UNDERSTANDING VULNERABLE ROAD USER CRASH RISK
(ON AUCKLAND'S HIGH RISK ROUTES)

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ABSTRACT

Like many large cities Auckland's busy and high-risk arterials carry the bulk of traffic flows and include a mix of active/vulnerable road users (cyclist / motor-cyclist / pedestrian). Auckland Transport is adopting Vision Zero and understanding vulnerable road user crash risks on such routes can be difficult due to the wide variety of factors that lead to crashes and the diverse nature of such users, which include many types of impairments. To supplement the limited information available on crash risk from crash history, two new methods have been developed. The Crash Risk Assessment Framework (CRAF) extends the Austroads safe system risk framework (where risk is broken down into exposure, likelihood and severity) to include several new pedestrian and bicycle crash types. CRAF can be used to assess the risk of serious and fatal crashes for existing routes and improvement projects at intersections and short (50 to 200m) mid-blocks. The multi-user assessment framework (MUAF) is a route inspection method that records and rates (from low to extreme) safety issues through observing road user behaviour and looking at operational matters along with design and maintenance faults. It considers different types of active/vulnerable road users including those with visual, hearing, sensual and physical impairments due to age, disabilities and temporal impairments (e.g. alcohol). The CRAF method focuses attention on medium to higher severity issues and speed management, while the MUAF method typical, but not exclusively, identifies lower cost improvements and maintenance activities. This paper will present the use of these tools on Mt Albert and Carrington Roads to assess the crash risk on the existing route and a number of improvement options. The paper also presents the GIS mapping tool that has been developed to display the results of the analysis.

INTRODUCTION

Since 2014 Auckland's road deaths and serious injuries has increased by more than five times the rate of travel growth and triple the rate of the rest of NZ. In 2017, 64 people died and 749 were seriously injured on Auckland's roads. A significant proportion (45%) of these deaths and serious injuries involved active/vulnerable road users (pedestrians, pedal cyclists and motor-cyclists/moped). In the urban environment a relatively high proportion of serious injuries and deaths occur on urban arterials (80% in Auckland). Auckland Transport (AT) recognised the safety challenge of urban arterials in Auckland. The study presented in this paper is one of several that is looking at how to target and address the risk factors that lead to trauma crashes.

AT have adopted a 'vision zero' policy that concludes "It can never be acceptable that people are killed or seriously injured" on Auckland's roads. It is acknowledged that to achieve vision zero (i.e. to eliminate death and serious injury) there needs to be a paradigm shift in responsibility from the 'people using the roads' to the 'people designing and operating them'. A key focus is on moving towards a safe (transport) system, which will require infrastructure changes and speed management and a focus on active/vulnerable road users. It is also important to 1) identify behaviours by road users that require education and enforcement to change and to 2) take into account other outcomes desired on each route for these vulnerable/active road users, like those assessed as part of a) non-motorised user audit (Department of Transport, 2005) b) healthy streets review (Transport for London, 2017a and 2017b) and c) walkability review (Abley, 2011).

To target and address fatal and serious crash risk on urban arterials in Auckland a safe system investigation process (SSIP), that incorporates the following steps, has been adopted by AT:

1. Route Prioritisation Process to identify high risk routes and the high-risk sections

2. Diagnosis of Safety Issues on routes using CRAF/MUAF and (historical) Crash Data

3. Development of Improvement Options that achieve or move towards a safe system

4. Development and use of new tools to support Funding Applications

5. Implementation of improvement options that maximise highest benefits

AT use a number of performance metrics to identify the high-risk urban arterials, including Urban KiwiRap risk mapping (Step 1). This risk mapping is based on historical crash data. AT have developed and agreed a list of high-risk urban arterials to target improvement works. This list includes the Mt Albert Road and Carrington Road corridors discussed in this paper. This paper outlines the diagnosis tools that were developed at a road segment level to identify safety issues (Step 2) were developed along with a list of potential improvement options (Step 3) to address the identified crash risk. This method has been applied to Mt Albert Road and Carrington Road and a number of other high-risk urban arterials in Auckland.

CRASH DIAGNOSIS TOOLS

Three methods were used to diagnosis the safety issues faced by vulnerable road users. This includes the traditional analysis of historical crash data. Historical crash data is useful for prioritising high-risk routes and for understanding general crash trends along a corridor (e.g. high number of pedal-cyclist crashes). Crash data is often not particularly useful for active road users at a detail road element level (intersection and short mid-block lengths) due to the relatively low crash numbers, especially the more severe crashes. Low crash numbers may also reflect a low usage of the route by some active/vulnerable road user types (e.g. bicyclists), as high crash risks may put off some users, resulting in a high latent demand. Using historical crash analysis method, it tends to drive a reactive outcome rather than a proactive / safe system solution that can prevent fatal and serious crashes from happening in the first place. Hence two additional crash diagnosis methods (CRAF and MUAF) have been developed that help crash investigators understand the risk faced by different road users as they use arterials roads, where crash data is not sufficient on its own.

