Micromobility Risk Assessment Framework

Auckland Transport

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Quality Assurance Information

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1. Risk Assessment Framework

1.1 Introduction

In this stage learnings developed throughout the research will be utilised to construct Risk Assessment Frameworks (RFAs).

The intent of the RFAs is to assist Auckland Transport as part of its decision-making process for accepting and regulating new shared mobility, and for prioritising infrastructure to support micro-mobility.

The frameworks, although built off findings in the research also involve a number of theoretical considerations where data is not available. Thus, they should only be used at a high level and can only provide an indication of the risk present at the site or for devices, rather than a prediction of the number of crashes that will occur. In later studies, this model should be developed further as more data becomes available.

There are two aspects to the safety of a given micromobility mode: the device itself (with all its functions and properties) and the environment in which it is found. Thus, there are two different aspects that can be evaluated for risk. To evaluate these two different aspects two RFAs have been created. The first is the Micromobility Device Risk Framework, which as the name suggests, looks at determining the risk inherent to the device. The second is the Micromobility Infrastructure Risk Framework, which looks at the risk that the infrastructure poses to micromobility devices, and does not depend on the micromobility device itself. The Micromobility Infrastructure Risk Framework does however consider exposure as one of its key criteria. This means it considers both the inherent risk of the infrastructure and also the infrastructure risk given the number and types of road users present.

The benefit of evaluating a micromobility mode for risk is to identify what safety issues exist for that device in different infrastructure. Alternatively, evaluating the environment (which could be thought of as a given homogeneous road segment) allows for a risk level of different environments to be compared against each other and for the prioritisation of improvements to different road segments.

1.2 Micromobility Device Risk Framework

When it comes to the vehicle itself, speed has been determined throughout the research to be the key variable that determines safety, including both the speed of the micromobility mode and the speed environment. This is shown in the X-KEMM-X modelling section of the report where an increase in speed of the device or other vehicles leads to an increased risk of concussion and it is also shown in the CAS data analysis which determined that higher speed environments lead to higher likelihood and higher severity of injuries.

Taking some of the most common pre-existing modes of transport such as pedestrian, cyclist, motorcyclist and car into consideration, and the infrastructure to which they have been assigned, a framework can be derived. **Table 1.1** shows this basic framework for traditional travel modes.

Table 1.1 Historical Maximum Speed Vehicle Allocation

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="5">Maximum speed</td></tr>
<tr><td>5km/h - 10km/h</td><td>15km/h-20km/h</td><td>20km/h - 30km/h</td><td>30km/h – 50km/h</td><td>50km/h+</td></tr>
<tr><td rowspan="6">Infrastructure</td><td>Footpath</td><td rowspan="2">Pedestrian</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared Path</td><td colspan="3" rowspan="4">Cyclists</td><td></td></tr>
<tr><td>Protected bike path</td><td></td><td></td></tr>
<tr><td>On-road bike lane</td><td></td><td></td></tr>
<tr><td>Local Road</td><td></td><td rowspan="2">Heavy Vehicles, Car and Motor bike</td></tr>
<tr><td>Motorway</td><td></td><td></td><td></td><td></td></tr>
</table>

From here, the areas of the matrix that have not already been assigned can be integrated (as well as re-evaluating some of the assigned areas) to determine what risks they would have for micromobility modes.

This framework is an expansion of an existing study (Haworth, 2019) that investigated evaluation regulation for micromobility. While that was a primarily theoretical examination of micromobility, this framework expands further on these ideas by integrating theoretic assumptions with data gathered through the research.

Limitations

This framework considers only safety. Other features of modes of transport such as road user comfort should be considered subsequently to determining the outcome from the RFA. This also means that the outcome cannot be considered as “where micromobility devices should be allowed to go” and instead what level of risk do micromobility riders create by using a given infrastructure. This includes risk both to micromobility riders and to other road users.

Micromobility Device Scoring

A scoring table is illustrated below in **Table 1.2** which can be used to evaluate the risk associated with the micromobility device. The risk score as illustrated by the colour code in **Table 1.3** should be used to evaluate risk across different features of the device, and the summed total of component scores can be used to compare different device risks.

