From Road Condition Data Collection to Effective Maintenance Decision Making:

Saskatchewan Highways and Transportation Approach

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Paper prepared for presentation at the *Roadway Inventory and Condition Rating Data for Effective Maintenance Decision Making* Session
of the 2003 Annual Conference of the Transportation Association of Canada
St. John's, Newfoundland and Labrador, Canada

Abstract

An effective road maintenance program requires that road authorities strategically target their investment to those roads that provide most benefits in return. The main goal is to determine maintenance strategies that minimize the long-term costs of preserving the road network in a desired condition. This process begins by obtaining adequate information about the road network being analyzed so that the right decisions can be made at the right time. Saskatchewan Highways and Transportation (SHT) collects various road condition data either by using an automated data collection system or by manually rating the road network. The SHT automated data collection system consists of the longitudinal profiling subsystem, transverse profiling subsystem and digital video distress collection subsystem.

Collected road condition data are then post processed and stored in the centralized database to be later analyzed in the SHT Asset Management System (AMS) that is concerned with optimizing available funding and providing most benefits for the entire road network. The main purpose of this paper is to describe the road condition data collection process in Saskatchewan and how obtained information is used to derive an effective road maintenance strategy.

Key words: road maintenance program, minimize the long-term costs, road condition data, automated data collection system, optimization, SHT Asset Management System.

1.0 Introduction

An effective road maintenance program demands strategic allocating of the limited resources (funding) to those roads that provide most benefits in return. The main goal is to determine maintenance strategies that minimize the long-term costs of preserving the road network in a desired condition. In order to achieve this goal, road agencies need sound management practices and procedures in place to increase their chances of making the right decisions about the road infrastructure. The strategy is simple: have the right treatment for the right road at the right time. However, accomplishing this is a much more complex process. It essentially starts by obtaining adequate information about the road network through the collection of the road condition data that fully describe both surface and structural level of road deterioration. The collected data should be objective as much as possible, reliable, repeatable and used in the decision making process.

The later is usually achieved by processing data in some type of a prediction model to allocate funding in the most efficient way and determine the maintenance treatments that will most benefit the observed road network. There is an array of different optimization modeling software packages and techniques available on the market to assist road managers with this task. Some of the programs use probabilistic formulations and others use deterministic approach to modeling. The maintenance and preservation strategies derived from these models should lead to the minimization of the long term costs of preserving the road network in a desired condition.

The main purpose of this paper is to describe the road condition data collection process as adopted by the Saskatchewan Department of Highways and Transportation (SHT). It also explains how collected data are used in the decision making to arrive at an effective road maintenance strategy. SHT is responsible for over 26,000 kilometers of the provincial highways. More than half of those are classified as pavement structures, that being either granular (structural pavement with sealed surface) or asphalt concrete pavement (structural pavement with hot mix surface). Slightly less than 50% of the provincial highway network is categorized as non-structural roads, predominantly thin membrane structures that provide dust free surface but lack structural capacity and gravel surface roads. SHT uses its asset management system to help manage this vast provincial road network and properly allocate its annual funding to provide most benefit for the entire road system in the long run.

2.0 SHT Decision Making Framework

The SHT road maintenance decision making framework is established through the department’s asset management system. The asset management system enables the preservation managers to answer many questions regarding different what-if scenarios. Some of the most commonly asked questions might be: What is the current condition state of the road network?; Have the network conditions been improving or getting worse? (i.e. how efficient have the adopted maintenance strategies been over the past few years?); What funding is required to maintain the existing level of service?; What will be the impact of different funding levels on the level of service?; What funding is required to provide a desired level of service?, etc.

In addition to providing answers to possible what-if scenarios, the asset management principles are applied in expanding annual budgets in the most optimized way. The key principle here is to assign funding on a needs basis, not necessarily to the roads in the worst condition but rather to those ones that would provide most benefits in return. Due to inherent uncertainty associated with the deterioration of its road network, SHT applies probabilistic principles to the network level analysis. The probabilistic model is developed around the Markov process decision theory that, in brief, states there is a probability a road network will move from one condition state to another over a certain observed time period. Funding is then assigned in the most optimized way by applying a linear programming algorithm. Furthermore, as the focus of the analysis shifts to the project specific analysis, the probabilistic approach is replaced with the deterministic one. The SHT deterministic model uses deterioration curves (sometimes also called survival curves) to predict the deterioration rates of the observed road distresses over a certain time period.

The SHT preservation managers and engineers use this model to determine best timing to apply the major maintenance treatments to most improve road conditions. The following treatments are considered major by SHT: full seal, microsurfacing, thin overlay and structural overlay. Full seal is the application of graded aggregate and asphalt emulsion to the full width and length of the road segment to prevent moisture from entering the subgrade and slow the deterioration rate of the asphalt mat. Microsurfacing is the application of a mixture of polymer-modified asphalt emulsion, mineral aggregate, mineral filler, water and other additives and retarders. Thin overlay is a thin hot mix treatment while structural overlay applies thicker layer of asphalt concrete hot mix and usually includes mill and fill.

In addition to the network and project level analyses, a scheduling and planning tool is used to provide maximum flexibility to the maintenance crews and enable them to plan and schedule the minor maintenance treatments to be executed either by the crews themselves or contracted out.

