Leveraging Technology Investments
Integration of GPS, GIS, and Maintenance Management

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ABSTRACT

Working together with the North Dakota Department of Transportation (NDDOT), the objective of this pilot project was to develop an application to perform the following:

- Track highway maintenance needs
- Compare those needs to current funding to illustrate how much work can be done in budget
- Display this information in a geographical information system

The types of work items to be tracked were decided based on input from NDDOT maintenance managers. These items include:

- Spot Items
- Crack Treatments
- Surface Treatments
- Asphalt Overlays

The software will run on a handheld computer and a desktop computer. The hardware will include the handheld computer and a portable GPS receiver. The software written for the program will run alongside of ESRI ArcGIS™ geographical information system software.

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EXECUTIVE SUMMARY

This research project attempts to ease the data collection burden of the North Dakota Department of Transportation's (NDDOT) maintenance manager, while increasing and improving pavement condition information. The pilot project used handheld computer and global positioning system (GPS) technology to capture pavement condition and location data. This data collection effort was designed to be assimilated into current roadway management operations. This technology potentially can reduce field work of the maintenance manager.

A significant issue was identified while conducting the pilot study. Merging the existing highway reference system and GPS coordinates was more difficult than anticipated. Outputs from any program must be in nomenclature normally used by the roadway manager. GPS coordinates, which rely on latitude and longitude, are not meaningful. All project references must be referred to by a highway and a mile point.

Desktop software was developed to process the collected data. The reports generated portray various maintenance programs, as chosen by the maintenance manager. The software records funded projects and denotes unfunded maintenance projects as a backlogged maintenance need. These data elements give all maintenance managers key information when planning future maintenance programs, assessing pavement conditions and performance over time, and reporting adequacy of maintenance budgets.

To complete this project, continued development should occur. The second phase should contain tasks to centralize the system and provide additional software for statewide maintenance planning and programming. Additional geographic information system (GIS) programs should be written and GIS products should be posted to a NDDOT website. Additional accuracy of GPS locations can be obtained through more expensive GPS units.

All evidence points to a potential useful maintenance management tool for all levels of roadway management within NDDOT. Historical data can help transportation managers measure the performance of the system and the effectiveness of repair and rehabilitation strategies.

CHAPTER 1. INTRODUCTION

The N.D..Department of Transportation (NDDOT) has invested thousands of dollars in developing a Geographic Information System (GIS) for managing transportation assets. One of the early benefits of this effort was the integration of all existing databases. The resident transportation data can be accessed from the Roadway Information Management System (RIMS). Another benefit was the development of a robust mapping system, which replaced an archaic manual system of mapping. NDDOT transportation managers now are searching for secondary benefits from this investment in technology. One area of NDDOT operations that could benefit from the Geographical Information Systems investment is a Maintenance Management Program.

In addition to leveraging existing technology, NDDOT wishes to incorporate new technology into its programs, including Global Positioning Systems (GPS). Through the use of hand-held GPS receivers, transportation managers will be able to accurately locate, mark, or find specific transportation elements on the roadway. These data points can then be referenced in a database with appropriate attributes and displayed on maps through the GIS system. This combination of technology will be the basis for improvements in maintenance management through this project.

BACKGROUND

District maintenance coordinators plan their biennial major maintenance programs with funds allocated to them by the NDDOT central office maintenance managers. This planning is done in the office and is usually planned over a long period of time based on anecdotal data and maintenance section input. Current practice still requires district maintenance coordinators to review the actual condition of roads annually with their section leadmen. This is necessary since spring roads can be negatively impacted by frost heaves and damage associated with weakened pavement sections during the spring thaw.

This annual inspection means that they visually review their highway system and determine which roads will receive reactive maintenance efforts from a palette of maintenance practices. These reactive and routine maintenance practices include pot hole patching, blade and scotch patching, and crack sealing etc. District maintenance coordinators review maintenance needs from these visual inspections and allocate appropriate dollars from their district maintenance budgets to accomplish the work. Summer work plans are prepared and the sections and/or contractors perform approved maintenance. This process is almost "one-way." Maintenance needs are supposed to generate maintenance dollars. In real life this rarely is the case. Funds are scarce throughout the department and these funds are sometimes used to match federal aid for construction. Other priorities can impact the amount of maintenance funds actually spent on maintenance of roadways. These funds also are used to purchase equipment and maintain capital maintenance facilities. There are many needs for few dollars.

Maintenance coordinators consult with district engineers and consider such things as upcoming construction projects when deciding the timing of maintenance work. Roads planned for reconstruction or major rehabilitation normally are excluded from extensive maintenance, as these expenditures would be wasted. Historically, there have been more project needs than available maintenance dollars. However, the extent of this maintenance backlog is not quantified by maintenance type uniformly across the state. There is no current system to collect, store, and analyze this maintenance condition data.

The goal of the pilot study is to examine a maintenance management system that tracks maintenance needs uniformly over time. Another goal is the incorporation of new and existing technology to make the new maintenance program system simple to use at little or no additional cost to the department.

