Improving the Road Treatment Decision-Making Process through ArcPad™

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Abstract

Adding the spatial element to road condition assessment through the use of ArcPad™ on hand-held computers has been a vital step in improving the decision-making process for road treatments. The City of Saskatoon has moved from defining road condition based on representative sampling to carrying out a more comprehensive "snapshot" of the road that catalogs user-specified road distresses. Despite collecting more data, the process is faster - the manual calculations and data entry of the previous method having been eliminated. The data is ready for use upon download, facilitating on-going refinements to multi-year planned preservation programs. Spatial condition data also enables the treatment decision process to be expanded to include maintenance planning.

INTRODUCTION

Ideally, a road agency should have as much data on road distresses as possible with which to make the best possible treatment decision. However, the cost to obtain perfect condition data to make perfect road treatment decisions is prohibitive. The risk of making an incorrect decision can be minimized, though, through the treatment selection method and through the choice of distress drivers for each treatment.

Some data can be more useful than other data and still be obtainable at similar cost. Spatial condition data is still practical for database-based decision-making while also providing geographic referencing. By collecting all the distresses on site, rather than a representative sampling, the "picture" provided is comparable to seeing the actual site. This allows non-homogeneous portions of a presumed homogeneous road segment to be identified readily.

Integrated decision-making with other infrastructure within the road right-of-way becomes feasible, allowing coordination of maintenance and preservation planning. The spatial element also facilitates analysis of the interaction of infrastructures such as the impact of water main breaks on road condition.

BACKGROUND

Centrally located on the Canadian Prairies, Saskatoon currently has a population of 208,000 people serviced by 1,000 kilometres of roads. Long-term infrastructure preservation planning, including pavement management, is carried out by the Asset Preservation Section, Public Works Branch, Infrastructure Services Department. The section's mission statement is.

"To sustain the Public Works infrastructure at minimum long-term costs, subject to minimum acceptable levels of service."

This group combines experience in design, construction, and operations of both surface and underground infrastructure with expertise in economic decision analysis and statistics. Economics is the group's primary consideration.

Pavement management began in Saskatoon in 1993. The method of rating condition has evolved over time, from collecting considerable detail to the current method that collects only enough detail to facilitate appropriate treatment selection. Each refinement of the road rating process was intended to improve the use of the information collected for making treatment decisions.

In 2003, the City's rating method changed from a paper-based method to one using hand-held computers with a customized ArcPad™ application. The data entry process used to generate detailed databases was eliminated. Spatial data was downloaded directly from the handhelds at frequent intervals, improving the availability of the data for end use analysis and program development. After only one rating season, with approximately one-third of all of the city's roads rated, the improvements in cost and time were apparent.

PREVIOUS RATING PROCESS AND THE INTERIM FRAMEWORK

By 1997, the rating methodology had stabilized. More than forty separate distress indicators for every segment were being collected for every segment. Specific data was further manipulated by addition or multiplication to create more indicators. Despite this plethora of information on every segment, few indicators were actually used for developing treatment programs. The data was also intended for use in calibrating performance prediction curves for Saskatoon's roads. The original curves used in the pavement management software were developed from expert judgment.

In 1999, three years of consistently collected condition information was analyzed. This analysis indicated that the precision of detail was not reproducible in a statistically significant manner. It was also evident that this had been too short a period to measure significant changes in condition. The entire road rating methodology and subsequent use of the data for program development and performance prediction needed to be reconsidered.

Until enough time could pass for appreciable differences in condition to be measured, an interim framework was created for use in defining annual road preservation programs [1]. This framework was developed through a cooperative process that included operations and maintenance staff and project management staff. Site visits, discussions, and structured review of targeted conditions was used to answer the fundamental question:

What is the condition of the road and what should we do about it?

The underlying assumption to this process was that any given treatment would be appropriate over a range of conditions, rather than only at some precise condition state. A segment needing a specific treatment will continue to need that treatment as its condition changes, until a threshold is reached that moves it into the range of another treatment. The intent was to define, in broad terms, these treatment thresholds. The interim framework uses only a few simple distress descriptors to accurately select appropriate treatment in the majority of situations. This simplified rating method has proven to be less prone to error than the previous precise and detailed method.

Some existing condition descriptors continue to be used as they were, but modifications were made to how others were collected. The former rating process was narrowed to only 8 distress indicators with minimal manipulation on these. This simplified rating method was implemented in 2003 for the start of a planned three year-long city-wide rating. Until this rating has been completed, the interim framework continues, of necessity, to make use of some of the earlier condition data.

