS_90 and QNS_94 is over 12 percent. The change in pilot study needs for the simulated runs (AUTO_98, AUTO_2002, and AUTO_2006) is between two percent and 3.5 percent. The next section describes the differences in the ratings and the pavement performance and its impact on the total needs.

Performance Comparison

This section presents the analysis of differences in the forecasted surface ratings of the base record ratings and the automated distress ratings. Figures 17 and 18 show the different surface ratings comparisons. The different surface ratings were calculated using either the performance models from the HWYNEEDS program (the base records ratings) or from the performance models estimated here based on the automated distress data. Figure 17 shows a comparison between the overall condition (BR and AUTO) considering all of the corridors and corridors that had base record inventory data collected between 1994 and 1997. The difference between the corridors collected in 1996 and 1997 when compared to the automated data is 0.3 points (on a five-point scale), while the difference between 1994 and 1995 data is about 0.9 points. Figure 18 shows the difference when comparing the deteriorated ratings. A difference of about 0.3 points overall and the same for the corridors collected in 1996 and 1997 is calculated.

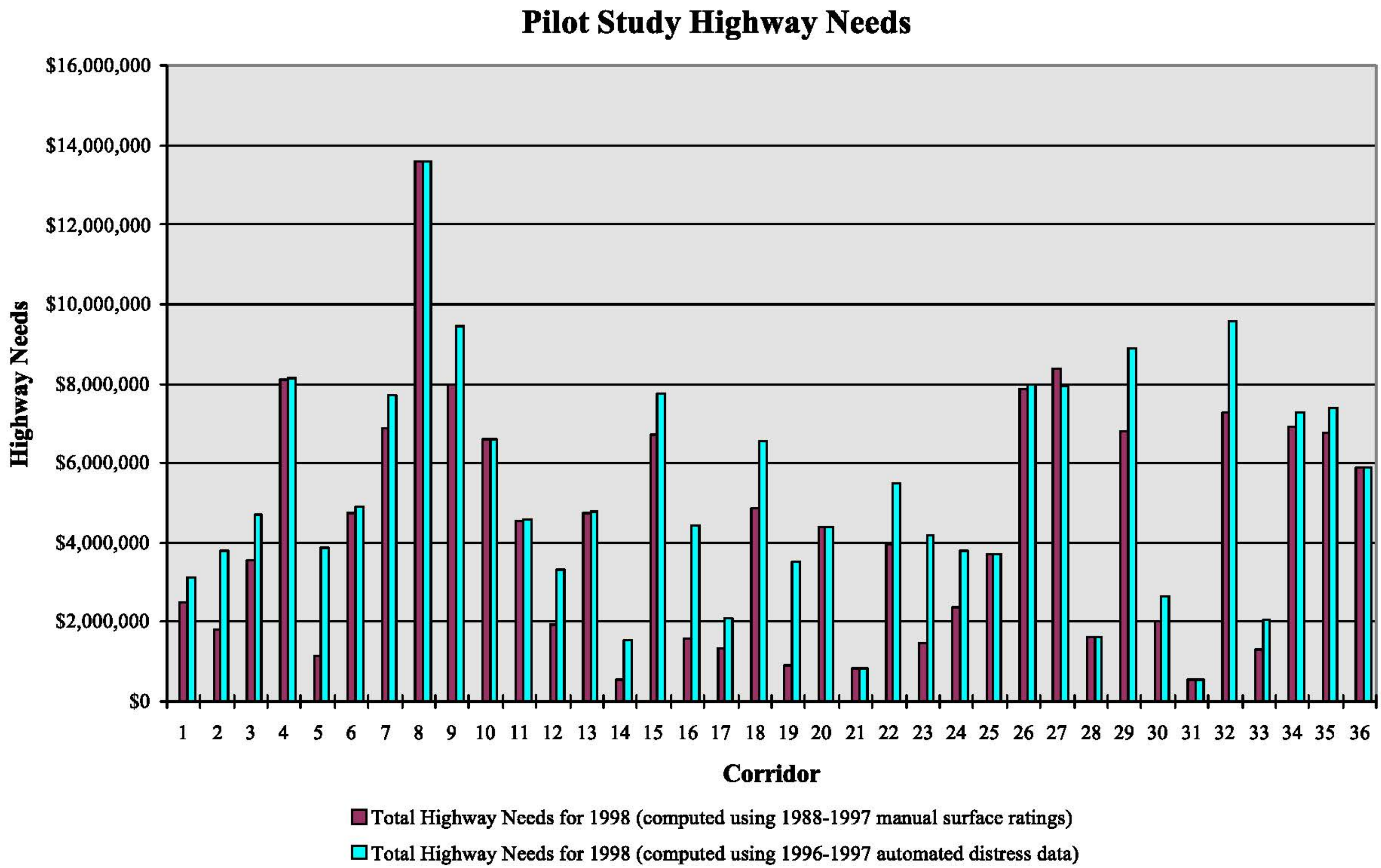

Figure 10. Base Record Ratings vs. Automated Distress Ratings (Needs Changes)