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Crash Risk Assessment Framework (CRAF)

This process is based on the Austroads' Safe System Assessment Framework (Austroads, 2016), which breaks crash risk into an assessment of exposure (volume of users), likelihood (e.g. crossing facilities provided) and severity (operating speed). This framework looks at the risk of DSi for key crash types on urban and rural roads. Crash types include, loss-of-control. head-on, intersection, pedestrian, cyclist and motor-cyclist. For each crash type, the exposure, likelihood and severity is scored from 0 to 4, with 0 being no risk (e.g. there are no pedestrians allowed on the road) through to 4, high risk of a DSi. The score for exposure, likelihood and severity are then multiplied together to produce an overall score for each crash type. A high score (maximum of 64) indicates a very high risk. Many jurisdictions, especially in Victoria are using this framework to assess routes and safety improvement projects.

CRAF includes a more detailed breakdown of pedestrian and cyclist safety, through adding different pedestrian and bicycle crash categories (only one for each in Austroads Framework) and by removing crash types that are not common in urban areas (e.g. head-on crashes). The CRAF focuses on ten different crash types that can occur on urban arterials, including three pedestrian, four cyclists and one each of pedestrians versus cyclists, motor-cyclists/mopeds versus cars and intersection (motor-vehicle only). Rarely do all ten crash types features on a road section. The ten crash types include (diagrams for each crash type are provided in Appendix A):

1. Pedestrian crossing side road/access vs left and right turning vehicle (P1)

2. Pedestrians crossing main (study) road vs through vehicle – uncommon (P2)

3. Pedestrian crossing side road/access vs through vehicle (at crossroad) (P3)

4. Pedestrians vs cyclist conflicts (on shared path or footpath) (P4)

5. Cyclists sideswiped by vehicle on a mid-block section (C1)

6. Cyclist vs right and left turning vehicle (emphasis on right turning) (C2)

7. Cyclists sideswiped by vehicle through intersection (often extra lanes) (C3)

8. Cyclist on main road vs through vehicle on side road (at crossroads) – uncommon (C4)

9. Motorbike vs turning vehicle (at side road or access) (M1)

10. Intersection – vehicle vs vehicle (4 wheel plus - turning in and out of side road and access) (V)

The CRAF process is undertaken at a road element level along a specific corridor (it has been developed for urban arterials). Typical road elements vary in length from 50 to 200m. This can include major intersections (traffic signals & roundabouts), and road lengths that include; railway level crossings, bridges, priority cross-roads (especially across three or more lanes), one or more priority T-intersections, school or other vulnerable user crossings. Element boundaries also occur at speed limit changes, change in number of lanes (including addition of bus lanes and clearways), bus stop sections (especially when bus stops are provided on both sides of road) and land-use changes (e.g. higher numbers of commercial/industrial accesses).

For each road element a score is calculated for each relevant crash category for 1) exposure, 2) likelihood and 3) severity. The raw score ranges from 1 to 5 for exposure and 1 to 4 for likelihood and severity depending on the level of risk. For exposure the risk is dependent on the number of road users of each type that might collide. Depending on crash category this includes pedestrians crossing the road, cyclists and motor-cyclists travelling along the road, vehicles travelling along the road, pedestrians walking along the footpath, cyclists turning in and out of side-roads and vehicles turning in and out of side-roads and accesses. The volume bands used in the analysis are shown in Table 1. Where possible these are based on counts. With counts not readily available for vulnerable users these counts are often estimated based on short term observations of usage levels (hence some level of uncertainty exists with these).

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Volume bands	1 Low	2 Med-Low	3 Med	4 Med-High	5 High
Traffic Volume	up to 15,000	15,000 to 25,000	25,000 to 30,000	30,000 to 40,000	Over 40,000
Side-road/Access Vol (per 100m)	<100	100 to 300	300 to 3000	3000 to 15000	Over 15000
Pedestrian Vol (Across & Along)	<50	50 to 100	100 to 200	200 to 500	Over 500
Cycle Volume (2 way)	<100	100 to 200	200 to 500	500 to 1,000	Over 1,000
Motorcycle Volume (2 way)	<50	50 to 100	100 to 200	200 to 300	Over 300

Table 1 – Exposure (Daily User Volume) risk bands (ADTs)

The exposure rating is based on a combined scoring of the two movements that are in conflict (e.g. crossing pedestrians versus through traffic volumes). When both are high then an exposure of 5 is selected. For example, the score is 4 for a daily pedestrian crossing volume of 200 to 500 and daily vehicle volume of 25,000 to 30,000. This differs from the Austroads framework which tends to focus on one of the user volumes. For example, the number of daily pedestrians for pedestrian crashes.

For likelihood the risk band depends on the facilities provided along a section. The raw score for likelihood is derived using the facilities specified in Tables 2 and Table 3. Further refinement of these criteria is likely as experience with the tool occurs.