Some examples of the minor maintenance treatments adopted in SHT are: spot sealing, deep patching, machine patching, crack sealing (cold pour or hot pour), thermopatching, etc. The SHT crews are constantly improving their existing maintenance treatments and adopting new ones. Figure 1 is used to present the SHT asset management process flow. Similarly, the process and information flow between different components in the maintenance decision making process in SHT can be presented as Figure 2.

3.0 Road condition data collection

The effective decision making in SHT starts with the gathering of reliable information about the current condition of the road network. Every year in the fall, after all planned construction and preservation work has been completed or is near completion, SHT evaluates its road network conditions by collecting current road surface condition data. Road conditions can be observed through condition indices or measured through road surface distresses. The indices, in most cases, are not directly related to specific maintenance treatments like the surface distresses are. The condition data are related to those road distresses that affect the level of service. Such collected data provide the foundation for the optimization process that include budget allocations and the development of treatment strategies for those roads that need repair and maintenance. This information should not only capture the results of the deterioration process but also point to the cause of it.

The condition rating is done according to the surface condition rating manuals that ensure the high quality of collected data and measurement procedures. The obtained info is then sorted out into four different categories according to the road surface type: gravel, thin membrane surface (TMS), granular and asphalt concrete (AC) pavements. The following distresses are used to describe conditions of TMS, granular and AC pavements: International Roughness Index (IRI), cracking, rutting, surface condition and depressed transverse cracking. In addition, structural indicator (SI) is calculated for the structural roads to indicate if the road structural capacity meets the loading demand. Similarly, performance index (PI) is also calculated for the TMS roads based on grade height, underlying soil conditions and percentage of the truck traffic. Conditions of the gravel surface roads are fully described by manually collecting data for protruding rock, surface gravel and stability. Protruding rock and surface gravel are visual observations while stability is measured at a chosen representative gauging line within the gravel road segment.

SHT has just recently moved to a fully automated data collection system for the TMS, granular and AC pavements with work still being in progress to integrate some hardware and software components. This system consists of the three major functional components used for measuring cracking, rutting, IRI and depressed transverse cracking. These major components and their accompanying hardware and software have already or will have been installed on the SHT van shown in Figure 3 and 4. Schematic presentation of the automated data collection system is shown in Figure 5.

Rutting is the longitudinal, normally continuous, surface depression in the wheel paths due to repeated load applications. It may occur due to a variety of reasons such as an inadequate structural design, poor quality of building material, highly channelized traffic flows, soft asphalt cement and high asphalt temperatures. Bad rutting not only affects the level of service (general perception of a good road) but can also be a safety hazard by contributing to the vehicle steering difficulties.

The INO Laser Rut Measurement System, mounted in the tilted position at the back of the vehicle, is used for measuring road transverse profiles and calculating rutting deformations. It consists of two laser sensors with such mounting configuration (location, height and tilting) that enables capturing of minimum of 4.2 meters of the transverse profile width. Images are captured at approximately one meter interval at highway speeds. The maximum rut depth is then reported in each wheel path and output summarized into the 50-meter intervals.

Road roughness is an indicator of the riding comfort. It accounts for all deformations such as bumps, dips, road patches and others that contribute to the roughness of the road. SHT uses and reports the severity of roughness in an International Roughness Index (IRI) format as developed by the World Bank and described in the National Cooperative Highway Research Program (NCHRP) Report 228. IRI values are presented in meters of accumulated vertical displacement per kilometer of road length.

The Longitudinal Profiling System, obtained from International Cybernetics Corporation, consists of infrared laser sensors, accelerometers and a distance measuring instrument. Two IRI laser sensors are mounted at the front of the data collection van and so spaced to allow measuring road roughness response in both wheel paths. IRI values are computed for the left and right wheel paths using the left and right laser sensors and their accompanying accelerometers. These calculations are then summarized into the 50-meter intervals in the output file. In addition to the calculation of IRI values, work is in progress to develop an algorithm to determine number of depressed transverse cracks and the severity of depressions based on longitudinal profile information collected by the two lasers sensors.

There are many types of cracking that the Department recognizes such as fatigue cracking, block cracking, longitudinal cracking and transverse cracking. Fatigue cracking is defined as cracking developed under repeated traffic loading, usually within wheel paths and characterized by series of interconnected cracks. Similarly, block cracking is interconnected cracking that divides pavement lane into small rectangular pieces. Like fatigue cracking it is also measured in square meters of affected area. Longitudinal cracking is defined as single cracking parallel to the center line. This type of cracking is recorded in lineal meters. Transverse cracking is the type of single cracking that is perpendicular to the road center line and is also measured in lineal meters.

A recently conducted pilot project looked into possibility of integrating an automated cracking data collection system with the SHT existing data collection vehicle. As a result, the Video Distress System from Roadware will be incorporated. The system will collect high resolution pavement digital video images using two digital video cameras and accompanying strobe lights. The field of view obtained from the collected images covers the entire lane width. The post processing software is used to automate cracking data detection from the collected digital images and report results in the 50-meter intervals.

SHT calculates Structural Indicator (SI) for all structural pavement segments. SI is used to determine if the structural capacity of the road meets traffic loading demands. Loading is computed as the Equivalent Single Axle Loading of 80 kN (ESAL) of the commercial truck traffic. The structural capacity is the loading that the current road infrastructure can handle. It is based on an E7G value, a method used to standardize any structure to an equivalent granular thickness supported by California Bearing Ration (CBR) 7.0 subgrade. The E7G value is calculated from the thickness of asphalt concrete, base and subbase as well as the subgrade CBR value. It also takes into account the current condition of the AC mat.

