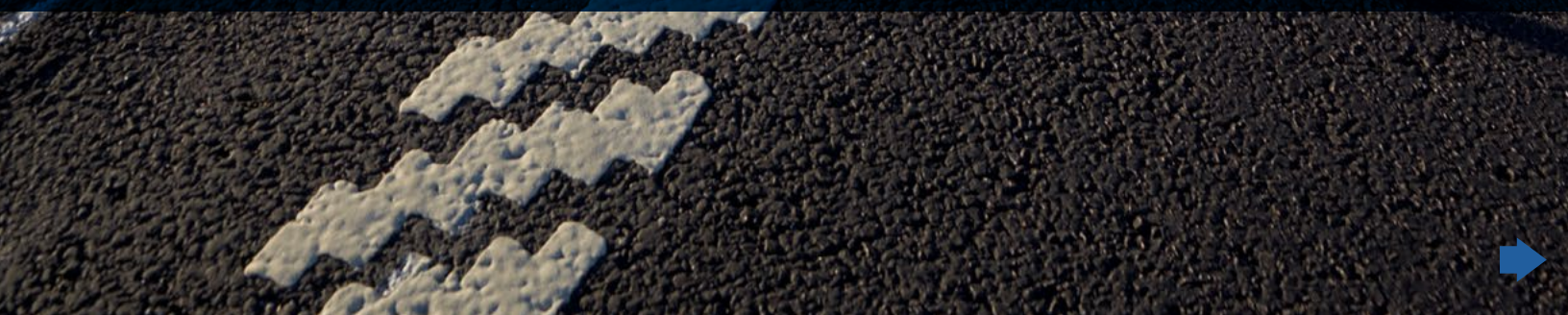
GEMS

Going the Extra Mile for Safety

2+1 Roads

Swedish Innovation

Canadian Rural Road Solution?



Introduction

In May and June of 2018, I travelled to Ireland and Sweden to research the 2+1 road systems that are used in those countries. The purpose of the trip was to gain information to determine the feasibility of implementing 2+1 road profiles in North Eastern Ontario, particularly on the Trans-Canada, Highway 11 as well as to learn more about the 2+1 pilot projects that were implemented in each country.

The trip was on behalf of The GEMS (Going the Extra Mile for Safety) Committee and The Temiskaming Shores and Area Chamber of Commerce. Letters of support were received from our MP in our region, Mr. Anthony Rota. The letters were used to make official requests to Government organizations in Ireland and Sweden and to indicate to them that the GEMS committee had government support for the project, however there was no financial support from any level of Government.

The research trip consisted of 3 days of meetings and tours in Ireland with Irish officials and experts. In Sweden the trip consisted of 6 days of meetings and tours with Swedish officials and experts and 5 days of personal driving on Swedish 2+1 roads collecting dashcam and photographic material. The distance traveled on 2+1 roads was approximately 1200 km.

I was overwhelmed by the reception I received by both the Irish and Swedish officials. They have been extremely helpful by providing a vast amount of information and expertise on the topic of 2+1 and 2+2 road issues and design. Everyone I met with was extremely well prepared and they shared many presentations and materials with me. I am very grateful for the tremendous amount of information that was provided to me for our GEMS Committee project.

A second research trip was also completed in December of 2018 to focus on winter operations, median barrier types and driving under winter conditions. This trip occurred from December 7 to December 12 and I travelled from Stockholm to Northern Sweden as far north as the Arctic Circle. Much of that travel was on 2+1 roads and an extensive amount of photo and video material was collected. Information that has been added to the original report from the winter research trip will be indicated in bold print.

Goal

The goal of this report is to summarize the information gathered during the visits to Ireland and Sweden. This information will be shared with the GEMS committee to use in subsequent meetings and information sessions.

TABLE OF CONTENTS

Table of Contents

Appendix 1

TABLE OF CONTENTS

A Brief History of 2+1 Collision-Free* Roads in Sweden

In the early 1990's Sweden was facing a road safety situation that was less than desirable. The Country experienced high rates of traffic fatalities and serious injuries. Most of these statistics occurred on their 13 metre, two-lane roads that consisted of 2 travel lanes that were 3.50 m wide with paved shoulders of 2.75 m wide. The total road platform was 12.5 to 13m wide. The Swedish Government decided that they needed to address the rates of fatalities and serious injuries and they began to implement a road safety program called Vision Zero. In very basic terms, Vision Zero recognizes that humans make mistakes and therefore the road system should protect road users from human error as much as possible. The underlying principle is that no one should die or be critically injured on the road system. Vision Zero includes various components but one of the most significant is road design. The Vision Zero principle became part of all road design in Sweden and includes the protection of all road users and on all roads, whether urban or rural. One of the most significant components of Vision Zero on the Swedish national road system has been the implementation of what are called 2+1 roads. They consist of a road where there are 2 lanes in one direction and one in the other separated by a lane dividing barrier which has traditionally been a cable barrier. This pattern changes from side to side as the road user travels along the route, giving each direction passing opportunities on a regular basis. For road users in Canada, this would be similar to continuous, alternating passing lanes with the difference being the added safety of a dividing barrier.

Although there was some initial resistance to the model, a very successful pilot project on the E4 route changed the public's view of the design when they realized that it was working very well. Sweden decided that the 2+1 model was a solution for their high fatality and serious injury rates on roads with volumes between 2,000 AADT (Average Annual Daily Traffic) and 20,000 AADT. The data collected over the last 25 years has shown that fatality rates have dropped between 75% and 80% on the over 3,000 km of 2+1 which are now in place in Sweden. Sweden continues to convert 13m two-lane roads to 2+1 roads with various projects slated for completion in 2018. They were so successful that they are now converting 9m two-lane roads to the 2+1 model by widening portions of these roads to allow for the 2+1 profile. The 2+1 road model is widely accepted across Sweden.

