Paper Title:	How micro mobility could impact our future transport ecosystem
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What's the strategic, technical or professional context for your paper? *Context should outline your intent to develop knowledge in the profession and demonstrate the value of looking beyond your personal interest or that of your employer.	**Context** Micro mobility (e-mobility) has the potential to transform the sustainability, efficiency and capacity of our transport networks. This paper identifies the potential shape of that transformation and through using a socio-technical approach, identifies the likely barriers and approaches to reduce those barriers.
What will attract people to read your paper and attend your presentation? What kinds of people or roles would benefit most? *This is your main selling point – for the people attending the conference	**Relevance** This paper presents a framework for understanding and discussing the potential for micro mobility in New Zealand and the outcomes it could create. This will enable transport professionals, transport advocates, urban planners, regulators, and transport technologists to make the well informed decisions on transport planning, urban design, and traffic operations.
What is the particular question, issue or idea you intend to address in this session? * Consider this an executive summary but be specific and relevant to your audience.	**Focus** What actions can individuals / professional bodies / public sector organisations involved in transport (including ITS-NZ) take to enable proper discussion and evaluation of the potential of micro mobility technology for our future transport network? What are the key issues and evidence base for micro mobility? How could various actions impact the outcome for micro mobility as part of the transport ecosystem?

Introduction

We are at the beginning of a potential micro mobility revolution where cheap and efficient e-mobility has the potential to transform the transport network. Micro mobility is currently dominated by e-bikes and e-scooters, but new variants continue to emerge based on low powered electrically driven transport devices.

There have been numerous innovative technologies both in transport and in other sectors that have failed to achieve any deserved success. If conditions are not right, then the adoption of great technology can be delayed for decades or even stopped altogether.

This paper examines current and emerging micro mobility technology using a socio-technical approach. In this approach we look at the interaction between technology, regulators / agencies, and the public. The hypothesis of the approach is that disruptive technology innovations are not automatically accepted, even if valuable, without a “window of opportunity” being created by the mixture of public support and necessary bureaucratic change.

This paper identifies the likely contributors for this “window of opportunity” to open for micro mobility in New Zealand. The paper concludes that a “window of opportunity” will likely open for micro mobility and it is important that we plan and invest in the transport network in anticipation of this in order to get the best outcomes in terms of a sustainable, efficient and safe transport network.

It recommends a strategy to maximise the benefits of micro mobility for the New Zealand transport system and highlights the unique role that independent professional organisations such as ITS NZ can contribute in this.

Micro mobility Technologies

The definition of micro mobility is still up for debate, particularly around the maximum weight and power before micro mobility becomes a motor-scooter or small car. A focus on e-scooters is not necessarily useful long-term, as the variants of device design continue to evolve, and it is important to understand that micro mobility is not simply Lime, Jump, Wave, etc. but are also privately owned.

They are characterised by a small electric motor (typically around 250-300 watts to comply with NZ regulations, but with examples available up to 1500 watts and more) and more often than not combine electric propulsion with human effort through pedalling / pushing, *etc.*

The most common examples of micro mobility familiar to New Zealanders in 2019 are:

- E-Bikes (Electric Bicycles), including cargo bikes
- E-Scooters (Lime / Wave, Xiaomi, Ninebot, etc.)
- E-Skateboards (Boosted, Razor, Evolved, etc.)
- Hoverboards, Segway, various other types of niche devices, including uni-wheels
- ELF 2FR (enclosed electric bike for 2 people)

E-Bikes are the most prolific form of micro mobility, with tens of thousands sold in New Zealand each year.

E-Scooters were almost negligible in numbers until the rollout of global low power broadband that enabled Micro Mobility as a Service (**MMaaS**) firms to set up operations whereby the e-scooters could be located, unlocked, tracked and paid for via a smartphone App.

Bird was the first to launch their service in Santa Monica, California in September 2017, which makes it only 18 months since e-scooters were raised to public consciousness. In New Zealand, Lime were the first company to launch MMaaS with their e-scooters in Auckland and Christchurch in October 2018. More than a million rides were made in the first three months they were available. Since then new operators Jump and Flamingo have announced that they will enter the market in Wellington.