Table 1.2 Device Risk Framework Scoring Table

Micromobility Device Risk Framework					
Criteria	Speed Risk	Protective Equipment	User Experience Level	Stability	Total
Score	**Table 1.4** score	**Table 1.5** score	**Table 1.6** score	**Table 1.7** Score	Sum of component scores
Reasoning					
Totals					

Table 1.3 Device Risk Framework Scoring Legend

Micromobility Device Risk Scoring Legend	**Score**
Low	1
Medium	2
High	3
Very High	4

Maximum Speed Risk Score

The risk to both the individual e-rider and pedestrians (if applicable) depending on the maximum speed the device is capable of is considered in **Table 1.4**. The score will differ depending on where the device is being used, thus multiple maximum speed risk scores can be generated to indicate a score for each type of infrastructure.

For example, a device capable of a maximum speed of 5-10km/hr would experience low risk on a footpath or shared path. It would be considered to be at very high risk if used in an on-road bike lane or local road. In contrast, a micromobility device with a maximum speed of 30km/hr would experience low risk in a protected bike path, on road bike lane or local road with a speed limit of 30kph.

Table 1.4 Maximum Speed Risk Score

		Maximum Speed Device can Achieve					
		Speed limit	**5km/h - 10km/h**	**11km/h- 20km/h**	**21km/h - 30km/h**	**31km/h – 40km/h**	**41km/h+**
Infrastructure	**Footpath**	n/a					
	Shared Path	n/a					
	Protected bike path	n/a					
	On-road bike lane	n/a					
	Local Road	30					
		50					
		60+					
	Open Road	60+					

Protective Equipment

Next, we can consider the protection that the e-micromobility rider would have. The risk scale is adjustable dependent on the level of protective equipment available. There is no direct evidence to link the protection level to the equipment and further research is recommended.

Table 1.5 Protective Equipment Risk Score

	Protective equipment			
	No protection	**Helmet and jacket but no other protection**	**Micromobility device covers user and provides some protection**	**Micromobility device covers user and provides some protection and Helmet**
Protective Equipment Score				

User Experience Level

The level of experience of a user is a significant factor in risk.

Survey data suggests that 60% of e-scooter crashes occur within users' first ten rides. This is an individual risk, however, which cannot be modelled for a device as a whole but for the evolution or rollout of a new device. For an individual however, the individual risk score can be modelled as follows.

Table 1.6 Individual User Experience Risk Score

	User Experience Level			
	>100 uses	**>10 uses**	**5-10 uses**	**0-4 uses**
Individual User Experience Score				

Body Positioning/Stability

The category of body positioning on a device and the inherent stability of that position is not a matter which has been investigated. However, in principle it is clear that a person in a car is well balanced with four wheels on the ground.On a motor bike or a bicycle however stability while moving is also dependent on speed and skill. The same is true of micromobiity devices. However, the ability to have an additional point of contact on a device (such as handlebars, or being positioned seated) will intuitively result in an additional level of balance should the vehicle be destabilised. It should be noted that there is no epidemiological evidence to support this proposed framework, and that further research into vehicular stability would be required to indicate with greater accuracy the relative importance of being seated or the presence of handlebars.

Table 1.7 Stability Risk Score

	Body Positioning of Device			
	Seated, handlebars	**Seated, no handlebars**	**Standing, handlebars**	**Standing, no handlebars**
Stability Score				

Additional features for future integration

Finally we consider additional matters which may affect the inherent risk of a micromobility vehicle. There is at present insufficient evidence to be able to add these features into the Micromobility Device Risk Framework as no evidence has been found as to their contributing factor or otherwise to poor safety outcomes at this stage. However, it is noted that the following features may prove to be contributing factors in the risk factors associated with new micromobility devices, and that these features could be investigated further to allow them to be factored into a further developed Risk Framework.

- Braking system installed
- Wheel size

2. Micromobility Infrastructure Risk Framework

As this study is being undertaken with a Safe System approach, the Micromobility Infrastructure Risk Framework is influenced by the Safe System Assessment Framework (SSAF).

The SSAF has been designed to assess how closely road design and operation align with the Safe System objectives, and in clarifying which elements need to be modified to achieve closer alignment with Safe System objectives. (https://austroads.com.au/latest-news/safe-system-assessment-framework). By considering exposure, likelihood and severity for different crash types the SSAF is able to produce a comprehensive analysis of risk at a given site.

In the Micromobility Infrastructure Risk Framework, the same three elements have been considered along with crash types related to micromobility devices. These crash types include E-rider falls (including any crashes with stationary objects), E- rider collision with motor vehicle, and E-rider collision with pedestrian or micromobility rider.

The Micromobility Infrastructure Risk Framework Template below shows how these different variables are considered together to assess risk at a given site. The exposure, likelihood and severity scores should be multiplied together for a crash type to get the risk score of that crash type. The risk score of all three crash types should then be summed together to get the total risk score for the road environment being considered.