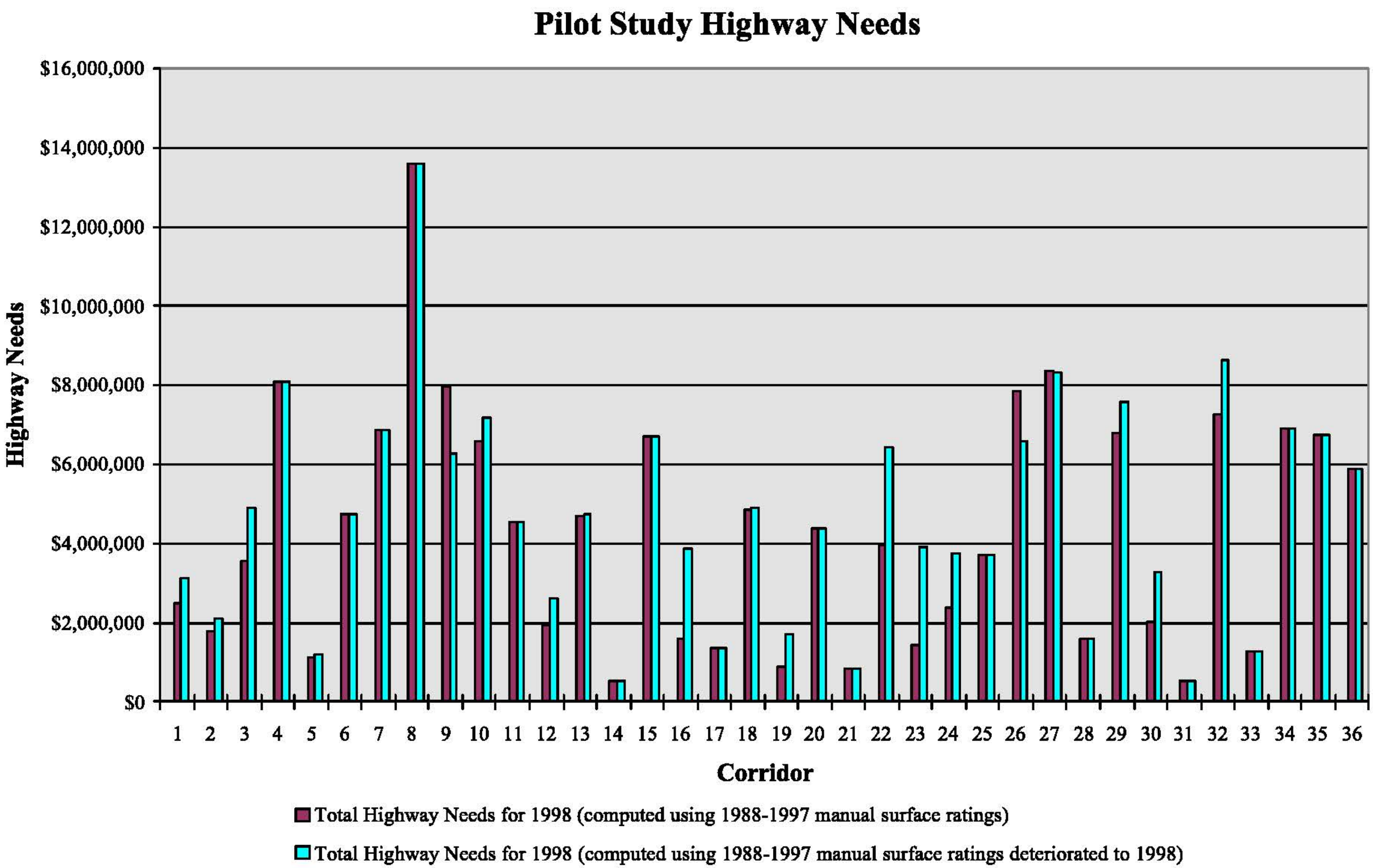

Figure 11. Base Record Ratings vs. Deteriorated Base Record Ratings (Needs Changes)

