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A study to determine the effects of employing a well maintained RWIS network on accident rates on major highways in the US state of Idaho

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ABSTRACT

Maximizing roadway safety, mobility and efficiency, while minimizing maintenance-related costs, is the common goal of winter maintenance engineers around the globe. Road Weather Information Systems (RWIS) have proven track records in enabling road authorities to meet the aforementioned goals. However poor system maintenance, often due to the lack of reliable budgets, has for a number of authorities led to poor reliance and trust in their systems.

Keywords: RWIS; Crash data; Accident reduction

1 INTRODUCTION

Over the last 20 years the use of Road Weather Information Systems (RWIS) has become widespread in countries that experience traffic disruption due to winter weather such as ice and snow. It has been clearly demonstrated that savings can be made in terms of winter maintenance activities by using an integrated set of applications and techniques such as thermal mapping. However the effect on accidents rates is more difficult to assess due to the potentially random and chaotic nature of accident occurrence. A number of studies exist to identify the effect of weather on traffic flow however the aim of this study is to see if there are any indications that a well maintained RWIS network has any effect on traffic accident occurrence.

This study looks into the effect on state wide accident rates across Idaho before and after the implementation of a well maintained RWIS network. Well maintained in this context is one using accurate sensing equipment that is constantly monitored for sensor faults and when a fault is identified it is rectified as part of a standard maintenance regime. Hence ensuring as high quality of data and its availability as possible. This data is then used to maintain the highways through a network of regional centres and maintenance depots all geared to responding in a logical, defined way to conditions that present themselves. For this study this crossover time was taken as 2007, after which the network is deemed to have been implemented in a "well maintained" manner.

Staff at Idaho Transportation Department (ITD) have developed a number of different projects in recent years aimed at reducing traffic accidents and that there has been a general decline in the national trend for fatal traffic accidents. However ITD Staff suspected that following the implementation of their RWIS the number of reported accidents was still far lower than should be expected and asked Vaisala consultants to take a look at the data to see if this was in fact that case.

The following is the report generated from this study and it outlines the approach taken and the results calculated. In summary these do indeed show a major improvement in road safety since the implementation of the well maintained RWIS network with potential savings being significant both in terms of financial measures but more importantly life and injury.

Method overview:

As can be seen below the highly detailed accident records kept by Idaho DOT meant that there were a number of potential ways forward to confirm or deny the hypothesis that accidents rates had dropped since the installation of the well maintained RWIS network.

On first inspection the use of local accident data to weather station location would seem to offer a good way forward. However after initial investigations it was felt that although a study of this nature could provide interesting results, the actuality of the chaotic nature of road accidents means that statistical noise would be very high at this resolution of data (micro-level analysis) hence it was decided to follow a more macro-level approach and look at data from the State as a whole as this was more likely to give an indication of whether the hypothesis was correct.

The key to understanding the effect of the RWIS network is to both look at accident averages before and after RWIS to see whether there are any discernable differences but also there is the need to understand the variability of these accidents according to weather related issues. In other words we need to take into account the weather when looking at the accident records to ensure we compare like for like numbers. To do this it was necessary to collect suitable weather data that would allow the variability of the climate to be effectively removed from the accident statistics.

Traffic accident data

Accident data was provided by Idaho DOT in the form of excel tables which identified each accident and its severity from all counties for the years 1997-2011 during the main winter period (1st September - April 30th). Information provided was comprehensive and included weather recorded at the time of accident and all other relevant information including.

Road Surface Condition,
Severity,
In City Limits,
County,
Speed Limit
Number Of Fatalities,
Road Surface,
Accident Time,
Number Of Persons,
Accident Date,
Number Of Units,
Number Of Injuries,

Unfortunately latitude and longitude data was only available from 2007 in general hence using GIS based analysis tools was precluded from this study.