THE CURRENT SPATIAL RATING PROCESS

The corporate recognition of the need for a common GIS platform led to the selection of ArcGIS™ in 2001 [2]. This enabled a spatial element to be added to road rating. Instead of road condition being represented solely by numbers in a database, these numbers could now be related to a visual representation of the road segment. This information was collected using a customized ArcPad™ application developed in-house. The application was written in Visual Basic. The drop-down menus and distress options mirror the existing rating methodology. Handheld computers from Ipac were used. Returning raters familiar with the previous method quickly embraced the change and enthusiastically supported it.

The advantages to spatial rating were readily apparent. The information was more complete as all distresses were collected over the entire segment. The previous method had combined representative sampling of some distresses with others being assessed over the entire segment. The selection of an appropriate 50 m long location that truly represented the overall condition of the segment was a major source of error. In three years of consistently collected road data, even the same raters were unable to define this representative section consistently for the same segments.

Despite being more comprehensive, the data ultimately proved faster to obtain. Table 1 below shows a direct comparison between the productivity under the previous paper-based and the current spatial method.

	Previous Method	**Current Method**
Training	4 days/team	1.5 days/team
Testing/Follow-up Coaching	1.5 days/person	0.5 days/person
Rating - Locals	11.5 segs/day/team	15 segs/day/team
Rating - Collectors	8.7 segs/day/team	10.1 segs/day/team
Rating - Arterials	12 segs/day/team	11 segs/day/team *
Quality Assurance of Rating	1.5 hours/day	1.0 hour/day
Data Entry	200 segs/day	Download only

Table 1: Comparison of Rating Methods.

Factors in the improvements include:

a) Training:
- Fewer distresses to learn.
- No complicated documentation to learn.

b) Testing/Follow-up coaching:
- Less to evaluate.
- Easier for the Rater Supervisor to see how the rater is thinking.
- Easier to determine when follow-up coaching might be needed.

c) Rating:
- Fewer distresses being rated in 2003 (*although this was offset by the need to rate all distresses over the entire segment).*
- Less time spent out of the vehicle.
- No manual calculations required.
- Easy to "double-check" what was rated against the site conditions before leaving site.

d) Quality Assurance:
- Easy for the Rater Supervisor to check rater's thoroughness and accuracy against on-site conditions.

Only the Arterials rating proved slower, largely because one three-person team was used for all the Arterials, rather than two two-person teams for all but the busiest Arterials.

Work tracking throughout the rating season became greatly simplified. The spatial method enabled the Rating Supervisor to easily track which segments were done and which still needed to be done.

With the current spatial method, the data was almost immediately ready for use. Data entry was not required as the condition data was downloaded regularly from the IPacs. Data entry for the previous method was typically done after rating in late summer and early fall. Because data entry was faster than rating, this timing allowed for the accumulation of enough rated segments to reduce the likelihood of downtime for the data entry clerks. This meant that the data might not available until December, too late to readily use for program planning for the following year. It also meant that followup to obvious rating errors might not be done due to snow cover.

The overall timeliness of the condition data for use in preservation planning was greatly enhanced by the spatial method. Once the data had been checked for obvious errors and some random quality checks carried out, the data was then available for use.

USE OF THE SPATIAL DATA

The output of the rating process is useful in two ways. The spatial data could be summarized for each segment and reviewed against the interim framework to either determine an appropriate treatment or confirm the treatment that had already been defined for the segment. The spatial data offered the additional benefit of geographic referencing, allowing a quick, easily comprehended view of the existing condition.

As shown in Figure 1 below, road distresses are represented by symbols, colour, and colour intensity. Blue dots represent small dips, generally “bird baths” in the gutters and blue triangles are larger dips, generally in the driving lanes or even curb to curb, with darker blue indicating greater severity. Purple crosses identify swales proportionally by colour intensity and symbol size. Lightning bolts symbolize areas of alligator cracking with red indicating depressed cracking. The symbology does not vary relative to the estimated area of cracking. Popout counts are taken on every road segment at 100 metre intervals and are symbolized by squares that are colour coded to correlate to the thresholds.

All of these distresses can be present on a single road segment as shown in Figure 1.

