

Combating Wrong Way Drivers on Divided Carriageways

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ABSTRACT

The issue of motorists entering the Auckland Motorway network via off ramps is a significant safety issue. This phenomenon of 'Wrong Way' or 'Ghost' drivers appears to be a growing issue around the rest of the country as the length of motorway and expressway grows and the driving population ages.

The bulk of motorists who make the mistake of turning down an off ramp against the traffic flow are people who would typically be deemed as competent drivers. These motorists appear to quickly recognise their error and make a hasty retreat.

Those drivers who make it past the off ramp and onto the mainline tend to be impaired drivers, either by way of drugs, alcohol or some age related impairment. It is these motorists who end up contributing to the death and serious injury road statistics.

Stopping these Wrong Way drivers once they are on a divided carriageway is a significant challenge. However there are some relatively simple tools that can be deployed to reduce the risk of a driver making a wrong turn in the first place.

The Auckland Motorway Alliance has successfully trialled some 'Wrong Way' detection technology as proof of concept and is now working towards the implementation of a raft of prevention measures.

Some of the findings the AMA has learnt are presented in this paper. There are also some helpful hints for all drivers to protect themselves, their families and friends against the risk of them featuring in the statistics as either a perpetrator or an innocent victim of Wrong Way driving.

1 - INTRODUCTION

The phenomenon of Wrong Way Drivers on multilane divided carriageways is a significant safety concern that currently claims the life of 2-3 people per annum in New Zealand and places many others at significant risk.

Wrong Way Drivers are sometimes referred to as 'Ghost Drivers'. In the context of this report, 'Wrong Way Drivers' are defined as:

- Motorists who make a wrong turn onto a motorway or expressway off ramp, i.e. turn into the opposing traffic flow.

Having made a wrong turn onto an off ramp the motorist tends to take one of two courses of action. They either:

- Recognise their error almost immediately and take immediate action to remove themselves from conflict; or
- Continue down the off ramp, either oblivious to their mistake or in a panicked state unable to think their way out of the situation.

Wrong Way Drivers can be categorised into three generic groups of motorist:

- Those motorists that would typically be deemed as competent motorists, but for whatever reason have been momentarily distracted, confused, be inexperienced drivers or drivers unfamiliar with NZ road rules and as a result have made a wrong turn; or
- Those motorists who are driving impaired; or
- Those motorists who have made deliberate choice to enter the network the wrong way, typically in an attempt to evade enforcement officers.

Based on historic crash records and conversations with the Auckland Motorway Police, impaired drivers can be grouped into two categories:

- Impairment through alcohol and / or drugs; or
- Impairment due to age related reasons.

At present, and historically, this issue of Wrong Way Drivers is most prominent on Aucklands' motorway network. However in recent years, there appears to be a growth of incidents, or at least an increased awareness of incidents around the rest of the country. This apparent increase in risk appears to arise from two principal areas:

- From a growing network of motorways and expressways there is a corresponding increase in the number of interchanges that are exposed to potential Wrong Way Drivers, and
- Through an aging population that is determined to hold on to their independence for longer and hence exposes the network to a higher concentration of aged drivers who may in fact be impaired for a variety of age related reasons.

Thus based on this, it is therefore reasonable to assume that if there are not adequate countermeasures deployed that the risk of incidents may increase further in time, primarily due to an ever increasingly aging population that wanting to remain mobile and independent.

The very nature of wrong way driving makes it a challenging issue to tackle. This paper explores some of those challenges and learning's from the Auckland Motorways experience.

2 – BACKGROUND

This section overviews the following elements:

- Understanding the Driver
- Risk by Time of Day
- Higher Risk Interchanges
- Some Key Enforcement and Design Issues
- Auckland Motorway Detection Trials
- Some International Experience

2.1 Understanding the Driver

Kemel, E. (2014) and Baratian-Ghorghi (2014) note some of the following characteristics of Wrong Way Drivers with respect to studies undertaken in France and in the United States respectively:

- That they are often the sole occupant of the vehicle
- 75% are male (Baratian-Ghorghi (2014)); 2:1 ratio Male:Female drivers (Kemel, E. (2014))
- 74% are experienced drivers
- 58% are alcohol related, this is double the typical rate for all fatal crashes
- 32% in the 25-45 year age range
- 33.5% in the 65+ age range making older driver over represented

The above patterns are similar to the Auckland experience.