Crash Risk/Score	1	2	3	4
Pedestrian 1 (P1) Intersection/Access (Vehicle Turning)	Signalised intersection with turning arrows	Single lane crossing/refuge island	Two-lane crossing together	Three-lane crossing together
Pedestrian 2 (P2) Mid Block/90 degree movement	Signalised crossings	Crossing aid/zebra or flush median with regular crossing aids on 2-lane road	Crossing aid or flush median on four lane road or centreline on 2-lanes	Four plus lane road with no crossing aids or centreline
Pedestrian 3 (P3) Intersection (Vehicle Straight)	Signalised intersection with turning arrows	Signalised Intersection with filtered turns	Uncontrolled across 2 traffic lanes	Uncontrolled across three plus lanes
Pedestrian 4 (P4) Ped versus cyclist off-road cycle/shared path	Clear separation of Cyclists and Pedestrians	Wide shared path (3m plus)	2 to 3m shared path	Narrow shared path or cycling on footpath

Table 2 – Likelihood Categories for Pedestrians (P1 to P4)

Crash Risk/Score*	1	2	3	4
Cyclist 1 (C1) - Mid Block side swipe	Separated cycleway	cycle lane	No facility and wider traffic lanes or no parking	No facility and narrow traffic lanes near parking
Cyclist 2 (C2) - Intersection/Access (vehicle turning)	Separated cycleway with cycle signals and signal with arrows	cycle lane	No facility and wider traffic lanes or no parking, good visibility	No facility and narrow traffic lanes near parking, poor visibility

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Cyclist 3 (C3) - Intersection/Access Approach side-swipe	Separated cycleway	cycle lane	No facility and narrow approach lanes, on access/minor intersection	No facility and narrow approach lanes, on major intersection
Cyclist 4 (C4) - Intersection (vehicle straight)	Traffic signals		Minor priority crossroads	Major priority controlled cross-roads

Table 3 – Likelihood Categories for Cyclists (C1 to C4)

For 'motorcycle (M1)' and 'intersection (V1)' crashes the scores are 1) signalised intersection with turning arrows, 2) signalised intersection with filter turns, 3) non-signalised T-intersections and accesses and 3) non-signalised crossroads and locations with major visibility restrictions.

The severity rating is based on estimated 85%ile speed of fastest moving vehicle type (normally motor-car) with scores reflecting 1) less than 40km/h, 2) 40 to 50km/h, 3) 50 to 60km/h and 4) 60km/h plus.

The raw scores can be modified (i.e. increased) in two ways. The first modification is if a number of additional risk factors are present. Risk factors include; high-turnover parking, clearways, bus and HOV lanes, high levels of congestion, high proportion of trucks, poor vertical and horizontal alignment and poor surface quality. The second modification is if there are one or more high or extreme MUAF issues on a road element related to a crash type (discussed below). The impact of the changes is to increase the range of scores for exposure, likelihood and severity beyond 4 (the 'base' score). The overall CRAF score is calculated by multiplying the 'base' or 'modified' exposure score by the likelihood score and the severity score.

The overall process may include a CRAF assessment of the existing route, the identification of high-risk sections of the route for different crash categories, prioritisation of high-risk sites to investigate further, and can also be used to assess the likely effectiveness of various upgrade options, at least whether mildly or highly positive or negative.

Multimodal User Assessment Framework (MUAF)

MUAF is a narrative- and evaluation-based assessment that combines the element of network inspection (urban), road safety auditing, multi-modal user audit and knowledge of risks associated with vulnerable road users. The purpose of the assessment is to collect behavioural, interaction and safety elements associated with all road users, and especially those elements that may lead to fatal and serious injuries.

The specific focus in an urban context are vulnerable road users, including pedestrians, pedal and motor cyclists. Within these groups are highly vulnerable road users, such as children and those with a disability. The behavioural elements of the assessment include desire lines, conflicts (observed), lack of clear guidance/direction, user composition and interaction, and driver behaviour.

The assessment is undertaken via a walk-over of the route in both directions, ideally at different times of the day. The assessor observes road user behaviour and identified route deficiencies. The data is recorded via a dicta-phone, with observations recorded in compliance with a field guide. The field guide includes four key elements, 1) location (name of road and position along it), 2) road user type (pedestrians, cyclists, both modes, classes of more vulnerable pedestrians – school, elderly and mobility and visually impaired), 3) Description of the issues/problem and 4) risk level (six levels from low to extreme).

ASSESSMENT OF MT ALBERT AND CARRINGTON ROADS

Description of Routes

Mt Albert Road and Carrington Road (that abut each other) are two of a number of arterial roads that criss-cross the Auckland Isthmus. The overall route extends from the Royal Oak Roundabout (Manukau Road) in the south to Great North Road in the north (see Figure 1). These road intersect with a number of other arterial roads including Pah Road (traditional route to the Airport), Mt Eden Road, Dominion Road, Sandringham Road and New North Road. The route generally runs parallel to the recently completed Waterview tunnel motorway (south-western motorway).