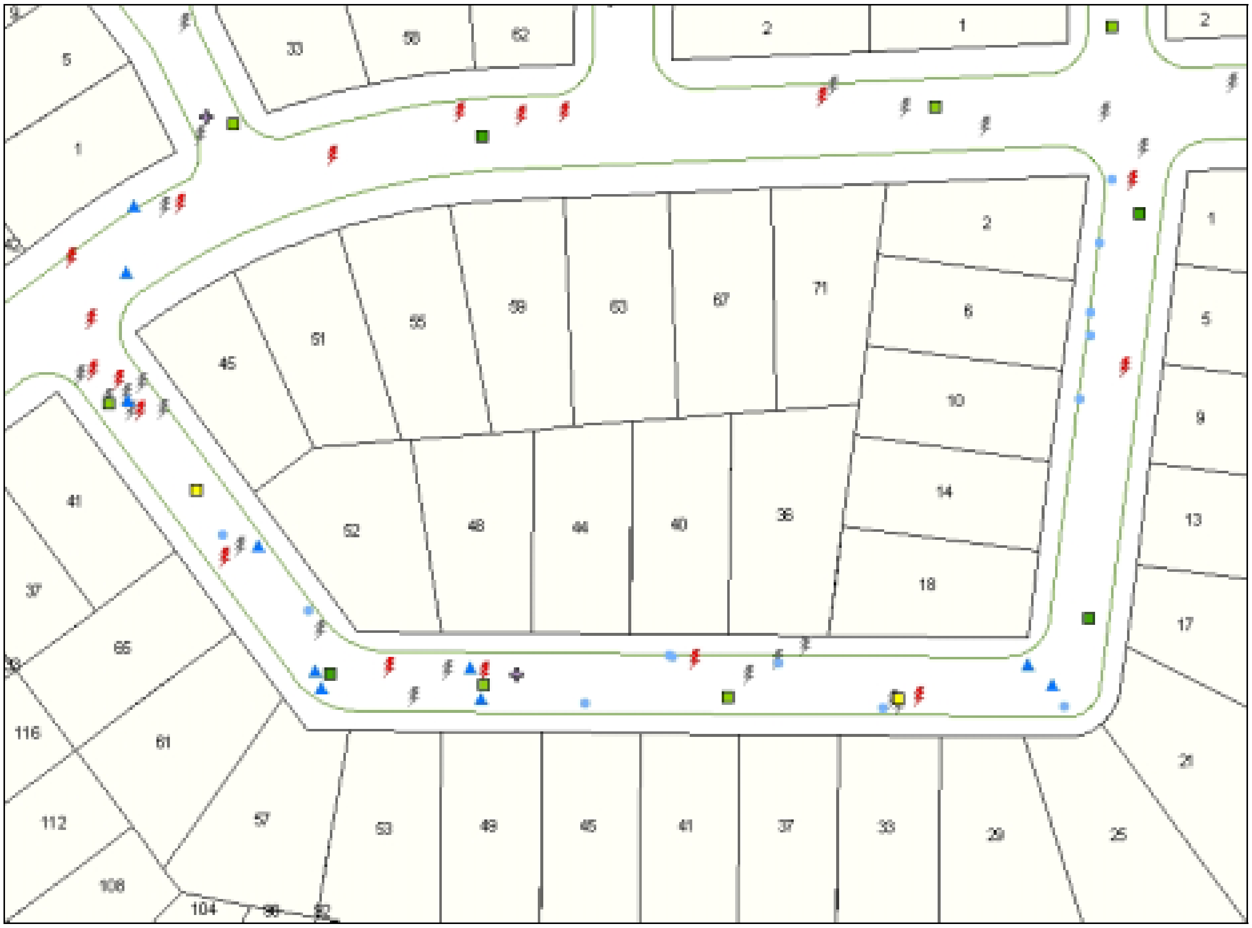

Figure 1: Spatial Representation of All Road Distresses.

For program development using the new condition data, the advantages were also readily evident. The on-going refinements to multi-year planned preservation programs could be first judged against the spatial representation of the road segment, then double-checked by site visits as necessary. A quick visual check can often confirm the treatment before the actual treatment criteria of the Interim Framework is applied. While the construction season was still underway, priorities can be adjusted and preparatory work for the major treatments in the following year still carried out in advance.

Not every segment justified a site visit to confirm treatment. Some treatments were easy to confirm through ArcMap, as exemplified by the obvious seal candidate across the center of Figure 2 below. The popout counts fall within the thresholds for treatment (as indicated by red boxes rather than green or yellow ones).

Figure 2: Seal Candidate.

Because of the homogeneity criteria used for the original segmentation of the City's road networks, most segments will still be appropriate for full segment treatments. The spatial condition data, however, facilitates subsegment treatment selection. These treatments target smaller areas than the entire segment, thus ensuring that more segments are treated with available funding. Figure 3 below indicates how one crescent, which was effectively constructed as a single entity, demonstrates the impact of some different construction influences for part of the road. The entire south leg displays different characteristics from the remainder.