**The Term "Collision Free Road" is a term used by the Swedish Government to describe their 2+1 roads. The term is used to highlight the fact that head on collisions that result in fatalities and serious injuries are virtually eliminated on 2+1 roads. Minor collisions still occur but the kinetic energy that results from these collisions is drastically reduced and therefore injuries are more likely minor in nature.*

A Brief History of 2+1 Roads in Ireland

In the early 2000's the Irish Road Authority and Government were searching for solutions to their road safety issues much like Sweden was a decade before. The Irish had high fatality rates on their two-lane roads with many head on collisions that resulted in fatalities and serious injuries. Their next step was to look at the Swedish 2+1 model as a potential solution. Swedish officials were very helpful by sharing what they had learned and sharing the very positive results that they had experienced. In 2004 the Irish Road Authority implemented a series of 2+1 pilot projects across Ireland. The results in Ireland were similar to those in Sweden. Fatality and serious injury rates dropped significantly and there was also general acceptance by road users after they had been implemented for a period of time. In Ireland, the 2+1 model was further modified in some locations as the Irish economy went through a period of rapid growth and traffic volumes exceeded what some of the 2+1 roads could handle. In these situations, 2+1 roads were easily transformed into 4-lane roads or 2+2 roads as they are called in Ireland.

TABLE OF CONTENTS

2+1 Roads in Other Countries

Due to the success of 2+1 roads in Sweden and then Ireland, other countries have looked at 2+1 roads as one component in the Vision Zero goal. These countries include Denmark, Norway, Estonia, Germany, Finland, Poland, Lithuania, Australia New Zealand and Japan. These roads sometimes have different design features but the original Swedish principle is the same. Many of these countries have implemented the 2+1 into their networks with positive results and others are at the pilot project stage.

Safety Statistics

Safety results from 2+1 roads in Sweden and Ireland have been exceptional. The reduction in fatality and serious injury rates has been very significant. 2+1 roads are almost equal in safety performance as motorways (divided highways). From an economic perspective the investment in 2+1 roads shows a better return than motorways where volumes are below 20,000 AADT. Generally, it costs $150,000 CAD to save a life by building 2+1 roads and 4.5 million CAD to save a life by building a motorway (divided highway). The elimination of most cross-over, head-on collisions and the elimination of unsafe passing resulted in these very significant reductions in fatalities and serious injuries.

Safety Statistics on 2+1 Roads

Type of Road User	Location	Reduction of Fatalities
All	Links	79%
All	Junctions	76%
Motorcycles	All	40-50%

Evaluation of 2+1 Roads with Cable Barrier – Sweden - A. Carlsson – VTI – 2009

TABLE OF CONTENTS

Road Dimensions

Although safety was the first priority for the implementation of 2+1 roads, cost was also a significant factor. Swedish authorities needed a solution that would be cost effective and still put them on the road to Vision Zero. Using existing road platforms was the most economical option in Sweden. The 12.5m to 13m road platform was capable of being divided into the 2+1 model. It allowed 2 travel lanes of 3.25m or 3.5m on one side and one 3.5m lane on the single side. These are divided by a barrier that sits in a median strip that is 1.5m wide.

13m road platform Sweden (Google 2014)

13m road converted to 2+1 – same location

TABLE OF CONTENTS

Traffic Volume Factors

In Sweden and Ireland, the initial 2+1 roads were converted from 13m roads and the volumes of these roads varied. In some cases, as mentioned earlier in regards to Ireland, the volume of traffic became too much for the 2+1 model. This has happened as well in Sweden and some early locations that were converted to 2+1 some years ago require a 2+2 model or divided highway model now. The general conclusion is that 2+1 road models work best in volumes below 20,000 AADT. This will vary somewhat in certain situations, for example where the road is used for weekend traffic out of a city to the countryside, the regularly reasonable volumes will increase at certain peak times to levels above the 20,000 AADT for short periods and cause delays when traffic is required to merge in the one lane sections. This break down will occur at 1500 vehicles per hour. Where upper flow of traffic is a consistent 18,000 to 20,000 the 2+1 model performs better. Generally, the 2+1 roads are used in Sweden on roads between 2,000 to 20,000 AADT.

Traffic Speed and Performance

Travel speed has generally increased slightly on 2+1 roads. In Swedish studies when traffic flows are at 500 vehicles per hour on 110 km/h 2+1 roads there are average speeds of 108.5 km/h with a 5km/h speed increase on the two- lane sections. These speeds will vary between one and 2 lane segments when traffic flow rates increase at peak times. In recent years Sweden has modified their speed limit policies and 13m roads that have been converted to 2+1 roads are generally now posted at 100km/h. Posted speeds on earlier 2+1 roads were either posted at 90km or 110km. Traffic performance has been generally very good on 2+1 roads in normal designed traffic flow situations with slight decreases in travel times to destinations.