Most micro mobility has a range of 20km to 50km. Due to the current pricing structure for MMaaS amongst other reasons, trip lengths for MMaaS are short (typically a matter of a few kms or less). For privately owned micro mobility it is expected to be much longer, but little data is currently available.

New types of micro mobility are constantly bring introduced to the global market, with variations on wheel diameter, seats, cargo capacity etc. The defining characteristic is that the bulk and weight of the micro mobility is “human scale”.

New designs continue to emerge, and we can expect that innovation in the sector around design will continue at pace.

How Micro Mobility could transform Transport Networks

Micro mobility has the potential to transform transport across four areas when compared to a car-dominant system:

- Sustainability (reduce emissions by 99% per trip compared to a car)
- Efficiency (increase capacity by up to 600% for a 3.5m wide lane)
- Affordability (reduce commuting costs by at least 98% compared to a car)
- Safety (potentially due to more people travelling at slower speeds, although this is unclear as yet)

These are transformational figures for sustainability or efficiency alone.

Should micro mobility grow exponentially, it could dramatically improve the performance of the transport network.

We will look at each of these four areas in turn. Later in this paper we will look at whether people will adopt the use of micro mobility or whether it will remain niche.

Sustainability

The Ellen MacArthur Foundation[i] has published the infographic (Figure 1) which identifies the actual amount of fuel which is used to move the person in the vehicle. It is a small fraction of the 14% of fuel that actually used to move the vehicle and isn't lost through inefficiencies.

The infographic from Wired[ii] in Figure 2 demonstrates the better utilisation of energy, with an e-scooter being around 20 times more energy efficient than an electric car, which itself is 5 times more energy efficient than an internal combustion engine powered vehicle.

Based on these ratios, a strategy for a future low carbon or zero carbon transport system would focus heavily on enabling micro mobility.

Efficiency

Micro mobility can theoretically run on cycleways, shared paths and footpaths, as well as on the road. Even where regulated off a certain part of the transport system such as footpaths, micro mobility riders are still tending to use the most pragmatic routes.

For the same 3.5 metre width as a traffic lane that if used by cars has a people moving capacity of around 2,000 people per hour, a micro mobility lane could reach 14,000 people per hour[iii] (Cycling Embassy of Great Britain).

To grow people carrying capacity in a road corridor, re allocating a lane, or kerbside parking to micro mobility could double or triple capacity, and at a very low cost.

