TRANSPORTATION 2021 CONFERENCE
MICRO MOBILITY TO DECARBONISE TRANSPORT: THINK PIECE PAPER
(This paper has been peer reviewed)

Author: Toa Greening
B.Tech [Information Engineering]
Director microCAR NZ Ltd
toa@microcar.co.nz

Presenter: Toa Greening

INTRODUCTION

Auckland is New Zealand's largest city and with that title comes the award for the greatest congestion in the country. The challenging geographic layout of Auckland being a narrow isthmus, low population density, unpredictable weather, disaggregated workplaces, amenities, communities and the COVID-19 pandemic makes movement around Auckland City a challenge at the best of times. Any proposal that could reduce both traffic congestion and carbon emissions should be recommended for further research and development.

Micro Mobility (Micromobility, n.d.) is typically a range of small, lightweight vehicles operating at low speeds and are human powered or electric. The key is that the profile is singular/small/narrow and that it makes optimal use of existing road/footpath infrastructure. Motorcycles also make optimal use of road infrastructure and studies (Commuting by Motorcycle, 2011) have shown that if the uptake was >10% on the roads then that would be enough to reduce congestion >40%. Of course, not everyone can ride a scooter, bicycle or motorcycle to work for various practical reasons and with the COVID-19 pandemic many have moved away from public transport and returned to single commuter Internal Combustion Engine (ICE) vehicles.

The narrow profile microCar Electric Vehicle (EV) is an enclosed three or four wheeled vehicle that has the same road profile as a large motorcycle but is fully enclosed like a car. It is proposed that if the uptake was >10% on the roads then that would be enough to reduce congestion >40%. The reduction in greenhouse gases would be two-fold from both the new EV mode of transport and the reduction in traffic congestion.

This paper explores how a microCar EV transportation mode of travel might operate on Auckland motorways and also the entire road network to significantly reduce both Auckland's congestion and its carbon footprint.

"The world as we have created is a process of our thinking. It cannot be changed without changing our thinking." - Albert Einstein

BACKGROUND

It is estimated that over the next 30 years (Auckland's capacity for growth, n.d.) Auckland's population is expected to increase by more than 40% with 62% of new residential dwellings being built within the existing city limits and 38% into new urban and rural Greenfield areas. With most of our transportation networks already at capacity, $60 billion ($60b plan for Auckland transport, 2013) will need to be spent in Auckland on transport infrastructure over the next 30 years.

By using standard transportation models used by transportation authorities for current travel modes, Auckland needs to build more motorways, highways, arterial routes, train tracks, bus lanes, cycle lanes, bridges and tunnels to accommodate the 30-year population growth. While many projects are now underway, often Central Government and Auckland Council are locked in a debate whether enough is being done to plan and fund improvements to the Auckland transport network over the next 30 years. That said, Auckland Council requires significant additional funding to complete those transportation projects for the next 30 years.

This equates to $30,000 per ratepayer, which may be funded by the following:

- Increased Taxes – Personal/Company, GST, Rates, Petrol, Land, Capital Gains
- Increased User Charges - Tolling, Road User Charges, Parking, Fines
- Asset Sales - Ports of Auckland, WaterCare Ltd, Airport Shares, Public Land and Facilities
- Increased Debt – which must be paid for by the previous three sources

We will take a fresh look at the funding challenges facing Auckland's transportation networks and present an innovative solution to the impending funding and transportation crisis.

The Problem

Our motorways are at capacity because there are too many cars on the road at peak hour. Our buses and trains are full at peak times because too many people are trying to use them due to the congested motorways.

Problem Scenario	Solution Challenges
There are not enough roads and motorways to accommodate the current number of vehicles at peak times	Building more roads and motorways requires a huge investment into the road network
The bus and train networks are at capacity because of historical under investment into public transport	Moving people out of cars into public transport requires a huge investment into public transport infrastructure and rolling stock

Both scenarios require significant investment in the transportation network as well as decades to plan and build.

The Risks

The identified $60B transportation network investment costs are only for known projects and will require increased taxes, road user charges, asset sales and debt to fund. This estimated funding does not address what may be required for the congestion of our residential streets from intensification and new motorways/streets required to connect to the new urban Greenfield areas.

Risk Scenario	Solution Challenges
Local Government funding sources are finite and insufficient to cover future transportation network upgrade costs	The resulting debt crisis is passed onto the tax/rate payers

The Solution

The problem is not the number of single occupancy vehicles on the motorways at peak traffic times. It is the width of the single occupancy vehicles on the motorway at peak traffic times. The solution is to optimise the capacity of the motorway by rolling out a fleet of narrow motorcycle width 1-2 person microCar EVs that can be driven two (What is the formation in which you ride called, n.d.) to a standard lane like a motorcycle in staggered formation (Figure 1). The change to a narrow profile electric vehicle will potentially double the capacity of the motorway network.