In addition, a pilot project is underway to evaluate ground penetrating radar (GPR) and heavy weight deflectometer (HWD) technologies. The main goal of the pilot project is to evaluate possibility of the correlation between GPR and HWD results for the type of roads in Saskatchewan. If such a correlation factor can be determined then, the GPR technology could be used to collect information on the network basis at highway speeds. Collected GPR data would be used to estimate the road structural capacity and ultimately determine SI values.

4.0 Data repository

Once all data are collected and the validity checks performed by the SHT testing services and preservation staff, raw data are then first summarized into the 50-meter intervals for each highway control section. Additional data validity checks are performed on the summarized data and if deemed satisfactory those files with the 50-meter interval summary data are processed through the post processing software utility. The results are saved in the centralized database software – Asset Register Pro (ARPro). The ARPro software was designed and developed in the Delphi programming environment. The program resides on the centralized network server and is accessible to all staff for viewing. ARPro is essentially a collection of Paradox dBase databases that store all relevant information regarding provincial highways system (Figure 6).

Highway control sections are divided into smaller segments that exhibit the homogenous surface conditions throughout the entire length. The collected surface condition data are aggregated for the segments and the results are used to determine segment distress scores that can be either discrete (e.g. cracking score of S1 meaning slight severity and extent level 1) or continuous (e.g. IRI score of 2.1). Figure 7 shows the pavement segments database with segment info and summarized data for the pavement surface distresses.

In addition to serving as a centralized data repository, the ARPro software is also used to perform data integrity checks, calculate distress scores (level of severity and extent) and view various pre-designed reports. These functions are triggered by executing the Delphi scripts written to perform numerous operations in the background. Even though ARPro enables exporting of collected data in various other formats (e.g. Excel, MS Access, dbf, etc.) for further analysis and mapping, dBase database formatting is required when data are used in the SHT asset management software to re-allocate funding and determine appropriate maintenance treatment strategies.

5.0 Asset management models

It is common knowledge that all roads deteriorate under traffic and environmental impacts. Highway engineers and managers make effort to predict what this deterioration will be over time under different loading patterns in different climate conditions. Through numerous studies they have proved they can accurately simulate deterioration patterns on a specific road segment level by measuring the road response to loading under various environmental conditions (dry subgrade, wet subgrade, freeze-thaw periods, etc.). However, it's long been realized that on a network level there are too many variables and uncertainties to be able to accurately determine the road network deterioration. Hence, models have been developed to predict road deterioration on a network level based on probabilistic principles. These probabilistic models are generally used to optimize and split budgets at a network level.

However, as the focus of the analysis shifts towards the sub-network and project specific level analysis, the probabilistic models tend to be replaced with the deterministic models. Some of the deterministic models use deterioration curves sometimes also called survival curves that predict the deterioration of road distresses / indices over a certain time period. Those models are used by road engineers and managers to determine best timing to apply the maintenance treatments to most improve road conditions.

Saskatchewan Highways and Transportation has constantly been improving its Asset Management System since implemented in the early 1990's. Reliable highways preservation and maintenance decisions are always derived through the use of the accurate performance models that assume the road network assets depreciate / deteriorate over time. Over the years SHT has seen some changes in prediction models its staff use. To manage its assets SHT currently uses Performance Prediction Technology (PPT) models and fully integrated Maintenance Management System (MMS) developed through a partnership with Vemax Management, City of Saskatoon and Manitoba Department of Highways.

The probabilistic model, called Strategic PPT, that applies principles of semi-Markovian chains theory is used at a network level. This model is used as a management support tool in optimizing and funneling down budgets targeted towards overall strategic goal. For its sub-network analysis aimed at optimizing specific maintenance treatments including structural and non-structural rehabilitation, microsurfacing, full seals, etc. for a given network size, the preservation staff utilize the deterministic model called PPT Tactical. Both models are driven by the existing road condition data collected on the Saskatchewan road network in an objective and reliable manner.

5.1 Strategic PPT

Strategic PPT is software used to optimize the total cost of maintaining a road network at a designated level of service. It allows for the prediction of the future conditions of the road network, treatment needs for different asset preservation strategies and costs of those strategies. Strategic PPT converts the condition data rating scores into its own rating system. For each distress type Strategic PPT groups condition ratings into two or three rating levels depending on the distress type. In case of two rating levels 1 represents good and 2 represents poor. Similarly, in case of three rating levels 1 represents good, 2 represents fair and 3 represents poor highways.

Strategic PPT models are fully probabilistic in dealing with the pavement deterioration process. It means that since no one can exactly predict how the road network will deteriorate there is still a way of accounting for that deterioration by assigning certain probabilities to the road depreciation process. Therefore, to provide for the probabilistic approach to the road network management Strategic PPT applies the semi-Markovian probabilities to solve a road management problem. Semi-Markovian models are developed from Markov theory “which specifically recognizes the probabilistic nature of pavement deterioration and explicitly recognizes the problem as an asset depreciation problem that can be retarded through maintenance”. [9]

Within the standard configuration of the Strategic PPT model, for example for AC pavements, there are 8 possible combinations of ratings (2x2x2) meaning there are 8 unique ways to describe the condition of a road segment. Each combination is called a condition state with the condition state 1 the best and the condition state 8 the worst. Strategic PPT calculates the percentage of the network in each condition state and consequently determines the proportions of the road network in good, fair and poor conditions for each distress. Also, for each of the 8 condition states a probability exists that a road segment in one particular condition state will either remain in that state or move to another condition state over one year period during which it receives a particular treatment. After all possible probabilities are calculated the result is a 8x8 transitional probability matrix.