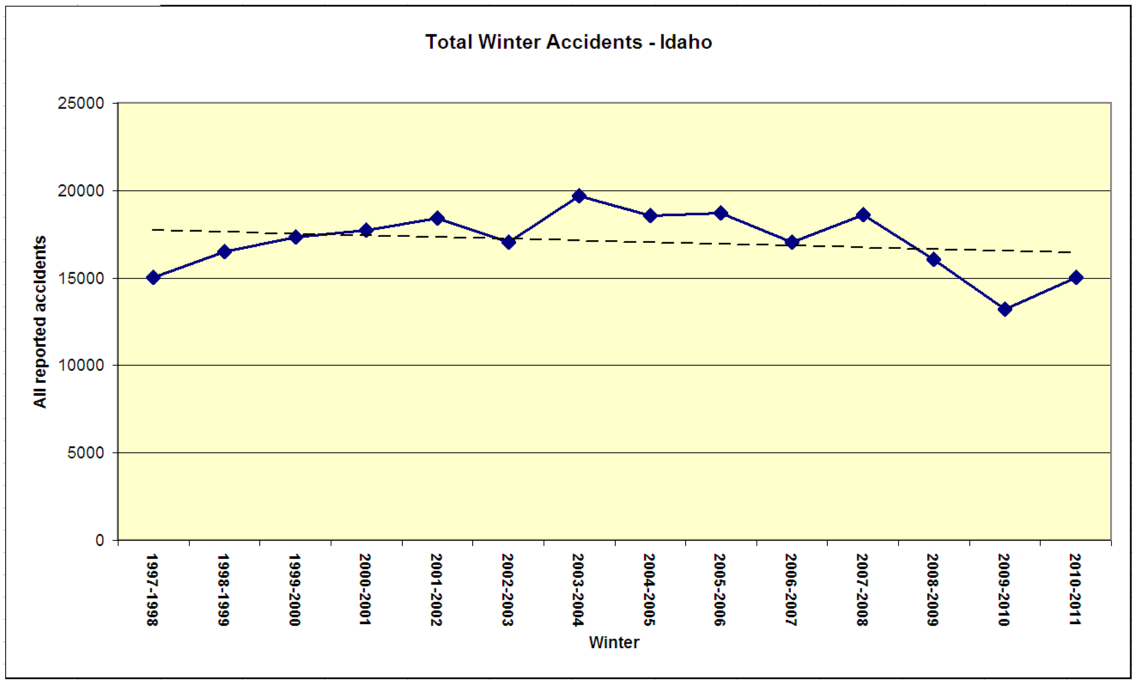

Figure 1: Actual accident reports from Idaho from 1997 until 2011

From Figure 1 it can be seen that accident rates vary from winter to winter each year but in the last few years there appears to be a significant drop in reported accidents. The overall trend as seen by the dotted line also shows a slow decrease which would be expected from general technology advances such as automatic braking systems and proximity alerts etc. However to see whether the start of the RWIS program shows and significance in terms of average accident rates before and after we need now to normalise these figures with respect to the weather to ensure that the last few years are not being skewed by unseasonably mild winters etc.

Weather data

The first thought would be to use weather station data but of course that does not exist prior to installation, hence a more general weather data set is required. There are a number of data sets that could be used but after investigation it was decided to use the snow data gathered and published on the internet by http://www.wrcc.dri.edu/Climsum.html.This data set provides snow depth data for each reporting site with a good coverage across Idaho.

The aim from this weather data was to create a very simple index that demonstrates how bad a particular period has been with respect to winter conditions. To do this it was decided to concentrate on snowfall. There are many ways this can be done but for the sake of timeliness a simple summation of observations was used in this study. However choosing the sites to use was given care in terms of ensuring a balanced view is given from the higher mountainous regions to rest of the State.

Idaho itself offers very varied weather climates across its area hence to take get a proper representation of the weather affecting roads it was decided to create climatic domains in which weather data could be sourced in such a way that we reach a balanced view of State-wide conditions. Figure 2 shows the broad climatic domains used in the study.

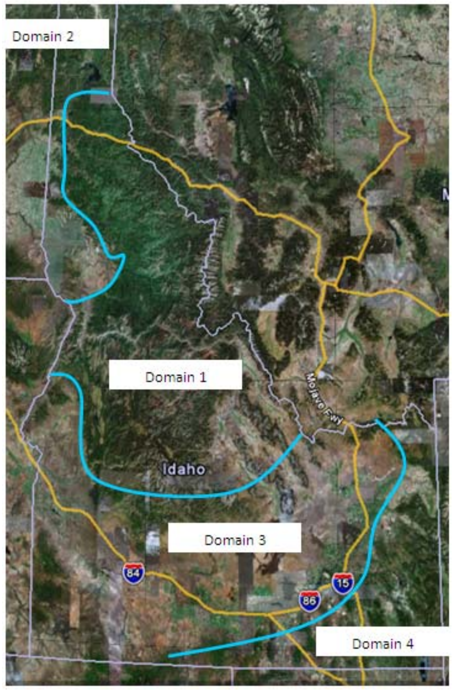

Figure 2: Climatic domains used across Idaho

Now from each of these 4 domains 5 stations sites were identified that held as much data as possible whilst also represented a good coverage across the domain. These are shown in figure 3. From these data points information on total snow amounts throughout the winter period were drawn and calculated.