Table 2.8 Micromobility Infrastructure Risk Framework Template

Micromobility Infrastructure Risk Framework Template				
Criteria		E-rider falls	E- rider collision with motor vehicle	E-rider collision with pedestrian or micromobility rider
Exposure	Score	**Table 2.9** score	**Table 2.18** score	**Table 2.27** score
	Reasoning			
Likelihood	Score	**Table 2.12** score	**Table 2.21** score	**Table 2.30** score
	Reasoning			
Severity	Score	**Table 2.15** score	**Table 2.24** score	**Table 2.33** score
	Reasoning			
Totals		Multiple of the exposure, likelihood, and severity scores	Multiple of the exposure, likelihood, and severity scores	Multiple of the exposure, likelihood, and severity scores

The scoring for each criterion should be conducted using the tables in the following section. When analysing the results from the Micromobility Infrastructure Risk Framework, it is important to keep in mind that not all risks are equal. Though there have not been any fatalities between micromobility users and vehicles recorded in the research analysis of Auckland's micromobility, in an international study it has been found that 80% of the first 24 e-scooter deaths in the US involved motor vehicles (Harmon, 2020). This is supported by other studies that also state: motor vehicles are involved in about 80% of crashes that result in the death (ITF, 2020).

Figure 2.1 below shows the flow chart for how the values for the framework are obtained. The figure identifies the three elements that make up the results from the framework: exposure, likelihood and severity. These three elements are considered for micromobility device falls (which includes any micromobility device collision not including another road user), collision with motor vehicles and collision with pedestrian or other micromobility device.

