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Smart Solutions for Northern Roads

By: William Dunstan

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Our main offices:

- Thunder Bay on Robinson-Superior Treaty territory and the land is the traditional territory of the Anishnaabeg and Fort William First Nation.
- Sudbury is on the Robinson-Huron Treaty territory and the land is the traditional territory of the Atikameksheng Anishnaabeg as well as Wahnapitae First Nation.
- Kirkland Lake is on the Robison-Huron Treaty territory and the land is the traditional territory of Cree, Ojibway, and Algonquin Peoples, as well as Beaverhouse First Nation.
- Each community is home to many diverse First Nations, Inuit, and Métis Peoples.

We recognize and appreciate the historic connection that Indigenous peoples have to these territories. We support their efforts to sustain and grow their nations. We also recognize the contributions that they have made in shaping and strengthening local communities, the province, and Canada.munities, the province and the country as a whole.

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About the Author

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William Dunstan is a recent graduate of Carleton University's Public Affairs and Policy Management program. During his undergraduate studies, William learned about the wide world of public policy and developed a particular research interest in economic policy and regional development. Professionally, he has worked in several policy-related roles both in the think tank sphere and with the federal government. Originally from Ottawa, William developed a love for Northeastern (or Central) Ontario and the region's high quality of living during his time as an Experience North intern in 2021.

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Executive Summary

The road network in Northern Ontario suffers from numerous gaps. These gaps exist primarily in the form of road inadequacies: deteriorating road surfaces, hazardous driving conditions, and frequent road closures during winter. In other cases, notably in the Far North, these gaps exist in the form of an actual absence of all-season roads. Regardless of their form, shortcomings in the road network present barriers for people seeking to access communities, services, economic opportunities, and other resources in Northern Ontario. In many cases, they result in injuries and deaths due to collisions.

There are numerous options to make road travel in Northern Ontario safer and easier – whether you're transportating goods from one coast to the other or visiting your doctor 2 hours away in Thunder Bay.

One way to improve Northern Ontario's roads is to introduce "smart road" technologies that have proven effective elsewhere in the world. Smart roads use advanced sensors and communications technology to enable safe and efficient road use. FAST installations reduce collisions during winter months by automatically spraying anti-icing liquids when they detect atmospheric conditions conducive to snow and ice build-up on the road. Dynamic speed limits (DSLs) can provide similar benefits by automatically reducing speed limits in response to dangerous weather conditions. Finally, section control offers an advantage over traditional speed cameras by monitoring drivers through an extended section of the road instead of at one point in time. These technologies are relatively inexpensive to implement but have a record of achieving substantial safety benefits.

Northern Ontario's road network could also be improved through changes to basic road construction and design. Researchers have recently developed several variants of "self-healing road surfaces" that allow the road surface to repair itself as it deteriorates. Self-healing road surfaces can reduce maintenance costs and related traffic disruptions.

So-called "mat roads" are another road construction technique that represents a less expensive option for building all-season roads in the Far North, connecting isolated communities to the rest of Ontario year-round. They use wooden mats to cross muskeg and wetlands, while the sections of road on higher, more stable ground use traditional gravel construction. Evidence suggests that mat roads could cost only half as much per kilometre as traditional gravel roads. Self-healing asphalt and mat roads have great potential to improve Northern Ontario's road network. Still, they are less proven than the smart road technologies discussed earlier.

This paper's recommendations are:

- Proven smart road technologies like FAST, DSLs, and section control should be implemented on roads in Northern Ontario.

- For equally promising but less proven techniques like self-healing asphalt and mat roads, the Ontario government should provide support for further research and trials.

Introduction

Roads are often forgotten in conversations about "innovative" or "smart" technologies. This is unfortunate, as new innovations in road construction and design offer many opportunities to improve the speed, safety, and comprehensiveness of the road network in Ontario's northern, central, and western regions[1]. In these regions, however, numerous gaps in the road network threaten these connections. Many sections of highways suffer from deteriorating road surfaces, hazardous driving conditions, and frequent road closures during winter. In the Far North, permanent roads are often lacking altogether.