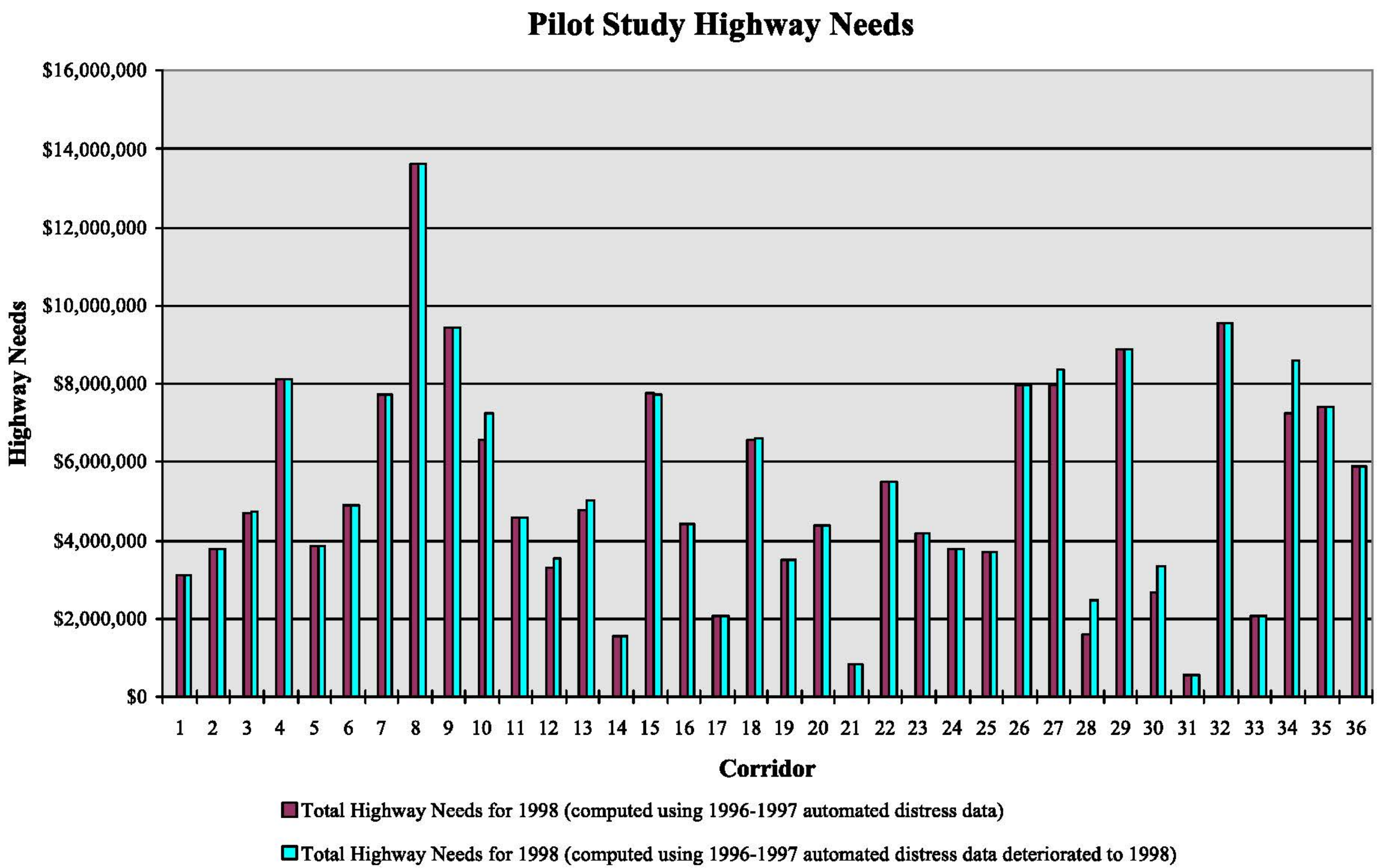

Figure 12. Automated Ratings vs. Deteriorated Automated Ratings (Needs Changes)