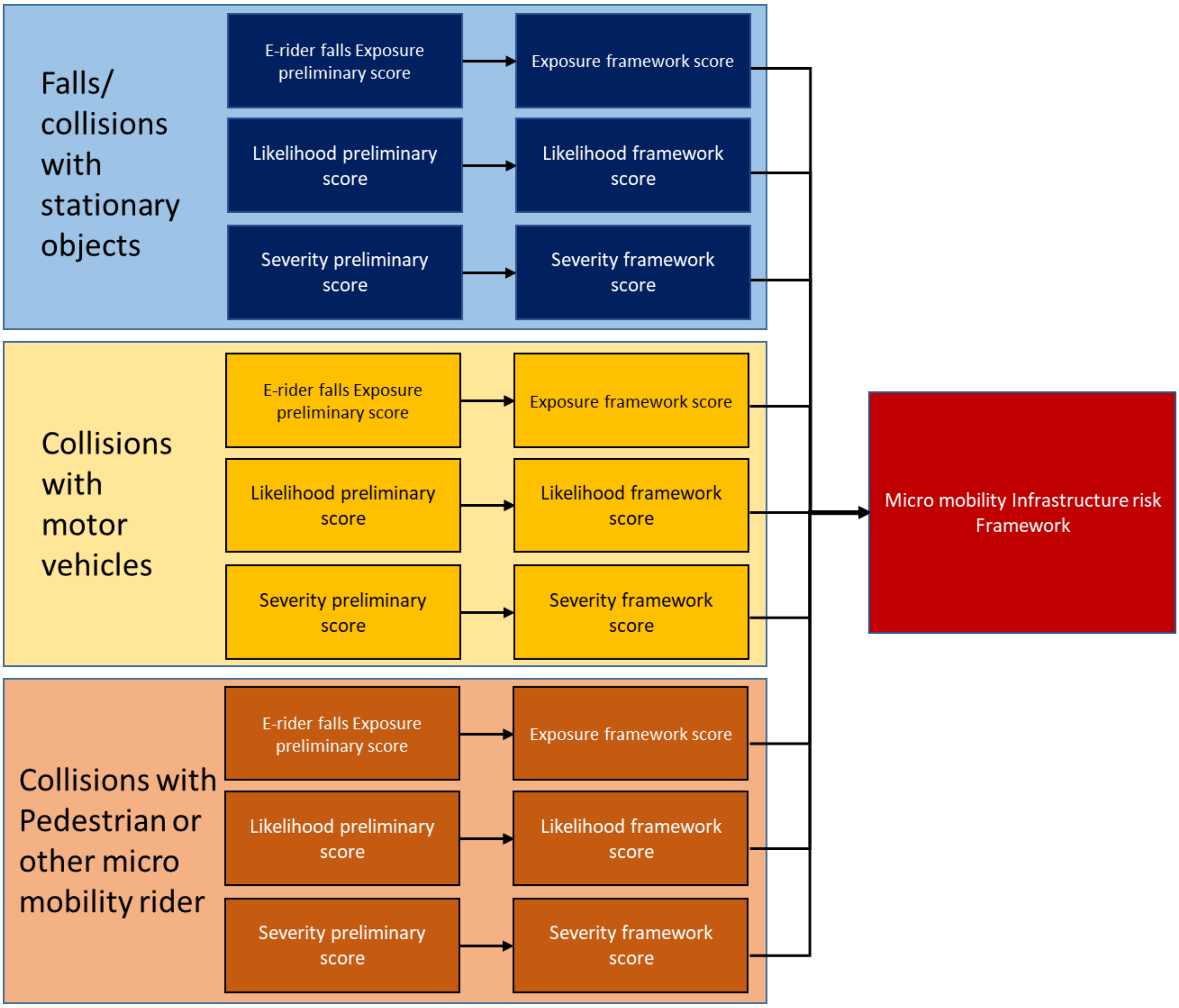

Figure 2.1 Micromobility Infrastructure Risk Framework Flow diagram

2.1 E-Rider Falls

Exposure to Falls

The exposure to falls criterion considers the number of micromobility users estimated to use an environment.

Table 2.9 E-rider Falls Exposure Framework Scores

E-rider Falls Exposure Framework Score	
E-rider falls exposure framework score	E-rider falls framework score
0	0
1	1
2	2
3	3
4	4

Table 2.10 E-rider Falls Exposure preliminary score

E-rider falls Exposure Preliminary Score						
		Score and criteria for score				
		0	1	2	3	4
Micromobility volumes	Number of e-micromobility users over a 3-hour peak period	0	1-20	21-50	51-80	80+

Table 2.11 E-rider Falls Exposure Considerations

Exposure Considerations	
Consideration made	Reasoning
Number of micromobility users	The greater the number of micromobility users the higher the chance that a micromobility mode will be exposed to an aspect of the roadway that could result in a fall; thus, the higher the exposure.

Likelihood of Fall

Likelihood considers the features of infrastructure which might increase the potential to precipitate a micromobility rider fall.

Table 2.12 E-rider Falls Likelihood Framework Scores

E-rider Falls Likelihood Framework Score	
E- rider falls likelihood (calculate from sum of **Table 2.13**)	Scoring for framework table
0	0
1-15	1
16-29	2
30-37	3
38-44	4

Table 2.13 E-rider Falls Likelihood preliminary score

E-rider Falls Likelihood preliminary score						
Risk type		Score and criteria for score				
		0	1	2	3	4
Infrastructure available	The types of Infrastructure available along the segment in question	Off road cycle lane	n/a	On road cycle lane	n/a	No cycle lane or cycle path provided
Permanent street objects	Number of Permanent street objects (on average in 30m segment)	0	0-5	5-10	10-15	15+
Temporary street objects	Number of Temporary street objects (on average in 30m segment)	0	0-1	1-2	2-5	5+
Parked micromobility vehicle	Parked micromobility vehicle (on average in 30m segment)	0	0-2	2-5	5-10	10+
Parked motor vehicle	Parked motor vehicle (on average in 30m segment)	0	0-5	5-10	10-15	15+
Effective pathway width (m)	Effective pathway width (the lowest width of the pavement where e-scooters are allowed to ride)	5+	3.5-5	2-3.5	1-2	0-1
Speed	The 85th percentile speed of micromobility riders along this segment	0-4	5-10	11-20	20-24	25+
Surface quality	The surface quality where micromobility riders are visually seen riding (with a high consideration given to infrastructure used more often by	Good condition	Minor defects	Reasonable defects	Major defects	Unable to navigate.

E-rider Falls Likelihood preliminary score						
Risk type		Score and criteria for score				
		0	1	2	3	4
	the micromobility riders witnessed)					
Place vs travel score	The extent to which the segment of road is used to travel or as a place	Travel	More travel than place	In the middle between place and travel	More place than travel	Place
Gradient	Gradient	Flat	0%-5%	5%-10%	10%-15%	15%+
Intersection density	Average number of intersections along a street within an average 500m segment (cross roads count as two intersection)	0	1-3	3-6	6-8	8+