This briefing note explores five innovative techniques in road construction and design that could address these shortcomings and offer a strong return on public investment. The briefing note begins by discussing three promising "smart road" technologies that could improve safety for road users by using advanced sensors and communications to monitor and regulate traffic and road conditions. This is followed by a discussion of two innovative approaches to road construction and design that could reduce construction and maintenance costs in Ontario's northern, central, and western regions. These two approaches could save money for governments – and ultimately taxpayers – and they could make much-needed expansions to the road network financially feasible.

The Ontario government should invest in innovative techniques in road construction and design to keep residents of the province's northern, central, and western regions connected and safe. Smart road technologies like fixed automated spray technology, dynamic speed limits, and section control that have been proven to improve road safety should be introduced in these regions. The Ontario government should also support further exploration of two less tested but very promising innovations in road design and construction: self-healing road surfaces and mat roads.

[1] Compared to the rest of Canada and globally, Northern Ontario is not so North. In fact, we are south of: Winnipeg, Calgary, Edmonton, Regina, Vancouver, London (UK), Berlin, and Paris.

Smart Roads

Intelligent transportation systems, or "smart roads," use advanced sensors and communications technology to enable safe and efficient road use. Three smart road technologies that could improve road safety are fixed automated spray technology (FAST), dynamic speed limits, and section control.

Fixed Automated Spray Technology

Fixed automated spray technology is a promising option for improving road safety during winter. FAST systems automatically spray anti-icing liquids when they detect atmospheric conditions conducive to forming ice or bonded snow on the road surface. The technology is best suited for bridges that freeze before the rest of the road, especially those in remote locations that are costly to service manually. The Ontario Ministry of Transportation (MTO) currently maintains eight FAST installations across the province, but only one in its northern regions: at Burk's Falls, near the southern boundary of the northeastern region. Existing FAST structures have provided a financial benefit to MTO and the public, and a detailed analysis of accident data is forthcoming (IBI Group 2019). Data are available for Ontario's first FAST installation on a highway ramp structure near Prescott. That installation reduced accidents by 100 per cent during its first season, and delivered a favourable benefit-cost ratio[2] while also reducing the environmental impact of road clearing (Hanson et al. 2018, 8). Elsewhere, an evaluation of two FAST installations in North Dakota concludes that these systems significantly reduced the number of accidents during winter and also provided a favourable benefit ratio (Birst and Smadi 2009). That study is particularly noteworthy because the installations examined are in areas with winters that are as long and cold as those experienced along Highway 17 and other stretches of Ontario's northern highway network.

That said, FAST spraying cannot occur under extreme cold or high winds, which has inspired concerns about these systems' effectiveness in specific environments. FAST installations in Ontario are usually instructed not to spray when the temperature is below –20° Celsius (IBI Group 2019, 65). The North Dakota FAST installations are not used when the pavement temperature falls below –24° Celsius (-12° Fahrenheit) or when wind speeds exceed 24 kilometres per hour (15 miles per hour) (Birst and Smadi 2009, 17). The fact that FAST provides a favourable benefit-cost in North Dakota despite the limitations imposed by harsh winters suggests that implementing these systems could be a worthwhile investment across much of Ontario's northern, central, and western regions.

Dynamic Speed Limits

Highway speed limits are set for ideal conditions. When conditions are less than ideal, due to heavy traffic or, more commonly on northern highways, bad weather, the posted speed limit might exceed the speed at which it is safe to drive. Dynamic speed limits (DSLs) adjust to match prevailing road conditions, leading drivers to slow down and thus reducing accidents. Sensors are installed along the road to detect weather and traffic conditions. This information is then relayed either to an operator who manually adjusts the speed limit or to an algorithm that does so automatically.

DSLs have been implemented successfully in British Columbia on roads similar to those that make up Ontario's northern highway network. El Esawey et al. (2021) examine the impact of DSLs on a section of a rural, undivided, two-lane highway and a divided, four-lane freeway during the winter season (October–March). They find that DSLs reduced collision frequency by 35 per cent and delivered more than $4 in benefits for every $1 in costs (El Esawey et al. 2021, 11–14).