Domain 1	**Domain 2**	**Domain 3**	**Domain 4**
Kellogg	Bonners Ferry	Emmett 2E	Oakley
Fenn R.S	Saint Maries	Swan Falls P.H	Preston
Taylor Ranch	Moscow Uofl	Richfield	Lifton
New Meadows R.S	Winchester	Aberdeen Exp.Sta	Soda Springs APT
Chilly Barton Flat	Grangeville	St Anthony 1WNW	Driggs

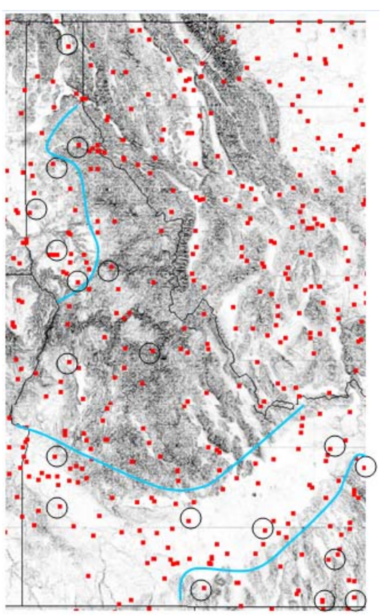

Figure 3: Station chosen from each climatic domain (circled)

For each domain a pseudo weather index was created from the data from each station by adding the monthly snowfall amounts together. These domains where then added together to create a state index such that each domain has equal weighting. Hence if snow was prevalent across the whole State then the total value would be high. However if snow was patchy during the month then the total weight of snow readings would be reduced. Snowfall was measured in inches between 1st July-June 30th but only snowfall data between September-April were used

Analysis – relationship between accidents and snowfall

The final analysis was kept at a very high level to ensure a state-wide picture was maintained. Figure 4 shows a direct comparison between the snow 'index' and total state-wide accidents.