Table 2.14 E-rider Falls Likelihood considerations

E-rider Falls Likelihood considerations	
Consideration made	Reasoning
Infrastructure available	Dedicated infrastructure such as off road paths assist micromobility riders, having fewer objects that could obstruct the vehicle's path of travel and surfacing that is more suitable for those modes. Thus the lower the likelihood that a micromobility vehicle would fall.
Permanent street objects	Street objects create obstacles for micromobility riders. This creates the potential for either the rider to collide into the object or fall trying to avoid the object. The more objects the higher the likelihood that a conflict will be created and thus the higher the likelihood that this type of collision will occur. From the survey that was conducted as part of this research it was found that permanent street objects were involved in 35% of crashes with objects, making them the most likely stationary object to be collided into. Hence their inclusion in this framework.
Temporary street objects	Street objects create obstacles for micromobility riders. This creates the potential for either the rider to collide into the object or fall trying to avoid the object. The more objects the higher the likelihood that a conflict will be created and thus the higher the likelihood that this type of collision will occur. From the survey that was conducted as part of this research it was found that temporary street objects were involved in 15% of crashes with object. Though lower than the permanent street objects collision percentage, given that there are anecdotally significantly less temporary street objects on the network than permanent street objects these were given a higher weighting in the per object scoring.
Parked micromobility vehicle	In the survey that was conducted as part of this study, parked e-micromobility vehicles were one of the top four most struck objects. Where a non-moving object was struck, 11% of responders said this was a e-micromobility vehicle. Thus, the more parked micromobility vehicles, the higher the likelihood a collision with a stationary object will occur.
Parked motor vehicle	In the survey that was conducted as part of this study, parked motor vehicles were one of the top four most struck objects. Where a non-moving object was struck, 11% of responders said this was a permanent street object. Thus, the more parked motor vehicles, the higher the likelihood a collision with a stationary object will occur.
Effective pathway width	Through the research there was insufficient location data relating to collisions to identify the effect that pathway width has on falls. However, theoretically the narrower a footpath, the more restrictions there are to manoeuvre, the more likely conflicts will exist between micromobility vehicles and street objects.
Speed	The higher the speed the longer the stopping distance and thus the higher the likelihood that a fall or collision will occur when a mistake is made by the rider. The research has shown that speed is a key factor in micromobility crashes.
Surface quality	The worse the surface quality, at the same speed, the higher the likelihood that a fall will occur.

E-rider Falls Likelihood considerations	
Consideration made	Reasoning
Place vs travel score	The survey conducted as part of this research shows that a relatively high percentage of collision/falls occurred when an e-rider is changing between infrastructure types (32%). The more a road section is considered a place rather than a location to travel through, the higher the number of changes between infrastructure and thus the higher the likelihood that a fall will result.
Gradient	From the crash data analysis of crashes between vehicles and micromobility modes it was found that 71% of serious crashes occurred on what was recorded in the system as a "hill road". Though that was between vehicles and micromobility modes, in a lot of the crash analysis the vehicles were either stationary or almost stationary. Thus, it was the stopping distance of the micromobility mode that often determined the likelihood of the crash. The higher the gradient the longer the stopping distance and the harder the vehicle is to control; thus, the higher the likelihood that a fall will occur.
Intersection density	The survey conducted as part of this research shows that a relatively high percentage of collision/falls occurred when a e-rider is changing between infrastructure types (32%). The more intersections, the greater the frequency that a micromobility rider must transition from one infrastructure to another. Thus, the more intersections the higher the likelihood that a fall will occur.

E-rider Falls Severity Framework Score

Table 2.15 E-rider Falls Severity Framework Score

E-rider Falls Severity Framework Score	
E- rider falls severity (calculate from sum of **Table 2.16**).	Scoring for framework table
0	0
1-15	1
16-25	2
26-30	3
31-37	4

Table 2.16 E-rider Falls Likelihood Preliminary Score

E-rider Falls Severity Preliminary Score						
		Score and criteria for score				
		0	1	2	3	4
Speed	The 85th percentile speed of micromobility riders along this segment	0-4	5-10	11-20	20-24	25+
Gradient	Gradient score	Flat	0%-5%	5-10%+	10-15%	15%+

Table 2.17 E-rider Falls Severity Considerations

Severity considerations	
Consideration made	Reasoning
Gradient	Higher gradients result in mean higher micromobility operating speeds and longer deceleration times, leading to higher severity collisions. In the crash analysis that was undertaken as part of this research, while 6.4% of “flat road” crashes resulted in a serious injury, 36% of crashes on a “hill road” resulted in a serious injury. Though that was between vehicles and micromobility modes, in a lot of the crashes analysis the vehicles were either stationary or almost station. Thus, the higher the gradient the higher the severity of the injury that results.
Speed	The X-KEMM-X model that was created by Monash University as part of this research shows that higher impact speeds result in higher the severity injuries.