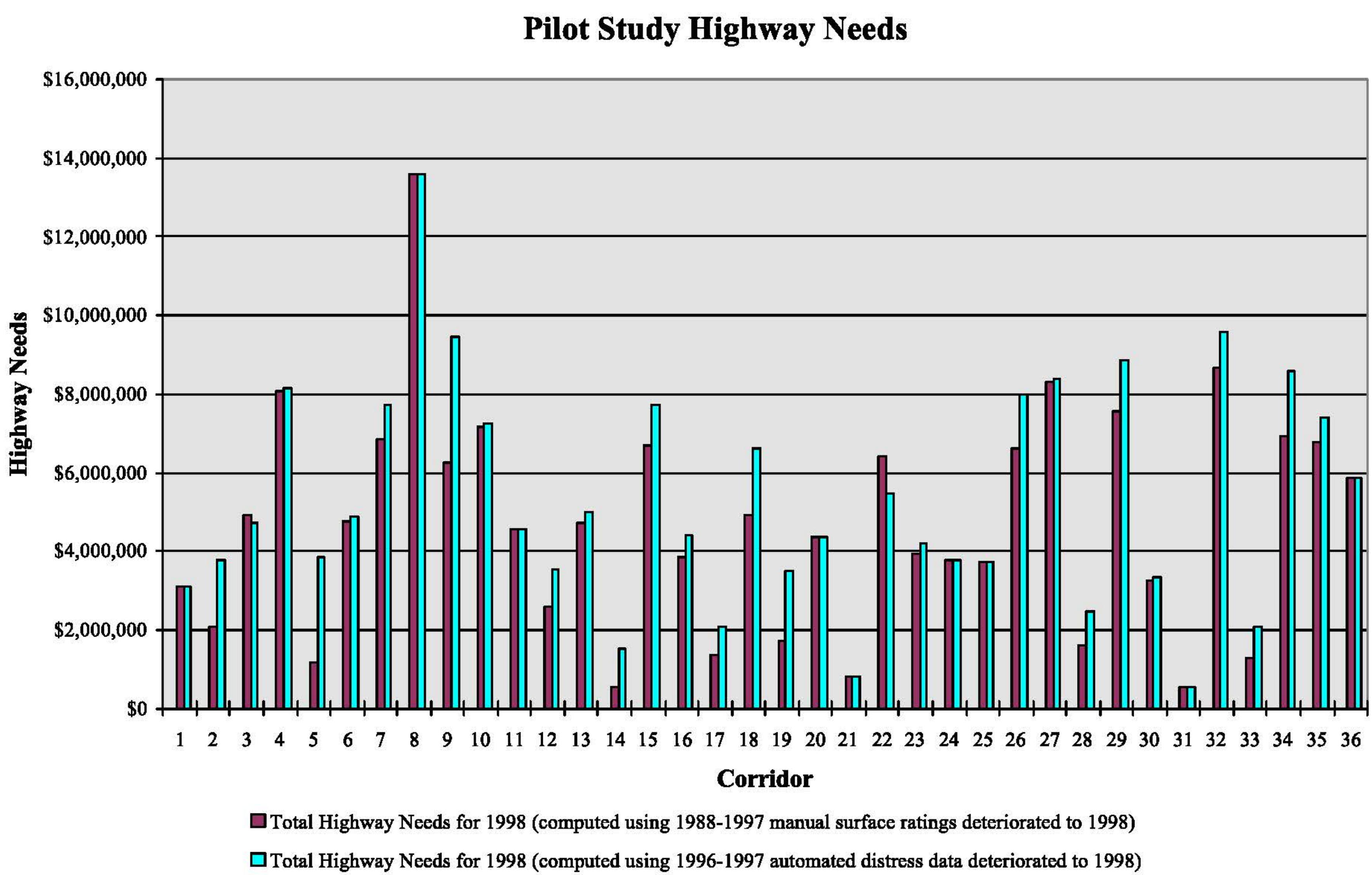

Figure 13. Base Record Ratings vs. Automated Distress Ratings - Deteriorated (Needs Changes)