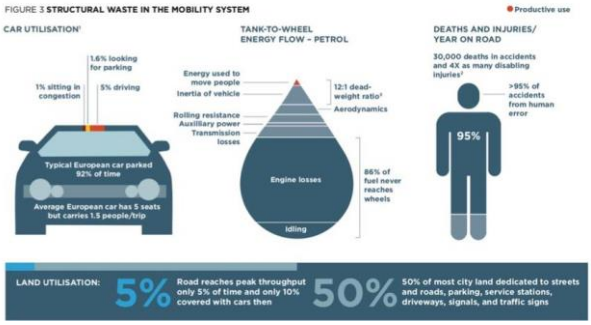

Figure 1 –Fuel used to move a person

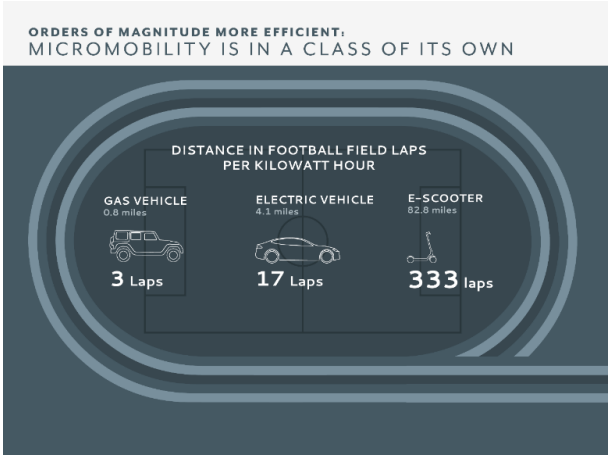

Figure 2 – Energy Efficiency of Micro Mobility

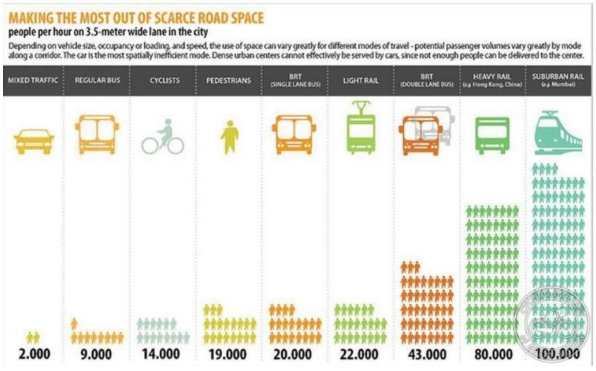

Figure 3 – Lane Capacity of Micro Mobility

Affordability

The infographic from Wired[iv] (Figure 4) highlights the different operating costs for vehicle types, with the annual energy cost of micro mobility being similar to a cup of coffee, assuming private ownership. The MMaaS options such as Lime and Wave, are currently 100s of times more expensive per km as they cover other costs such as labour for charging, vandalism etc.

Replacing a car with micro mobility for short commutes, would reduce transport costs for those trips for individuals by more than 99% when parking and capital and maintenance costs are included.

Figure 4 – Fuel Cost of Micro Mobility

Safety

Safety for micro mobility is currently a complex issue with e-scooters mixing with pedestrians on footpaths. Without clearly separated paths, there is a potential for collisions at 25kph or higher between scooterers and pedestrians.

Studies in both US[v] and through ACC information in New Zealand show that e-scooter riders are having injuries. Only a very small proportion of these injuries (around 5%) involve anyone other than the rider. This suggests that it is scooter control competence which could explain the current injury rates, and we could expect these to decrease over time.

The fatality rate from e-scooters, based on global Bird and Lime ridership is similar to motor vehicles, with a fatality for every 10 to 20 million trips.

Data separating e-bike injuries from non-assisted bicycles is only ad hoc, although due to speed we would expect e-bike injury rates to be higher. There is discussion in New Zealand around the need to wear helmets on e-scooters, as are mandated in New Zealand for E-Bikes and bicycles in general.

Conversations around micro mobility safety are inherently related to infrastructure, with for example separated paths providing reduced chance of collisions with pedestrians or motor vehicles.

A Socio-Technical Analysis of Micro Mobility Innovation

The basis of socio-technical change is that technology fulfils societal functions, but only in association with "human agency" and "social structures". So transitions to new technologies are complex processes that involve interaction between social groups, e.g. commercial transactions, political negotiations, power struggles and creation of coalitions. Technology fulfils a social function, but only if it has a 'social license' to do that.

A socio-technical model of change[vi] is shown below in Figure 5.