Barrier Types and Effectiveness

As indicated earlier 2+1 roads have reduced fatality and serious injury rates. These reduction levels are around 80% over conventional 13m roads. One of the major reasons for this significant improvement is the implementation of a median barrier or lane dividing barrier, which virtually eliminates head on collisions and significantly reduces run off collisions. The reduction in these types of collision applies to all road users including trucks, cars and motorcycles. The barrier types that were used initially in Sweden were cable barriers that consisted of 3 or 4 cables under tension with supporting posts that hold the upper cable at a height of .5m to .7 m above the road. These cable barriers, which are clearly the most common type of median barrier used, have proven to be very effective and are the least costly option to install but generally have somewhat higher maintenance costs when compared with steel barriers. Currently in 2018 some projects in Sweden are installing solid steel lane dividing barriers which are more costly to install but generally are less costly to repair and maintain. The Irish Road Authority is also looking at steel, lane dividing barriers. Design and technology advances are providing more options to Road Authorities who are installing lane dividing barriers and therefore further improving the performance of 2+1 roads in terms of safety and operations.

As of the end of 2018, the use of the solid steel barrier has now become standard for installation on Swedish and Irish 2+1 roads. These barriers will also be required to meet a higher impact standard. All median barriers, both cable barriers and semi-rigid steel barriers, are rated for snow plow resistance from a low rating of one to a high rating of 4. The steel barriers have a snow plow rating of 4 which means they can better withstand a touch by a snow plow during winter. The wire rope barriers have a rating of 2 and are therefore less resistance and will require more maintenance.

TABLE OF CONTENTS

Oval steel style barrier (Photo - GEMS)

Rectangular steel lane dividing barrier (Photo - GEMS)

Wire rope lane dividing barrier (Photo- Trafikverket)

Wire rope lane dividing barrier (Photo -GEMS)

One of the key components on any barrier in preventing serious injuries and fatalities is its ability to absorb the energy of a collision. Cable barriers are particularly effective and therefore serve to protect drivers and passengers in a collision. Semi-rigid steel barriers also absorb energy in a collision but at a level somewhat lower than cable barriers. Barriers are tested to the EN 1317 standard and must meet this standard to be used in road construction. The EN 1317 Standard tests barriers for vehicle containment levels, impact severity rating and deflection limits. Barriers posts are installed in the road surface after a socket has been pressed through the asphalt into the road base. The posts that support the cable barrier or the steel barrier can be removed easily when replacement is necessary.

TABLE OF CONTENTS

Socket which is inserted into asphalt (GEMS)

Post inserts into socket (GEMS)

Final Installation of steel barrier (Nordic Road Safety)

TABLE OF CONTENTS

Intersection Types

In Sweden, intersections on 2+1 roads are designed in a variety of ways depending on various factors, including traffic volume and road alignment. These intersections can be "at grade" or "grade separated" intersections. Grade separated intersections are overpasses or underpasses that are used when traffic volumes are high and do not allow for safe" at grade" intersections. This report will discuss the types of at grade intersections as these would be best suited for highway 11 where traffic volumes do allow for safe at grade intersections. There are primarily 3 types of "At Grade intersections". Left turn lane intersections, right to turn left intersections and straight crossing sites. Roundabouts are also used at some intersections.

Left Turn Intersections

These intersections are identical to many of the left turn intersections on 2 lane roads in Canada. The intersection allows the road user to signal a left turn and then move to a dedicated left turn lane and negotiate the turn only when there is no oncoming traffic. In the 2+1 model these intersections are the same, however in some newer designs the barrier will be placed so that it curves out slightly and protects the left turning vehicle from a possible rear end collision from a trailing vehicle.

Traditional Left Turn Lane Intersection in Sweden (Google)

Right turn intersection – Ireland (equivalent to left turn lane in Sweden (Google)

TABLE OF CONTENTS

Right to Turn Left (RTTL) Intersection (Jug Handle)

This type of intersection is used in situations where it is more appropriate and safer to exit the roadway to the right, then turn perpendicular to the travelled road and stop. At the stop the road user can then look both ways and proceed across the road through an opening in the barrier and proceed straight across or travel back in the direction from which they came.

Example of a RTTL intersection in Sweden (Google)

Straight Crossing Intersections (Personal Entrances)

These types of Intersections are primarily used for crossing the roadway at very low volume locations which are usually used by land users or land owners only. They consist of an opening in the barrier that allows the land owner access to both directions of the road but is for access to that property only or for crossing from land on one side of the road to another.

Example of personal crossing in Sweden (Google)

TABLE OF CONTENTS

Road Painting and Markings

On 2+1 roads in Sweden and Ireland, painted rumble strips are used to divide the median barrier strip as well as the shoulder of the road in some locations. These rumble strips warn road users should they wander from their lane of travel. They are an important component of a safe road system and the Vision Zero principle. They are there to correct any road user error and put them back onto the correct path of travel while preventing a collision.

Painted rumble strip at cable terminal – Sweden (GEMS)

TABLE OF CONTENTS

Signage

With the implementation of 2+1 roads in Sweden and Ireland, there were some requirements to implement some new signage to indicate various road features to road users. Some of the signage that may be different from 2 lane roads include merging and merge warning signs, stop area signs, right-to-turn-left intersection signs and no left turn signs at certain intersections. Many signs are placed on both sides of the road facing the direction of traffic so that if the visibility of a sign is obscured by a large truck, the road user is still aware of upcoming changes in the road.