Improved road safety during winter via DSLs could provide an especially favourable benefit-cost mix in Ontario. On some northern highways, half of all collisions and an equal share of fatal crashes occur during periods of snow and ice cover on roads (WSP 2019, 9). Given these dangers, authorities often close highways due to winter storms. Some winter closures could be avoided with a greater assurance that motorists will drive according to the prevailing conditions. On the cost side, implementing weather-only DSL systems could be relatively low cost given that the detection infrastructure already exists in most parts. Ontario maintains an extensive network of road weather stations, known as the Road Weather Information System, covering much of the northern highway network (Ontario 2020).

[2] A benefit-cost ratio measures the relative costs and benefits of a proposed project. When benefits exceed costs, the ratio is greater than 1 or "favourable," and the project can be considered worthwhile to pursue.

Section Control

Section control — alternatively referred to as "point-to-point speed cameras" or "average speed cameras" — represents an advance on traditional fixed-speed cameras. Whereas fixed cameras capture motorists' speed at a single location, section control can determine speed over an extended stretch of road. Two cameras placed several kilometres apart take a photograph of each passing vehicle. The system uses the time elapsed between the first photograph and the second to calculate speed.

Section control prevents more collisions than fixed-speed cameras, and the benefits of section control tend to spill over to nonmonitored sections of road (De Ceunynck 2017, 1). A review of studies from various European countries finds that section control, on average, reduces collisions resulting in deaths and serious injuries by approximately 50 per cent and collisions overall by approximately 30 per cent (De Ceunynck 2017). These studies found positive effects on a range of road types — tunnels, large highways, two-lane roads — suggesting that section control can deliver benefits on highways across Ontario.

Section control, however, might not deliver the same magnitude of benefits on much of the northern highway network. Many sites from the studies mentioned above are heavily travelled or were chosen to receive section control because they previously experienced a high number of collisions. At the same time, section control is relatively inexpensive to implement on lightly travelled, undivided two-lane roads. Each camera can monitor both directions, removing the need for two cameras, and less computer processing power is required to monitor low traffic volumes (Cameron 2008, 7–8). This scaled-down section control could reduce costs and improve the benefit-cost ratio for lightly travelled two-lane roads in the northern highway network. Additionally, section control could further improve the safety benefits provided by DSLs. If drivers know that their speed will be monitored across an extended road segment, they are more likely to adhere to the lower speed limit.

Innovative Approaches to Road Construction and Design

Road innovations are not limited to "smart road" technology. Advances continue to be made in the basic design and construction of roads. New techniques in road construction and design can allow roads to be built and maintained at lower cost or in challenging areas. Two such techniques are self-healing road surfaces and mat roads.

Self-healing Road Surfaces

Maintenance is a significant expense for all roads. This is particularly true in Ontario's northern, central, and western regions, where harsh winters take a toll on road surfaces. Emerging technologies for self-healing road surfaces could lower the cost of maintaining roads and thus enhance the financial feasibility of specific expansions to the road network. Self-healing road surface technology is varied. Some mixtures use nanoparticles to repair microcracks in asphalt. Others use induction heating to cause bitumen to fill cracks. Still others use rejuvenating agents to extend asphalt life (Tabakovic and Schlangen 2015). Critically, all techniques allow the road surface to repair itself as it deteriorates from wear.

Self-healing road surfaces offer benefits beyond direct reductions in maintenance costs. When maintenance activities are less frequent and less intensive, so are related traffic disruptions. This is important because traffic disruptions impose substantial social costs by delaying shipments and wasting road users' time. There are environmental benefits to reduced maintenance requirements, too. Rodriguez-Alloza et al. (2019) estimate that a form of self-healing asphalt that employs induction heating would produce 16 per cent fewer greenhouse gas emissions over its lifecycle compared to conventional asphalt. The downside of self-healing road surfaces is that they entail higher initial construction costs. Nevertheless, the added long-term benefits likely exceed the higher construction costs. Dutch authorities estimate that, if self-healing asphalt extended the lifespan of road surfaces on highways in the Netherlands by 50 per cent, the combined direct and indirect savings would be sufficient to make adopting this technology cost effective, even if initial construction costs were 13 times greater than that of standard asphalt (Netherlands Enterprise Agency 2011, 76–8).