There is also a cost associated with each condition state that the program uses to calculate budget needed to upgrade the road network to or maintain in a particular condition state. The program uses that cost model and applies a linear programming optimization technique to perform an accurate budget allocation for the road network. As the level of distress and consequently condition state increase it generally costs more money to upgrade or maintain the system.

5.2 Tactical PPT

The main purpose of a Tactical PPT model is to produce a schedule of treatments, for a given road network, that will maximize the benefits obtained from the available budget passed down from the Strategic PPT analysis. It optimizes budgets by analyzing the road network condition data to allocate the most cost - effective treatments to the segments of the road network.

Road networks generally deteriorate through time. A survival curve (Fig. 8) is used to describe the degree of deterioration of a road at a particular time point. The y-axis represents the conditions of a road, 1 being the best and deteriorating toward 0, while X-axis contains a discrete time period, usually years. Therefore, it’s usually possible with some certainty to predict and determine the way a road will perform over the time. Some software such as Tactical PPT will enable performance curves to be distorted from the average performance models for specific segments to take into account weaknesses in pavement and more severe environmental factors or traffic loads.

To maximize the benefits from the available funding, the model selects those segments that will most benefit from a particular treatment until the budget is fully expended. This is accomplished by applying a linear programming technique known as the Branch-and-Bound technique. In order to know which treatments to apply to combat different distresses Tactical PPT uses current road condition data.

5.3 Maintenance Management System (MMS)

MMS is a software tool SHT maintenance crews use for scheduling, budgeting, planning and monitoring of their workloads. It is also used to record all activities and related expenditures in a day to day business conducted by the crews. Key concepts in MMS are resource groups, asset groups and assets. A resource group is a collection of resources (people, materials and equipment) responsible for performing activities on assets. It is generally associated with maintenance sections. Assets are physical property of SHT. The most common example of an asset is a road. An asset group is a grouping of assets with similar characteristics such as traffic loading, surface type, functional classification and so on. Asphalt concrete pavements principal highway system is considered as one of the asset groups.

The main goal of MMS is to best utilize available resources in performing maintenance work on the assets owned by SHT. The level of service and current condition of a particular asset group determine the amount of work required on that asset group. MMS uses current road condition data imported from the ARPro database. The percentage of the asset group (road network) in a particular condition (good, fair and poor) is determined. Minor maintenance activities are then applied to road segments to either improve conditions or maintain status quo. Major maintenance activities are keyed in as inputs from the Tactical PPT analysis. Combined, major and minor maintenance activities define an annual maintenance program.

The key to having a successful maintenance program is to link performance targets for the road network, Strategic PPT, Tactical PPT and MMS. The common factor in all of them is the road condition data and budget provided to improve road conditions to meet set targets. An SHT strategy defines performance targets for the road conditions for different road systems, Strategic PPT optimizes available funding to meet the targets, Tactical PPT determines a list of major maintenance projects to improve conditions of the road network and MMS establishes a list of minor maintenance treatments contributing to the strategic targets. This relationship is graphically depicted in Figure 9.

5.4 Modeling Support Tools

In order to generate accurate models for Tactical and Strategic PPT runs there is need to annually update treatment costing and benefits that are a major driving input in delivering budgets and producing lists of maintenance projects. To update its asset management models SHT has developed a computer program that captures and stores road condition changes over two consecutive years as a result of road maintenance activities in the period between data collection. Road condition data are stored in the ARPro database while maintenance activity and related costing are retrieved from the Common Data Entry System (CoDES) financial system.

Two different types of viewers are developed to review captured data and present results in an appropriate form to use in the Tactical and Strategic PPT model updating. The Tactical viewer is a query procedure and reporting tool that summarizes condition improvements (gains) and costs associated with various maintenance treatments and also graphically displays a rate of deterioration (survival curve) for the observed road(s). Similarly, the Strategic viewer summarizes probabilities information related to the condition states of different maintenance strategies by tracking road condition changes and costing.

The conceptual idea of using modeling support tools to capture historical data and present results in a useful format for the modeling purposes is a very good one. However, it has to be realized that due to many changes associated primarily with the data collection methods, the captured historical condition data are quite often not compatible with each other resulting in a limited use of it. In addition, any changes in the definition of the maintenance activities or surface distresses require that the software code is updated for the modeling support tools and that the databases with the captured data are recalculated to reflect those changes. This process of constantly modifying software and re-running databases is costly and extremely time consuming. All of this had contributed to SHT preservation staff using centralized modeling support tools less and less frequently.

6.0 Monitoring and performance measures

Once the maintenance strategy is set for an upcoming fiscal year, the final two steps are undertaken to ensure the selected strategy is lived through and has indeed been the right choice. SHT keeps records of all preservation activities and associated expenditures through its financial computer systems – Common Data Entry System (CoDES) and Project Costing. Therefore, CoDES and Project Costing can be considered not only a system to keep financial records but also as a monitoring tool. In addition, the preservation staff use spreadsheet workbooks to keep track of the progress, time-wise and budget-wise, for both major and minor preservation programs.