Barrier ahead sign – Sweden (Google)

Lane location sign – Sweden (Google)

Lane drop signs on both sides of road –Sweden (Google)

RTTL Sign Sweden (Google)

No Left turn sign – Sweden (Google)

2 lane length sign – Sweden (Google)

TABLE OF CONTENTS

Road Maintenance

Road maintenance on 2+1 roads, like any type of road is a vital component to the proper performance of the road. On 2+1 roads there are various components that need proper maintenance. The median barriers require regular maintenance. Some require more than others. Cable barriers may require tensioning as well as repairs when a vehicle contacts them. Solid steel barriers do not require tensioning but still require repairs when contact is made. In Sweden crews are carrying out maintenance and repair activities on a daily basis on the more than 3,000 km of 2+1 roads. These repair activities are usually as a result of collisions with the barrier by road users and this indicates that the barriers are doing a very effective job of preventing fatalities and serious injuries. Depending on the design and the extent of damage to barriers, repairs may be scheduled in a period of up to two weeks. Some barrier designs are still effective after a contact and therefore repairs do not always need to be immediate.

Set- up for maintenance activities on 2+1 roads are usually carried out on the two- lane portion of the highway, allowing traffic to move past on each side of the work crew. Barriers can also be removed or lowered temporarily to allow work to be done on the single lane side while allowing traffic to continue in both directions on the two-lane side using temporary traffic control measures.

In Ireland, any cable tensioning and maintenance takes place on a regular basis, however collisions causing damage to the barrier are often dealt with immediately if possible. In many cases repairs are made as any collision is being managed by emergency services and completed as the scene is put back into regular service.

Barrier repair traffic control (GEMS)

TABLE OF CONTENTS

Winter Maintenance

Winter operations on 2+1 roads are generally the same as 2 lane roads. This was a common answer to the winter maintenance question when posed to Swedish Officials. Some issues that can be a problem are with barriers on the side of the road, not the median barrier. Snow can accumulate to a greater degree on the side of the road with a W Style barrier as opposed to a cable barrier, as the snow passes through the cable barrier more easily.

There is significant snow fall in many parts of Sweden and plow operators remove snow, as is the practice in Canada, by moving snow from the centre and moving it to the edge of the road. When on the one lane section this process is straight forward and on the two- lane section it will require another pass similar to our passing or climbing lanes in Ontario. In Sweden, some plow operations are done in tandem where two trucks plow together.

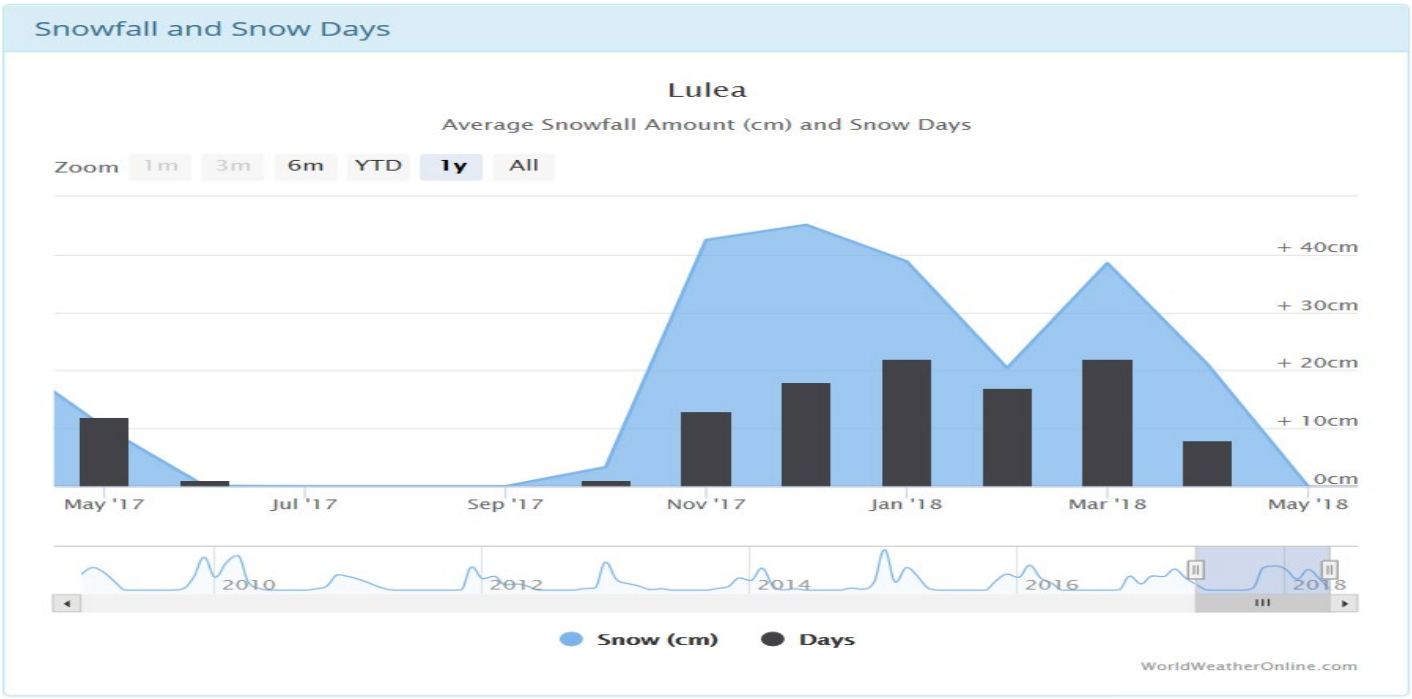
Winter in Northern Ontario and in Central and Northern Sweden are very similar. Snow amounts are similar as are temperatures. Temperature extremes in Northern Sweden are very similar to Northern Ontario however Northern Ontario will on average have slightly colder temperatures and depending on the region slightly greater snowfall.