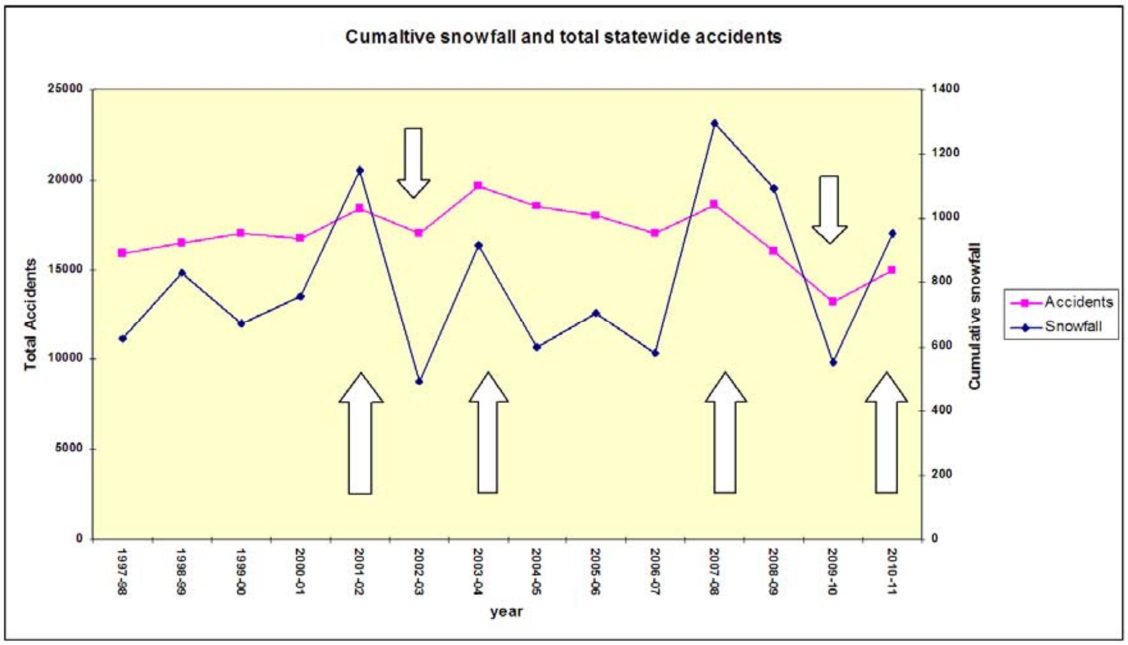

Figure 4: direct comparison between snow index and traffic accidents

From inspection it can be seen that there is certainly a relationship between accidents and total snowfall across the State. It is also noticeable that snowfall has continued at the same or even higher level over the last few years whilst accident rates have appeared to reduce However when analysing this from the perspective of deviation from the average it can be seen (Figure 5) that there is a significant statistical relationship between the two data sets. This to such a level that it was felt we can safely move to the next stage which was to analyse the potential difference between before and after RWIS accident rates. Figure 5 shows that 40% of the variation in traffic accidents can be explained by the variation in snow amounts as referenced against the long term averages.

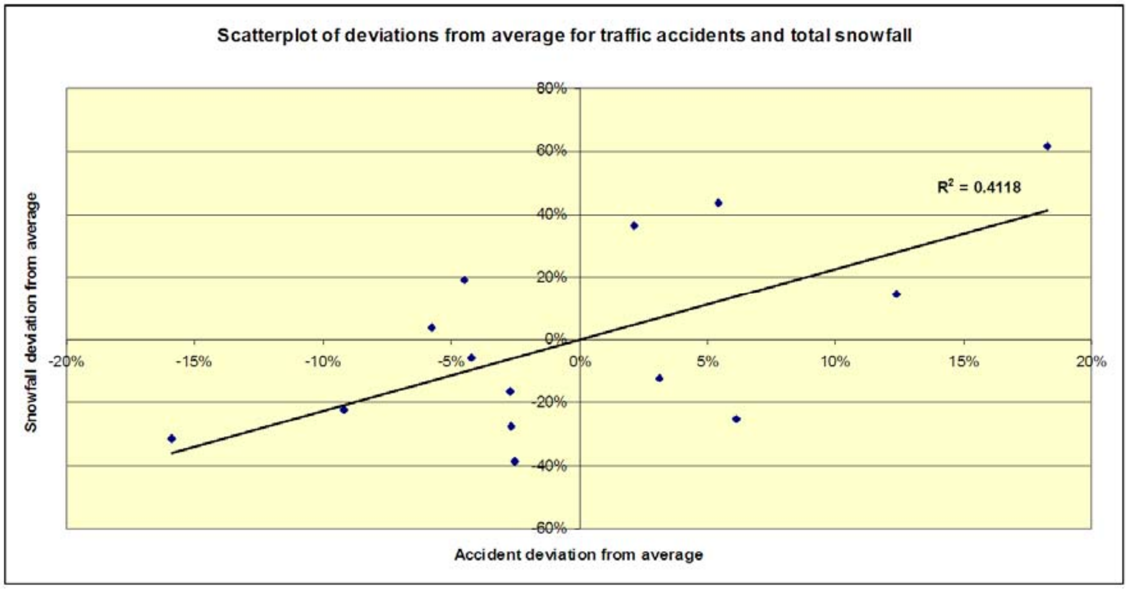

Figure 5: scatter plot of variations from average and their relationship; $r^2 = 0.41$

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Analysis – before and after accident rates.

	Accident average	Snowfall average
Before RWIS	17488	732
After RWIS	15714	974
% difference	-10.1%	33.0%

Figure 6 comparison of before and after RWIS

As can be seen from figure 6 the averages tell their story very strongly in that even though there was a 33% increase in snow activity the accident rate dropped by just over 10%. From earlier we know that there is a link between snow and accident that amounts to just over 40%. Hence if we increase the accident rate by 33% and take 40% of that (the amount attributable to weather using this method) we can get an estimate of how many more accidents we would have expected to see if pre-RWIS conditions had persisted (Figure 7).

