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CARSEY PERSPECTIVES

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Saving Salt, Protecting Watersheds, in Winter Road Maintenance

Highlights from a Social Venture Innovation Challenge Winner

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Every winter, the surface of the earth in the northern United States becomes considerably more salty. The reason is, for availability, cost, and effectiveness, nothing beats salt-based deicers for keeping roadways clear of ice. But the effects of road salt on aquatic ecosystems, freshwater drinking supplies, infrastructure, and vehicles is significant. When chlorides get into groundwater, it can be very difficult to get them out. They do not biodegrade over time, and the accumulation in soils can be retained for decades.[1] As few as 50 pounds of salt can contaminate 10,000 gallons of water.[2] The New Hampshire Department of Environmental Services estimates that there are almost 50 chloride-impaired watersheds within the state, and it lists over 100 of the state's drinking water sources as contaminated due to chlorides.[3] Groundwater experts suggest that the chloride problem may be much larger than we know, due to limited testing and the cumulative impact of the chemical.

Therefore, given what we know about the harmful effects of salt, it makes sense to use it sparingly. But as any homeowner who has tossed it on a sidewalk knows, it is hard to estimate the right amount to use and, if anything, we err on the side of caution, resulting in liberal applications. Municipalities have an even tougher time getting it right. A public works department must deploy dozens or hundreds of spreaders, managing them so they do not miss a road and adjusting their management approach to accommodate changing temperatures and the unique weather fluctuations of each winter event. When trucks are moving through complex road systems it can be challenging for operators to know the last time deicing material was applied to a particular surface. When in doubt, operators apply more material.

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It was in seeing that there was significant opportunity for innovation within the winter road maintenance industry that I decided to launch a company where we could work to help address some of the industry's challenges. In 2012, I launched the New Hampshire based company, Sensible Spreader Technologies LLC (SST), and we are currently helping municipalities and private contractors increase efficiency, increase safety, and reduce deicer waste by showing operators in real time what's been covered and what hasn't. SST's Coverage Indication

About the Social Venture Innovation Challenge

The Social Venture Innovation Challenge invites individuals and teams from across the state of New Hampshire to identify pressing social and/or environmental issues at the state, national, or global level, and then find an innovative business-oriented approach to solving them.

The Challenge is organized by the Center for Social Innovation (CSIE) and is a joint venture between **CSIE**, the **Paul College of Business & Economics**, **Carsey School of Public Policy**, **UNH Sustainability Institute**, **NH EPSCoR**, **UNH Innovation**, and **Net Impact UNH**.

About the Center on Social Innovation and Enterprise

The Center for Social Innovation and Enterprise offers innovative pedagogy, applied research, and meaningful engagement opportunities for students and faculty from across the University of New Hampshire in "social innovation"—the application of market-based and cross-sector strategies to develop sustainable, scalable solutions to societal problems.

As a joint venture of the **Peter T. Paul College of Business and Economics** and the **Carsey School of Public Policy**, this interdisciplinary Center contributes to the growing field of social innovation by working at the nexus of individual entrepreneurs and business models with public policy and systemic change in our research, teaching, and practice.

Technology (CIT) uses mobile devices, wireless sensors, cloud computing, and real-time electronic maps to show operators the concurrent locations of other vehicles in the fleet and the plowing and deicing operations that have taken place over specific intervals. SST developed this technology after measuring the regular occurrence of material-based overlap within short time durations at multiple municipal locations.

Material-based overlap occurs when operators reapply material in areas that have already received sufficient quantities of deicing material. We observed that the highest likelihood for overlap occurred in and around grid-type infrastructure, typical of urban environments, but overlap was also observed in rural settings.

During the winter of 2013–14, SST conducted pilot programs with two New Hampshire municipalities, one urban and one rural. Figure 1 illustrates graphed locations of data packets that were collected by two of the data loggers from a winter event in the rural site. Each data packet contained information regarding location, application rate, direction, and speed collected at a 4 second sample rate. Figure 2 shows a position plot of two maintenance vehicles over time using the location and time components of the same data set shown in Figure 1.

FIGURE 1. LOCATIONS OF DATA PACKETS COLLECTED IN 2013–14 PILOT STUDY

In looking thorough our data, we were able to see that certain roads were traversed multiple times within short intervals, while others were sometimes overlooked. One of the biggest insights obtained from analyzing these position plots was that it can be very challenging for operators to systematically move through a complex network of city streets, and this difficulty can result in missed roads and high-frequency, sometimes redundant, travel on others. The challenge is further complicated by low-light conditions, low visibility, one-way streets, traffic, and the presence of other winter maintenance vehicles. Figure 3, also a position plot, looks at the intensity of deicing material spread over time. It shows that some sections of the city had received significantly higher application rates (indicated by the brighter more prominent sections in the map graphic) than others and that high application rates didn't always correlate with high-traffic areas. It was evident that there was a variance in application rates from truck to truck and that the most popular travel routes for the winter road maintenance vehicles typically received the most chloride exposure.