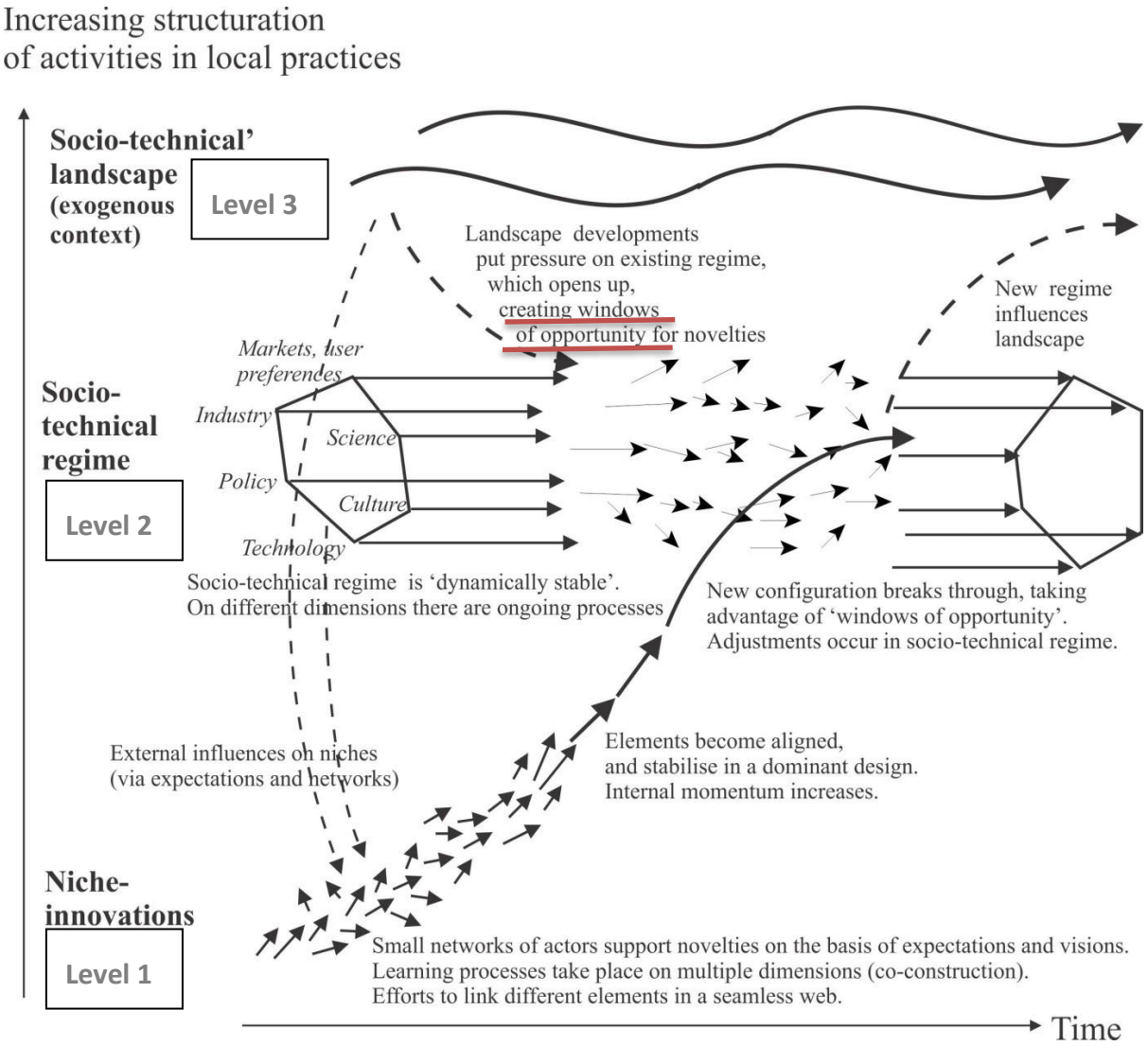

Figure 5 – A Socio-Technical Change Model (Geels, 2005)

According to this model (Geels, 2005), there are 3 levels to a technology ecosystem:

1. At the bottom is emerging transformative technologies that start in niches, typically geographic and demographic (Level 1).

2. In the middle is the socio-technical regime. This is the stabilising effect of organisations, regulations, funding, expectations, culture, market dominant players / monopolies, and vested interests. Stability at the regime level is not inertia, but rather dynamic stability, meaning that innovation still occurs but is of an incremental, not transformational nature (Level 2).

3. At the top is the social context or landscape (Level 3). This is the importance of social changes, political movements, in essence the importance of timing. Any change in the stable socio-technical regime (Level 2) can only occur from pressure from this level that opens windows of opportunity for change.

For an innovation to be accepted and grow into the mainstream, there needs to be pressure from Level 3 to open a "window of opportunity". Without that pressure, the innovation will struggle to be more than niche and incremental, and likely to be opposed by vested interests.

Will a "Window of Opportunity" open for micro mobility?

For a "window of opportunity" to open up requires that at Level 3, there is a strong push from society for micro mobility, which then follows at Level 2 that there is an acceptance that change is required (as opposed to resisting change through the status quo). At the same time at Level 1 there needs to be maturity towards a recognisable, accepted micro mobility format (i.e. people know what micro mobility is, and accept that it is relevant and mainstream).