Accident rate Before RWIS	17488	
Adjusted for increase in snow	23259	33% increase
total Difference	5771	
Adjusted for attributable relationship	2366	41% of difference

Figure 7: theoretical accident rate post RWIS under pre-RWIS conditions

As a result of this we estimate that each **year from 2007 onwards a saving on average of 2366 accidents** was made by installing a well maintained RWIS system, hence for **the 4 years operation we are looking at an estimate of 9464 accidents saved.**

Financial analysis

Notwithstanding the clear benefit to the travelling public of such a reduction in accident rates a true cost saving will also be realised. Along with the accident statistics provided by the Idaho DOT were a clear breakdown of accident types and their associated costs. They are as follows in figure 8.

Cost per fatality	$4,200,000
Average accident litigation	$15,000
Average fatality litigation	$1,100,000
Cost per serious injury (A injury)	$301,470
Cost per visible injury (B injury)	$84,440
Cost per not visible injury (C injury)	$55,972
Cost per property damage	$6,480

Figure 8: actual average accidents costs by type

The long term averages in terms of percentage types can be seen in Figure 8

Accident type	Average Number of accidents	Percentage of total %
A Injury = Serious/Incapacitating	808	5
B Injury = Visible/Non-incapacitating	2154	12
C Injury = Possible/Complaint-Not Visible	3162	18
Fatalities	158	1
Property Dmg = No Injuries-only property damage	11338	64

Figure 9 breakdown of accident types and their proportion of average

Above we have stated that there is a saving of 2366 accidents per annum hence we can now apply the percentage accident types to that figure and as a result conclude a cost saving based upon usual accident type profiles. The results can be seen in figure 10

Accident type	Average Number of accidents	Percentage of total %	Cost by type	Ratio of saved accidents (2366)	Estimated costs of saved accidents
A Injury = Serious/Incapacitating	808	5	$301,470	108	$32,689,835
B Injury = Visible/Non-incapacitating	2154	12	$84,440	289	$24,418,512
C Injury = Possible/Complaint-Not Visible	3162	18	$55,972	425	$23,767,650
Fatalities	158	1	$4,200,000	21	$89,054,836
Property Dmg = No Injuries-only property damage	11338	64	$6,480	1523	$9,866,093
			Total	2366	$179,796,926

Litgation costs	Cost	total saved a	Saved litigation costs
Litigation costs per accident (non-fat	$15,000	2345	35,171,947
Litigation costs (fatal)	$1,100,000	21	23,323,886
	Total	2366	58,495,833

Total savings from reduced accident per annum: $238,292,759

Figure 10 accident cost profile applied to the yearly accident savings as estimated above.

So as can be seen even taking a careful approach and only applying 40% of the accident drops to the financial figures we can see clearly from above that the actual cost saving to Idaho can be estimated at somewhere in the region of $180m, with further litigation costs saved of something in the order of $58m each year. Hence since investment made into RWIS in the state of Idaho savings in the order of $960M may have been made.

Conclusion

As stated in the beginning of this study, ITD staff have implemented a number of practices aimed at reducing traffic accidents including:

- Increased traffic law enforcement
- Various safety programs

The confidence in the RWIS system has also had a positive and definitive impact on the ITD 511 system. RWIS data is now being utilized by the general public for planning purposes, allowing them to delay journeys due to inclement weather or to re-route their journeys.
The state police now regularly use the RWIS data to provide daily briefings of road weather conditions around Idaho, which allows them to be better prepared.
The above are in addition to new approaches that ITD maintenance staff have been introducing for their snow storm treatments. A renewed interest in RWIS data is allowing more objective treatment operations, which in turn improve surface conditions in a shorter time frame.
Add to the above the reduction in the overall national accident figures since 2007 and the result is safer roads. However these still do not correspond with the magnitude of the reduction shown in this study.

It is appreciated by all concerned with this report that further study may improve the correlations above and allow a year by year assessment, but it is clear that the order of magnitude on return on investment is enormous and apart from the financial cost saving the reduction in suffering for all highways users is immeasurable but never the less a great testament to the efforts made within the state to ensure that the highways are as well looked after as possible.

Suggested areas for further study include:

- The inclusion of total traffic volume
- Increasing the sample size and scope
- Analysis of other high impact programs e.g. 511

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