TEAM MEMBERS

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ISSUES WITH THE EXISTING PROCESS

The existing maintenance management program does not capture total needs in a way that can answer various management questions. It also does not provide an historical perspective to look back to see if pavement conditions in a district or section are getting worse or improving with respect to maintenance needs. The current program does not have the ability to provide the Pavement Management System (PMS) with an accurate portrayal of specific maintenance problem areas. Currently, maintenance expenditures are coded to the mile they are performed, not the actual location.

A district normally does not have a historical record of their maintenance needs compared to the actual maintenance performed each year. Thus their total maintenance backlog of needs is unknown, with the possible exception of major maintenance projects. The NDDOT central office tracks these programs through the budgeting process and through annual maintenance program plans. What is not currently known is the maintenance backlog after all planned work is completed. The existing maintenance management system does not capture that data.

The current maintenance management system is a legacy system and is dated. Maintenance activities are not captured or linked in any repeatable way across district borders, or summarized statewide. Each district manages their own maintenance program with the funds provided. They have all developed their own systems for collecting, analyzing, and programming annual maintenance programs. They are not uniform and therefore cannot be summarized easily at the state level. There also are no performance measures in place to track the difference between planned and executed projects.

RESEARCH OBJECTIVES

The objective of the pilot project is to develop a prototype maintenance program management system, which integrates existing and emerging technology. Another objective is to provide accurate maintenance data to supplement the PMS to answer the following questions for maintenance managers:

1. What are total maintenance needs: by type of work, section, district, system, and statewide?
2. For a given level of funding, what is the maintenance backlog by type of work? What is the impact of cutting or increasing the maintenance program?
3. What has been the impact of past maintenance funding? Are maintenance needs underfunded and increasing over time?
4. What is the construction program impact on maintenance needs and backlog?
5. What are the impacts of skipping a construction project(s) on district maintenance programs?
6. What level of maintenance funding is appropriate to maintain the system at acceptable conditions?

PROJECT PHASES

This proposal is for developing a pilot-project maintenance program management system in the Fargo District of the NDDOT. The pilot is designed with two main phases. The current study is a pilot feasibility study. The department will analyze and study recommendations and then decide if there will be a phase two. The second phase is intended to be the go ahead for the development and implementation of a new NDDOT maintenance management system.

Phase 1 - Pilot Study

1. Develop a methodology for maintenance managers to use GPS and GIS technology to capture electronically in the field, locations on a district network for various maintenance work.

2. Develop an automated palette of standard maintenance practices for maintenance coordinators to use with GPS/GIS to determine and electronically capture specific maintenance needs.

3. Develop software that uses selected maintenance work and develops estimates of proposed district maintenance projects by type.

4. Develop interactive software that can develop alternative maintenance funding scenarios for the district network and display the alternative work plans and resultant unfunded maintenance backlog. This portrayal will be in graphical GIS and report format. Alternative funding and work scenarios can be planned, captured and displayed in formats identified by the user.

Phase 2 – Design and Implementation

1. Develop a system to capture maintenance needs data statewide, allowing central office maintenance managers the ability to analyze maintenance program effectiveness.

2. Develop software and methodologies for maintenance managers at all levels to input and track actual maintenance work performed compared to work planned.

3. Develop a graphical interface, which displays budgeted and planned maintenance work by type, including unfunded maintenance backlog. Users also would be able to review maps of completed maintenance work.

CHAPTER 2. GENERAL GPS TERMINOLOGY

Geographic Coordinates - Coordinate system based on the Earth's axis of rotation and the plane of the Equator. Locations on the Earth's surface are represented by latitude and longitude.

GPS - Global Positioning System: A system of satellites that transmit continually and make it possible to identify geographical locations through a receiving unit by triangulation, a trigonometric operation for finding a position or location by means of bearings from two fixed points a known distance apart

Latitude - A position's distance north or south of the equator measured by degrees from 0 to 90; if the position is south of the equator, the value is negative

Longitude - The distance, measured in degrees, east or west of the Greenwich meridian, a theoretical line drawn from the North Pole, through Greenwich, England, to the South Pole; if the position is west of the meridian, the value is negative

UTM - Universal Transverse Mercator: A grid coordinate system that projects global sections onto a flat surface to measure position in 60 zones

GPS RECEIVERS FOR STUDY

The two receivers chosen for review were the iGPS Receiver PocketPak™ and the NavMan™ GPS3000. The iGPS Receiver PocketPak™ is a vehicle-mounted receiver that requires an AC adapter for power. It is small and easy to move from one vehicle to another. The NavMan™ GPS3000 is PDA mounted (attaches to the handheld device) and has its own internal battery. This device also can use an AC adapter for power. Most users choose to use the AC adapter occasionally to avoid draining the batteries, which can result in a loss of any data that has not previously been downloaded to the desktop computer. Accuracy for both these devices is comparable, between five and 15 meters. Both devices use the NMEA 0183 output format, so compatibility was not an issue. These receivers were recommended by NDDOT employees who had experience using them.