There are a number of locations along the route that generate high numbers of vulnerable road users and access turning movements, including big-box retail, commercial shopping areas (e.g. Three Kings), schools and the Unitech (on Carrington Road). There is a growing bus patronage on this route with the associated risks created by crossing pedestrians.
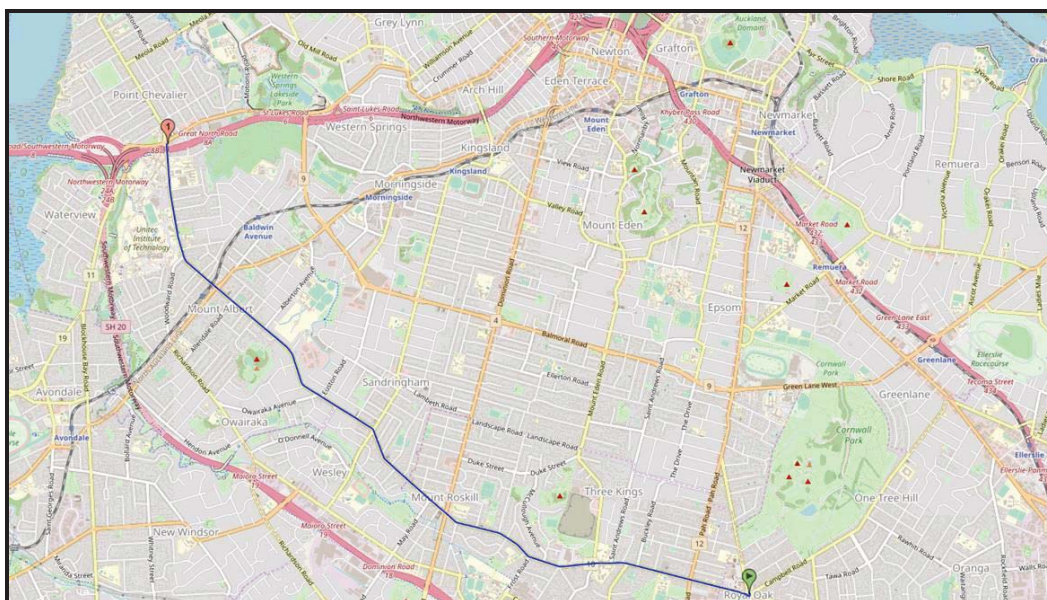

Figure 1 – Mt Albert and Carrington Road Location Map (blue line)

CRAF and MUAF Analysis – Existing Routes

The CRAF process included a walk-over to score each applicable crash type (P1-4, C1-4, M1, and V1) for each sub-section along the Carrington Road and Mount Albert road corridors. Figure 2 shows each walking section. These eight walking sections where further divided into approximately 10 road element sections each for the CRAF analysis. Sectioning is not required for the MUAF assessment, as issues are recorded at a specific location (utilising the Mobile Road app for smart phones).

Figure 2 – Mt Albert and Carrington Road Sections

The sites scores were compiled in a spreadsheet tool for each section and crash type. Table 4 shows the highest risk locations for each crash type. Scores above 27 (exposure 3* likelihood 3* severity 3) are considered high risk, while score above 48 (exposure 4 * likelihood 4 * severity 3) are considered extreme, and have often been modified due to observed MUAF risk elements. Notably the highest risk scores along this route are associated with pedestrians crossing the main road (P2) (many of the pedestrian crashes are of this type) and pedestrians being hit while crossing sideroads and accesses (P1). The risk score of the latter is on average lower due to lower speed of turning vehicles compared with through vehicles. However, there are several places where the intersection/access alignment (e.g. Y-junctions and those with large flares) does lead to higher route exit speeds and to lesser extent higher entry speeds.

Cycle crash risk (as measured by CRAF) is typically lower than the risk observed for pedestrians due to the current low level of cyclists on these routes. While there were a number of cycle crashes on Carrington Road, cycle lanes are provided, making this section safer than parts of Mt Albert Road which have clearways and often narrow kerbside lanes for cyclists. Interestingly most of the cyclists that were observed on Mt Albert Road were cycling on the footpath, no doubt because of the high perceived crash risk of riding on the road. Refinement of the two new methods should consider the risks associated with such behaviour.

Pedestrian Movement	Corridor	Section	Risk Score	Cyclist Movement	Corridor	Section	Risk Score	Vehicle Movement	Corridor	Section	Risk Score
	Mt Albert A	9	72		Mt Albert A	9	64		Mt Albert A	8	60
	Mt Albert A	1	60		Mt Albert A	3	48		Mt Albert A	10	48
	Mt Albert A	3	60		Mt Albert A	5	48		Mt Albert A	7	48
	Mt Albert B	5	54		Mt Albert A	6	48		Mt Albert A	6	48
P1 - Vehicle Turning	Mt Albert D	1	36	C1 - Mid block SS	Mt Albert A	7	48		Mt Albert A	5	48
	Mt Albert F	3	36		Mt Albert A	8	48		Mt Albert A	3	48
	Mt Albert D	3	30		Mt Albert A	10	48		Mt Albert A	2	36
	Mt Albert C	4	30		Carrington B	7	32		Mt Albert A	1	36
	Mt Albert A	6	30		Carrington B	9	32	M1 - Intersection	Carrington B	10	32
	Mt Albert B	7	30		Mt Albert A	9	48		Mt Albert A	8	48
	Carrington B	7	112		Mt Albert A	5	48		Mt Albert A	2	45
	Mt Albert A	3	100		Mt Albert F	1	45		Mt Albert A	1	45
	Carrington B	9	84	C2 – Vehicle Turning	Mt Albert A	8	36		Mt Albert A	10	40
P2 - Vehicle Straight	Mt Albert A	1	75		Mt Albert A	6	36		Mt Albert A	7	40
	Mt Albert A	2	75		Mt Albert A	2	36		Mt Albert A	6	40
	Mt Albert B	5	72		Mt Albert A	1	36		Mt Albert A	5	40
	Mt Albert F	5	60		Mt Albert F	3	30		Mt Albert A	3	40
	Mt Albert F	6	60	C3 - Intersection	Mt Albert A	9	64		Carrington B	10	48
	Mt Albert F	4	45		Mt Albert A	1	54	V1-Intersection	Carrington B	9	36