2.1.1 The 'Competent' Driver

Detection equipment monitoring two Auckland motorway off ramps for wrong way movements are triggered almost weekly at each of the sites they monitor! In nearly every case, these drivers have recognised their error almost immediately (within 10-20m of entering the ramp) and have beaten a hasty retreat.

Consideration is currently being given to attempting to contact these motorists to gain further insight into the reasons they believe they made their error, and what alerted them to the fact that they had made an error. This will enable remedial action to be better targeted. It is assumed that most of the errors will have occurred due to distraction, confusion, inexperience or being unfamiliar with NZ driving rules.

The CCTV footage captured in Auckland from the sites being monitored indicate that drivers are making these mistakes 24 hours of the day.

2.1.2 The Impaired Driver

Impaired drivers tend to have a 'tunnel vision' when driving. That is they are most focused on looking directly over the bonnet and focusing most of their attention on keeping their vehicle within their lane. This means that most of the signage they pass is in their peripheral vision and hence is not noticed or comprehended and is therefore rendered largely ineffective. This presents a real challenge in that signage is the primary tool that is provided to the motorist to guide them through the network.

Impaired drivers are slower to react and hence information overload from too much signage (should they even note it), complex geometry or closely spaced decision points may increase the risk of making a wrong decision.

Auckland experience shows that most Wrong Way drivers who make it onto the main carriageway, do so during the hours of darkness. This mirrors international experience (see section 2.2).

It is also noted that the Wrong Way Driver who makes it onto the mainline, based on observations on Auckland's Motorways typically move to their left, the side of the carriageway that they would normally drive on. This places them in the 'fast' lane for the opposing traffic they face.

Over the past two decades, those motorists (except those evading enforcement) that have ended up travelling the wrong way on Auckland's motorways and involved in an accident (and hence able to be investigated) have been found to have been impaired in some manner.

2.1.3 The 'Fleeing' Driver

A driver trying to evade enforcement officers and deliberately driving the wrong way down an off ramp to evade capture is unlikely to be influenced significantly by way of any engineering solutions that are practical at this time.

No options are put forward in this paper to prevent this type of driver behavior. However the detection tools would provide an early alert to any such activity.

2.2 Risk Profile by Time of Day

The risk of wrong way drivers ending up on the main carriageway in NZ seems to be influenced by time of day and opposing traffic volumes.

Pour-Rouholamin, (2014) and Kemel, E. (2014) note that 80% of Wrong Way incidents occur at night time with 45% between 0200-0400hrs (Texas), and 55% between 1800-0600hrs (France).

2.2.1 Heavily Trafficked Interchanges

While incidents have been recorded during daylight hours on Auckland's motorways, these are rare. The most common time of day for incidents to occur is during the hours of darkness when opposing traffic volumes are relatively light. A vehicle stopped at the limit lines of an off ramp is an effective means for preventing a wrong way movement, and this is common on busy routes during daylight hours.

For the driver impaired due to alcohol and/or drugs, the hours of darkness corresponds to when there is less likely to be opposing traffic on the off ramps.

For the driver impaired due to age related reasons, the hours of darkness corresponds to the time of day that they are not typically out on the road and thus can lead to them becoming disorientated or confused more readily.

2.2.2 Lightly Trafficked Interchanges

Interchanges on motorway or expressways that have light traffic flows on the off ramps can be more susceptible to wrong way movements at any time of the day. This is because the likelihood of an opposing vehicle sitting at the limit lines of the off ramp, blocking the path for the Wrong Way Driver, is less likely.

2.3 Higher Risk Interchanges

Having on and off ramps adjacent to one another is a heightened area of risk for a driver to enter a network the wrong way. This situation typically arises in a couple of ways as shown in Figures 1 and 2:



Figure 1: Local road leading to on and off ramps



Figure 2: Parclo Interchanges with on & off ramps adjacent

While Auckland has experienced motorists entering the network the wrong way via interchanges of these types of design, experience has also shown that motorists can enter at locations that had previously been considered as relatively low risk sites.

Figure 3 highlights two features that would typically be considered low risk, but have also been exposed by impaired drivers.