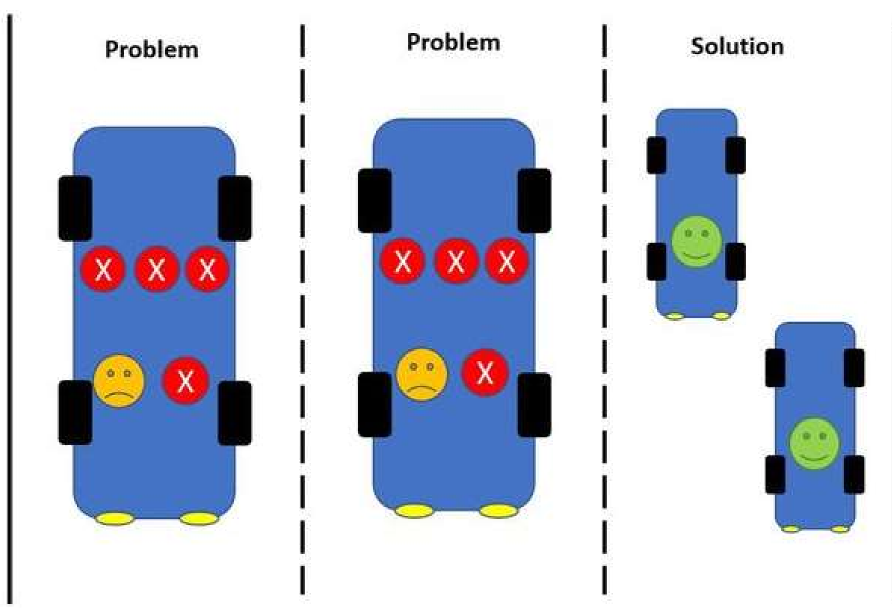

Figure 1 - microCAR EVs in Staggered Formation

TRAFFIC CONGESTION COSTS

Overview

The following report by consulting company Sinclair Knight Mertz (Reaction to the leaking of the CCFAS, 2012) for Auckland Council provided several future traffic scenarios in the event that the Inner-City Rail Loop did not go ahead.

The Sinclair Knight Mertz report (Reaction to the leaking of the CCFAS, 2012) advised that by 2021 most bus networks near and in the city centre will be at capacity or overloaded in terms of what can be provided on existing roads. Private motor vehicle speeds will have halved from 16km/h in the morning peak to 8km/h. The rail network will have reached the maximum number of services possible. And by 2041, the bus network will be significantly over capacity and the average morning peak car speed in the city centre will be 5km/h. Car journey times to the city centre from the west and south will increase by 30 to 50 per cent, adding an extra 30 minutes each way from the South Auckland growth area.

Auckland Transport has provided a 30 year plan (Auckland's capacity for growth, n.d.), which is primarily based upon the Auckland Plan 2050 and follows Waka Kotahi NZTA capital works programme but adds the Inner City Rail Loop and a second harbour crossing to the list of critical projects. The combined costs from both AT and Waka Kotahi NZTA is $60B. However, the looming transport issues of intensification and new urban Greenfield areas are ignored meaning that the future costs could be far greater than currently planned.

Auckland Council Debt

By the end of 2020 the Auckland Council treasury (COVID-19 Financial Update, 2020) department reports debt level of nearly $10 billion and liabilities totalling $14 billion.

What does this transportation challenge and looming debt crisis mean?

It means that there is a requirement to come up with innovative ways to solve the city's infrastructure funding and transportation requirements.

MICROCARS

Overview

A microCAR (Microcar, n.d.) is the smallest automobile classification, usually applied to very small cars (smaller than city cars). Below (Figure 2) are eight examples of 3 and 4 wheeled microCARs in development/production with dimensions and top speeds compared to the BMW motorcycle model typically used by the Police.

The majority of these are neighbourhood electric vehicles (Neighborhood Electric Vehicle, n.d.) and more suited to short local commutes on residential streets. The Commuter Cars T600 and Smart Fortwo are motorway capable with the Smart Fortwo also being four-star ANCAP rated (Smart Fortwo, n.d.) in Europe. The NZ Post Paxter is currently allowed on residential roads and footpaths via an exemption to the Land Transport rules (Exemption Letter, 2016).

Finally the NZ Ohmio Hop is an example of autonomous micro EV Public Transportation. This is mentioned in the context of a potential shift to smaller public transportation vehicles to move people around our cities. It is also noteworthy that the Ohmio NZ are in the process of bringing the vehicle assembly to New Zealand (Driver-less shuttles may be built in Christchurch, 2021).

