

SIRWEC 2016 KEYNOTE ADDRESS

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The State of Road Weather Research

It is a pleasure to bring together the knowledge and ideas of the Transportation Research Board's committees on Winter Maintenance and Surface Transportation Weather, with those of the Standing International Road-Weather Commission.

I have three key messages to bring to the conference:

- Our work is critical to transportation systems and to all of the aspects of society that rely on them.
- The discipline of road-weather information has made huge advances since early days and continues to improve to support our transportation agencies.
- We are headed toward some interesting places; advances in knowledge are poised to make important improvements to the safety and sustainability of road systems.

Road-weather is a critical discipline. This will be illustrated with some real-world case studies from the Province of Ontario, Canada.

By way of introduction, Ontario is centrally located in North America, on the north shore of the Great Lakes. It covers a lot of geography, extending over 1000 km east to west and 1600 km north to south. It is Canada's second largest province in area but largest in population, including close to 40% of the national population. It has a well-developed highway network comprising over 16,000 centerline kilometers, with average daily traffic ranging from less than 500 on resource roads in the north, to more than 400,000 on urban freeways in the Greater Toronto Area. Most of Ontario's population is located in the industrial heartland near Toronto, within 200 km of the US border. Weather conditions vary considerably due to the large geographic extent and to the influence of the Great Lakes.

The first case study is a weather event on Highway 400, a north-south running freeway with AADT of 84,000, connecting Toronto with Barrie and recreation areas to the north. A sudden snow squall in February, 2014, resulted in a collision involving 96 vehicles that closed 15 km of the highway in both directions over 12 hours and injured 3. 42,000 trips were interrupted by this one winter event.

The second case study occurred on Highway 401 near Belleville, near the shore of Lake Ontario to the east of Toronto. Highway 401 is a multi-lane freeway that is the commercial backbone of Ontario's highway system, connecting the US border at Windsor in the south with Quebec and Canada's Maritime Provinces in the east. The AADT near Belleville is 40,000. A black ice event under clear weather in the early morning of March 15, 2015, resulted in a collision of 50 vehicles, a one-way closure for 18 hours and 4 injuries. 15,000 trips were interrupted.

The third case study is an event on Highway 401, 20 km from the Windsor-Detroit border, where the AADT is 24,000. On the morning of September 3, 1999, an unexpected fog bank descended, reducing

visibility to nil within seconds. It resulted in a collision of 87 vehicles, multiple fires, 62 injuries and 8 deaths. The 24 hour full road closure interrupted 24,000 trips.

The fourth case study is on Highway 402, a multi-lane freeway with AADT 25,000. This highway connecting the American border at Sarnia with Highway 401 at London, plays a key role in the transportation of auto parts and vehicles between American assembly plants near Detroit and Canadian ones at Cambridge, Brampton and Oshawa. To be clear, transport trucks on this route function as travelling warehouses for just-in-time delivery to the auto plants that are important to the economies of Ontario and Michigan. On December 13, 2010, a major winter storm travelling across central North America hit Highway 402. The effects were devastating because of extreme snow and exposure to strong winds from the winter-bare agricultural fields along the route. An entire average winter snowfall fell on December 13. 360 vehicles and their occupants were trapped over a 40 km section of highway when plows could no longer operate. The highway was closed in both directions for 3 days. Fortunately most occupants were rescued by snowmobile within the first day but one person who tried to find his own way to safety through the howling wind and whiteout of snow died of exposure. 75,000 trips were delayed and the auto industry was affected by parts shortages for several days following.

These examples from just one small area of one Province of Canada illustrate the effect that weather can have on surface transportation and the importance of the work that everyone at this conference does. Research on a wider scale by the US Federal Highway Administration, shows that 22% of American vehicle accidents are related to adverse weather. Weather is associated with reductions in highway speed and capacity, and obviously injury and loss of life as well as economic impacts. The examples show the high numbers of vehicles per incident and the long time to recovery compared with simple collision accidents. Road-weather is important!

The first meeting of SIRWEC was held in 1984. It is useful to look back to that era to recognize how both the world and the road-weather industry have matured in 30+ years.

Significant events of 1984 include:

- Introduction of the Apple Macintosh desktop computer
- Madonna's first hit (Holiday)
- The last time that the Detroit Tigers won the World Series (so far).

My own experience in 1984 provides a parallel to understand how our industry has developed. In the 1970s and early 80s there was a rapid expansion of marine transportation in Canada's arctic waterways related to oil and gas exploration and mineral extraction. There was also rapid development in marine weather forecasting and sea-ice mapping to support the marine industry. I spent much of 1984 mapping sea ice. But the purpose of mapping sea ice is not limited to the act of cartography; it is to provide understanding of ocean-weather conditions to support marine transportation. The parallel to road-weather information is surprisingly close. There is also a close parallel in the development and maturity of the technologies that is interesting to relate.

A wise person once said there is a progression from information to knowledge to wisdom. For arctic navigation that process began with classification of sea ice by its coverage and physical properties, and then by mapping the classifications through a historical progression of technologies. Immediate observation of sea surface conditions provides information required to choose a safe and efficient course through an ice field immediately ahead of a ship. The technology for ice observation and mapping progressed from shouting down from the crow'snest of a sailing ship, to airborne observation,

to ship-based radar, to airborne radar and then to satellite. The scale, temporal and spatial coverage increased with each step.