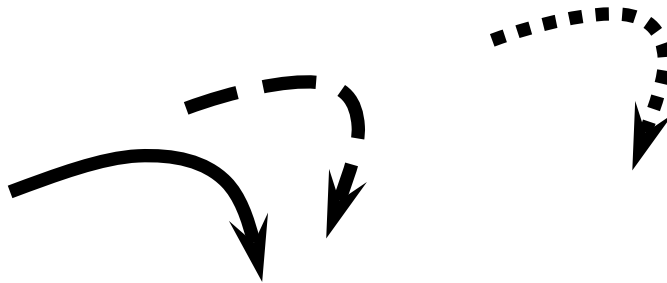


Figure 3: Typical Diamond Interchange layout



The presence of a divided median island would imply that the opportunity for someone to enter the network via the off ramp left turn slip lane (solid arrow above) would be near impossible; however has not been the case. The off ramp slip lane has been exposed to motorists already on the wrong side of the local road carriageway when approaching the interchange! Thus such features also need consideration when assessing risk.

An obtuse right turn onto an off ramp (dashed arrow above) would normally also be considered low risk. But for this particular site, as the on ramp (dotted arrow) requires the motorist to turn through 130 degrees, a motorist who is familiar with the site, but mistakes the off ramp for the on ramp would not think anything of turning past 90 degrees to enter the motorway as anything out of the ordinary.

Thus experience has shown that any interchange can be at risk and all approaches, however unlikely on face value to be at risk, should be assessed.

From Auckland experience, risk appears to be greater for the right turn movement onto the highway than for the left turn movement. This stems from the fact (when driving on the left hand side of the road), for a left turner the on ramp will be the first turn they come across and is more intuitive to take as it will often have geometry to compliment this, i.e. a slip lane. On the other hand, the right turner will typically pass an off ramp before getting to the on ramp, thus if they make a mistake and turn early they will end up on the wrong ramp.

2.4 Some Key challenges

2.4.1 Enforcement

For most driving enforcement, we presently rely heavily on the use of technology by way of speed or red light cameras and the presence of the police to intervene. These traditional methods of response are somewhat limited in the case of Wrong Way Drivers.

While it is possible to use a camera to record an infringement, action needs to be immediate due to the high risk posed by the Wrong Way Driver to other road users. Thus while a camera is ineffective in terms of being used as a deterrent, detection technology can be used to send an immediate alarm to those monitoring the network so that they can advise Police of the need for action and set warning messages by way of Variable Message Signs (VMS) for other motorists to advise them of the approaching risk.

Motorists can be warned of an approaching Wrong Way Driver by way of VMS, however these are typically spaced infrequently on our motorway networks, thus their impact can be limited. This is compounded when there are lots of entry points due to closely spaced interchanges.

While the Police can be given early warning, their actions are limited as they will not pursue the motorists down the wrong side of a highway as this also places them and other motorists at further risk. If Police cannot attract the attention of the Wrong Way Driver, while tailing them from the correct carriageway, the remaining option is to enter the carriageway downstream of the Wrong Way driver and set road spikes but this can be difficult to achieve within the timeframes available.

2.4.2 Interchange Design

While there are 'standard' interchange arrangements, diamond, half diamond, clover etc on Auckland's network they are all subtly different due to the adjacent site specific constraints. This may result in a very compact interchange or having the principal cross road at differing angles, or ramps intersecting with the local roads at locations that are simply not intuitive. This creates a challenge in that many 'standard' treatment solutions may not fit into the 'standard' interchanges that have been or are being constructed. This makes it difficult to recommend a single best practice solution, thus this paper presents a range of tools for designers to consider.

2.5 Auckland Motorway Detection Trials

In response to the growing concern over the number of Wrong Way Drivers, the Auckland Motorway Alliance (AMA) trialed some detection equipment at two motorway off ramps. The first was installed in 2011 at Newton Road and the second at Union Street in 2012. Off the shelf cameras were installed at these sites and were calibrated to recognise movement travelling the wrong way down the off ramps. These cameras were to serve two purposes; one to test if detection, and hence early warning was possible and secondly to record the offending movement so that the reason behind the movement could be better understood with the view to identifying remedial works.

On detection of a wrong way movement the cameras, that are recording continuously, saves footage to file from 30 seconds prior to the trigger until after the movement ceases to be detected. On triggering, wig wag lights are also set off on the 'Wrong Way - Go Back' signs to try and attract the driver's attention to the fact that they have made a wrong turn.