FIGURE 2. PLOT OF TWO MAINTENANCE VEHICLES DURING WINTER EVENT

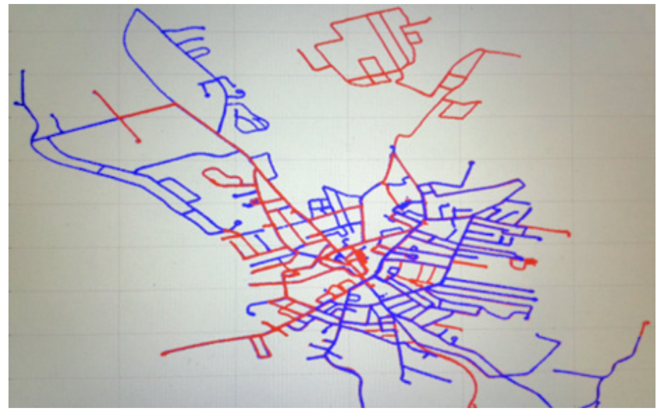


FIGURE 3. INTENSITY OF DEICING MATERIAL SPREAD OVER TIME

In further analyzing the data that we collected from the winter events during the 2013–14 pilot programs, SST discovered that there was a significant material-based overlap problem: overlap was occurring 10 to 30 percent of the time a spreader was in operation, and within 1 to 2 hour durations. In other words, operators have a high likelihood of redundantly reapplying material in the same areas. Material-based overlap within 1 to 2 hours of an initial application is significant because it can typically take 1 to 2 hours for road salt to activate and reapplying material to a section that just received it can prove to be in many cases unnecessary and excessive.

The Coverage Indication Technology that SST developed from these pilot projects shows operators where material has been applied and where it is needed over time. In most cases, we estimate that municipalities can save from $2,000 to $6,000 per truck, per year, in just material savings with CIT systems.

The Coverage Indication Technology that SST developed from these pilot projects shows operators where material has been applied and where it is needed over time. In most cases, we estimate that municipalities can save from $2,000 to $6,000 per truck, per year, in just material savings with CIT systems. In addition to the material savings, efficiency increases of 10 to 30 percent not to mention increases in safety, are possible as well, since the system will indicate roads that have not been treated and/or plowed. CIT has the capability of changing the way municipalities approach winter road maintenance through its ability to rapidly share data throughout the entire fleet, thus increasing fleet intelligence. Moreover, CIT opens the possibility that fleet management can be more decentralized and more collectively self-organized, allowing fleets to operate more dynamically based on continuously updated, real-time data.

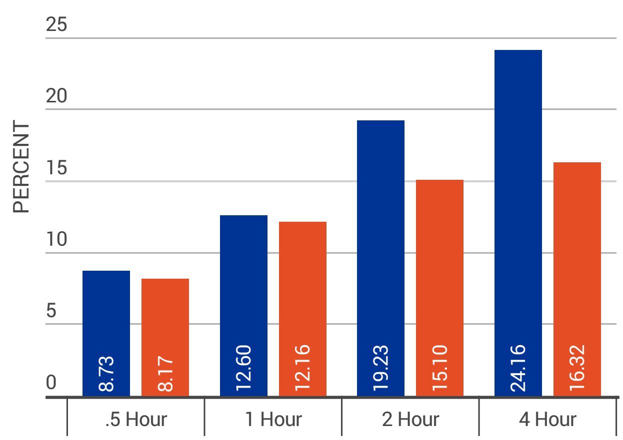
Figure 4 compares the amount of material-based overlap measured in the first winter of data collection (2013–14) to the following winter season (2014–15), when CIT was installed in the vehicles. Material-based overlap was much lower after the implementation of CIT. The company anticipates that overlap will decline further as drivers become more comfortable using CIT.

Coverage Indication Technology (CIT) Versus Automatic Vehicle Location (AVL)

Automatic vehicle location (AVL) technology, introduced over a decade ago, is sometimes mistaken for Coverage Indication Technology (CIT). But AVL is strictly a tracking technology: it involves mounting a GPS to a truck and collecting vehicle position and perhaps equipment information over time and storing it for later analysis (not unlike a black box on an airplane). The problem with AVL technology is that the data are not made available to operators in real time and are typically days old when they are viewed (if viewed at all).