Using this model and examining the current situation with micro mobility in New Zealand in April 2019, these things will need to happen at each level for a window of opportunity to open:

Level 1:

Currently micro mobility is seen as two distinct modes: e-bikes which are understood and accepted because they look and ride like bicycles which have tradition and recognised regulations; and e-scooters / e-skateboards which are seen as something based on what used to be recreational devices, which have no tradition as transport and little regulation to normalise them. So for micro-mobility to be accepted as a mature technology, the standardisation and normalisation of micro mobility needs to be accelerated:

- This can happen through regulation which in essence sets rules which limits what micro mobility is and looks like. This would need to happen in a manner that enables a dominant micro mobility design to emerge, which may not be the current designs.
- There needs to be a move away from MMaaS e-scooters as the dominant micro mobility mode to where people are choosing micro mobility devices that match their needs and expectations, and use them for personal transport. As one example, a transition to e-scooters with larger diameter

pneumatic-tyre wheels and a seat and basket would mainstream a design that suits a larger proportion of the population, reducing the “niche” appearance of micro mobility.

Level 2:

There is already a mandate to provide infrastructure for bicycles and e-bikes, and as more safe routes are rolled out this will increase demand for micro mobility. Also the regulations in New Zealand as at April 2019 are quite enabling for micro mobility.

- There is a need for regulation to normalisation the mode, potentially tying it in with more accepted micro mobility such as e-bikes
- The language around “walking and cycling” will need to broaden to include micro mobility, this may be helped by regulation.
- There needs to be official training or guidance in the use of micro mobility, so that people become familiar with the role of micro mobility.

Level 3:

This requires a range of people to be advocating for micro mobility, beyond e-bikes:

- Understanding that they are legitimate transport devices, not just recreational devices
- Better understanding the safety issues around scooters, not simply the magnitude of ACC claims, for example.
- Understanding the transformational benefits in sustainability, efficiency and affordability.
- A willingness to invest in personal micro mobility to reduce the marginal cost of a micro mobility trip, rather than using MMaaS which is expensive per km / per use.

Status Quo and the role of transportation experts and advocates

The status quo is that there is little information in the public arena about the potential for micro mobility to alter sustainability and efficiency outcomes. Almost all information is in mass and social media, and that is focussed on perceptions of safety.

Based on a socio-technical perspective, this status quo is highly likely to lead to restrictive regulation on micro mobility based on “safety concerns”, reflecting the Level 2 ‘Regime’ effect.

To create the “window of opportunity” where regulation is likely to enable the growth of micro mobility as an accepted transport mode, the actions outlined in the previous section of this paper will need to occur.

Most of these actions rely on people and organisations involved in transport, such as transport planners, transport engineers, urban designers, health and safety experts, transport economists, policy analysts, and others to play a role.

Based on examination of the socio-technical innovation model, the key risks for micro mobility failing to grow into a mainstream mode include:

- Society sees micro mobility as recreational devices, rather than a legitimate transport mode.
- Micro mobility is not seen as a standardised, normalised mode, there are no rules, or the rules are highly restrictive.
- The environmental and economic benefits of micro mobility remain mostly unknown.
- The cost structure of micro mobility remains mostly a MMaaS model, which limits the growth of micro mobility distance travelled.

Focussing on the role of advocacy / interest groups and professional bodies, and ITS NZ specifically, a recommended strategy for ITS NZ is to work on these risks, particularly where public education and engagement would help:

- Bringing conversations around the transformative benefits of micro mobility around sustainability, efficiency, and affordability. Move conversations away from a sole focus on safety. (Level 3)
- Advocate for a wider range of micro mobility types, vendors, freight etc, in order to avoid e-scooters being seen as only micro mobility format other than e-bikes. (Level 1)
- Push for standardisation of rules and regulations for micro mobility, particularly that links E-Bikes and other micro mobility rather than separate rules. (Level 2)
- Show how road space allocation (re-allocating road space to micro mobility and cycling) can have a significant effect on capacity of the transport network, particularly important for growing and congested cities. (Level 2)
- Role model the normalisation of the mode (beyond e-bikes), working with Corporates and members to show that micro mobility is a form of transport, not simply a device for “wheeled recreation”. (Level 3)

If Micro Mobility gains a “Window of Opportunity”

If micro mobility is successful in becoming a mainstream mode, it will change the way we operate design and invest in our transport networks in the coming decade.