	Mt Albert A	5	40	Side Swipe	Mt Albert A	10	48		Carrington B	8	36
	Mt Albert A	7	40		Mt Albert A	8	48		Carrington B	7	36
	Mt Albert A	8	40		Mt Albert A	7	48			
P3 - Mid block	Mt Albert D	1	36		Mt Albert A	6	48			
					Mt Albert A	5	48			
					Mt Albert A	2	36			
					Mt Albert A	3	36			
					Carrington A	5	32			
					Mt Albert D	8	30			
				C4 - Intersection Vehicle Straight	Carrington B	14	36			
					Mt Albert B	5	30			
					Mt Albert E	8	27			
					Mt Albert D	1	24			

Table 4 – High CRAF Risk Road Sections

Mt Albert - Section A features in a number of the high-risk (sub-) sections. This is one of the highest volume road sections and includes peak period clearways, but through most of its length effectively operates as 4-lanes due to low kerbside parking demand.

The MUAF analysis highlighted a large number of reoccurring and some site-specific issue along both routes. This included the following:
1. Bus stop locations and pedestrian desire lines with a lack of crossing opportunities and facilities.
2. Pedestrians (including vulnerable) using flush medians to cross on two to four lane roads.
3. Poor visibility for pedestrian at mid-block crossing (desire lines).
4. Turning traffic into side streets and accessways causing various risks for pedestrians.
5. Cyclist hazards from A/C overlays resulting in high lips at edge of seal alongside kerb channel.
6. Very narrow road side parking widths resulting in larger vehicles protruding into the cycle lanes.
7. Need for effective cycle lane markings through intersections.

Table 5 shows the number of low, medium-low, medium, medium-high, high and extreme MUAF risks identified along both routes (total length of 8km) for each road user type. The 109 high and extreme risks were considered in the CRAF scoring. On average 45 issues were recorded per kilometre.

Risk Category	Pedal Cyclist	Pedestrian	Both Users	Vulnerable	TOTAL
Extreme	4	7	1	15	**27**
High	17	11	7	47	**82**
Medium-high	25	17	8	49	**99**
Medium	23	12	9	30	**74**
Medium-low	19	13	5	22	**59**
Low	3	10	1	5	**19**
TOTAL	**91**	**70**	**31**	**168**	**360**
Total per KM	11	9	4	21	45

Table 5 – MUAF Issues by Road User Type

Option Development

The high-risk locations and routes identified in the CRAF and MUAF assessments were used, along with experienced gained while walking the routes, to select sections of the route for option development. This following six sites/sections were identified:

1. Segar/Unitec Access 2 (Section 9 of Carrington B)
2. Farm Road Unitec Access (Section 7 of Carrington B)

3. Mt Albert Road/Alberton Avenue Intersection (Sections 4, 5 & 6 in Mt Albert F)
4. Three Kings Shopping Centre (Section 5 of Mt Albert B)
5. Hillsborough Road Intersection (Section 9 of Mt Albert A)
6. Royal Oak Road to Pah Road (Sections 1, 2 & 3 of Mt Albert A)

While options were developed for all the locations this section only provides details on locations 1, 2 and 4. While only two sections (Sections 7 and 9) were identified as high risk on Carrington Road it was decided after reviewing the MUAF issues further to develop improvement options for the entire corridor outside the Unitec campus. Many of the issues in these two sections also occurred at other locations along the route, and hence a route treatment is preferable for consistency, and to ensure that there is not crash / risk potential migration.

The key issues along this corridor include high numbers of vulnerable users, particularly pedestrians and cyclists accessing the Unitec, school, bus stops, and several other facilities in the area. A major concern along Carrington Road is the lack of high-quality crossing facilities for pedestrians, which was observed to lead to high risk behaviour by pedestrians crossing Carrington Road (see Figure 3).

Figure 3: Pedestrians crossing Carrington Rd

Figure 4: Downhill vehicles northbound on Carrington Rd

Another issue, that affects the severity of crashes on this corridor, is the high speed of vehicles including northbound vehicles travelling downhill (this can be seen in Figure 4). The wide-open feel of this corridor, due to the set-back of land-use, also contributes to the higher vehicle speeds, particularly outside of peak periods.

There are numerous 3-arm intersections and Unitec accesses with stop or give-way control onto Carrington Rd. These are considered high risk due to the relatively high right and left turn vehicle movements combined with crossing pedestrians and cyclists. In this instance there is no separation of movement leading to the risk of conflicts with serious consequences. This results in a high crash risk potential for cyclists and pedestrians travelling along Carrington Road as well as crossing from the side roads and accesses.

Cycle lanes on this part of Carrington Road (Unitec area) are disrupted by bus stops along the corridor, putting cyclists at risk of side swipe or rear end crashes when buses are stopped or approaching/leaving their stops. Figure 5 shows the worst example on this on the corridor, where two bus stops are opposite one another. In this case drivers are forced onto part of the flush median when buses are parked at the bus stops which puts crossing pedestrians at risk and create a pinch-point for cyclists. There are several other locations where there is a single bus stop that requires drivers to use the flush median in one direction to overtake buses putting them in conflict with pedestrians and cyclists.