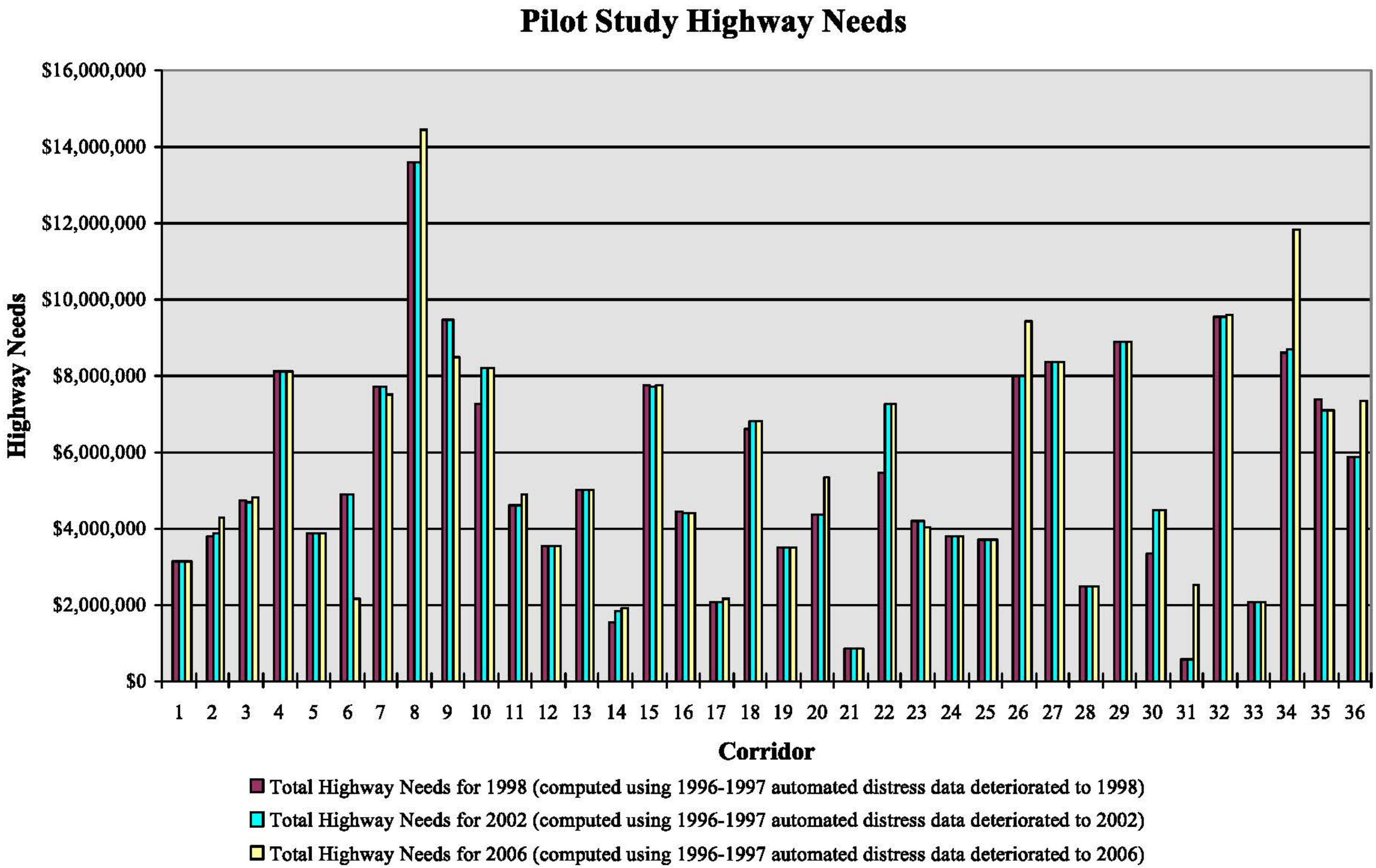

Figure 14. HWYNEEDS Simulated Runs Using Automated Distress Ratings

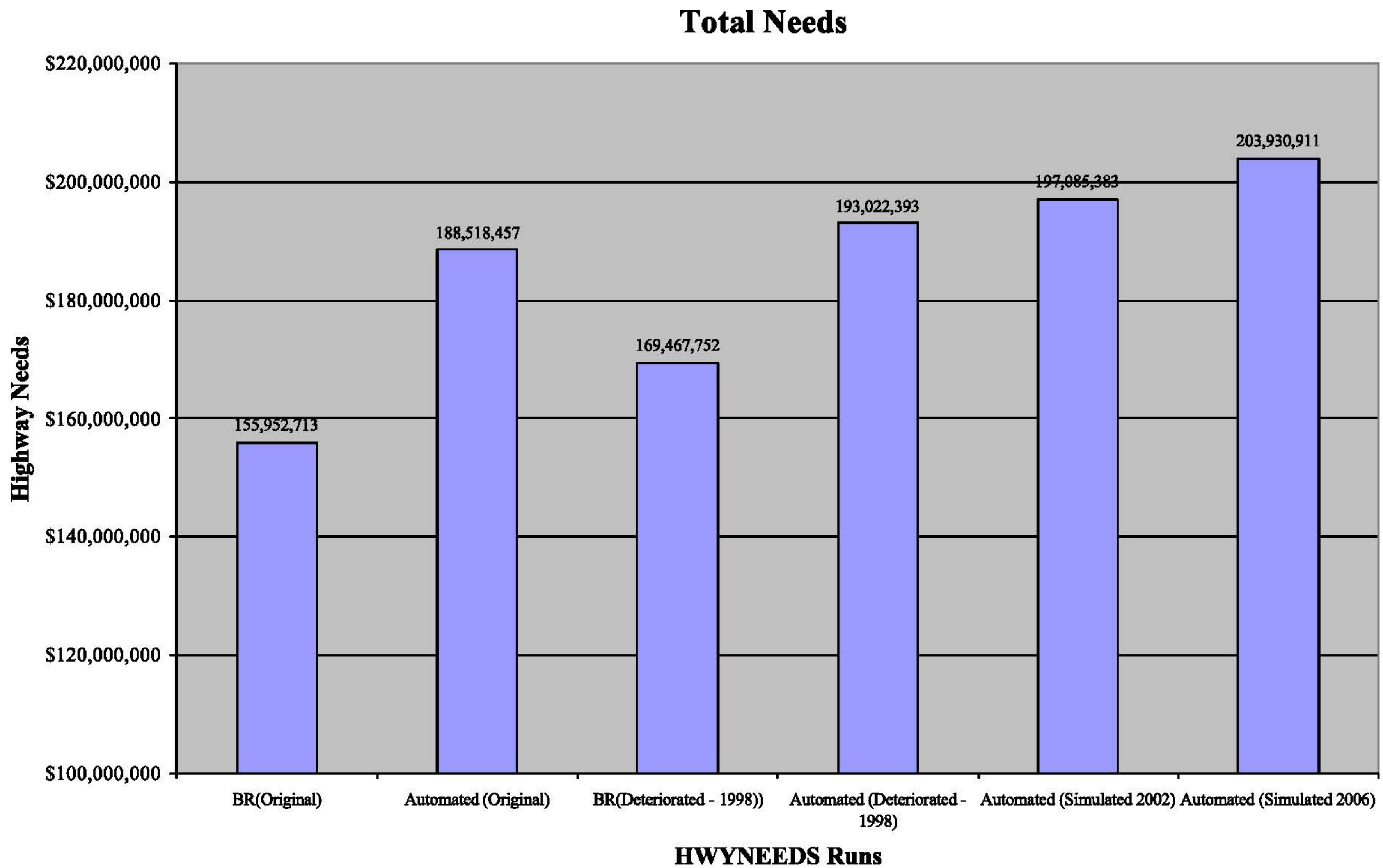