2.2 E-Rider Collision with Motor Vehicle

E rider Exposure with Motor Vehicle

Table 2.18 E-rider vs Motor Vehicle Exposure Framework Score

E-rider vs motor vehicle exposure framework score	
E- rider collision with motor vehicle exposure preliminary score (calculate from sum of **Table 2.19**).	Scoring for framework table
0	0
1-2	1
3-4	2
5-8	3
9-12	4

Table 2.19 E-Rider vs Motor Vehicle Exposure Preliminary Score

E-rider vs motor vehicle exposure preliminary Score						
Equation		**(Number of micromobility users score x ADT score) /2 + (Number of micromobility users score *Speed limit score)/4**				
		Score and criteria for score				
		0	1	2	3	4
Number of micromobility users	Number of e-micromobility users over a 3 hour peak period	0	1-20	21-50	51-80	80+
Speed limit	The posted speed limit	>60	50-60	40-50	30-40	<30
ADT	Average daily traffic	0	0-2,000	2,000 – 5,000	5,000 – 10,000	10,000+

Table 2.20 E rider vs motor vehicle Exposure Considerations

Exposure Considerations	
Consideration made	Reasoning
Number of micromobility users	The greater the number of micromobility users the higher the chance that a micromobility mode and a vehicle could have conflicting paths of travel; thus, the higher the exposure.
Speed limit	Research has shown that there is a clear link between speed limits and which infrastructure micromobility riders choose. One study from the literature review stated there where the speed limit was 20 mph (32kph), 18 percent of riders used the footpath. Where the posted speed limit was 30 mph (48kph) or higher, more than half of riders rode on the footpath (PBOT, 2018).
Average daily traffic	The greater the number of vehicles present the higher the chance that a micromobility mode and a vehicle could have conflicting paths of travel; thus, the higher the exposure.

E rider Likelihood of Collision with Motor Vehicle

Table 2.21 E-rider vs motor vehicle collision Likelihood Framework Score

E-rider vs motor vehicle collision Likelihood Framework Score	
E- rider collision with motor vehicle likelihood (Calculate from the sum of **Table 2.22**)	Scoring for framework table
0-5	0
6-10	1
11-15	2
16-21	3
22+	4

Table 2.22 E-rider vs Motor Vehicle Collision Likelihood Preliminary Score

E-rider vs motor vehicle Likelihood preliminary Score						
Equation		Sum of all scores in table				
		Score and criteria for score				
		0	1	2	3	4
Infrastructure available	The types of Infrastructure available along the segment in question	Off road cycle lane	n/a	On road cycle lane	n/a	No cycle lane or cycle path provided
Effective pathway width	Effective pathway width (the lowest width of the pavement where e-scooters are allowed to ride)	5+	3.5-5	2-3.5	1-2	0-1
Speed	The 85th percentile speed of micromobility riders along this segment	0-4	5-10	11-20	20-24	25+
Speed limit	The posted speed limit	<30	30-40	40-50	50-60	>60
Gradient	The steepest gradient over any 30m subsection	Flat	0%-5%	5-10%+	10-15%	15%+
Intersection density	Average number of intersections along a street within an average 500m segment (cross roads count as two intersection)	0	1-3	3-6	6-8	8+

Table 2.23 E-rider vs Motor Vehicle Likelihood Considerations

E-rider vs. Motor Vehicle Likelihood Considerations	
Consideration made	Reasoning
Infrastructure available	Different infrastructure such as off-road cycle lanes are designed to micromobility riders, having fewer conflict points with vehicles than the roadway. Thus, the lower the likelihood that a micromobility vehicle would come into conflict with a vehicle.
Effective pathway width	Through the research there was insufficient location data relating to collisions to identify the effect that pathway width has on falls. However, theoretically the narrower a footpath, the more restrictions there are to manoeuvre, the more likely conflicts will exist between micomoblity and vehicles pulling out of driveways. Riders are also more likely to choose the roadway over the footpath where the footpath is narrow.
Speed	The higher the speed the longer the stopping distance and thus the higher the likelihood that a collision will occur. The research has shown that speed is a key factor in micromobility crashes.
Gradient	From the crash data analysis of crashes between vehicles and micromobility modes it was found that 71% of serious crashes occurred on what was recorded in the system as a “hill road”. Though that was between vehicles and micromobility modes, in a lot of the crash analysis the vehicles were either stationary or almost stationary. Thus, it was the stopping distance of the micromobility mode that often determined the likelihood of the crash. The higher the gradient the longer the stopping distance and the harder the vehicle is to control; thus, the higher the likelihood that a collision will occur.
Intersection density	Intersections have more conflict points than midblocks between e-riders and vehicles. It was also found in the crash analysis that some collisions occurred due to either micromobility modes running the stop light at intersections or vehicles running the stop light. Thus the more intersections the higher the likelihood that a collision will occur.