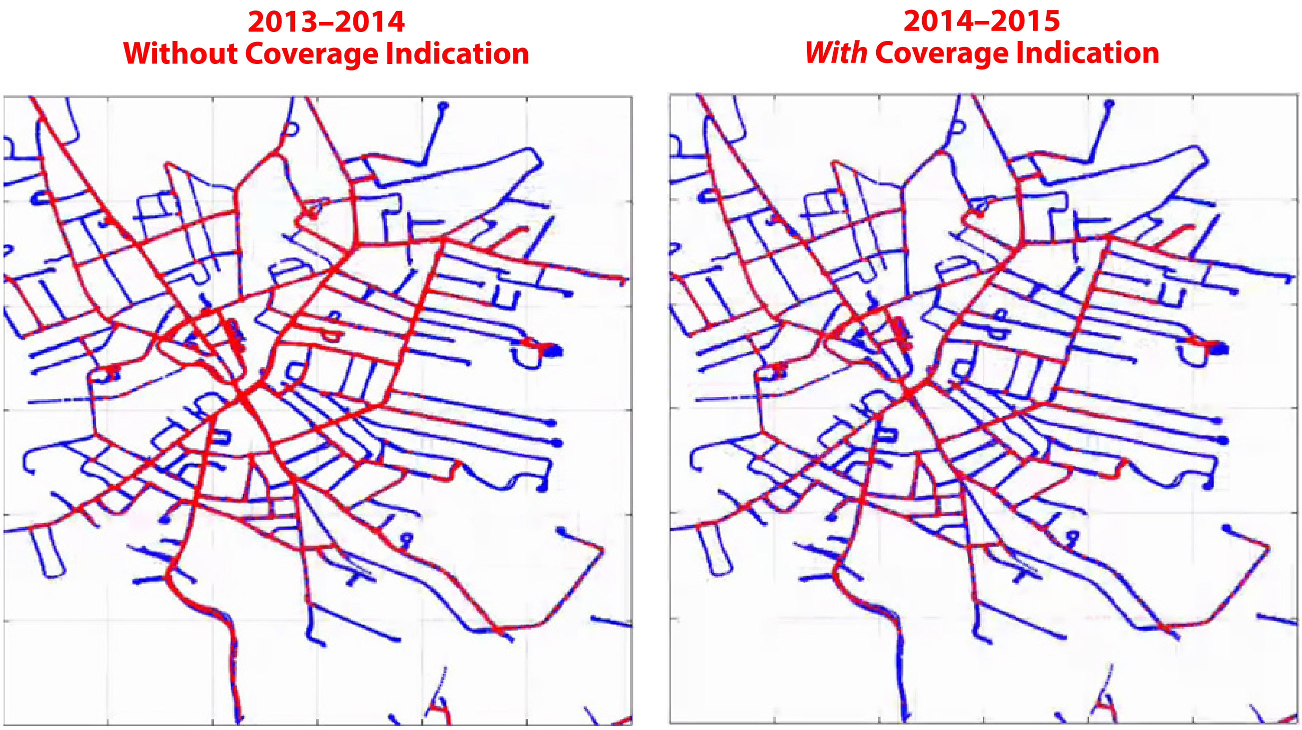
Unlike AVL systems, CIT uses cloud computing to share plowing, salt spreading, and location information throughout the entire fleet in real time. This empowers operators to make better decisions in the field and encourages the fleet to work together effectively. In addition, newer operators who may be less familiar with local routes can be aided by the mapping information that CIT provides. CIT has also proven useful in situations where one worker needs to cover another's route.

FIGURE 4. MATERIAL-BASED OVERLAP, 2013–14 VERSUS 2014–15



In both years some material-based overlap may have been intentional, as operators reapply material to areas requiring high levels of service. But redundant trips down roadways could be reduced by applying higher initial amounts in the high-level-of-service areas, reducing the need for the truck to transit the road more than once.

FIGURE 5. MATERIAL-BASED OVERLAP IN SAMPLE MUNICIPALITY, 2013–14 VERSUS 2014–15



Note: Red lines indicate areas of material-based overlap.

Figure 5 shows the results of an analysis that compared the material-based overlap detected during five comparable winter events over each winter at one of SST's municipal customers. In order to make an accurate comparison, the geographic region of analysis was limited to the area shown in each figure. The reduction between winter 2013–14 (a season without CIT) and winter 2014–15 (when CIT was in use) was 33 percent.

CIT has also been implemented in street-sweeping applications. In addition to picking up trash, routine street sweeping helps to remove substances like zinc (which accumulates from brake dust) and remnants from auto exhaust that can form toxic residues over time. Figure 6 shows an image of the Sensible Spreader Foreman-view software during a street sweeping operation in the Boston area. Foreman-view software can be loaded onto a mobile device and used to monitor fleet progress in real time. Each color indicates work completed by separate vehicles working during the same 12-hour period. From a management perspective, it can be helpful to quickly view the work completed by a separate vehicle and the amount of work performed by each truck/operator. From an operator's point of view, it can be motivating because the work is displayed on the screen as it is accomplished.