At the end of the decision-making cycle and before the next one starts, the performance success is evaluated through the performance measures concerning road conditions and asset values. Performance measures present a means of tracking the success of the preservation strategies over the years. This enables various analyses at different management levels and introduces accountability in the decision-making process. Road conditions can be compared over a few year period to evaluate how well maintenance strategies met their road condition targets. In addition, the replacement cost analysis is an easy way to not only determine the value of the highway assets but also to indirectly follow the impact of various decisions on the road infrastructure.

7.0 Summary

Making good decisions regarding road maintenance is a complex process that involves determining the right treatment for the right road at the right time. The effectiveness of the decision-making relies on the decision makers having available adequate information about their road infrastructure. It is no wonder then that a successful decision-making process starts with the collection of objective, reliable and repeatable data about those road distresses that impact the level of service provided for a specific road network. In addition to capturing the rate of the deterioration, the collected data should also be used to determine the main cause of that deterioration so that an appropriate action can be taken to fix the problem.

To make effective decisions about its road network SHT has equipped its data collection van with equipment that provides for the automated data collection at highway speeds. The following road distresses are collected annually to describe conditions on TMS, granular and AC pavements: IRI, cracking, rutting, surface condition and depressed transverse cracking. Structural indicator is also calculated to provide information about the structural capacity under the traffic loading demand. In addition to the automated data collection process, the SHT preservation staff also manually rate the gravel surface roads by collecting protruding rock, surface gravel and stability data.

Collecting data for the sake of merely having it available in a database without real plan to ever use it is a poor business decision. The collected data should be used to support the organizational decision-making process. The SHT road maintenance decision-making framework is developed within its asset management system. Collected road condition data are used to make the long-term decisions about the entire road network and specific projects as well as to aid in day to day decision-making. SHT uses a probabilistic approach to making decisions at the network level taking into account inherent uncertainty associated with the road network deterioration. Using this approach budgets are allocated in the most optimized way to achieve the performance targets for the entire road network. Decisions regarding specific projects and day to day business are made using a deterministic approach that enables the SHT preservation managers and engineers to choose treatments for road segments that would contribute to providing an adequate level of service.

Once the maintenance strategy is set for an upcoming fiscal year, the final two steps must be in place to ensure the selected strategy is followed through. SHT keeps records and monitors all preservation activities and associated expenditures through its financial computer systems – Common Data Entry System (CoDES) and Project Costing. At the end of the decision-making cycle, the performance success of applied maintenance strategy is evaluated through the performance measures concerning road conditions and asset values.

8.0 Bibliography

1. Saskatchewan Highways and Transportation: “*2001 Surface Condition Rating Manual – Pavements*”, SHT, 2001
2. Saskatchewan Highways and Transportation: “*2001 Surface Condition Rating Manual – Thin Membrane Structure*”, SHT, 2001
3. Saskatchewan Highways and Transportation: “*2001 Surface Condition Rating Manual – Gravel Surface*”, SHT, 2001
4. Saskatchewan Highways and Transportation: “*Request for Proposal for Integrated Roadway Longitudinal and Transverse Inertial Profile Measurement System*”, SHT, 2001
5. International Cybernetics Corporation: “*Saskatchewan Highways and Transportation Proposal for Integrated Roadway Longitudinal and Transverse Inertial Profile Measurement System*”, 2002
6. Roadware Group Inc.: “*Saskatchewan Highways and Transportation Proposal for Integrated Roadway Longitudinal and Transverse Inertial Profile Measurement System*”, 2002

7. Saskatchewan Highways and Transportation: “*Structural Indicator Distress Manual*”, SHT, 2002
8. Saskatchewan Highways and Transportation: “*Design and Implementation of an Asset Management System*”, Summary Departmental Documents, 1994
9. Clayton, Sparks & Associates Ltd.: “*The Principles and the Practices of Asset Management – Course Notes*”, 1993