Regular mapping over a number of decades allowed the development of a climatology of sea ice that is critical to planning and designing both shipping routes and ship structures, as opposed to planning a route at a specific time and place.

Information transitioned to knowledge as the physics of ocean-weather became better understood, allowing the motion of ice flows and pack ice to be forecast over hours or days ahead. Ice forecasts provide actionable knowledge to marine navigators.

The final step in information flow for arctic, marine navigation is the decision support tools that combine maps of current ice conditions with forecasts of future conditions, with recommended routes computed by overlaying current and forecast conditions with the ice transiting capabilities of a given ship or convoy. The expected result is safe and reliable marine transportation through inclement ocean weather conditions.

The parallels in the road-weather industry begin with classifying and mapping road-weather conditions. Even in the early days of maintenance on modern highways a radio report from a patrol vehicle or plow would be provided for each affected route, with the capability to assemble the reports into an agency-wide map of current conditions. Road reports were supplemented by different levels of technology, beginning with RWIS embedded and weather sensors at a gradually increasing spatial density. Weather radar helps to interpolate between observing stations, and the detail of surface classification is improved through overhead optical sensors and cameras. Mobile sensors and real-time communication provide the latest advance in moving from spot to spatial observation.

Various road-weather climatologies are now available, often in the form weather severity indices such as the ClearRoads index which maps winter conditions in a consistent manner across the continental United States. Like the marine transportation industry, climatologies are useful for long-term planning of infrastructure and maintenance standards, but not for route planning.

Coupling of site-specific observations with physically-based models allow future prediction minutes or hours ahead that is the modern road-weather forecast. Depending on the observed information the forecast may include both the near-surface meteorology and the road surface contaminant condition. This is the actionable information about present and future conditions that field maintenance crews need to make efficient decisions about their critical activities; plowing, salting or sanding.

As with marine navigation, decision support tools allow forecasts to be overlaid with information about maintenance operations to predict the outcomes of the operations and assess the effectiveness of different tactics ahead of time, and with traffic information to help road users assess alternate travel routes, schedules or modes.

Road-weather has shown a progression from information to knowledge leading to wise choices. But where is it headed in the future?

The Transportation Research Board 2016 International Conference on Winter Maintenance and Surface Transportation Weather highlighted topics that encompass recent advances and future directions in those areas. They are:

- Decision Support Systems
- Sustainability
- Equipment and Materials
- Big Data
- Resilience and Climate Change.

While the discussions focused on winter conditions, many aspects have year-round resonance for Road-Weather systems. Three topics in my opinion have made significant advances very recently and are poised to change the way weather information supports surface transportation. They are:

- Big Data
- Micro-forecasting
- Protecting the environment.

Three key types of big data play a critical role to keep road systems operating efficiently by providing knowledge to the public, to field operations staff, and to those who monitor performance and accountability; traffic, road-weather conditions, and maintenance operations. Traffic data is obtained from in-road sensors and by tracking mobile devices, road-weather data from RWIS networks and operations data from various sensors linked to GPS on maintenance and patrol vehicles. The data helps road networks to operate efficiently now, and to analyze trends that will keep them operating efficiently in the future. Analysis in any specialty more often than not requires data from another specialty. They are so often used together on a project-specific basis that a fusion is inevitable, not only of the databases but of the monitoring technologies.

The implementation of RWIS at fixed locations by the roadside provided a huge advance in weather knowledge for operation of road systems. Over time, technologies such as dash-cams and various friction monitoring and mobile RWIS devices have increased awareness about the local variations in winter conditions that can make winter travel unreliable. The new technologies also provide useful data that can be used with meteorological forecasting to develop local-scale models, for micro-forecasting of road-weather conditions that will help road maintainers focus resources on the local, severe and unexpected conditions that have huge impacts on road safety and operations.

Road networks may affect roadside environments in many ways. Society has become more attuned to the potential impacts the longer major road networks have been in operation. Significant efforts have been made by highway operators to understand the impacts with the aim to develop mitigations of various types. One example is road salt management, where salt applications are varied with current and forecast weather conditions. It is also an area that is on the verge of the benefits of fusing big data. The key to mitigating environmental impacts is a good knowledge of exposure and susceptibility. Advances in knowledge about critical exposure levels of roadside biota to road salt were made one to two decades ago. Big data from maintenance operations is now able to provide reliable estimates of exposure to salt and other road maintenance or road-building materials, and GIS technology makes it relatively easy to overlay the occurrence of susceptible species with exposure levels, to map areas of concern for vulnerability to road salt. That will provide the actionable knowledge that is needed to focus resources on areas of concern and on how the concerns can be mitigated.

From information to knowledge to wisdom; we can see the critical role that the Road-Weather community has played since 1984 to advancing safe and sustainable transportation. I look forward to us

working together over the next two days to learn what the next big advances will be, and to setting the Road-Weather challenge for the future.