Figure 5: Bus stops and cycle lanes on Carrington Rd (sourced from google maps)

Two upgrade options were developed for this corridor from Section 12 (at the northern end of Carrington Road) through to Section 7. The first option was higher costs and included an off-road cycle path on the western side of Carrington Road and upgrading two new signalised intersections (at the Unitec accesses) and signalisation (Toucan) of the zebra crossing and new mid-block crossings at bus stops. Option 2 also has two new signalised T-intersections, retains the zebra crossing and retains on-road cycle lanes.

Section 4 along Mt Albert Road (at the Three Kings Shops) is a complicated section of road with multiple access points to surrounding side-roads and parking, as shown in Figure 6 below. This is a complex section of road for cyclists, pedestrians and motor-cyclists to negotiate; both crossing the main road and side-road/accesses. This shows up in the relatively high CRAF scores calculated for these modes. The MUAF also highlighted the poor condition of the pedestrian facilities in this section, along with high risk movement of users crossing at inappropriate locations.

Figure 6: Three Kings Shopping area on Mt Albert Road (sourced from google maps)

Several options were initially developed for this location. Option 1 (see Figure 7) included closing of the intersections of Dornwell Road and Hayr Road with Mt Albert Road, simplifying the road layout. It also shows changes to the entry / exits into the Three Kings Shopping Centre to reduce the number of turning movement locations onto Mt Albert Road. In addition, the provision of an on-road cycle lane and indented parking on Mt Albert Road. Option 2 was similar to option 1 but included a single lane entry and exit into Dronwell and Hayr Roads.

Figure 7 - Schematic of Option 1 for Three Kings Shops

CRAF Analysis - Options

The CRAF scores where then reassessed for the options. Table 6 shows the changes in risk score that occurred for the main pedestrians and cycle crash types. The largest reduction observed is in the risk of crashes involving pedestrians crossing Carrington Road. The formation of better cycle facilities also reduces the risk of side-swipe crashes. The risk of pedestrian being hit by turning vehicles at the two high risk Unitec accesses has also been reduced through introducing the traffic signals, allowing separation \ protection of the turning and crossing movements.

	Section	6 Score	7 Score	8 Score	9 Score	10 Score	11 Score	12 Score
P1 - Vehicle Turning	Existing	6	24	12	24	16	4	6
	Option 1	4	12	6	12	12	4	3
	Option 2	4	12	6	12	12	4	6
P2 - Vehicle Straight	Existing	48	112	32	84	24	24	24
	Option 1	16	16	8	6	12	12	8
	Option 2	16	16	8	12	12	12	16
C1 - Mid block SS	Existing	16	32	16	32	16	16	24
	Option 1	4	4	4	4	6	12	6
	Option 2	8	8	12	8	12	12	12
C2 – Vehicle Turning	Existing	4	12	4	32	8	4	4
	Option 1	2	6	2	4	8	4	4
	Option 2	4	12	4	8	8	4	4
C3 - Side Swipe	Existing	16	16	16	16	16	16	16
	Option 1	8	4	4	4	8	12	6
	Option 2	8	8	6	8	12	12	12

Table 6: CRAF Scores for Upgrades on the Unitec Corridor (Carrington Road)

MAP-BASED ANALYSIS TOOL

An interactive application has been developed to visualise the CRAF and MUAF results captured. The premise behind the structure of the application is to provide a single common platform view of the CRAF and MUAF information, potentially from multiple contributors, in a standardised and easily understood format.

This application is web based and is built using ESRI technology. The information held within the application is secure, with access gained via single factor authentication. Access to this information can be granted to different users and/or organisations, either in its entirety or partly, dependent upon requirements.

The user has the ability to search and view the captured information via an intuitive interface that allows for the data to be displayed in a variety of manners including thematic ranges, charts and heat maps. All the visualisation aspects of the application are zoom and scale dependant, which enables the user to focus on discrete sections of the network and drill down to greater levels of detail as required.

All features contained within the application retain the original source data tables. This data can be queried, with the resultant views showing either partial or full field detail. This is particularly useful when working with the MUAF information, where the information held within can often be voluminous.

Figure 7 and 8 show the section of Mt Albert Road from the Frost Road to Hillsborough Road, at the higher level and at a more detailed level (around Hillsborough Road). The crash location (and severity), MUAF issues (heat maps) and the CRAF scores by crash type are shown.

Figure 7 shows that the CRAF scores are highest at 1) Mt Albert Road A – section 9, which is the Hillsborough intersection and 2) Mt Albert B – section 5 which is the Three Kings Shopping centre. Both have a cluster of vulnerable road user crashes (squares) and MUAF risks (circles).