FIGURE 6. SENSIBLE SPREADER VIEW OF STREET SWEEPERS IN BOSTON AREA

Note: Colors indicate routes of individual sweepers.

Conclusion

According to the Greek philosopher Plato, "Necessity is the mother of invention." In the case of CIT, the necessity for its implementation seems obvious, yet the path to achieving widespread usage is more obscure. Municipal governments are typically slow to adopt new technologies due to long procurement cycles and due to the unwillingness to take a risk on something new. However, it is necessary that all governments (large and small) continuously scrutinize their budgets and look for ways to operate more efficiently. If there are proven methods/technologies that can bring about significant increases in efficiency and offer a positive impact on public safety, economizing resources and protecting the environment, it should be seen as necessary to adopt these methods/technologies sooner rather than later. Although a tool or a solution might be available that can offer significant benefit, a catalyst is typically needed to bring about large scale change on an industry-wide scale.

An initial catalyst (or a sign that change may be imminent) for the winter road maintenance industry can be seen through the Clean Water Act, which delegates authority to the EPA to regulate the point sources of pollutants into waters of the United States. The EPA is now starting to enforce the reporting of contaminants such as deicing chemicals within areas that have been deemed "sensitive," like chloride-impaired watersheds, for example. This mandatory reporting is known as the MS4 Annual Reporting Requirements. MS4 stands for municipal separate storm sewer systems, and two of the first states to adopt such requirements are Massachusetts and New Hampshire.[4] This annual report largely involves a self-assessment review of compliance and the plans of the organization involved for mitigation of pollutants in the future.

Prior to MS4 reporting, there has been little if any regulation controlling and or monitoring the use of deicing chemicals within the industry. CIT offers a great opportunity for municipalities to perform more accurate reporting and to allow them to address the mitigation of chloride damage in sensitive areas, and although more regulation is likely needed, it is these types of regulations that will likely necessitate the need for the implementation of better tools and better practices.

When it comes to the preservation of natural resources for future generations, what we have tomorrow depends on our level of stewardship today. Adopting new technologies that can lead to increases in efficiency and sustainability may help ensure long-term prosperity for future generations. The implementation of a tool like CIT, which allows operators to know where and how frequently they have spread deicing chemicals, is a small but important step in a better, safer direction.

Endnotes

1. Victoria R. Kelly et al., "Long-Term Sodium Chloride Retention in a Rural Watershed: Legacy Effects of Road Salt on Streamwater Concentration," *Environmental Science & Technology* 42, no. 2 (2007): 410–15; Amy L. Rhodes, Robert M. Newton, and Ann Pufall, "Influences of Land Use on Water Quality of a Diverse New England Watershed," *Environmental Science & Technology* 35, no. 18 (2001): 3640–45; M.L. Bester et al., "Numerical Investigation of Road Salt Impact on an Urban Wellfield," *Groundwater* 44, no. 2 (2006): 165–75.

2. Stephen McCracken, "Chlorides, Environmental Regulation, and Management in NE Illinois," DuPage River Salt Creek Work Group, http://iowa.apwa.net/content/chapters/iowa.apwa.net/file/2014%20Spring%20Conference%20Presentations/Chlorides,%20Environmental%20Regulations%20and%20Management%20in%20NE%20Illinois.pdf.

3. New Hampshire Department of Environmental Services, Water Division, http://des.nh.gov/organization/divisions/water.

4. "NPDES Phase II Small MS4 General Permit Annual Reporting Requirements," *NPDES Phase II Small MS4 General Permit*, US EPA, n.d. Web. 19 Feb 2016.

About Carsey Perspectives

This new series gives us a vehicle to present analysis that, unlike our Carsey Research series, is not based on original data analysis. We hope you find it useful. Feedback, as always, is welcome (amy.sterndale@unh.edu).

About the Author

Andrew Jaccoma, MBA, Managing Partner - Sensible Spreader Technologies LLC, took first prize in the Community Track of the 2014 Social Venture Innovation Competition for his Sensible Spreader Technologies entry. He lives in Portsmouth, New Hampshire (andrew@sensiblespreader.com).

About Sensible Spreader Technologies LLC

Sensible Spreader Technologies LLC aims to increase road safety, reduce wasteful dissemination of deicers, and lessen society's impact on the environment by integrating the latest in sensor technology and cloud computing software into road maintenance equipment (www.sensiblespreader.com). Founded in 2012 by Andrew Jaccoma, the team now includes Chris Dundorf, BS; Don Spencer, MS; and Christopher Rakowski, BS.

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