The following graphs compare New Liskeard (Temiskaming Shores) in Northern Ontario Canada and Luleå in Norbotten, Sweden as an example of some of the winter weather similarities. The 2+1 roads in the Lulea area are E4 and E10 and these roads also extend further to the north and into climates that are harsher yet. The graphs indicate that snow and cold temperatures are common in Sweden and the same can be said of Northern Ontario.

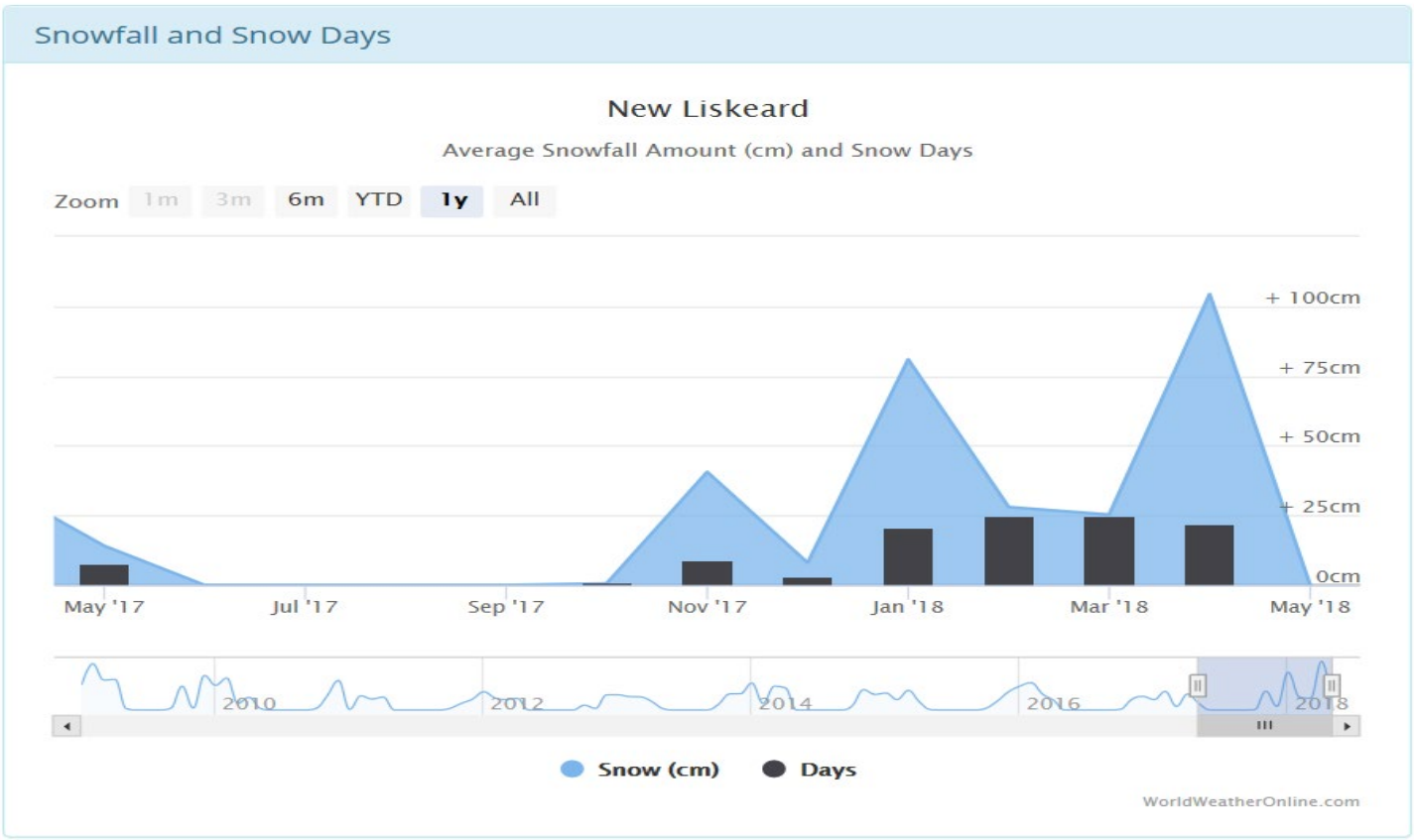
During the research trip in December 2018 more information on plowing operations was obtained. Sweden will also plow 2+1 roads with wide wing plows (see picture below) that allows the operator to move the plow out on the 2 lane sections and then retract it on the one lane sections. This operation works well but is not used in all areas. All new 2+1 roads in Sweden have at least one parking area in the one lane sections and these parking areas can be used by any vehicle but are also used by snow plow operators to pull over to allow traffic by if necessary. Because the one lane sections are not longer than 2-3 km, it is never a long wait to move past the plow. As mentioned above tandem plowing operations are used on some 2+1 roads as well.

Wide wing plow in Sweden (GEMS)