The potential benefits of self-healing road surfaces should make these innovative technologies of interest to decisionmakers in Ontario. A significant concern is the feasibility of these technologies on northern highways. Few large field trials of self-healing road surfaces have been completed, and few of any size in areas with harsh winters like those in Ontario's northern, central, and western regions. Therefore, adequate evidence does not yet exist to promote the widespread adoption of self-healing road surfaces on northern highways. However, financial support from governments could help advance research in this area, potentially bringing such benefits to the public sooner.

Mat Roads

Although gaps in the road network in Ontario's central and western regions primarily exist in the form of inadequacies, there is a genuine absence of roads in the Far North. For many northern First Nations, road access to the rest of Ontario is limited to winter roads, typically open for only a couple of months each year. Climate change is likely to further shorten the winter road season: since the 1990s, the average season length for Ontario's winter roads has been halved (Prentice 2017, 2).

There have long been calls to connect communities in the Far North to the rest of Ontario via all-season roads. Building all-season roads in the Far North would improve isolated communities' access to services and economic opportunities, while likely reducing the cost of living by allowing goods and materials to be driven into the community year-round. All-season roads could also enable the development of the Far North's vast natural resource wealth, such as the chromite, copper, and nickel deposits found in the Ring of Fire. As climate change leads to an increasingly unreliable winter road network, the need for all-season roads in the region is growing.

The primary barrier to building all-season roads in the Far North is cost: approximately $3 million per kilometre on average for an all-season gravel road (Prentice 2017, 2). Constructing gravel roads over wetlands and muskeg is particularly complex and costly, and often environmentally destructive. Given many communities' small populations as well as the large distances between communities, there are concerns that the benefits of building these roads will be insufficient to justify the costs. An innovative road construction approach called "mat roads," however, promises significantly reduced costs for building all-season gravel roads in areas, such as the Far North, that are covered with muskeg and wetlands.

Mat roads do not involve the use of new technology. Interlocking wooden mats have long been used to allow heavy equipment to cross unstable ground and to access construction sites for transmission lines, natural resource projects, and other developments. On a mat road, wooden mats are used to cross muskeg and wetlands, while sections of the road on higher, more stable ground use traditional gravel construction.

Per kilometre, a mat road costs only half as much as a traditional gravel road (Prentice 2021). One of North America's leading mat producers estimated that it could build a 16-kilometre stretch of matted road in northern Manitoba that would last for 12 to 15 years at a price of only $550,000 to $800,000 per kilometre (D. Blizzard Integrated Services Inc. 2019). The precise benefit-cost ratio would vary from road to road, but a 50 per cent reduction in construction costs certainly would improve the feasibility of many prospective all-season roads in the Far North. Moreover, placing wooden mats over muskeg and wetlands would impose a smaller environmental cost than building traditional gravel roads through these landscapes.

Recommendations

Ontario could leverage innovative techniques in road construction and design in order to deliver better transportation infrastructure in its northern, central, and western regions. Based on the evidence presented here, Ontario policymakers should consider the following recommendations.

Fixed automated spray technology systems should be explored farther north in Ontario: FAST has delivered a favourable benefit-cost mix in locations with harsh winters similar to those experienced in much of Ontario's northern, central, and western regions.

Dynamic speed limits, coupled with section control, should be introduced on sections of northern highways that have high rates of weather-related collisions: Much of the infrastructure already exists for a "weather-only" DSLs system. The DSLs system could improve road safety during winter, and section control could improve enforcement and driver adherence to dynamic speed limits.

The Ontario government should monitor ongoing developments in self-healing road surface technology and fund trials of such technology on northern roads: Self-healing road surfaces could reduce the financial and environmental cost of maintaining northern highways. The possible rewards of developing and implementing such technology warrant public investment in research.

Mat roads should be considered as an option for building all-season roads in the Far North: In geographies such as the Far North, mat roads appear to represent a less costly and environmentally disruptive alternative to traditional all-season gravel roads. When assessments are done regarding the financial feasibility of building all-season roads in the Far North, mat roads should be one of the approaches considered.