Figure 15. Total Needs Comparison

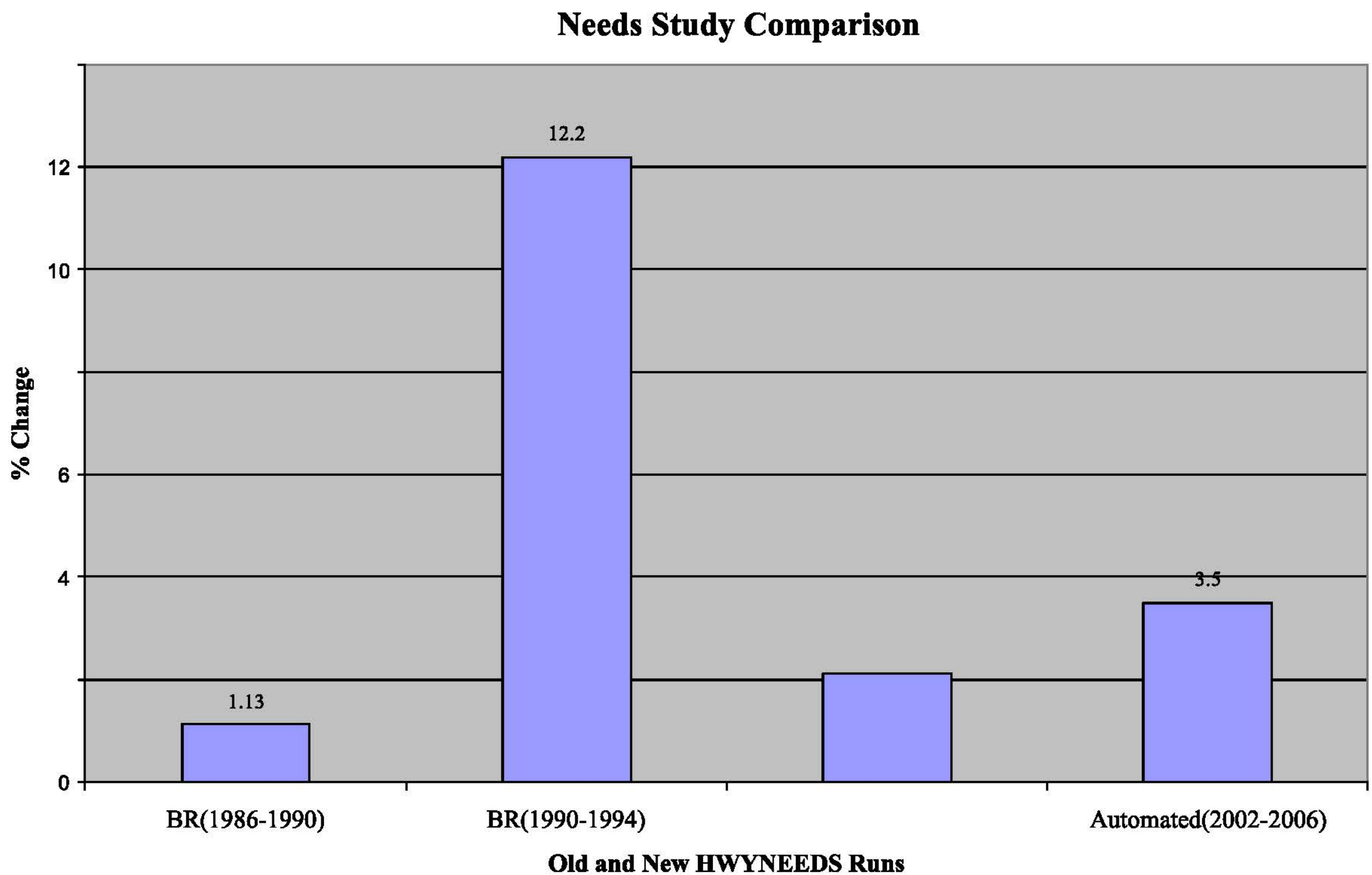

Figure 16. Total Needs Changes (1986 – 2006)