TABLE OF CONTENTS

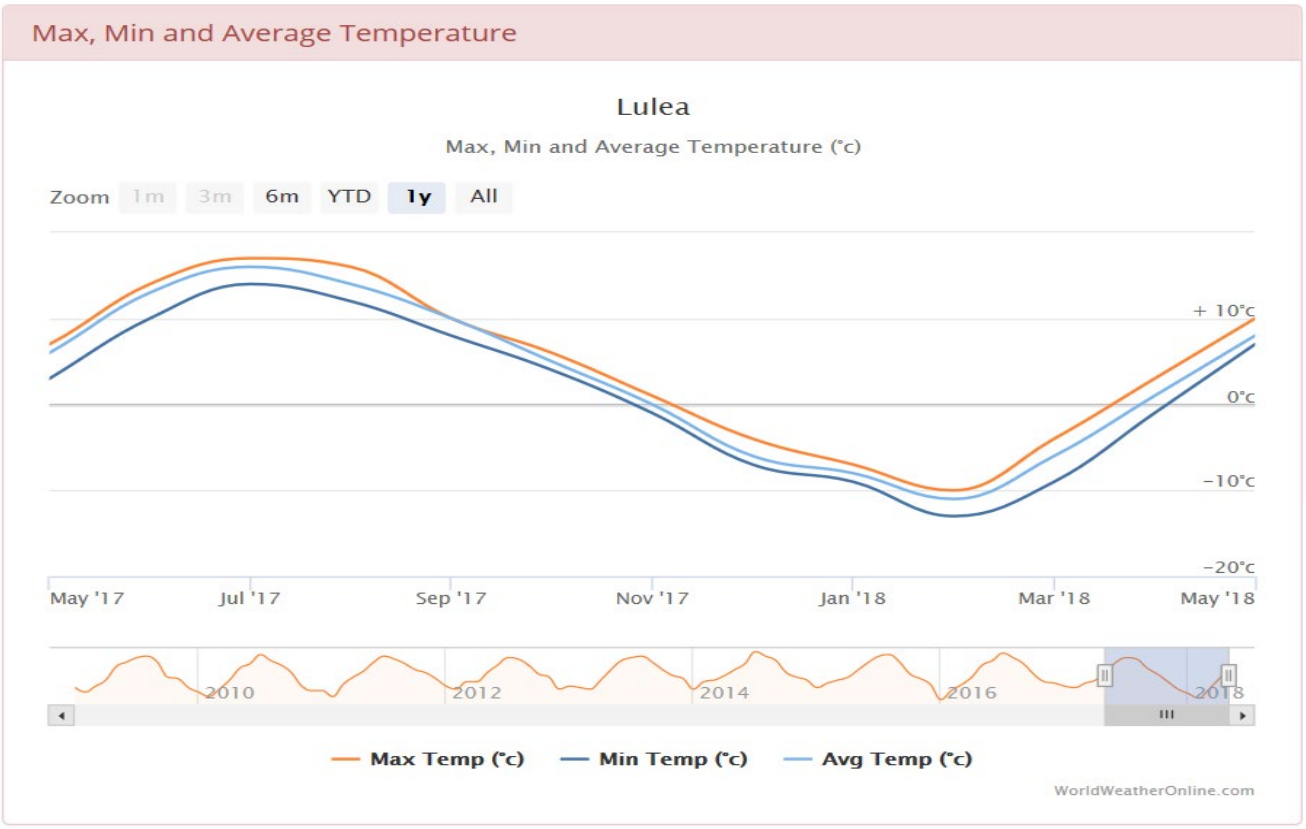


Graph of Snowfall in Lulea Sweden in 2017-2018 (WorldweatherOnline.com)

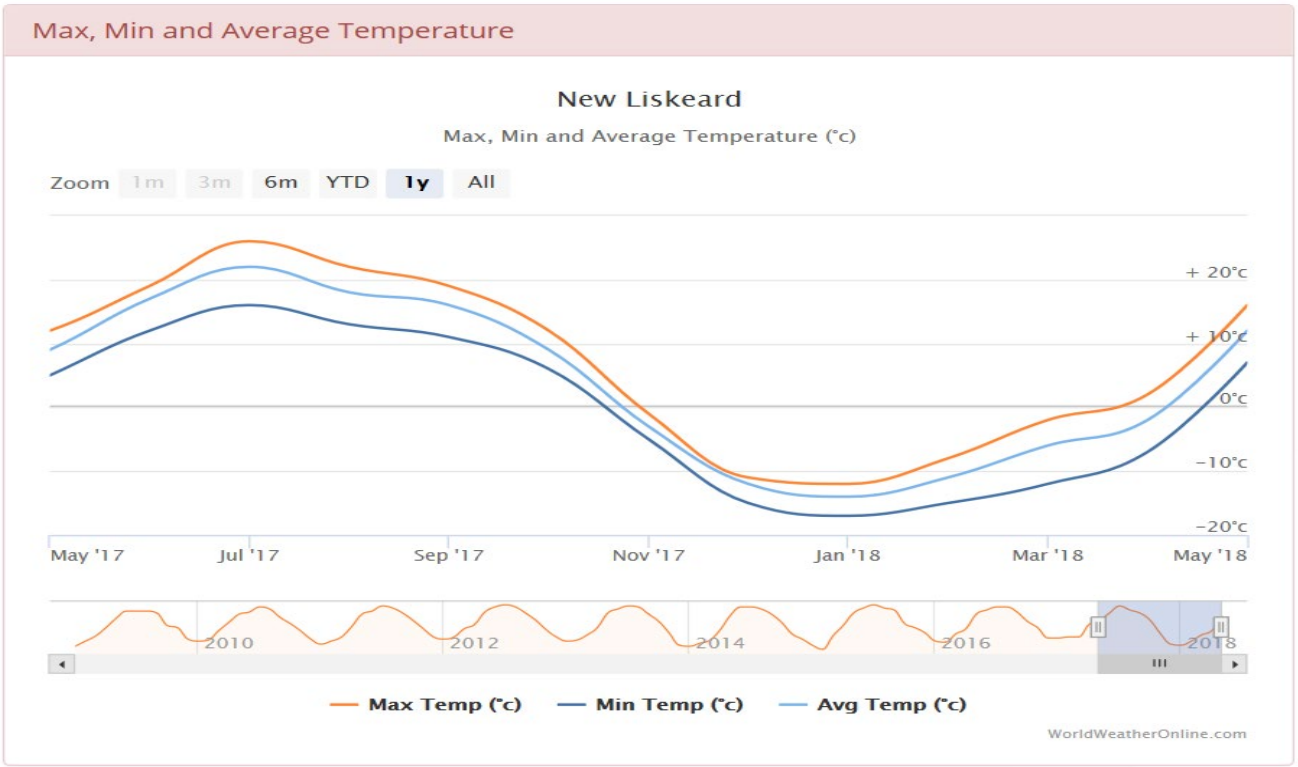


Graph of Snowfall in New Liskeard, Ontario, Canada in 2017 – 2018 (WorldweatherOnline.com)