Figure 4: Union Street Trial Site – Signs with flashing lights and Camera detecting Wrong Way Vehicle

These cameras have served this purpose well in understanding the potential for detection and monitoring. However they do have limitations as it is effectively one piece of equipment trying to undertake two separate tasks (detection and monitoring) and hence some compromises result. Being camera based detection the units can also be affected by weather conditions such as moving clouds or driving rain resulting in false triggers.

As part of a wider rollout of detection and monitoring for the Auckland Urban Motorway network due to start early 2015, there will be a dedicated radar based detection unit and dedicated camera monitoring unit at each site. This will enable false alarms to be minimised as the detection equipment can be dedicated to the one task and the monitoring cameras can be positioned for best coverage to understand the preceding vehicle path.

2.6 Highlighting Some International Experience

Papers by Pour-Rouholamin, (2014), Kemel, E. (2014) and Baratian-Ghorgi (2014) provide a sample overview of a range of data analysis and treatments that have been trialed and are in use in the States and Europe. Cross references are made in Section 3 where they relate to the effectiveness of particular treatments.

2.6.1 Road Spikes

Uni directional road spikes that deploy when triggered on the ramps have been considered in several jurisdictions but have largely been discounted. This is on the basis of concerns that motorists approaching them, in the correct direction of travel, are unlikely to understand that they can safely traverse them and may lead to erratic movements from them, endangering themselves and others.

2.6.2 Illuminated signs

Illumination of Wrong Way signage appears to be the commonly promoted approach for warning motorists that they are travelling the wrong way.

2.6.3 Radio and VMS messages

Some jurisdictions have the ability to interrupt radio broadcasts and issue warnings to motorists that a Wrong Way Driver is approaching. More common however is the use of VMS to warn motorists. This approach of using VMS has been used on Auckland Motorways to issue a warning along with the advice for motorists to move left out of harms way. The challenge is that these signs are spaced some distance apart so cannot alert all traffic quickly.

2.6.4 Embedded Pavement Warning Signs

In 2012 a trial started in Denmark and in Germany using signage embedded into the road surface. The signs are laid in strips in a sinus-milled area such that they are only visible to traffic approaching from the wrong direction. Early reports are that this has been very successful with no reports of Wrong Way Drivers since the trials began.

Due to issues with milling a sinus profile in Open Graded Porous Asphalt (OGPA), the Auckland Motorway Alliance is presently looking at modifying this concept to achieve a similar effect by using laser light to project warning signs onto the pavement to alert motorists. This approach would not be affected by resealing as it is a projected image onto the road surface rather than an embedded image in the road surface.

3 - THE TOOLBOX

The following pages present arrange of tools that could be used to help reduce the likelihood of Wrong Way incidents occurring. The tools identified are largely the result of a series of nighttime inspections undertaken on the Auckland Motorway network that highlighted vulnerable aspects of the network. The inspections were undertaken over the period September to December 2014, covering every motorway and expressway interchange (that were not the subject of a current Capital Project works site). This review was undertaken at night time, being the time of day that most incidents have been recorded. The audit team comprised safety engineers and 'human factors' personnel.

Some of the tools presented are already in common use overseas to target Wrong Way driving. Due to the limitation of the length of this paper, only a selection of tools can be presented. For the full toolbox, contact Auckland Motorways (see Section 3.18).

3.1 Height of Wrong Way Signs

Typically road signs are installed at a height of up to 2.5m clearance to their underside in urban areas to provide clearance for pedestrians and cyclists. We tend to follow suit on off ramps for the Wrong Way signage, yet there are no pedestrians or cyclists to contend with.

Impaired drivers tend to have their sights focused over the bonnet of their vehicle and down to the road surface. This makes Wrong Way signs erected at 2+ metres in height, less effective as they are more likely to be out of the peripheral vision of the driver. Overseas practice suggests lowering the height of these signs to be more in line of the driver view.



Figure 5: Sign placed at approximately 2.5m in height is likely to be out of the line of vision for impaired drivers.

The California DoT (Pour-Rouholamin, (2014)) has used this technique since the 1970's with evaluation indicating a reduction in Wrong Way incidents from 50-60 per month to 2-6 per month for impaired and elderly drivers.