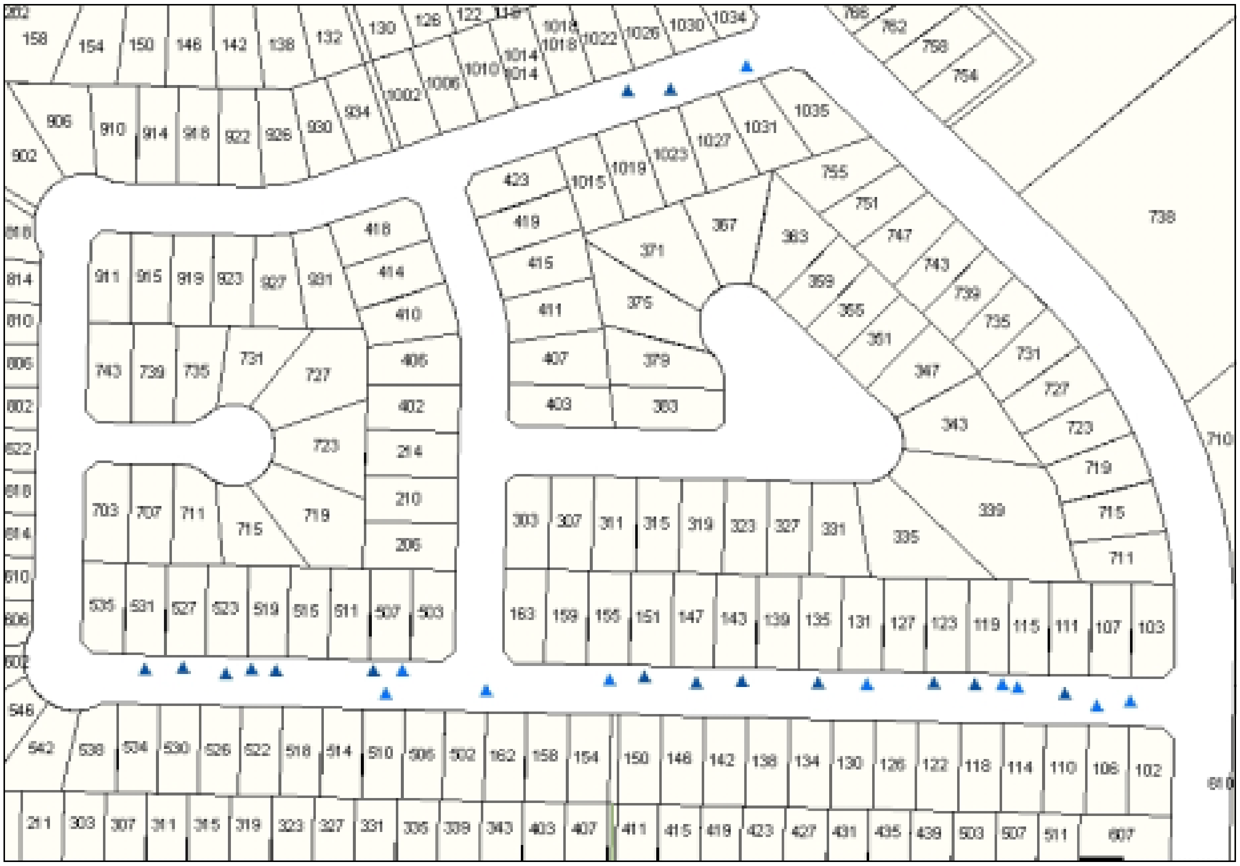

Figure 3: Subsegmentation Example.

INTEGRATION ACROSS ASSETS IN THE ROAD RIGHT-OF-WAY

With the spatial rating data, integration of infrastructure management across assets in the road right-of-way could now be better addressed. ArcGIS enables information about different assets to be brought together in a single platform. Each infrastructure type (roads, watermains, sewers, etc.) is represented spatially through a layer in ArcMap™.

ArcMap facilitates analysis of one infrastructure in coordination with another. Multi-asset planning of work can be done, allowing for economical treatment choices and timing.[3] Queries can be carried out between assets. Watermain breaks, for example, can be displayed against road condition to locate potential wetted-up subgrades that may result in premature road failure.

Figure 4 below shows road distress details along with information about the underground infrastructure within the road right-of-way.