E-Rider Severity of Collision with Motor Vehicle

Table 2.24 E-rider vs Motor Vehicle Severity Framework Score

E-rider vs motor vehicle severity framework score	
E- rider collision with motor vehicle exposure	Scoring for framework table
0	0
1-3	1
4-5	2
5-6	3
8-9	4
10-11	5
12-13	6
14-15	7
16+	8

Table 2.25 E-rider vs motor vehicle severity preliminary Score

E-rider vs motor vehicle severity preliminary Score										
		Score and criteria for score								
		0	1	2	3	4	5	6	7	8
Speed	The 85th percentile speed of micromobility riders along this segment	0-10	10-15	15-20	20-25	25+				
Gradient	Gradient score	Flat	0%-5%	5-10%+	10-15%	15%+				
Speed limit	The posted speed limit	10	20	30	40	50	60	70	80	100

Table 2.26 E-rider vs motor vehicle severity considerations

Severity considerations	
Consideration made	Reasoning
Gradient	Higher gradients result in higher micromobility operating speeds and longer deceleration times, leading to higher severity collisions. In the crash analysis that was undertaken as part of this research, while 6.4% of “flat road” crashes resulted in a serious injury, 36% of crashes on a “hill road” resulted in a serious injury. Though that was between vehicles and micromobility modes, in a lot of the crashes analysis the vehicles were either stationary or almost stationary. Thus, the higher the gradient the higher the severity of the injury that results.
Speed limit	Cars impacting with vulnerable road users at high speeds result in higher severity injuries. The X-KEMM-X model that was created by Monash University as part of this research shows that at higher impact speeds the higher the severity injuries are received.
Speed	The X-KEMM-X model that was created by Monash University as part of this research shows that at higher impact speeds higher the severity injuries are received. A micromobility user when it comes to the severity of the crash is primarily a vulnerable road user (VRU). has been determined by extensive research in the VRU space that vehicle speeds play a key part in determining the severity of a crash.

2.3 E-Rider Collision with Pedestrian or Micromobility Rider

E-Rider Exposure to Collision with Pedestrian or Micromobility Rider

Table 2.27 E-rider collision with pedestrian or micromobility rider exposure framework score

E-rider collision with pedestrian or micromobility rider exposure framework score	
E- rider collision with pedestrian exposure (calculate from sum of **Table 2.28**).	Scoring for framework table
0	0
1-15	1
16-23	2
24-31	3
32-40	4

Table 2.28 E-rider collision with pedestrian or micromobility rider exposure preliminary score

	E-rider collision with pedestrian or micromobility rider exposure preliminary score							
	Equation		**N1 x N2 + N1 x N3 + (N1 *S)/2**					
			Score and criteria for score					
			0	1	2	3	4
N1	Micromobility excluding cyclists	Number of e-micromobility users over a 3 hour peak period	0	1-20	21-50	51-80	80+
N2	Micromobility Including cyclists	Number of micromobility users over a 3 hour peak period (including cyclists)	0	1-40	40-100	100-160	160+
S	Speed limit	The posted speed limit	<30	30-40	40-50	50-60	>60
N3	Pedestrian volumes	Number of pedestrians	0	1-60	61-150	151- 239	240+

Table 2.29 E-rider Collision with Pedestrian or Micromobility Rider Exposure Considerations

Exposure Considerations	
Consideration made	Reasoning
Number of micromobility users	The greater the number of micromobility users the higher the chance that a micromobility mode could have conflicting paths of travel with either another micromobility mode or a pedestrian; thus, the higher the exposure.
Number of micromobility users	The greater the number of micromobility users the higher the chance that a micromobility mode and a vehicle could have conflicting paths of travel; thus, the higher the exposure.
Speed limit	Research has shown that there is a clear link between speed limits and which infrastructure micromobility riders choose. One study from the literature review stated there where the speed limit was 20 mph (32kph), 18 percent of riders used the footpath. Where the posted speed limit was 30 mph (48kph) or higher, more than half of riders rode on the footpath (PBOT, 2018). The higher the speed limit the more micromobility riders choose to travel on the footpath; thus, the higher the exposure of conflict between micromobility riders and pedestrians.