Behind each point there is meta-data. This includes the full description of the MUAF issues, the crash coding details and the CRAF component scores (for the exposure, likelihood and severity). The heat maps in this case show the concentration of high and extreme MUAF issues (but these can be changed to crashes and CRAF scores also).
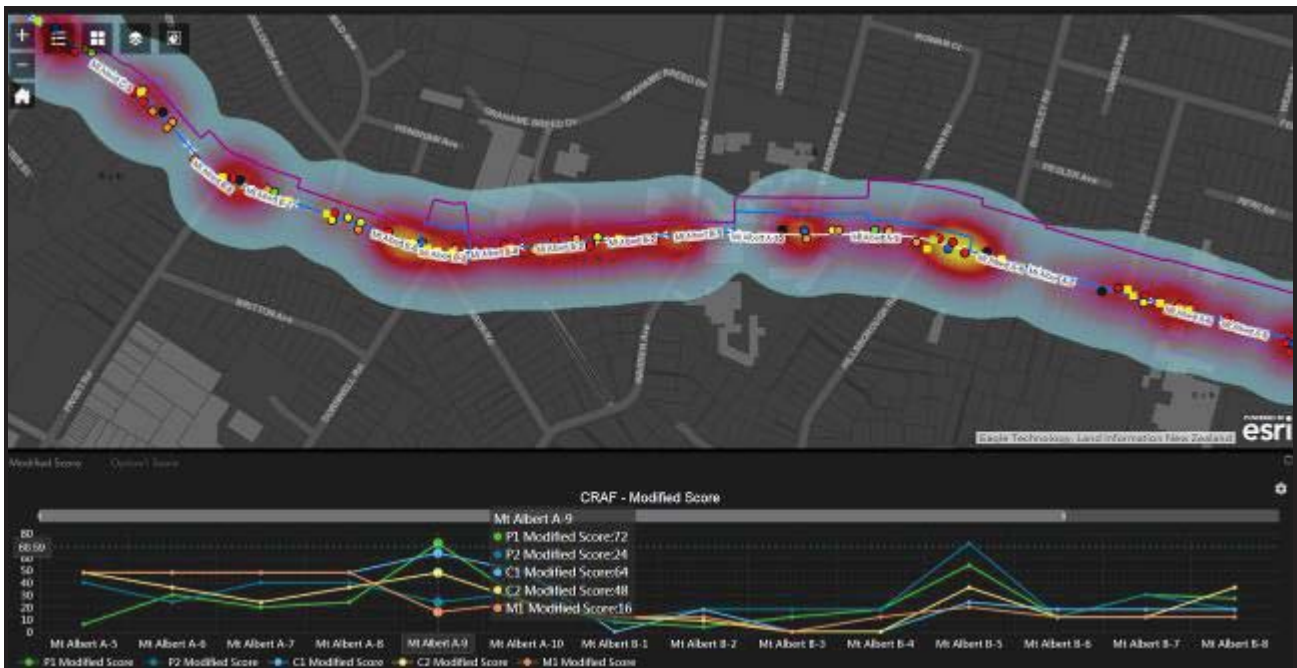

Figure 7 - Crash risk data for Mt Albert Road (CRAF scores below)
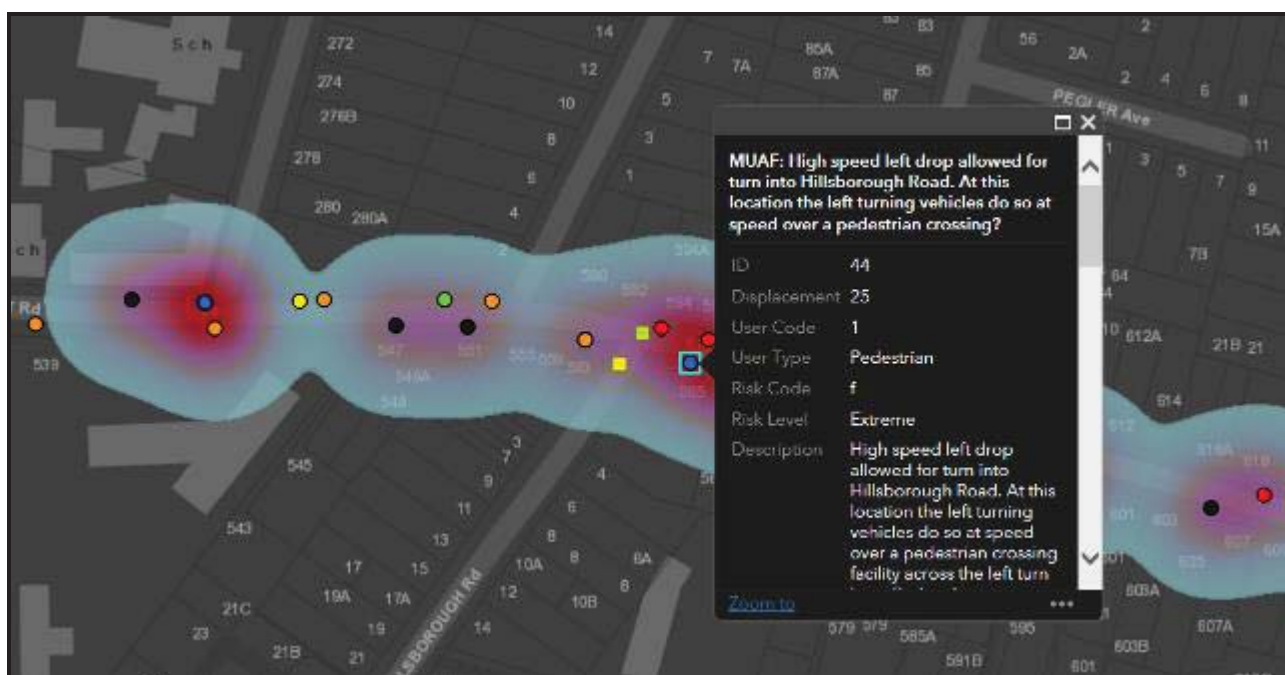
Figure 8 – Detailed Data at Mt Albert/Hillsborough Intersection with Meta-data

A spreadsheet tool has also been developed that estimates the crash risk for pedestrians and cyclists before and after improvements, based on estimated user volumes and facilities provided. It utilises crash prediction models and crash reduction factors from the Crash Estimation Compendium of the economic evaluation manual and other research sources. We have forwarded the outputs of this new tool to the NZ Transport Agency for their comments and inputs.