If Wrong Way signs have to be placed above driver eye height; consideration could be given to placing a reflective strip on the sign support pole to draw the driver attention up from ground level. This practice is adopted overseas in some jurisdictions, however the effectiveness is unknown.

3.2 Target Value of Wrong Way Signs

In order to increase the target value of the Wrong Way signs it is recommended that the larger 'Wrong Way – Go Back' signs are used. Not only does this present a larger target value, but they also give a clear direction as to what action to take. If detection is present at the site then consideration to drawing further attention to the sign by illuminating it is recommended. This can be achieved by using a steady light or the use of wig wag lights.

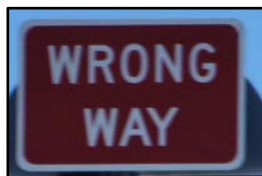


Figure 6:
The traditional Wrong Way sign has a lower target value



Figure 7:
Larger Wrong Way sign with increased target value and clear action point



Figure 8: Sign with wig wag lights

The Texas DoT (Pour-Rouholamin, (2014)) found that flashing lights reduced the frequency of Wrong Way incidents by 30% with a Benefit Cost of 13.1:1 in only 1.5 years.

3.3 Location of No Right Turn Signs

When provided, these are typically located in the median. The location should be such that they are clearly visible to a motorist stopped at the limit lines. Where the limit lines are located near the end of the median, and hence the RG 8 sign is located behind the stopped position of the driver, consideration should be given to relocating the sign forward, pulling the limit lines back, or extending the median island forward to allow the sign to be relocated. The object is to ensure that the driver cannot forget about the sign while stopped at the limit line.

Care needs to be taken to ensure that the sign does not obscure visibility to conflicting movements that may be existing from the off ramp.

3.4 Use of Simple Diagrammatic Signs rather than Stack Signs

The use of simple diagrammatic signs indicating interchange layout and relative location of on and off ramps is a relatively quick way of absorbing information. In contrast stack signs can take longer to interpret. A diagrammatic sign also is more intuitive for those with a language barrier.



Figure 9: A Stack sign can take longer to interpret.



Figure 10: While this sign is uncluttered and hence quick to interpret, it excludes the relative location of the off ramps. This may lead to a motorist entering the wrong ramp.



Figure 11: Diagrammatic sign clearly indicating the relative position of the on and off ramp locations

3.5 Visibility of other Signage on Off Ramps

Signage placed for other road users on alternative carriageways, should be placed such that the front face of the signage cannot be seen by a driver navigating an off ramp in the wrong direction of travel. Seeing regular road signs that a motorist is used to passing by, placed for adjacent road users, may give the impression that all is normal for the Wrong Way Driver as they expect to see such signs when driving.



Figure 12: Permanent warning sign for busway visible from off ramp

3.6 Traffic Signals – Green Arrows

Current practice in New Zealand (NZ), with a few exceptions, is to only use arrows on traffic signal aspects for turning traffic. It is recommended that for the through movement adjacent to the median (i.e. the traffic that will turn right onto the on ramp downstream) that they are presented with a green straight ahead arrow to reinforce the direction they are to travel through the intersection, rather than relying on advising what you cannot do, i.e. the provision of a No Right Turn sign.

Pour-Rouholamin, M., et al. (2014) supports this approach to reinforce the expected action, and that this consequently reduces the likelihood of Wrong Way incidents occurring.



Figure 13: Typical Signals at a diamond interchange



Figure 14: Proposed green Arrow at a diamond interchange

Note: This treatment may not be able to be used in the few cases were the left turn onto the on ramp is signalised and shares a common limit line with the through movement.

3.7 Sea of Red

A concept that has been identified but has yet to be worked through is described as providing a ‘Sea of Red’ to alert motorists that they are entering an off ramp and shouldn’t be there. The typical signs at the entry point to an off ramp are No Entry, Wrong Way, No No Pedestrians, No Cyclists and No Right Turn signs are predominantly red. Thus providing a ‘Sea of Red’ as an alert is the concept; and that you should never pass through these signs.