Pharos iGPS Receiver PocketPak™ (vehicle mounted)

GPS Description: A vehicle mounted GPS receiver that plugs into the handheld device

Advantages: Due to the fact that the unit uses an AC adapter to operate both the GPS and the handheld device, there is no risk of losing power.

Disadvantages: Without an internal battery, the device can never be used outside of the vehicle.

Cost: $260 / unit

NavMan™ GPS3000 (mobile)

GPS Description: A GPS receiver specifically designed to plug into or attach directly to a handheld computer

Advantages: Since the small and portable NavMan™ attaches directly to the handheld computer, it leaves the user with just one unit to use. This unit draws power from the handheld computer's battery, making it usable outside of a vehicle. The unit also can be plugged into an AC adapter to prevent loss of power.

Disadvantages: If the user fails to recharge their handheld computer regularly or use the AC adapter occasionally, the loss of power can result in lost data.

Cost: $200 / unit

GPS DECISION

The NavMan™ was chosen because team members like the option of using two different power supplies. It also was more portable and fit directly over the handheld computer, leaving the user with just one piece of equipment. The lower cost of the NavMan™ was also a factor in the decision.

Figure 2.1 – The Compaq iPAQ™ 3538 equipped with a NavMan™ GPS 3000 receiver

GEOGRAPHICAL INFORMATION SYSTEMS

A geographical information system (GIS) is a system that contains maps and geographic information, and can be used to analyze geographic data. The geographical information system is a useful visual tool for the maintenance coordinators. The graphical representation of their work can illustrate different work types, finished work versus unfinished work, and funded projects versus unfunded projects. The GIS can also document non-geographical attributes. Examples from this project would include priority of the work item, materials used, and the date that the data was collected.

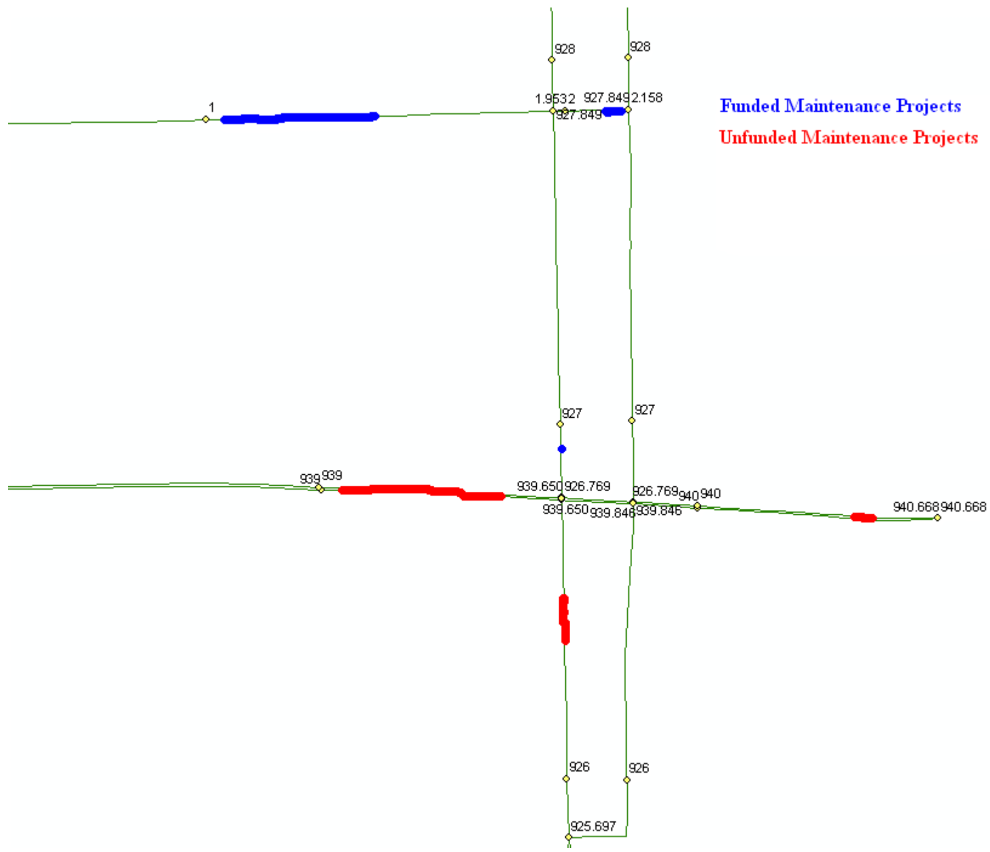

Figure 2.2 - A hypothetical use of a GIS map with points collected by a maintenance manager projected on a GIS map. Blue points represent projects that were funded and red points represent projects that were unfunded.

ISSUES IN LINKING GPS AND GIS

To report the location (highway and mile point) of a work item to a user of the maintenance program, it was necessary to "match" the collected GPS coordinates to points on an existing GIS map of North Dakota. The original map that we received from the N.D. Department of transportation was in the UTM coordinate system. The UTM coordinate system divides the earth into 60 distinct zones. A dividing line between two of these zones cuts through the state of North Dakota, causing difficulty in our plans to "match" collected GPS coordinates to highways and reference points on a map of the state. This problem was solved when the Department of Transportation developed a GIS server (http://web.appstest.nd.gov), which featured the North Dakota GIS map in geographic coordinates.