9.0 Figures

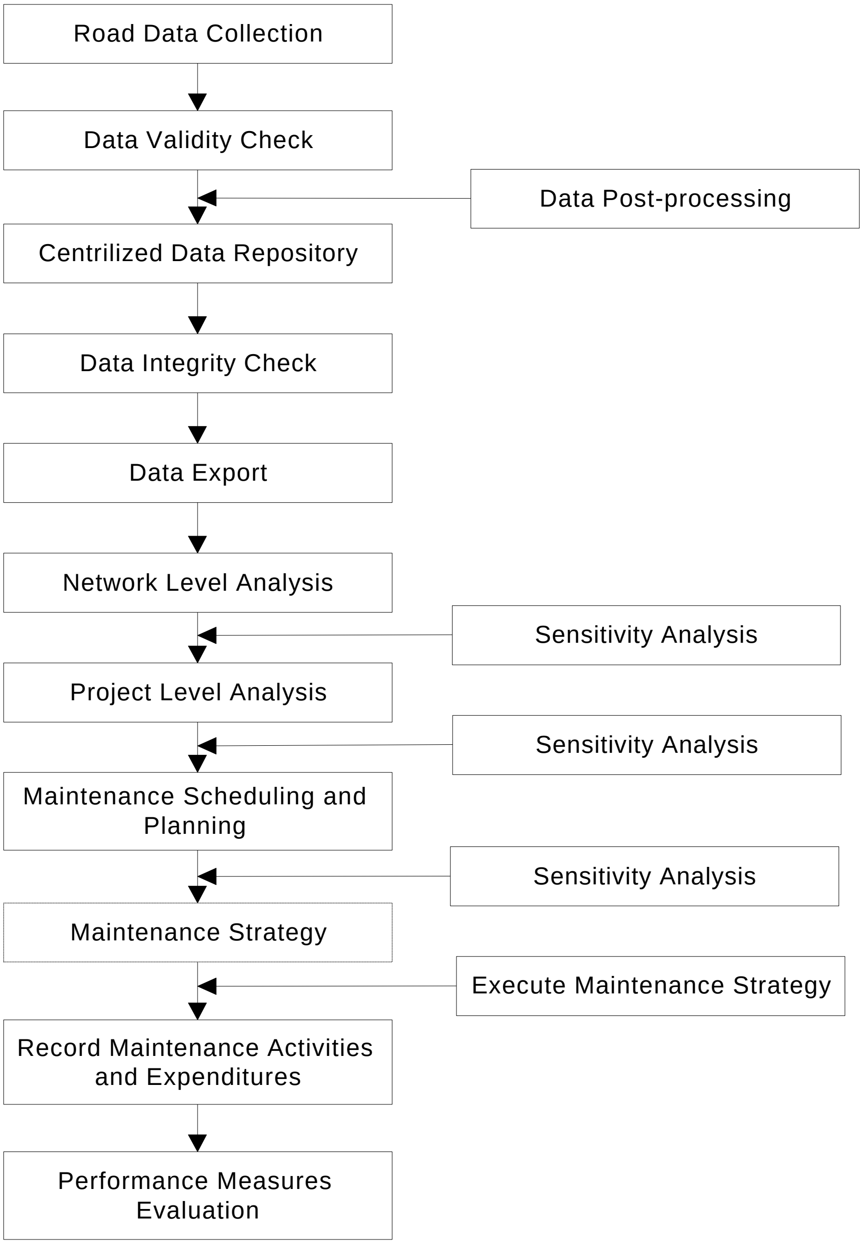


Figure 1 – SHT Asset Management Process Flow

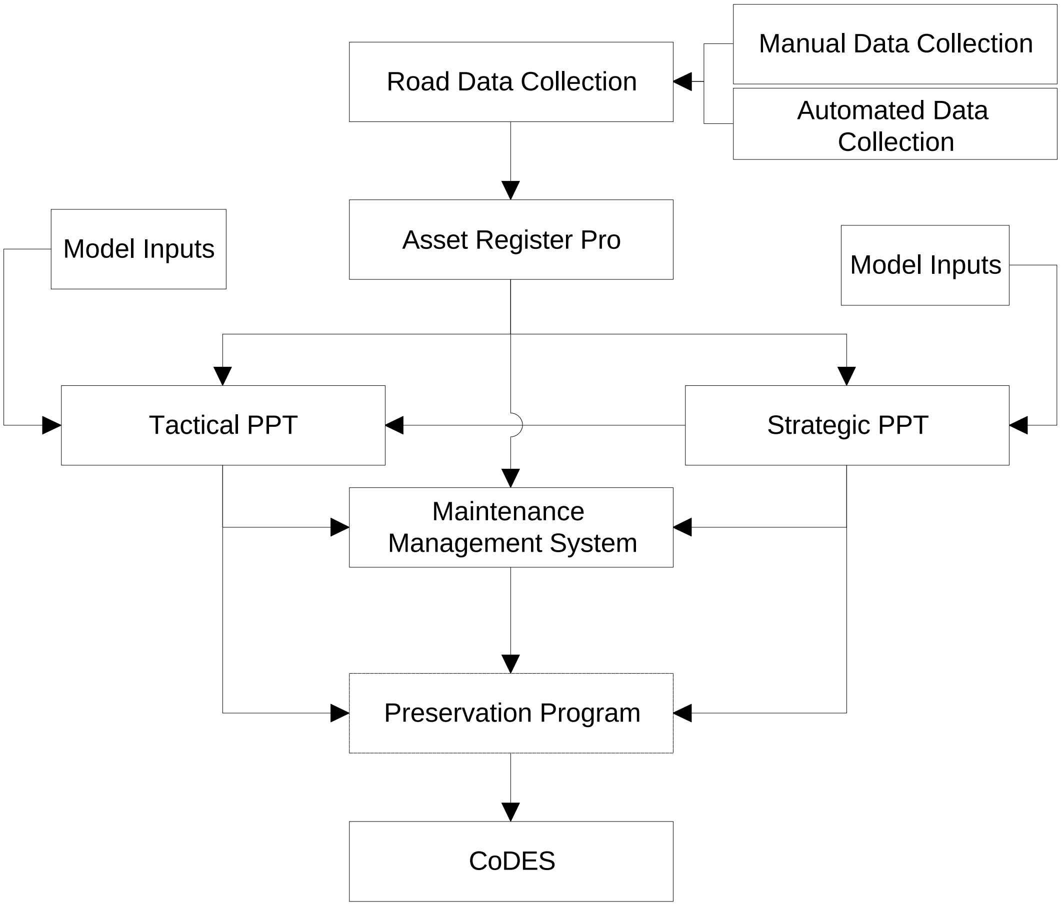


Figure 2 – Components of the SHT Decision Making Process

Figure 3 – SHT Automated Data Collection Van – Back View

Figure 4 – SHT Automated Data Collection Van – Front View