Figure 15: Creating a band of signs, a ‘Sea of Red’ as viewed from the limit line for turning traffic into the off ramp

The issue at present is that motorists will pass similar standalone No Pedestrian and No Cyclist signs when entering an on ramp. It is therefore recommended to use the combined on ramp sign for all on ramps. This combines the Speed Limit, Motorway Begins and No Pedestrian and No Cyclist information in one sign. This changes the format (look and feel) of the No Pedestrian and Cyclist information; i.e. it is OK to pass this information (style of sign) on an on ramp but not when the same information is presented in a more traditional format that would then only be seen on an off ramp.

3.8 Overhead Lane Assignment Signs

Where the principal cross road / interchange passes beneath a highway then overhead lane assignment signs should be considered and placed on the overhead bridge structure as these provide simple clear direction for motorists. For multilane approaches through an interchange (3 or more lanes) where a bridge or structure is not located such that it is suitable for erection of overhead lane assignment signs then an alternative structure to house these signs should be considered. Complex lane diagrammatic signs to the side of the carriageway should be avoided.



Figure 16: Lane assignment diagrammatic sign – Too much information to absorb quickly, & in this case too far to the left of the carriageway for right turners.



Figure 17: Simple Diagrammatic sign – Quicker to comprehend



Figure 18: Overhead Lane Assignment Sign giving clear guidance as to which lane to be in. Compared to Figure 16

3.9 Supplementary 'Tourist Arrows' on Off Ramps

Should a motorist progress down an off ramp past the various signs placed at the top of the ramp, there are then, typically, no further visual clues that they are going the wrong way other than any motorists who are approaching them. A simple low cost solution would be to paint straight ahead arrows on the pavement in the correct direction of travel, as are deployed at various locations on the State highway network for foreign drivers at rest areas. These would need to be located where the ramp is still a single lane before any short turning lanes are developed. This is a visual clue placed on the pavement, the area that impaired drivers tend to focus on. This option is based on the Wrong Way 'Tourist' arrow.



Figure 19: Supplementary direction arrows marked to reinforce direction of travel

Schrock, et al (2005) evaluated the effectiveness of directional arrows on two way frontage roads with results indicating a reduction of 90% of Wrong Way movements.

This section and Section 3.10 suggests a subtle variation on this theme. See also Section 3.16.

3.10 Supplementary straight ahead arrow

Motorists intending to turn right onto an on ramp typically have to first pass the corresponding off ramp. In Auckland's context this is typically a signalised intersection. Leading up to the limit line there are often straight ahead arrows painted on the pavement. Past the limit line but prior to the right turn these arrows change to right turn arrows. Consideration could be given to placing a supplementary straight ahead arrow within the intersection that is immediately visible to the driver stopped at the limit lines.



Figure 20: A supplementary straight ahead arrow located immediately in line of sight of a driver stopped at the limit lines.

This helps reinforce what to the driver what action they are allowed/supposed to do. This is considered easier information to process than a myriad of information advising the driver what they are not allowed to do. This could be used where it is not possible to locate the no right turn sign such that it is visible to a motorist stopped at the limit lines or where it is not possible to utilise a straight ahead traffic signal aspect.

Care is required to ensure that placement of a supplementary arrow does not impact on vehicle stability for, such as, motorcyclists turning right from the off ramp. Therefore the use of high friction paint markings should be considered.

3.11 Maintenance of Off Ramp Limit lines

Limit lines at the end of off ramps wear and can become very faded over time. This simple painted line across the carriageway is an important visual clue that a motorist should not enter the off ramp. Maintenance of these limit lines in top condition is recommended.

3.12 Design of Median Islands

Median islands should be extended as far into the intersection as possible without impacting on the tracking for any vehicles exiting the adjacent off ramp; special care needs to be taken for the tracking of heavy vehicles.

Dependent on other site geometry, pushing the island forward such that the medians nose sits in line with, or proud of, a line extended out from the left hand kerb of the off ramp:

- Should, when the limit lines are also brought forward, help lessen the prominence of the off ramp in the view of a potential Wrong Way driver as the off ramp starts to move into the peripheral vision of the said driver, and
- creates an obtuse turn onto the off ramp making it physically harder to make.