Data collected from the reviewed receivers is in a geographic format, which was the correct format to match information on the GIS server. However, instead of collecting data in the traditional decimal degrees format (abbreviated D.d), the receivers collected data in degrees and decimal minutes (D + M.m). For this data to be usable, it must be converted to decimal degrees. The conversion used is:

$$.d = M.m / 60$$
$$D.d = D + .d$$

Occasionally, the GPS receiver will collect an obviously inaccurate point. A common example of this would be a point that falls outside of the North Dakota border. Another obvious error would be a point that falls more than one mile from an interstate or state highway. Error handling was built into the program to automatically remove these points, which account for approximately 5 percent of the points collected with the NavMan™ receivers. When collecting surface treatment, crack treatment, or asphalt overlay work items, the removal of these points is not a problem. The receiver collects a line of points, one every tenth of a second, for these work items. The removal of a few of these points will not be noticed. When collecting spot items such as potholes, however, the receiver collects only one point. If this point is found to be inaccurate, the user must recollect this work item. Because the handheld program lacks GIS capabilities, this error is not detectable until the user links the handheld with their desktop computer. Fortunately, these points are much more likely to be accurate since the user is usually in a stationary state while collecting them.

Another accuracy problem arose late in the programming phase when the program was always assuming that collected points were either north of the closest reference point on a north-south road or east of the closest reference point on an east-west road. This could lead to an inaccuracy of up to one mile. After this problem was identified, a small program was developed to identify the direction of the collected point to the closest reference point. The actual location is then calculated depending on the quadrant where the collected point falls (northwest, northeast, southwest, or southeast). Figure 2.3 illustrates this error.

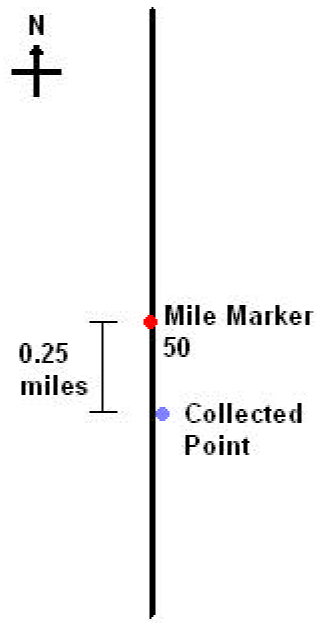

Figure 2.3 – If the distance from the mile marker to the collected point is .25 miles, the original GPS application would have returned the location as reference point 50.25, when the correct location is actually reference point 49.75.

CHAPTER 3. SOFTWARE ELEMENTS AND FUNCTIONS

The Maintenance Management software developed for this study consists of several elements. The data collection software for the handheld computers was written in Microsoft eMbedded Visual Basic®. Its main function is to collect GPS points and data regarding the work items. The desktop software was developed using Microsoft Access® and offers the user more functionality and advanced analysis tools. The desktop database can be linked to the handheld computer, and is updated each time that the user connects the handheld to the desktop computer. Another important element of the software is the North Dakota map developed using ESRI's ArcGIS™. This document contains the basic default elements of reference points, state roads, and sections (a boundary created by the NDDOT to divide their districts).