References

Birst, Shawn, and Mohammad Smadi. 2009. Evaluation of North Dakota's Fixed Automated Spray Technology Systems. Fargo: North Dakota State University Upper Great Plains Transportation Institute. Online at https://www.ugpti.org/resources/reports/downloads/dp-219.pdf

Cameron, Max. 2008. Development of Strategies for Best Practice in Speed Enforcement in Western Australia: Supplementary Report. Clayton, VIC: Monash University Accident Research Centre, 2008. Online at https://www.parliament.wa.gov.au/Parliament/commit.nsf/(Evidence+Lookup+by+Com+ID)/5BB2153A83B5CA4048257831003C1222/$file/ef.all.100503.aqton.wap.strategies+speed+enforcement+2008.pdf

De Ceunynck, Tim. 2017. Installation of Section Control & Speed Cameras. Loughborough, UK: European Road Safety Decision Support System. Online at https://www.roadsafety-dss.eu/assets/data/pdf/synopses/Installation_of_section_control_speed_cameras_23102017.pdf. Accessed February 8, 2022.

D. Blizzard Integrated Services Inc. 2019. "All-Season Integrated Mat Road." York Factory and War Lake First Nations in collaboration with D. Blizzard and the University of Manitoba Transport Institute.

El Esawey, Mohamed, Joy Sengupta, John E. Babineau, and Emmanuel Takyi. 2021. Safety Evaluation of Variable Speed Limit System in British Columbia. Victoria: British Columbia Ministry of Transportation and Infrastructure. Online at https://www.researchgate.net/publication/349339358_Safety_Evaluation_of_Variable_Speed_Limit_System_in_British_Columbia

Hanson, Randy, Rod Klashinsky, Kenneth Day, and Eric Cottone. 2013. "Evaluating Automated Anti-Icing Technology to Reduce Traffic Collisions." Presentation to Transportation Association of Canada Conference, Winnipeg, September. Online at https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1052.2185&rep=rep1&type=pdf

IBI Group. 2019. MTO FAST Policy for Site Assessment, Design, Construction, Operations and Maintenance. Prepared for Ministry of Transportation Ontario.

Ontario. 2020. Winter Highway Data. Toronto: Ministry of Transportation Ontario. Online at http://www.mto.gov.on.ca/english/ontario-511/winter-highway-data.shtml

Netherlands Enterprise Agency. 2011. Self Healing Materials: Concept and Applications. The Hague: Netherlands Enterprise Agency. Online at https://www.rvo.nl/sites/default/files/bijlagen/282975_ANL_V2011-10%20AgentschapNL%20IOP%20Selfhealing%20materials%20A5%20C.pdf

Prentice, Barry. 2017. "Actions to Move Northern Ontario Forward — Response to the Draft 2041 Northern Ontario Multimodal Transportation Strategy. No. 1: Winter Roads into the Far North. Thunder Bay: Northern Policy Institute. Online at https://www.northernpolicy.ca/upload/documents/publications/commentaries-new/prentice_winter-roads-en.pdf

Prentice, Barry. 2021, Febraury 23). "Could Wooden Mats Be the Solution to Brutal Winter Highways in the North?" Bay Today, February 23. Online at https://www.baytoday.ca/local-news/could-wooden-mats-be-the-solution-to-brutal-winter-highways-in-the-north-3451462

Rodríguez-Alloza, Ana María, Michael Heihsel, Jacob Fry, Juan Gallego, Arne Geschke, Richard Wood, and Manfred Lenzen. 2019. "Consequences of Long-Term Infrastructure Decisions: The Case of Self-healing roads and Their CO2 Emissions." Environmental Research Letters 14 (11): 114040. https://iopscience.iop.org/article/10.1088/1748-9326/ab424a

Tabakovic, Amir, and Erik Schlangen. 2015. "Self-healing Technology for Asphalt Pavements." In Self-healing Materials: Advances in Polymer Science, vol. 273, ed. Martin D. Hager, Sybrand van der Zwaag, and Ulrich S. Schubert, 285–306. Berlin: Springer Nature. Online at https://link.springer.com/chapter/10.1007/12_2015_335

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