SUMMARY

This paper outlines two new methods (CRAF and MUAF) that have been developed to enable road safety professionals to assess the pedestrian, pedal cyclists and motor-cyclists risk (with specific focus on the first two) along high risk arterials. The two risk assessment methods have been applied to the Mt Albert and Carrington Road corridors. The outcome from the analysis along with other useful information (crashes and traffic volumes) have been presented in a web-tool. For the high-risk areas identified in the (existing route) assessment a number of improvement options have been developed. The options have then been assessed using the CRAF method, with the resulting reduction in the CRAF score indicating the likely reduction in crash risk.

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APPENDIX A – Crash Category Diagrams (P1 to V)

Pedestrian Movements (pedestrians are blue lines, cyclists green and motorists red)
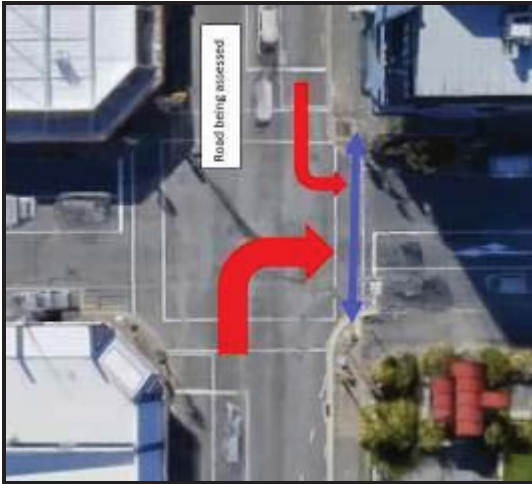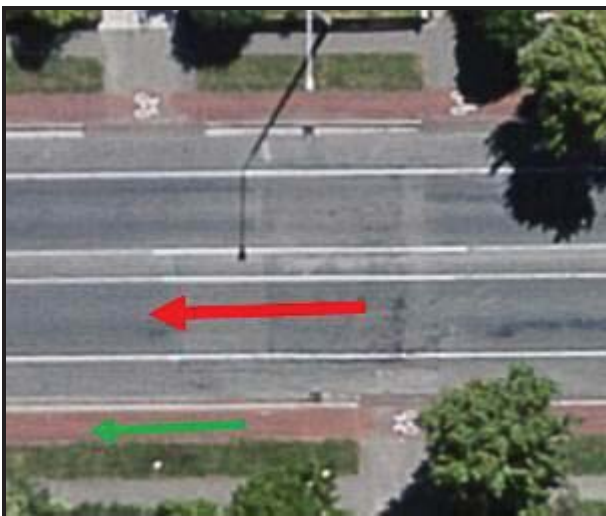

P1 Intersection (Vehicle Turning)
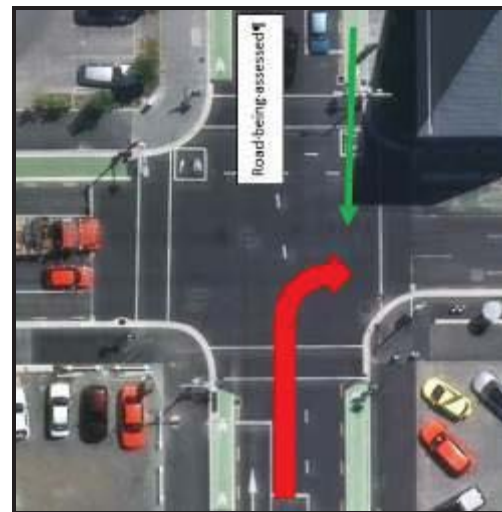

P2 Mid-block/90 degree movement

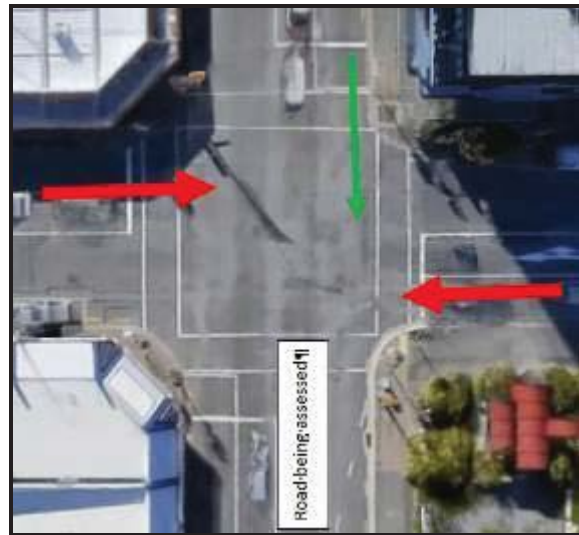P3 Intersections (vehicle straight through)

P4 Pedestrian and Cyclists

Cycle Movements

C1 Mid-Block Side Swipe

C2 Intersection/Access (vehicles turning)

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C3 Intersection/Access Approach side-swipe

C4 Intersection (vehicle straight)

Motorcycle Movements (motor-cyclists are light blue lines)

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