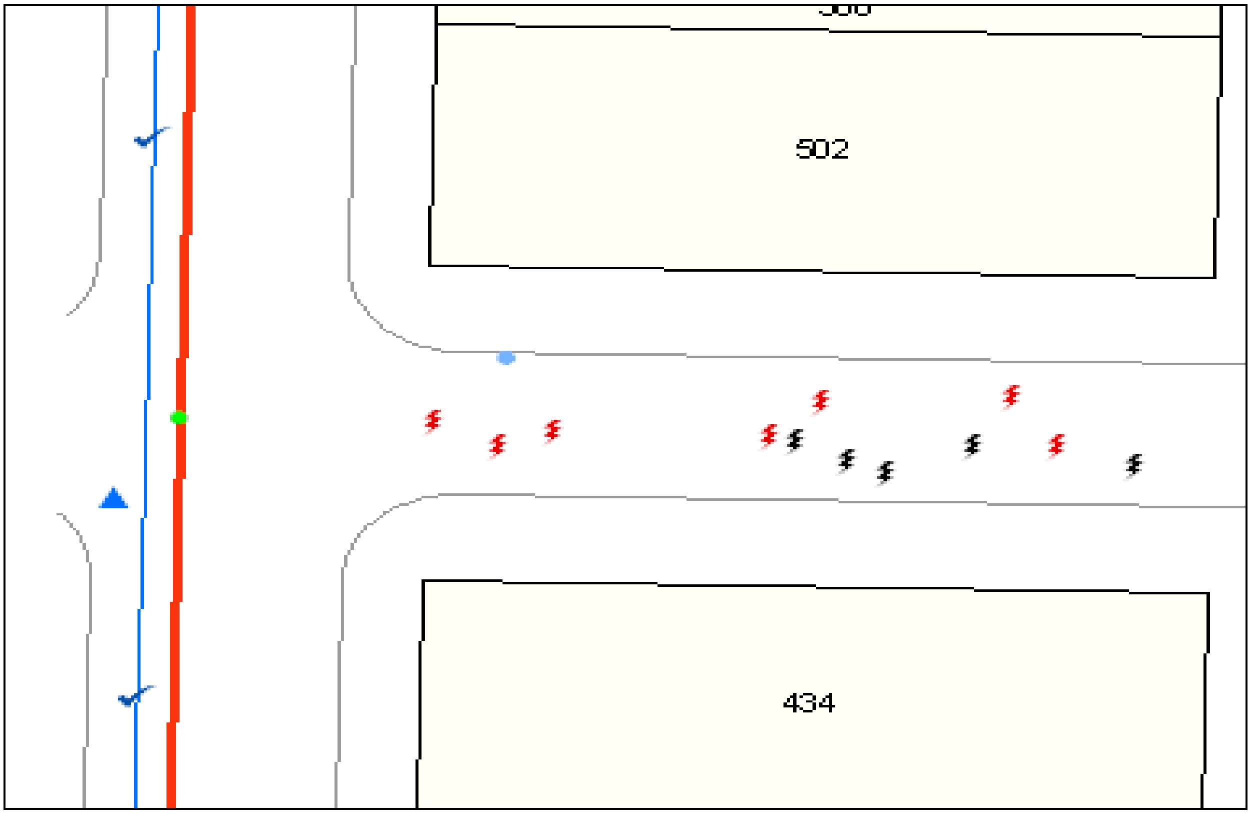

Figure 4. Integration Example

In this example the blue watermain on the north-south road has two checkmarks indicating where breaks had occurred. The red north-south line is a sewer that is up for rehabilitation. The green circle on this line at the intersection is a manhole that has been inspected and requires no repairs. This information can be reviewed against the road distress details and planned road treatment programs to generate an integrated action plan for the road segment. This permits targeted maintenance or a targeted treatment to be carried out on one infrastructure in advance of planned treatment on another.

CONCLUSIONS

The City of Saskatoon has had initial success with a customized spatial road rating application. Despite collecting more data, this process proved to be faster than our previous rating method. The spatial data is available sooner for use in road treatment decision-making and, with the added spatial element, has proven to be more useful than the previous tabular data.

REFERENCES

1. Gustafson, J-M and Higgins, L., *An Interim Framework for Asset Management*, 2002 TAC Conference, Winnipeg (2002)

2. Higgins, L. and Gustafson, J-M., *Condition Data Or Treatments First? – Back To Basics For One City*, Proc. 2004 CSCE Conference, Saskatoon, (2004)

3. Higgins, L, Gustafson, J-M. & Clancy, D.V., *Integrated Infrastructure Management Decision-Making Using ArcGIS™*, Proc. 2002 ESRI Conference, San Diego (2002).

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