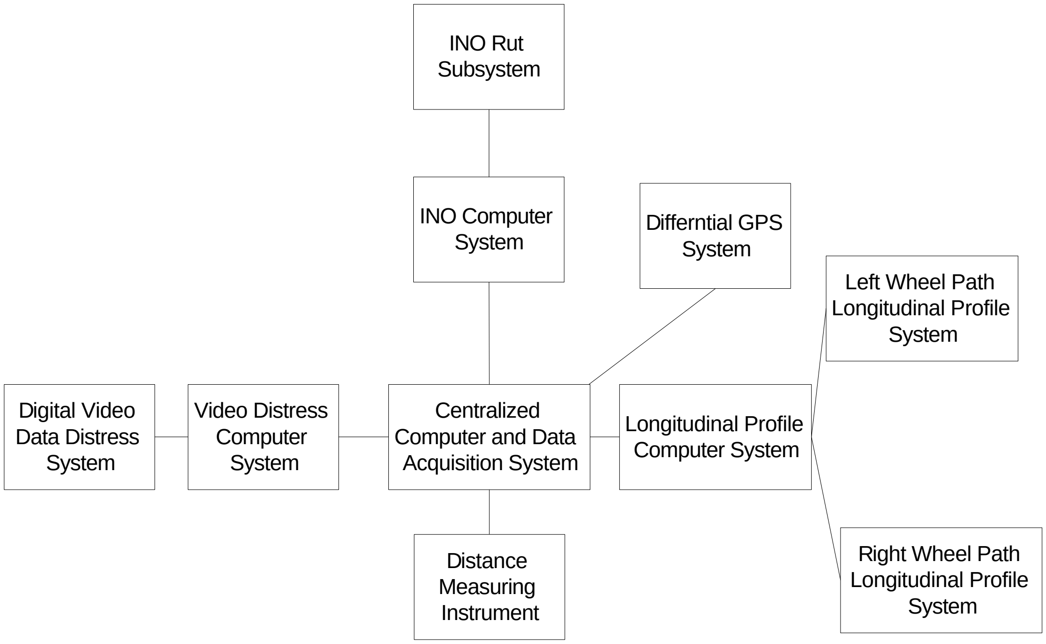
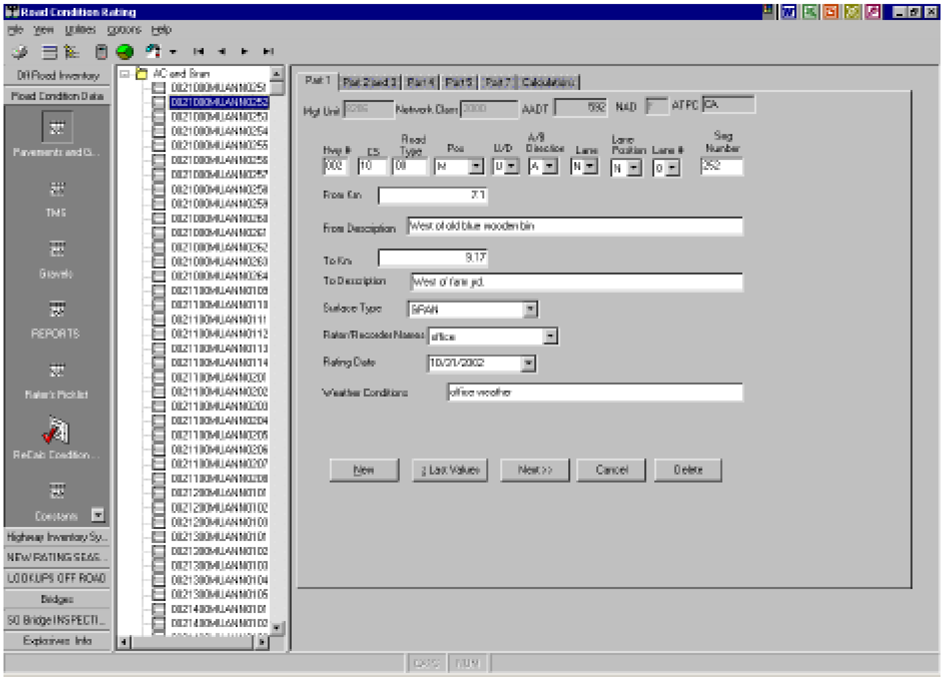


Figure 5 – Schematic Presentation of Automated Data Collection System

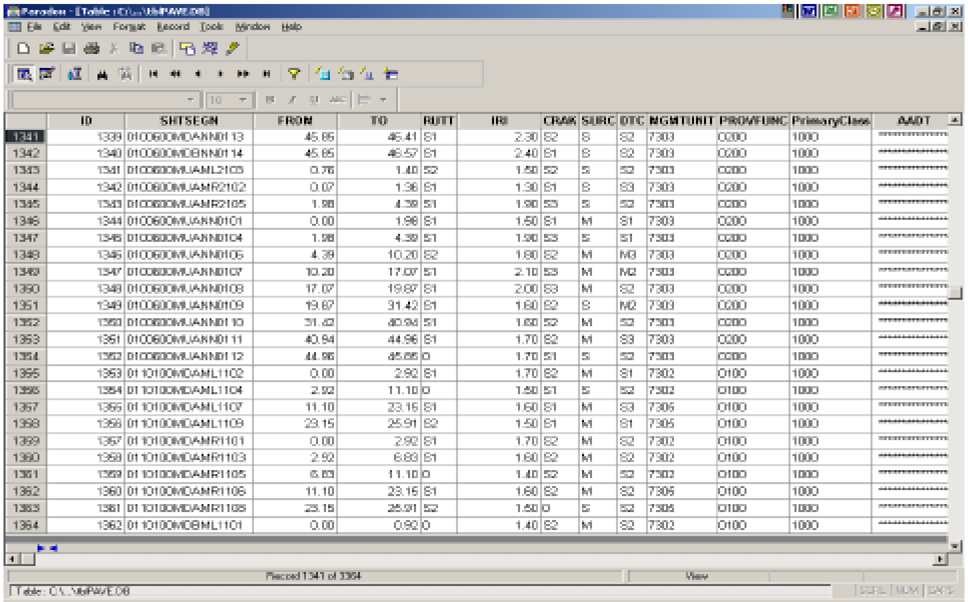


AADT 592
NAD F
ATPC CA

Hwy # 002
CS 10
Road Type 08
Pos M
U/D U
A/B Direction A
Lane N
Lane Position N
Lane # 0
Seg Number 252