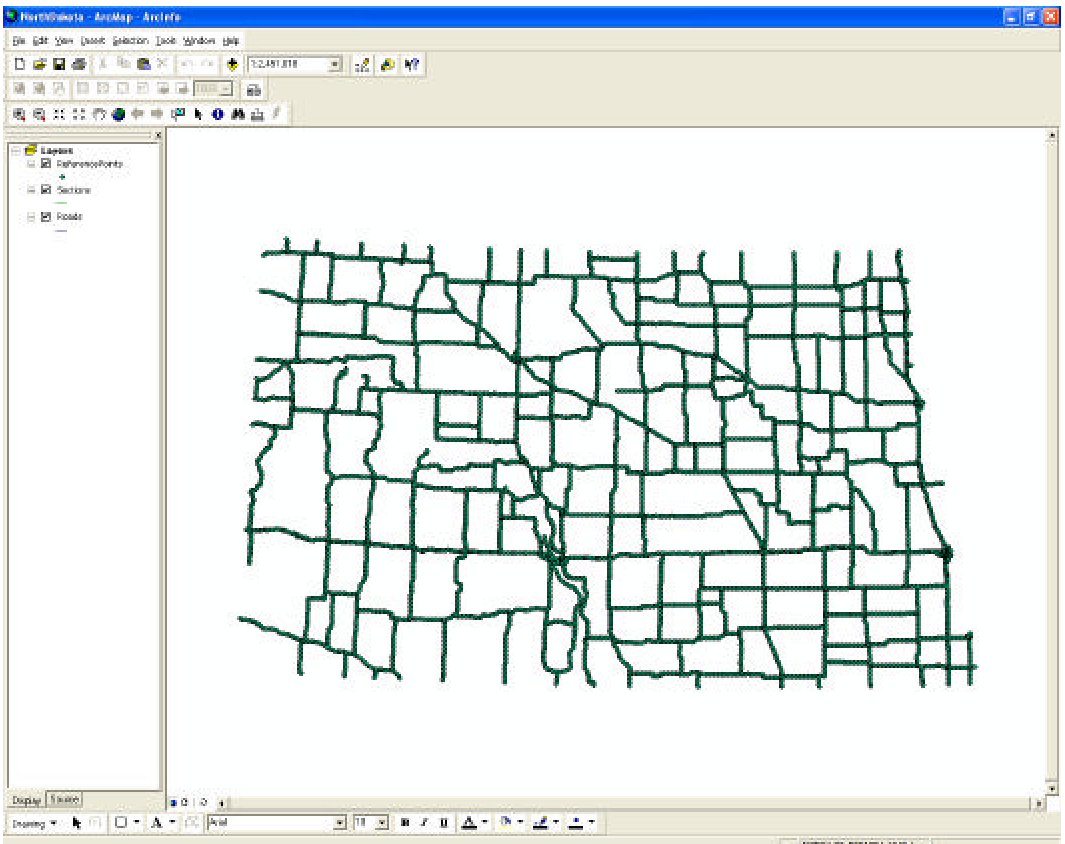

Figure 3.1 – This map of North Dakota shows the state and interstate highways**.**

While the software was developed with the help of the team described in Chapter 1, their comments on the final product were not available for the publication of this paper. The software is currently undergoing a stringent testing process with the N.D. Department of Transportation's Information Technology Department.

THE HANDHELD SOFTWARE

The Maintenance Management handheld program is designed to run on a Compaq iPAQ™ handheld computer. Its main function is to collect GPS locations and additional data for the following types of work items:

Spot Items – including potholes and any work item for which a single GPS point is collected rather than a line of points

Asphalt Overlays – including thin lift overlays, selective contract patching, blade patching, and wedge patching

Crack Treatments – including filling (with crumb rubber) and pouring (with road oil)

Surface Treatments – including fog seals, seal coats, and scotch patching

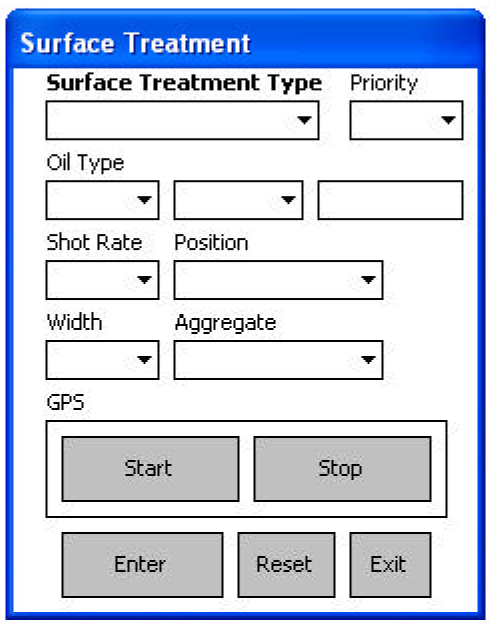

Figure 3.2 – This is the screen that is used to collect data on a surface treatment project.

ISSUES WITH MANUAL DATA INPUT

A major concern of the team was the ease of data input on the handheld computers. The screen of the iPAQ™ is 2.5 X 3.0 inches, and does not provide a convenient writing surface. When developing software, they tried to use mostly drop down menus, buttons, and check boxes. Fields that required a narrative statement could be entered by using the on-screen handwriting area or keyboard. These narrative fields contain information that is not standardized in any way, and its content is completely up to the user's discretion. The user also has the option of using a portable keyboard (see Figures 3.3 and 3.4) or entering the narrative at their desktop computer. Because of the highway and mile point label, the user does not run the risk of entering the narrative for the wrong section of road.

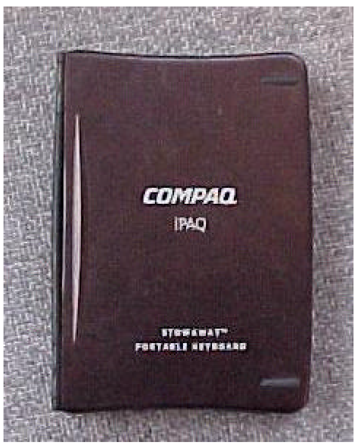

Figure 3.3 – The Compaq iPAQ Stowaway™ Portable Keyboard (collapsed)

Figure 3.4 – The Compaq iPAQ Stowaway™ Portable Keyboard (extended)

THE DESKTOP SOFTWARE

The main menu of the desktop program highlights the main functions of the software. Data from the GPS receiver is processed to be usable in ArcInfo™. Users are able to change the details of a work item, add a digital photo, or calculate an estimated cost (See Figure 3.6).