TABLE OF CONTENTS



Average Temperatures for Lulea Sweden 2017-2018 (WorldweatherOnline.com)



Average Temperatures for New Liskeard 2017-2018 (worldweatherOnlin.com)

TABLE OF CONTENTS

Commercial Truck Traffic

In discussions with officials from Akeri, the Swedish Trucking Association which represents trucking companies and the trucking industry, the comments regarding 2+1 roads are good. They see the exceptional reduction in fatalities on the 2+1 roads and that means safer roads and fewer fatalities and traumatic situations for their members as well. There have been various studies regarding commercial traffic on 2+1 roads. One study looked at various length of trucks and how passenger vehicles would pass these different trucks on the 2 lane sections. It determined that there really was no difference in how they passed the commercial vehicles whether they were 18M or 30M trucks. This study was to determine if truck size could be increased to reduce the number of trucks on the highways.

In regards to general passing of trucks by passenger vehicles, if the passenger vehicle is attempting to pass the truck very late in a two -lane section, this may require the truck to do some courtesy braking to allow the car in.

Speed studies on 2+1 roads generally indicate that truck speeds remain much more consistent than passenger vehicles. These variable passenger vehicle speeds are due to acceleration at both the beginning and end of two- lane sections. Trucks are required to travel at 90km/hr on 100km posted 2+1 roads.

On 2+1 roads if a truck breaks down on the one lane section then obviously this can affect traffic flow, although this is generally a rare occurrence, at least one parking or "SOS" area is placed in each one lane section. The single lane side is also designed to allow two vehicles to pass at slow speed.

Truck on 2+1 – Sweden (Google)

Example of truck type in Sweden (GEMS)

TABLE OF CONTENTS

Emergencies

When an emergency occurs on a 2+1 road in Sweden or Ireland there are of course systems in place to respond to those emergencies. The response will come from the Emergency Services or from Road Authority personnel. The lane dividing barrier which divides the road can be a factor that may affect the response to the emergency. In Sweden the response is generally to call for Emergency Services from the direction which is appropriate for the correct side of the barrier. This however may not be suitable if the information delivered to emergency services is incorrect or if there are long travel distances for the appropriate emergency services. When emergency services or the road authority personnel arrive, regardless of the direction there is the option to lower the cable barriers manually or remove sections of steel barriers to access the emergency scene. As with any emergencies there are traffic delays that occur but they are cleared as soon as possible.

The other factor that both Swedish and Irish officials highlighted was that serious emergencies are much less common and therefore there are many fewer long vehicle rescues and long investigations on 2+1 roads. There are increased levels of contact with the lane dividing barrier which will sometimes require a response from Road Authorities but these contacts also indicate the avoidance of a fatal or serious collision.

Although Emergency Services may have some increased issues with the lane dividing barrier there are significant benefits for these workers in terms of very significant reduction of post traumatic stress issues due to the very significant reduction in fatalities.

Construction Processes

2+1 roads in Sweden are built on existing 13m roads. During construction of these roads, traffic continues to travel on the roads with obvious delays and speed reductions as we see in Canada on road construction sites. Because the road is being converted to a 2+1 profile there is a third available lane at certain times for traffic after construction has proceeded past a certain point. Construction crews will attempt to keep two lanes open, however when that is not possible traffic control will be implemented to have traffic share a single lane. Traffic control is often achieved by using portable traffic light systems and only occasionally with the use of a worker on the road. Occupational Health and Safety is of the utmost importance in Sweden. Worker protection on these roads under construction include, blocker trucks, portable worker protection barriers, speed indicator signs, portable speed bumps, and significant construction zone signage. The flow of traffic in these construction zones is generally good and delays are reduced as much as possible.

Posted speed on 2+1 construction project – Sweden (GEMS)

2+1 Construction Project temporary traffic control – Sweden. (GEMS)