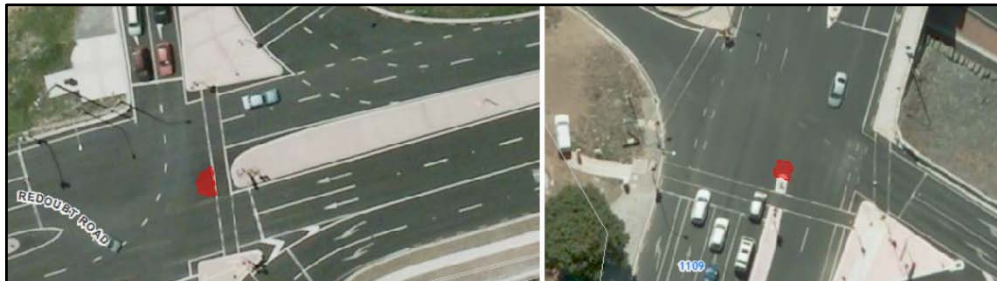


Figure 21: Extend the median island so as to distract from a potential right turn movement.

3.13 Median Separation for adjacent on and off Ramps

For on and off ramps situated adjacent to one another, any median barrier present should stop short of the end/start of the ramps. By having a median barrier extend to the limit line of the off ramp, it can disguise the presence of the on ramp, increasing the dominance of the off ramp, thus raising the risk that a motorist may turn into the wrong ramp. Clear visibility of the first 20-30m of the on ramp is recommended. A raised median island could be used in the place of the median barrier to keep the lanes physically separated without down playing its presence.



Figure 22:
Median barrier hindering conspicuity of the on ramp



Figure 23:
Clear visibility of both on/off ramps

The use of illuminated ground studs should also be considered in situations where the interchange format is in a parclo format.

3.14 Misleading Kerb Lines

In most cases there is no need for a large radius kerb line for the right hand kerb of an off ramp as vehicle tracking is not normally an issue. These kerb lines should be kept square as the radius can give the impression that the side road allows a left turn in. Squaring up the kerb line has two benefits; firstly it visually narrows up the 'side road' such that it does look like it should be turned into. Secondly it squares up any pram crossing (if present) and hence reduces the pedestrian crossing distance.



Figure 24: A curved edgeline is not ideal



Figure 25: Squared up edge lines are a better choice

3.15 Edge Line markings through Interchanges

Strong edgeline guidance should be used to direct motorists past off ramps. This is particularly important when other infrastructure such as kerb lines provide visually misleading clues.

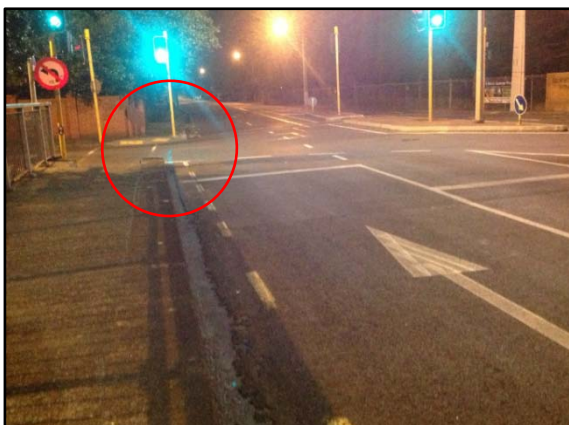


Figure 26: The misaligned kerb does not provide strong guidance through the off ramp. The NSAAT lines lead directly into the side road kerb face

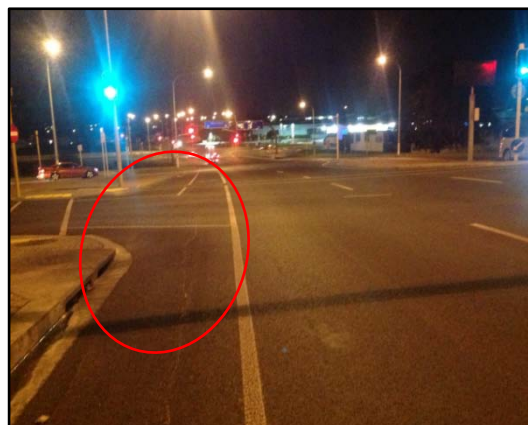


Figure 27: Example of good use of strong guidance past an off ramp

3.16 Local Road Transition to Divided Carriage way

Where a local road transitions into a divided carriageway or a roundabout is present it is recommended that audio tactile profile (ATP) markings are used in the median on the approach to the divided carriageway. The risk of someone crossing the center line unintentionally is lessened with the use of ATP.