From Km 7.1
From Description West of old blue wooden bin
To Km 9.17
To Description West of farm yd.
Surface Type SPAN
Rater/Recorder Names office
Rating Date 10/21/2002
Weather Conditions office weather

Figure 6 – Asset Register Pro Software



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1357	1355	01 10100MDAML1107	11.10	23.15	S1	1.60	S1	M	S3	7306	C100	1000	***************
1358	1356	01 10100MDAML1109	23.15	25.91	S2	1.50	S1	M	S1	7305	C100	1000	***************
1359	1357	01 10100MDAMR1101	0.00	2.92	S1	1.70	S2	M	S2	7302	C100	1000	***************
1360	1358	01 10100MDAMR1103	2.92	6.83	S1	1.60	S2	M	S2	7302	C100	1000	***************
1361	1359	01 10100MDAMR1105	6.83	11.10	O	1.40	S2	M	S2	7302	C100	1000	***************
1362	1360	01 10100MDAMR1106	11.10	23.15	S1	1.60	S2	M	S2	7306	C100	1000	***************
1363	1361	01 10100MDAMR1108	23.15	25.91	S2	1.50	O	S	S2	7306	C100	1000	***************
1364	1362	01 10100MDBML1101	0.00	0.92	O	1.40	S2	M	S2	7302	C100	1000	***************

Record 1341 of 1364

Table : C:\...\tblPAVE.DB

Figure 7 – Pavement Surface Distresses Database

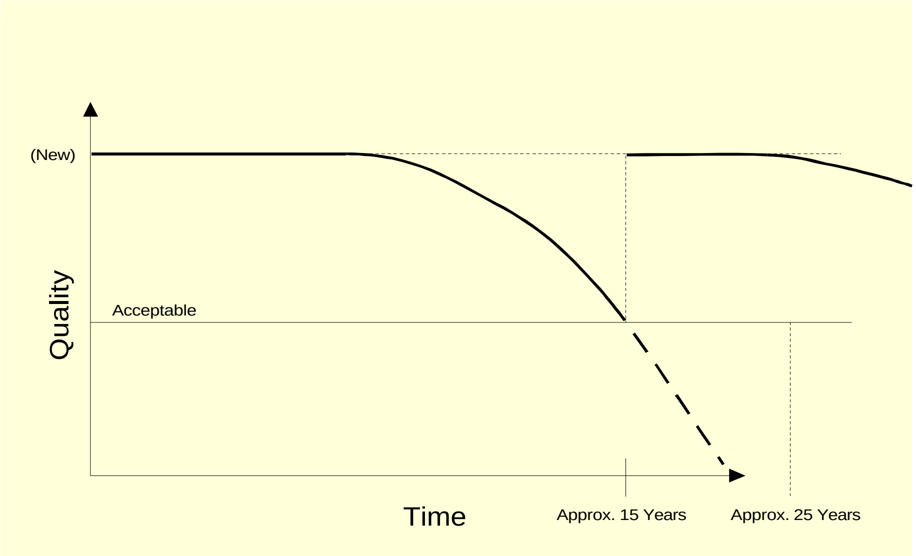

Figure 8 – Typical Pavement Survival Curve

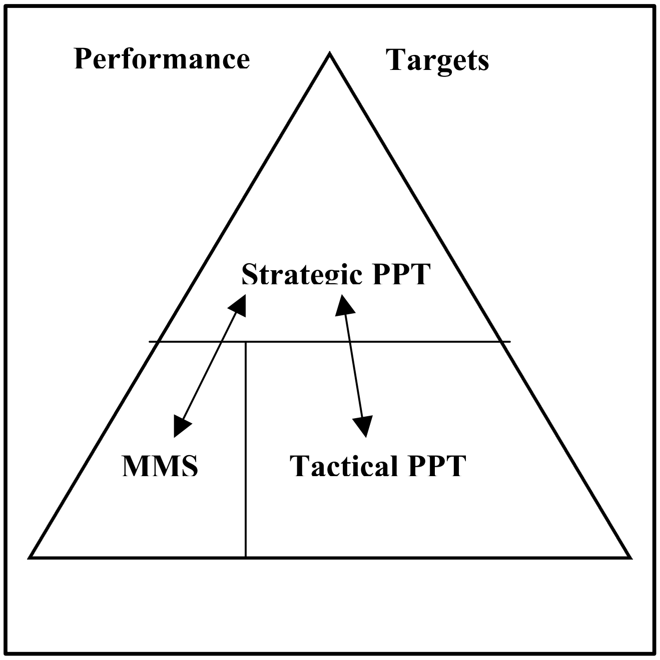

Figure 9 – Graphical Depiction of Successful Maintenance Strategy