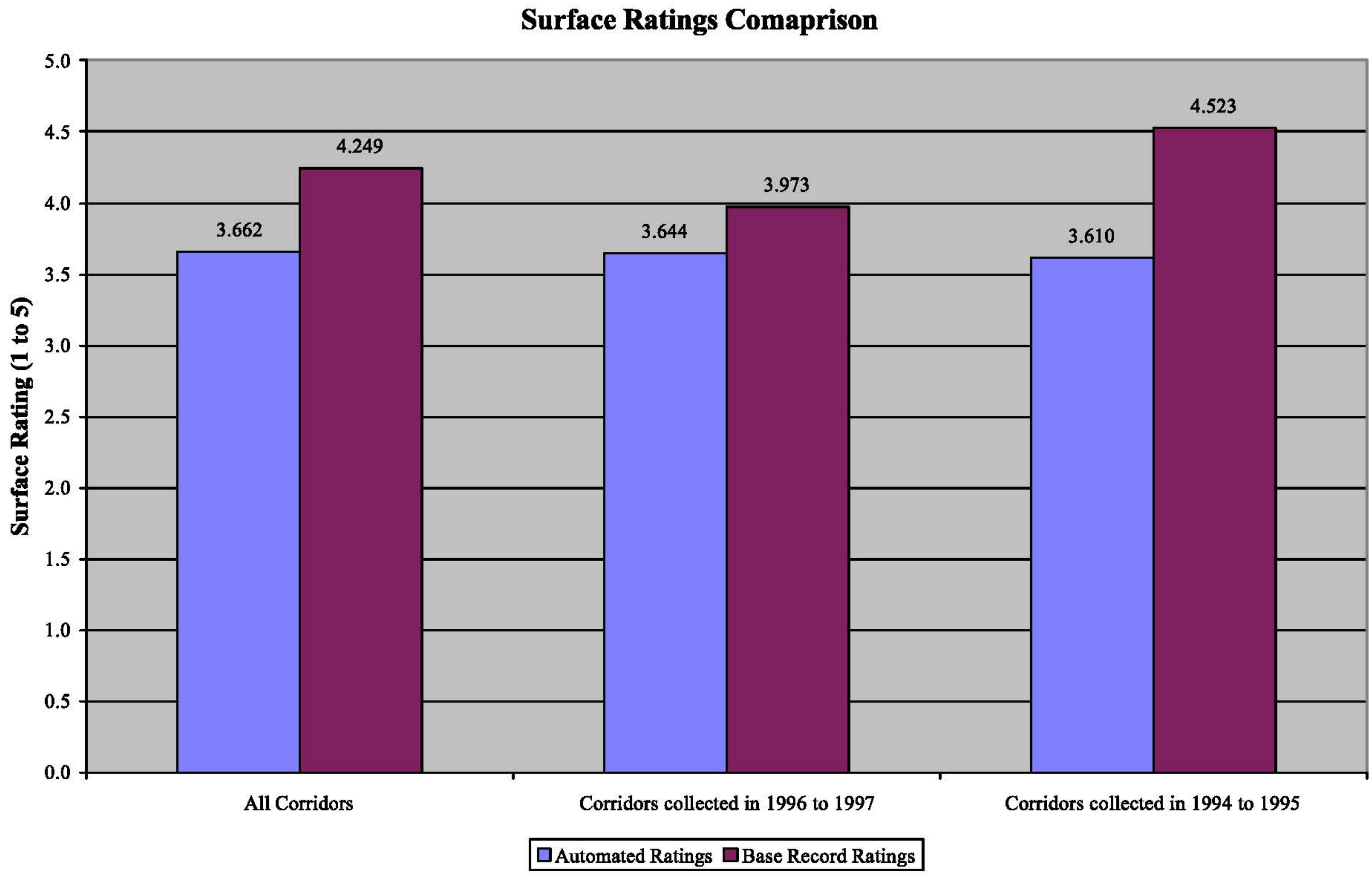

Figure 17. Original BR and AUTO Surface Ratings Comparisons

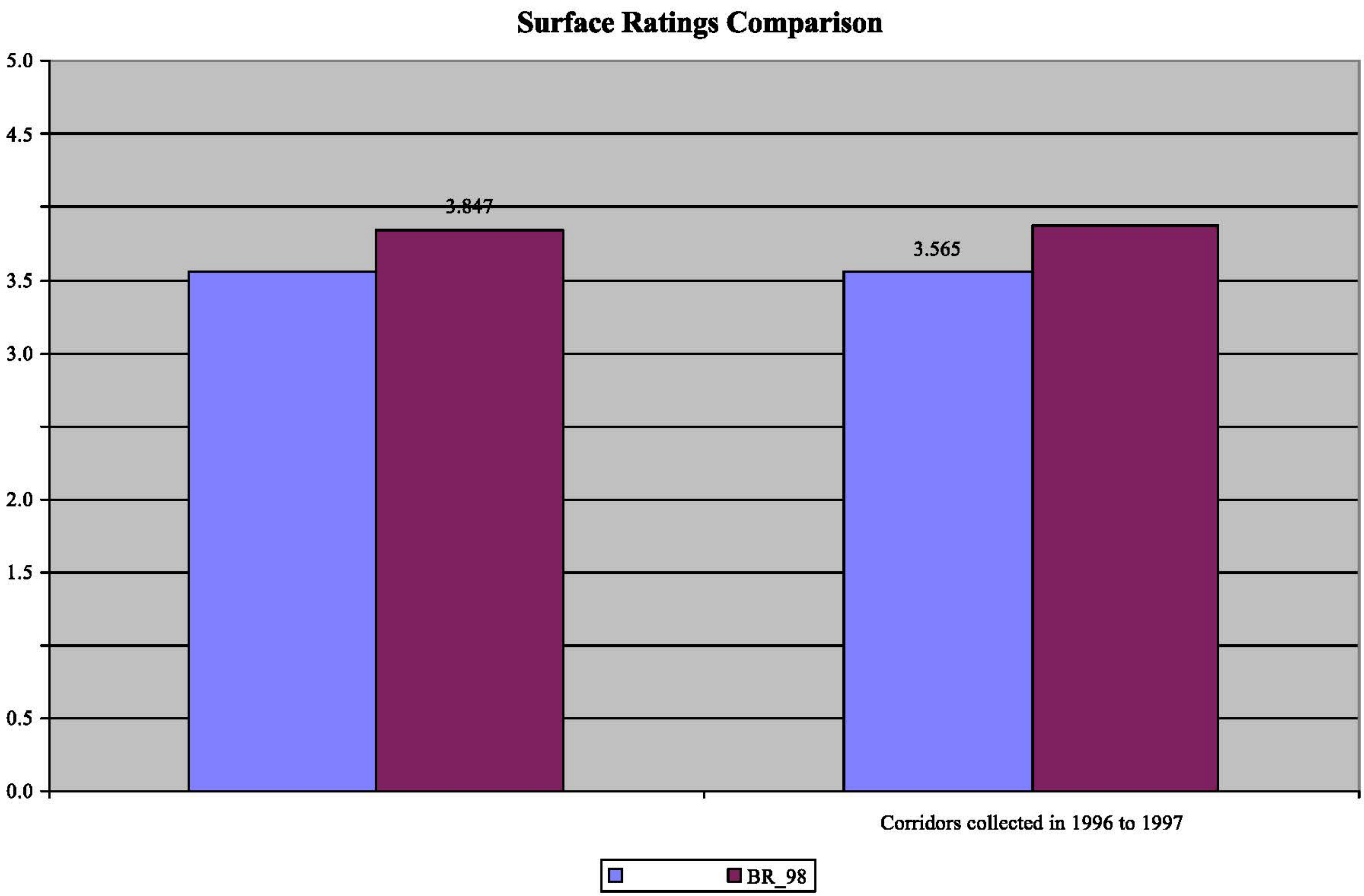

Figure 18. BR_98 and AUTO_98 Surface Ratings Comparisons

CONCLUSIONS

The results obtained from the HWYNEEDS program clearly show the feasibility and benefits of using the automated distress data in the quadrennial need study. The procedure developed to convert the individual distress measurements collected for the IPMP into a composite score to be used in the HWYNEEDS program is quite simple and easy to follow. Considerable input was solicited from the committee members to complete the development of the data conversion. This process will prove to be a very useful tool later on for individual counties to work with the IPMP data for their own resource allocation and pavement management processes.

The results also show that there was an increase in total needs by using the automated distress ratings. The resulting increase is due to the fact that when the composite score is totaled based on the assigned weight, the score is generally lower than the score assigned through the manual survey. The results also indicated that a difference occurs when the performance is predicted using a model based on automated collected data versus the default performance curves in the HWYNEEDS program. The larger the difference in predicted future surface ratings, the larger the increase in total needs.

Finally, the results show that the use of more current data will result in less volatility in the change in total needs between quadrennial needs studies. In other words, the more current the data are the smaller the shift in total needs.

RECOMMENDATIONS

This study was designed to investigate the feasibility and benefits of using the automated distress data as an input to the quadrennial need study and from the evaluation of the results, to make recommendations on ways to improve the current process. Recommendations follow:

1. Use of the automated distress data collected for the IPMP as input to the quadrennial need study was proven to be feasible and beneficial. There are several issues that need to be addressed before the automated distress data may be fully implemented as input to the need study. The first issue is that automated distress is not collected on all of the paved roads in the secondary system. Data are only collected on the federal-aid-eligible system that does not contain all paved secondary roads. Also, there are three regional planning affiliations (RPAs - 16 counties) that are not part of the IPMP, and no distress data are available for those counties. In 1998, the IPMP made it possible for counties to extend the distress data collection to the rest of their paved miles off the federal aid system (with additional cost). This will increase the coverage of the IPMP distress data and will encourage the rest of the counties to participate in the IPMP. Although these changes will encourage the full coverage of the paved secondary road system in the IPMP, it does not necessarily mean that all paved secondary roads will be part of the IPMP.