Figure 3.5 – The main menu of the desktop software

Users may add the material prices that are relevant to them in their district, but future versions of the software may contain a function to add the prices automatically from a central database. The cost scenario function can be used to produce a seasonal work plan that is within the district's budget, and organize that plan by work type. In addition to illustrating the work that can be done on a specified budget, the cost scenario function keeps track of work that **could not** be completed because of a lack of funding and saves this information for future used. A sample report from a cost scenario is shown in Figure 3.8. The user also has the option to print the following reports:

- Cost scenarios (Figure 3.7)
- Work item and ID number (for use with ArcInfo™)
- List of materials prices
- Materials usage summary with option to sort by section
- Section work plans sorted by work type

Calculations for estimating the cost of a work item were decided on by the team of NDDOT maintenance engineers. The factors used in these calculations, such as materials quantity and cost, are highlighted in Appendix B.

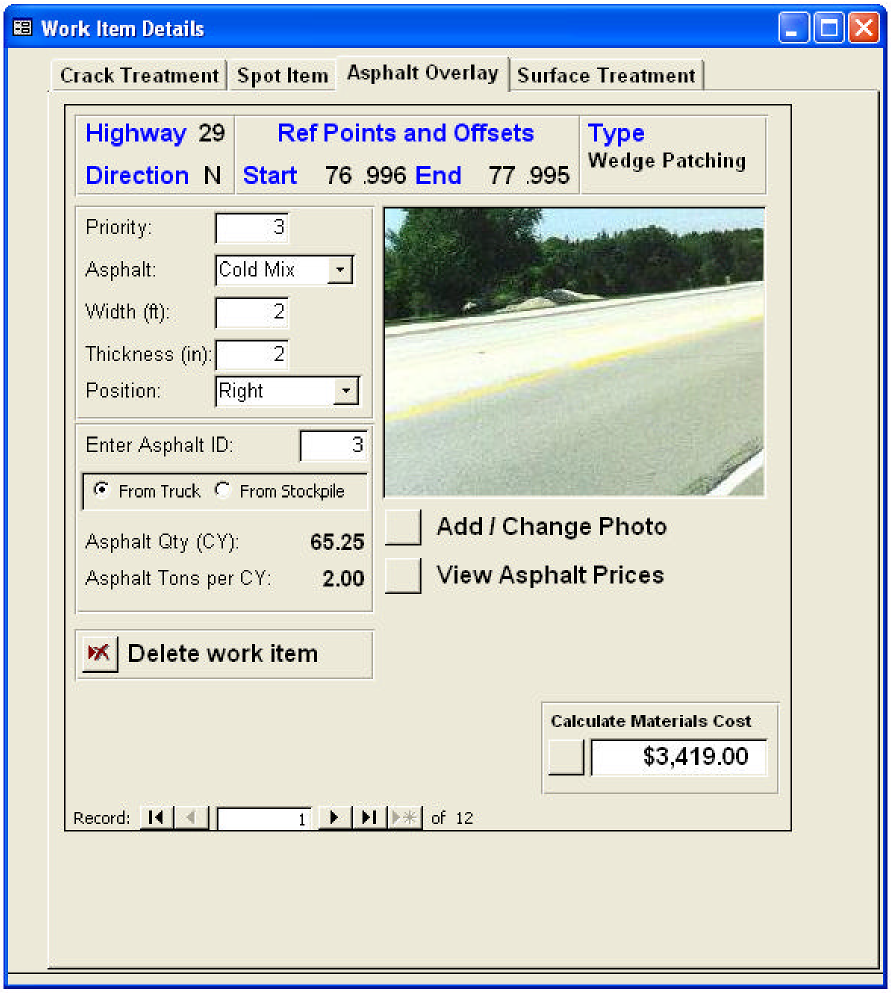

Figure 3.6 – A sample work item shown in the desktop software

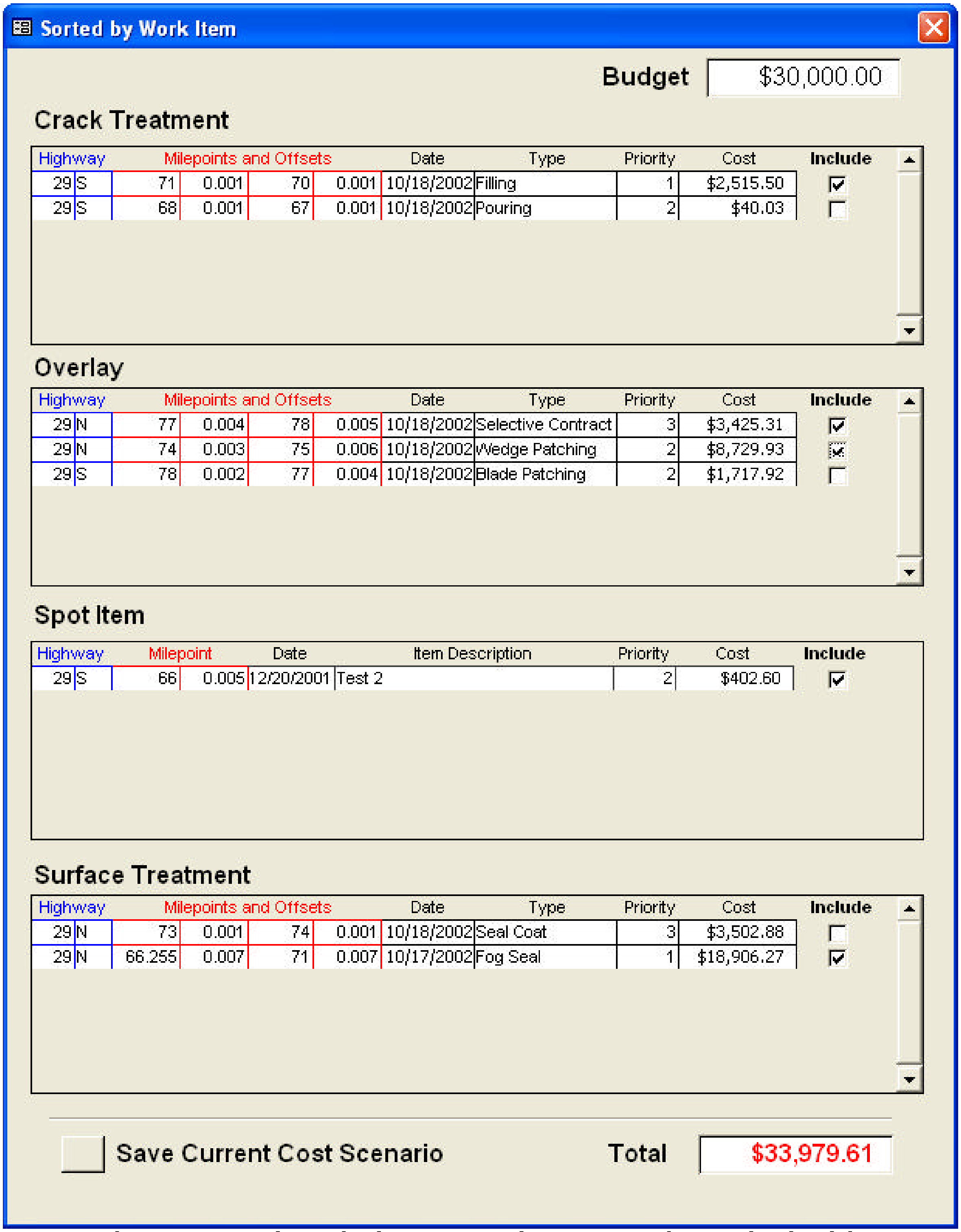

Figure 3.7 – This screen is used to make decisions regarding projects to be completed and those backlogged.

Summer 2002 Report

Friday, August 6, 2002

Surface Treatment Backlogged Projects

Projected Budget: $1,000,000.00

Total Projected Cost of Completed Projects: $992,438.28

Highway	**Mile Points**	**Type**	**Priority**	**Cost**
94	290.83 – 298.25	Scotch Patching	2	$173,487.42
281	900.01 – 900.82	Fog Seal	3	$20,257.02
29	63.26 – 64.26	Scotch Patching	3	$35,092.27

Total Cost of Backlogged Surface Treatment Projects = $228,836.71

Surface Treatment – Page 1

Figure 3.8 – A hypothetical cost scenario report of backlogged surface treatment projects

CHAPTER 4. SUMMARY AND CONCLUSIONS

Many pavement condition monitoring systems were developed in the 80s and 90s. Systems developed in that era were restricted by power of the computers and the analytical software available. In conjunction with those new pavement management systems, states also developed extensive databases of pavement conditions to measure, and hopefully predict future pavement performance. The pilot project summarized in this report was not intended to compete with these systems. It was intended to complement, or be integrated with these systems while providing more specific and timely data to maintenance planners.