	
Renault Twizzy Dimensions: 2.32m x 1.19m Top Speed: 80km/hr	**Commuter Cars T600** Dimensions: 2.60m x 0.99m Top Speed: 240km/hr
	
Toyota I Road Dimensions: 1.70m x 0.85m Top Speed: 60km/hr	**Microlino** Dimensions: 2.43m x 1.50m Top Speed: 90km/hr
	
SAIC-GM-Wuling Hongguang Mini Dimensions: 2.91m x 1.49m Top Speed: 100km/hr	**Carver** Dimensions: 1.49m x 0.98m Top Speed: 45km/hr

Smart Fortwo
Dimensions: 2.69m x 1.66m
Top Speed: 130km/hr

NZ Post Paxter
Dimensions: 2.29m x 1.18m
Top Speed: 45km/hr

BMW K1200LT
Dimensions: 2.50m x 1.08m
Top Speed: 209km/hr

NZ OHMIO Hop

Figure 2 – microCAR models vs BMW K1200L

Motorcycle congestion studies

A Belgian study (Commuting by Motorcycle, 2011) on the impact that commuting by motorcycles had on traffic congestion determined the following:

- "If 10% of car drivers would give up their car for a motorcycle or a scooter, traffic congestion would be reduced by 40%, according to a study performed in one of Belgium's most congested routes, typical of Europe's densest urban areas."
- "A 25 percent modal shift from cars to motorcycles was found to eliminate congestion entirely."

Therefore, we can conclude that to resolve congestion on the busiest parts of the motorway network, 25% of private vehicles, which experience congestion over the time period of 3 to 4 hours, could be replaced with a microCAR EV that has the same footprint (width very important) as a motorcycle.

Road Capacity Studies

Transport planners and various motorway studies (The costs of congestion reappraised, 2013; Guide to Traffic Management part 3: Transport Study and Analysis Methods, 2020) have concluded that the maximum capacity of the motorway lane is 1,800 cars per hour per lane. The below table on traffic volumes was extracted from Waka Kotahi NZTA (State Highway Traffic Volumes, 2013).

Description	Direction	Equipment	AADT (2008)	AADT (2009)	AADT (2010)	AADT (2011)	AADT (2012)
SH1 Khyber Pass On Ramp to Gillies Ave Off Ramp SB - Virtual	Inc	Virtual	101629	101189	98520	100593	103826
SH1 Khyber Pass Off Ramp to Gillies Ave On Ramp NB - Virtual	Dec	Virtual	98677	99521	96559	95647	97151
TOTAL			11134019	11331259	11353328	12343408	12549867

Table 1 – Kyber Pass Traffic Volumes

The busiest section on the Auckland motorway network is the Khyber Pass junction at approximately 125,000 in each direction for all three lanes per day. We know that congestion starts at >1,800 vehicles/hour so the key point for analysis is the total time of congestion. At present congestion can occur over a 3 to 4 hour period in both the AM and PM peaks.

Calculating the number of microCARs required to relieve congestion

The busiest part of the Auckland Motorway network is the Kyber Pass central junction. The following assumptions are made to calculate the number of microCARs required to relieve congestion. Each total lane count is the average lane count for the congested sections of the motorway.

Total Lanes

- Northern Motorway 3 lanes
- Western Motorway 3 lanes
- Southern Motorway 3 lanes
- Total of 9 congested lanes

Calculation

- Assume that the majority of vehicles in the AM and PM peaks are the same vehicles which are commuting to and from their place of work
- Assume that congestion at AM and PM peaks is a worst case of 4 hours per peak
- 9 congested lanes = 9 x 1,800 cars per hour capacity = 16,200 x 4 hours = 64,800 congested cars at each AM and PM peak
- 25% of peak congested traffic = 0.25 x 64,800 = 16,200 microCARs required to relieve congestion

Therefore, to relieve congestion across the Auckland motorway network a minimum of 16,200 private vehicles will need to be changed to microCARs.

IMPACT ON CARBON FOOTPRINT

Traffic Congestion Carbon Footprint

Referencing Real-World Carbon Dioxide Impacts of Traffic Congestion (Real-World Carbon Dioxide Impacts of Traffic Congestion, 2010) with typical traffic conditions in Southern California as an example, it was found that CO_2 emissions could be reduced by up to almost 20% through three different strategies: congestion mitigation strategies that reduce severe congestion, allowing traffic to flow at better speeds; speed management techniques that reduce excessively high free-flow speeds to more moderate conditions; and shock wave suppression techniques that eliminate the acceleration and deceleration events associated with the stop-and-go traffic that exists during congested conditions.

Scenario 1: Reducing the Carbon Footprint of cars on Auckland's motorway network

A typical passenger Internal Combustion Engine (ICE) vehicle emits about 4.6 metric tonnes (Greenhouse Gas Emissions from a Typical Passenger Vehicle, n.d.) of carbon dioxide per year.