2. The results section showed a substantial difference in the total needs between the automated distress data ratings and the base record ratings (20 percent increase). That difference was due to the decrease of the automated surface ratings of about 1 point (on a five-point scale) when compared with the base record ratings (3.6 and 4.3 for AUTO

and BR respectively). When the automated distress data ratings where compared with recent base record ratings (96 and 97), the difference was only 0.3 points (3.65 and 3.97 for AUTO and BR respectively). This finding leads to the second recommendation that relates to the frequency of condition data collection. The IPMP distress data are collected on a two-year cycle, which provides a more accurate and current measurement of pavement condition, which in turn will lead to a better representation of needs and fund allocations.

3. There are improvements that can be made to the current quadrennial need study process without considering the automated distress data. The results show that when the base record ratings used in the HWYNEEDS program are deteriorated to reflect the first year of the quadrennial need study (using HWYNEEDS deterioration rates), the difference between the automated ratings and base record ratings decreases to 13 percent from an original 20 percent difference. Using the deteriorated base record ratings should provide for a better condition assessment which will lead to a more equitable distribution of funds and less shifts in fund allocations.

4. The previous three recommendations dealt with the condition data issue only. There are improvements to be made in the HWYNEEDS program itself. The HWYNEEDS program is comprised of a set of procedures to help in determining needs and distributing resources. It is basically a pavement management system. There are several components of the HWYNEEDS program that need to be evaluated and updated to reflect local needs and conditions. Those items include the deterioration models, the decision trees, and the values assigned to a section's condition after a treatment is applied. Also, the methodology of the HWYNEEDS program needs to be investigated. In two cases during this project, there were situations where the total needs have decreased, substantially, for individual corridors even though the surface ratings decreased for the same corridors. A decrease in the surface ratings should result in more needs. The researchers investigated those anomalies and determined that since the HWYNEEDS program only performs a one-year prioritization analysis, it does not consider future condition ratings and future feasible rehabilitation alternatives. This narrows the scope of the analysis and results in making less than effective decisions. This is an inherit problem in the software and requires major changes to the HWYNEEDS program or even the selection of a new software system that allows for multi-year prioritization.

REFERENCES

1. James K. Cable. "Clarifying the Quadrennial Needs Study Process." Iowa Highway Research Board, HR-363, December 1993.

2. Jon Resler. "Sensitivity Analysis of the Quadrennial Needs Study Results Using Automated Pavement Condition Data." MS Thesis, Iowa State University, 1998.