Software developed and evaluated under this project can not compete with the legacy systems already in place. Many existing systems are network-level oriented because of the computer and software restrictions listed earlier. This maintenance management system is a **project** level existing condition reporting system. It was not designed to **predict** project performance. This pilot project was developed to determine if existing technology could be used to increase productivity of field data collection and ease the burden of collecting project specific pavement defects. This project has proven that with current technology and at minimal additional cost, this goal is achievable.

Benefits of the proposed handheld computer/GPS/GIS software system are many. The maintenance monitoring software can be used to collect and record planned maintenance work such as seal coats. More importantly, reactive maintenance work, such as spring breakup repairs, can be recorded and tracked over time. The annual collection of this data and other maintenance work provides a wealth of information about individual project performance. If desired by the agency and if resources are available, pavement defects can be digitally photographed and archived for future analysis. This becomes invaluable when in future years more extensive rehabilitation options are considered. Over a projects lifetime there will be many maintenance and construction activities which will cover these defects. Typical types of work are seal coats, minor repairs and overlays. Also, if an organization relies on an employee's past experience, that information is lost with retirements and transfers. This maintenance management system will capture all of this activity and display it visually through a GIS system and written reports in a new method of documenting maintenance expertise. The use of GPS technology allows many years of maintenance activity to be located, reviewed and analyzed by the pavement evaluator considering major repairs or rehabilitation on a specific project. Locations receiving numerous repairs over a projects life could be tested extensively to determine any additional rehabilitation work that may be required.