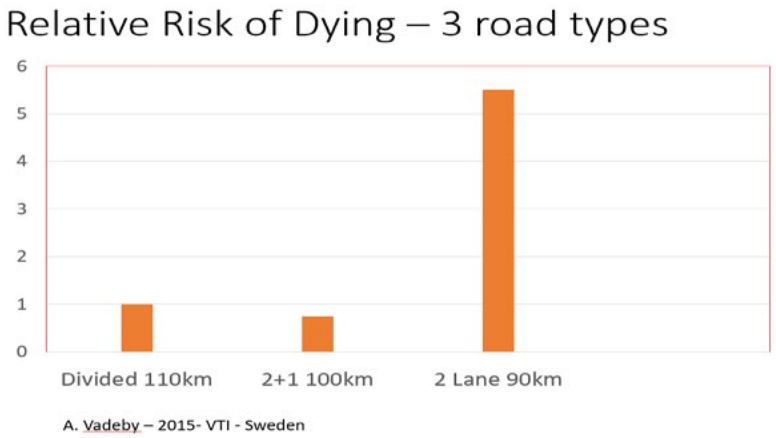
TABLE OF CONTENTS

Public Response

Various studies have looked at public response to the implementation of 2+1 roads. A Swedish study and an Irish study referenced surveys that have been done in both countries after implementation of 2+1 roads. In the Swedish case the 2+1 roads had been in place for a longer period of time and in the Irish case the study was done after the pilot project had been in place for approximately one year. In both surveys, public attitudes toward 2+1 roads had improved significantly. This was also the information received in both Ireland and Sweden during this research trip. There were many accounts of individuals and groups who were not in support of 2+1 roads and in some cases that opposition was very vocal. Now, however in both Ireland and Sweden the support for 2+1 roads is very high and the reason that most people support it is the very significant reduction in fatalities and serious injuries. It appears that it is part of everyday travel in rural Sweden and will become even more so as new 2+1 roads are being built.

Socio-Economic Factors

In a 2009 Swedish study, the societal benefits of road investments have been estimated. The study looked at "Road Safety Efficiency Value" which looks at capital cost per year divided by the annual decrease in fatalities. The efficiency value for fatalities is 7.4 million SEK (Swedish Kroner) (1.1 million CDN) for 2+1 roads and 2.5 million SEK ($385,000 CDN) for divided highways. These efficiency rates are considered quite high and translate to significantly less investment to save a life on a 2+1 road than on divided highways. It should also be noted that the relative risk of dying on a 2+1 road is much lower than on a 2-lane roads and slightly lower than on a four lane divided highway as demonstrated by statistics from both Sweden and Ireland.



Conclusion

Mobility and travel are vital parts of today's society. Mobility however should not necessarily be associated with significant risks such as death and serious injuries on our roads. As mobility and safety are important components of today's society, so too are efficiency and financial responsibility. When a 2+1 road design can match the safety performance of a four- lane divided highway at a significantly lower construction and maintenance cost, it clearly needs to be considered as a road model in areas where traffic volumes are best suited for its implementation.

Lastly, I would like to thank all those who assisted me with the research on 2+1 roads. Your assistance is very much appreciated. I would also like to thank the Ontario Ministry of Transportation for meeting with us prior to the trip to provide a list of questions regarding 2+1 roads. These were helpful as guidelines when discussing various issues with Irish and Swedish officials.

Mark Wilson – GEMS Committee

TABLE OF CONTENTS

Appendix

Swedish Contacts

Trafikverket – Swedish Transport Administration

Mats Remgard – *Road Safety Specialist*

Matts Ake-Belin – *Senior Advisor* (Vision Zero)

Lars Konigsson – *Project Manager*

Lisa Herland – *Engineer*

Per-Daniel Stoor – *Engineer*

Hans Holman – *Engineer*

Jesper Eriksson – *Vice Project Manager*

Jakop Andersson – *Project Engineer*

Dan Larson – *Land Negotiator*

Henrik Sjoblom – *Construction Manager*

VTI – Swedish National Road and Transport Institute

Dr. Anna Vadeby – *Researcher*

Johan Olstom – *Researcher*

Thomas Lundberg – *Researcher*

Terence McGarvey – *Researcher*

Tommy Petersen – *Crash Lab Manager*

PEAB Construction

Magnus Markang – *Project Manager*

Rickard Hagstrom – *Project Supervisor*

Per-Olav Soderman – *Site Manager*

AKERI – Swedish Trucking Association

Ulric Landberg – *Manager*

Irish Organizations and Contacts

Transport Infrastructure Ireland (TII)

Alastair DeBeer – *Engineer*

Albert Daly – *Engineer*

Harry Cullen – *Engineer (retired)*

Fiona Bohan – *Engineer*

Desmond O'Connor – *Statistician*

Keith Barry – *Road Maintenance Supervisor*

Helen Hughes – *Director of Professional Services*

Swedish Contacts – Dec. 2018

Swedish Transport Administration - Trafikverket

Annika Ohman – *National Coordinator – Road design team*

Hugo Naslund - *Manager- Road Maintenance*

Lotta Isaksson - *Manager - Road Maintenance*

Oskar Lundblad – *Specialist – Road Design*

Hakan Lind – Specialist – *Road Design*

Nordic Road Safety – Barrier Manufacturer

Anders Hamrin – *Marketing Manager*

Birger Larsson – *CEO*

SVBRF – Barrier Manufacturers Industry Association

Goran Fredriksson- *Manager*

References

[i] *Evaluation of 2+1 roads with cable barrier – A. Carlsson 2009*

[ii] *2+1 Roads with and without cable barriers speed performance – A. Carlsson, T. Bergh – 2009*

[iii] *2+1 Roads a Swedish Success Story- Bergh, T. Carlsson, A. Morberg, J. – 2009*

[iv] *Road Barrier Repair Costs and Influencing Factors – H. Karim, M. Alam, R. Magnusson – 2011*

[v] *The effect on passenger cars meeting margins when overtaking 30m trucks – J. Sandin – VTI – 2012*

[vi] *Traffic Performance on 2+1 Roads – Empirics and models – Olstan, J. ,Bernhardson, V., VTI – 2017*

[vii] *2+1 Roads a Swedish Success Story- Bergh, T. Carlsson, A. Morberg, J. – 2005*

[viii] *2+1 Pilot Programme Operational Safety Reviews & Monitoring - Bulpitt, M. – 2006*

[ix] Evaluation of 2+1 roads with cable barrier – A. Carlsson 2009

TABLE OF CONTENTS