In a study of a pilot e-scooter MaaS in Portland [v], they collected and analysed route data and survey responses. They found that e-scooter users preferred riding on low-speed streets (*circa* 30kph) and in bike lanes. Many of the highest utilised streets were part of Portland’s bikeway network. Staff observations also found lower rates of sidewalk riding on low-speed streets or those with dedicated space for non-motorized users. Users ranked bike lanes as their preferred road type, and sidewalks (footpaths) last. Creating 30kph zones for road users is key to unlocking the potential for micro mobility.

The infrastructure and safety initiatives being provided for cycling are also suitable for micro mobility. As most of the non e-bike micro mobility riders are not formerly cyclists, there will be a growing mandate for 'cycling' infrastructure.

In general terms, these are the areas where operations, planning and investment could change:

Road Space Allocation

A 1.7m wide or 3.5 m wide bidirectional micro mobility lane could provide capacity for growth in people moving capacity.

- Providing micro mobility lanes at bottleneck and on strategic routes.
- Micro mobility routes to and from public transport, schools and universities, local town centres.
- Creating wider footpaths / shared paths / separated paths

Safety

Road safety is moving towards a vision zero approach, which sees any injury from the transport system as unacceptable.

- Lower Speed Limits on Roads (30kph and less) to enable micro mobility vehicles to mix with other traffic.
- Speed limits and signage on shared paths, and regulations covering speed on footpaths.

Funding and Revenue

As micro mobility mode share grows, the impact on funding and revenue from transport will drop more quickly.

- Micro mobility users don't pay parking charges, fuel taxes, or Road User Charges (RUC).

Public transport Interface

Micro mobility is well suited to first mile / last mile of public transport trips. MMaaS devices can be left at stops, but personal micro mobility is more likely to be taken on board the PT vehicle.

- Examination of public transport vehicle design and policies on taking transport devices onboard.
- Set areas for MMAAS micro mobility at public transport stops and interchange points.

Transport Modelling and Forecasting

Traditionally, transport modelling and forecasting has had poor information and modelling capability for non-vehicle trips. Micro mobility will need to be incorporated into modelling techniques.

- Taking in account mode shift, and multi-modal journeys.
- Collecting data and surveying.
- Changes to New Zealand's "Economic Evaluation Manual" to account for micro mobility benefits.

Conclusion

Micro mobility could transform our transport network, providing substantial capacity increases, reducing the cost of travel and providing reductions in transport carbon emissions, at a very low cost to government.

There is a risk that the status quo will mean that the technology will remain niche, and only grow incrementally, with slow acceptance by the public, or even restrictive regulation reducing its use. This would mean the loss of the important transformational sustainability, efficiency and affordability benefits micro mobility could bring.

Transport innovation it is not just about technology, and a socio-technical change model identifies that there is an important role for transport, planning, urban design professionals, and for advocacy and professional bodies to play in informing public sentiment towards micro mobility.

This paper lists a number of recommendations, and there are a number of actions organisations such as ITS NZ can choose to take, so that the potential for micro mobility is truly tested and the opportunity is not missed.

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[i] http://www.ellenmacarthurfoundation.org

[ii] https://www.wired.com/story/e-scooter-micromobility-infographics-cost-emissions/ 12th August 2018

[iii] https://www.cycling-embassy.org.uk/dictionary/capacity

[iv] https://www.wired.com/story/e-scooter-micromobility-infographics-cost-emissions/ 12th August 2018

[v] https://www.portlandoregon.gov/transportation/78431

[vi] Geels, F.W. (2005) Technology Analysis & Strategic Management Vol 17, No 4, 445-476, December 2005 *"The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriages to Automobiles (1860 – 1930).*