Another advantage of this system is the information on backlogged maintenance. Most agencies do not have sufficient resources to fix every pavement defect annually. Major maintenance work must be prioritized based on funding allotted by the agency for that district or section. Those sections that cannot be immediately repaired are noted and logged. They can be accessed, studied and used to develop a future work schedule when their priority may be higher. The amount of backlogged maintenance can be summarized and tracked over time by statewide, region, district, or section areas. This information could be used to justify additional maintenance funds to lower rising backlogs, both statewide or by a specific area in the state. This system also could be used to depict potential locations where scheduled maintenance cannot be performed if maintenance funding is reduced, and vice versa if it is increased. Miles of backlogged maintenance categorized by type of effort is an excellent district and system performance measure of service.

Pavement management system data structures are extensive. Subsequent data resource requirements are very large. Pavement management systems are intended to predict performance therefore extensive data must be collected for analysis. This system does not require a large database. The maintenance system records the location, type and extent of current damage or distressed condition. Since the handheld database is much smaller, it requires very little time inputting data. One caveat however, concerns the storage of digital data. The current system does not allow the user to capture and store numerous digital pictures of specific damage. However, data storage costs are coming down rapidly so this may not be a major concern in the near future.

In summary, the maintenance management system shows exceptional promise as a low cost method of collecting, analyzing, and reporting current maintenance conditions for annual maintenance programming. The archival aspect is no less important. Actual locations of maintenance effort located through GPS technology is an information element long needed by the capital improvement planners. The following recommendations are based on the study and pavement monitoring status of the NDDOT's involvement in the research.

RECOMMENDATIONS

Listed below are general and specific recommendations, which the participating NDDOT could use to implement the maintenance management system:

1. Centralize the system in the main NDDOT office in Bismarck. The current system resides with separate databases in each districts' offices.

2. To ease the training burden and increase the utility of the software, automate a palette of GIS functions. The research team recommends using Visual Basic for Applications™ as the software package for this purpose.

3. In addition to automating GIS functions, the next version should improve functionality of the GIS maps
   a. Use of colors to differentiate between work types
   b. The availability and use of statistical analysis, graphs, and charts

4. Maintenance programs should be posted to maps on the future maintenance operations website using ESRI's Arc Internet Map Server.™ These maps should include options for viewing current and past programs plus unfunded maintenance projects. Consideration should be given to color coding the internet map so managers can get a visual update on the extent of the execution of the current annual maintenance program.

5. Improve error handling functionality in the next version. One item needing immediate attention is the removal of GPS points that do not fall within a reasonable distance of the project inspected.

6. An important function of the maintenance management system is development of work estimates. The handling of prices should be improved in the next version. Material prices could be automatically updated or refreshed from a central database on a given cycle or on demand.

7. The most important recommendation is that NDDOT consider developing a new maintenance management system. This minor pilot project revealed significant weaknesses with the existing system and the IT industry has improved exponentially since the system initially was developed. Pavement and bridge preservation activities and planned and unplanned preventative maintenance activities should be included in any new system.

Project specific monitoring systems are needed by all jurisdictions if the dream of pavement preservation is to become a reality. Without extensive preplanning and monitoring, maintenance project timing windows may be missed. Similar projects with similar attributes and characteristics should perform reasonably similar. However, the number of variables in pavement performance is staggering. Managers must have their eyes on the pavement and continually monitor pavement conditions if cities, counties, states and the nation are ever going to achieve the levels of efficiency and effectiveness desired by the taxpayers and users.

APPENDIX A: REFERENCES

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APPENDIX B: COST ESTIMATION FACTORS

Asphalt Tons per Cubic Yard – 2.0000
(Default value, subject to change)

Road Oil Weights Used (gallons per ton)

Default	**240.0000**
SC	**242.4024**
MC	**248.7140**
MC3000	**203.5316**
HFMS	**238.0936**
HFRS2	**242.1821**

Joint Sealant Weights Used (cubic yards per ton)

Polymer	**1.0105**
Crumb Rubber	**1.0320**

These figures were compiled from a survey of the NDDOT Maintenance Team to make the new process as accurate as possible.

APPENDIX C: BETA TEST USER SATISFACTION SURVEY

Maintenance Management Program User Satisfaction Survey
***Note – Survey results were not available for publication.**

Accuracy

1. Are the points collected by the GPS receiver reasonably accurate?

2. Are the cost estimations made by the desktop program reasonably accurate?

Reports

3. Please list any reports that provide insufficient data. What information would you like to see included on these reports?

4. Are there any additional reports that you would like to see added to the program?

User's Guides

5. Are there any topics that should have been covered more thoroughly in the Handheld Program User's Guide?

6. Are there any topics that should have been covered more thoroughly in the Desktop Program User's Guide?

7. Are there any topics that should have been covered more thoroughly in the ArcInfo™ User's Guide?

Phase II Plans

8. Are there any other work item types that should be included in future versions of the Maintenance Management Program

9. Are there any other features that you would like to see implemented into future versions of the Maintenance Management Program?