Exposure Considerations	
Consideration made	Reasoning
Pedestrian movements	The greater the number of pedestrians the higher the chance that a micromobility mode and a pedestrian could have conflicting paths of travel; thus, the higher the exposure.

E-rider Likelihood of Collision with Pedestrian or Micromobility Rider

Table 2.30 E-rider collision with pedestrian or micromobility rider likelihood framework score

E-rider collision with pedestrian or micromobility rider likelihood framework score	
E- rider collision with pedestrian likelihood (Calculate from the sum of **Table 2.31**)	Scoring for framework table
0-4	0
5-8	1
9-13	2
14-18	3
19+	4

Table 2.31 E-rider collision with pedestrian or micromobility rider likelihood preliminary score

E-rider collision with pedestrian or micromobility rider likelihood preliminary score						
Equation		Sum of all scores in table				
		Score and criteria for score				
		0	1	2	3	4
Infrastructure available	The types of Infrastructure available along the segment in question	Off road cycle lane	n/a	On road cycle lane	n/a	No cycle lane or cycle path provided
Effective pathway width	Effective pathway width (the lowest width of the pavement where e-scooters are allowed to ride)	5+	3.5-5	2-3.5	1-2	0-1
Speed	The 85th percentile speed of micromobility riders along this segment	0-4	5-10	11-20	20-24	25+
Surface quality	The surface quality where micromobility riders are seen riding (with a high consideration given to road surface quality)	Good condition	Minor defects	Reasonable defects	Major defects	Unable to navigate
Gradient	The steepest gradient over any 5m subsection	Flat	0%-5%	5%-12%	12%-20%	20%+

Table 2.32 E-rider collision with pedestrian or micromobility rider likelihood considerations

E-rider collision with pedestrian or micromobility rider likelihood considerations	
Consideration made	Reasoning
Infrastructure available	Different infrastructure such as off road cycle lanes are designed to micromobility riders, having less objects that could obstruct the vehicles path of travel and surfacing that is more suitable for those modes. Thus the lower the likelihood that a micromobility vehicle would fall.

Effective pathway width	Through the research there wasn't enough location data relating to collisions to identify the affect that pathway width has on collisions. However, theoretically the narrower a footpath, the greater the number of conflict points that are created between vulnerable road users. Thus, the higher the likelihood of a collision between a micromobility rider and other vulnerable road user.
Speed	The higher the speed the longer the stopping distance and thus the higher the likelihood that a collision will occur when a mistake is made by the rider. The research has shown that speed is a key factor in micromobility crashes.
Surface quality	The worse the surface quality, at the same speed, the higher the likelihood that a fall will occur.
Gradient	From the crash data analysis of crashes between vehicles and micromobility modes it was found that 71% of serious crashes occurred on what was recorded in the system as a “hill road”. Though that was between vehicles and micromobility modes, in a lot of the crashes analysis the vehicles were either stationary or almost station. Thus, it was the stopping distance of the micromobitlity mode that often determined the likelihood of the crash. The higher the gradient the longer the stopping distance and the harder the vehicle is to control; thus, the higher the likelihood that a collision will occur.

E-rider Severity of Collision with Pedestrian or Micromobility Rider

Table 2.33 E-rider collision with pedestrian or micromobility rider severity framework score

E-rider collision with pedestrian or micromobility rider severity framework score	
E- rider collision with motor vehicle exposure (calculate from sum of **Table 2.34**).	Scoring for framework table
0	0
1-2	1
3-4	2
5-6	3
7-8	4

Table 2.34 E-rider collision with pedestrian or micromobility rider severity preliminary score

E-rider collision with pedestrian or micromobility rider severity preliminary score						
Equation		Sum of all scores				
Scoring		Score and criteria for score				
		0	1	2	3	4
Speed	The 85th percentile speed of micromobility riders along this segment	0-10-	10-15	16-20	21-25	25+
Gradient	Gradient score	Flat	0%-5%	5-10%+	10-15%	15%+

Table 2.35 E-rider collision with pedestrian or micromobility rider severity considerations

Severity considerations	
Consideration made	Reasoning
Gradient	Higher gradients result in higher micromobility operating speeds and longer deceleration times, leading to higher severity collisions. In the crash analysis that was undertaken as part of this research, while 6.4% of “flat road” crashes resulted in a serious injury, 36% of crashes on a “hill road” resulted in a serious injury. Though that was between vehicles and micromobility modes, the basic principles still remain true in other conflicts. Thus, the higher the gradient the higher the severity of the injury that results.
Speed	The X-KEMM-X model that was created by Monash University as part of this research shows that higher impact speeds the higher the severity injuries are received.