Unless the driver is already on the wrong side of the local road on an approach to a divided carriageway, the underlying reason for crossing the centerline, along with fatigue, is likely the result of other visual clues, i.e. vegetation disguising the road geometry, road side infrastructure leading the eye the wrong way or poor lane delineation in inclement weather. These aspects should also be considered for treatment.



Figure 28: Local road transitions to on/off ramps should have ATP applied where indicated

To combat those motorists who may already be on the wrong side of the local road, consideration to using the 'Tourist' arrow on the approach to the divided carriageway is recommended to reinforce the correct direction of travel.

Schrock, et al (2005) evaluated the effectiveness of directional arrows on two way frontage roads with results indicating a reduction of 90% of Wrong Way movements. See also Section 3.9.

3.17 Location of ADS Signs

Due to the physical constraints of many interchanges, the options for locating Intersection Destination Signs (IDS) and Advance Destination Signs (ADS) can be limited. In the example below, the ADS sign is located in line with the off ramp. Thus there is the potential for a motorist sitting at the limit lines to interpret the arrow pointing right for the motorway to turn right at that point. In this scenario a diagrammatic sign that also indicates the presence of the off ramp would be better. Alternatively locate the ADS sign on a cantilever downstream on the over bridge past the off ramp.

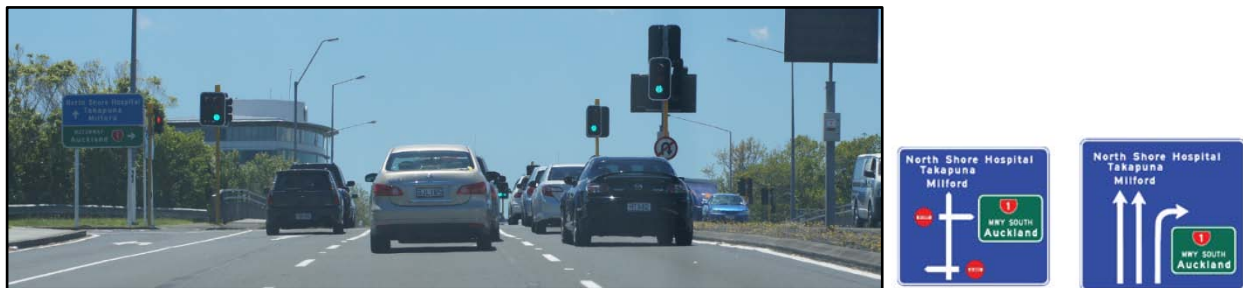


Figure 29: The location of IDS and ADS signage can be misleading as indicated in the photo above. Alternative sign design in this case may provide more intuitive information.

3.18 Other Considerations

Due to the limitation of the length of this paper, only a selection of options can be presented. For the full toolbox, contact Auckland Motorways.

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Greenlane, Auckland 1542.

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Other considerations include, but are not limited to:

- Signs – oversize, font size & style, illumination, orientation, relative heights
- Line marking – illuminated ground studs including follow me sequencing
- Barriers - Trailing end terminals & trailing end transitions
- Vegetation - set back, visual leads
- Orientation of pedestrian crossings
- Detection Systems - Loops
- VMS - warning messages, Ramp Signaling infrastructure
- Projected warning signs
- Embedded pavement warning signs
- Licensing – Testing for aged drivers

3.19 Take home messages - Protect yourself and your family

Don't be lazy and travel in the fast lane when traffic volumes are light

Experience has shown that nearly all Wrong Way Drivers will instinctively move to their far left when they enter the mainline (for countries that drive on the left hand side of the carriageway). This is the 'fast lane' for traffic travelling in the correct direction of travel. When traffic volumes are light, which corresponds with the most likely time to encounter a wrong driver, there is usually little need to stay in the fast lane following completion of an overtaking maneuver. Therefore the risk of you being involved in an incident can be significantly reduced by simply staying out of the fast lane.

- A Part Every Driver can Play -

Look after your elders

Too often we hear about elderly drivers involved in fatal and serious car crashes. In many cases it is later discovered that the family had concerns about the ability of their elders to continue driving competently; or that their licenses had been rescinded yet it was known that they were still driving. This may require a little more effort on the part of the wider families to monitor and act so to protect these vulnerable drivers. They protected and nurtured you when you were young, it may now be your turn to reciprocate and protect them.

- A Part Every Family can Play -

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