- Carbon Footprint of 16,200 (64,800 x 25%) ICE when compared to microCAR EV is 74,520 tonnes per year (16,200 x 4.6 tonnes).
    - This is the amount of Carbon reduced per year when 25% of total vehicles or 16,200 ICE vehicles are changed to microCAR EVs.

- Carbon Footprint of 48,600 (64,800 x 75%) ICE free flow is 44,712 tonnes per year (48,600 x 4.6 tonnes x 20%).
    - This is the amount of Carbon reduced per year by the remaining 75% of total vehicles or 48,600 ICE vehicles which are free flowing and producing 20% less carbon emissions.

- microCAR EVs provide an additional 60% (44,712 tonnes/74,520 tonnes = 0.6 = 60%) reduction in the total carbon footprint from the effects of free-flowing traffic of ICE vehicles
  - This is 60% additional reduction in carbon emissions due to free-flowing traffic when an ICE vehicle is changed for a microCAR EV

- The total reduction in Carbon Emissions for the motorway network is 119,232 metric Tonnes per year as per Table 2.

Cars Type	Cars Total	Carbon tonnes per year
microCAR EV	16,200	74,520
ICE free flow	48,600	44,712
Total		**119,232**

Table 2 – Auckland Motorway Network Emissions reduction

Scenario 2: Reducing the Carbon Footprint of all cars on Auckland's road network

The following section performs the same calculation for all cars on the entire Auckland road network under a very broad scenario where 25% of all Auckland's ICE vehicles are changed to microCAR EVs to reduce congestion. This makes a very broad assumption that at least 25% of those light passenger cars are driven by single commuters at the AM and PM peaks.

Referencing Waka Kotahi NZTA statistics for light passenger numbers (Fleet Statistics, n.d.) as follows:

1,132,557 Light Passenger Cars in Auckland 2019
3,284 Buses in Auckland 2019

- 25% of peak congested traffic = 0.25 x 1,132,557 = 283,139 microCARs required to relieve congestion across all Auckland road networks
  - Assumes the worst scenario where all Light Passengers Cars being are used at peak times

- Carbon Footprint of 283,139 ICE (1,132,557 x 25%) to microCAR EV is 1,302,439 tonnes per year (283,139 x 4.6 tonnes)
  - This is the amount of Carbon reduced per year when 25% of total vehicles or 283,139 ICE vehicles are changed to microCAR EVs

- Carbon Footprint of 849,418 ICE (1,132,557 x 75%) free flow is 781,464 tonnes per year (849,418 x 4.6 tonnes x 20%)
  - This is the amount of Carbon reduced per year by the remaining 75% of total vehicles or 849,418 ICE vehicles which are free flowing and producing 20% less carbon emissions.

- microCAR EV provides an additional **60%** (781,464/1,302,439) reduction in the total carbon footprint from the effects of free-flowing traffic
  - This is 60% additional reduction in carbon emissions due to free flowing traffic when an ICE vehicle is changed for a microCAR EV

- The total reduction in Carbon Emissions for the Auckland road network is 2,082,903 metric Tonnes per year as per Table 3.

Cars Type	Cars Total	Carbon tonnes per year
microCAR EV	283,139	1,302,439
ICE free flow	849,418	781,464
Total		**2,082,903**

Table 3 – Auckland Road Network Emissions reduction

The Carbon Cost of Congestion

The New Zealand Climate Change Commission released a report (Climate Change Commission 2021 Draft Advice for Consultation, 2021) on 31st of January which provided recommended emissions budget and 2050 targets for New Zealand to meet its Nationally Determined Contributions (NDC) under the Paris agreement.

Referring to Table 4 we are able to use the reports (Climate Change Commission 2021 Draft Advice for Consultation, 2021) data on the range of Carbon prices ($/tonne) determine the offshore mitigation costs from Carbon Credits that a mass microCAR EV deployment in Auckland could save New Zealand per year.

	Price ($/tonne)		
Multiplier for terms of trade	$30	$50	$100
No multiplier	$1.9b	$3.2b	$6.4b
1.8 multiplier for trade	$3.5b	$5.8b	$11.5b

Table 4 - Possible economic costs of offshore mitigation used to meet an enhanced NDC

If we reference the data from Table 3 and assume a worst-case scenario of a 1.8 multiplier for trade (Climate Change Commission 2021 Draft Advice for Consultation, 2021) as our basis for calculation. The below Table 5 provides an indication of the potential future savings that a mass microCAR EV deployment in Auckland could save New Zealand per year under the different Carbon price points and for a motorway or full road network scenarios.

	Price ($/tonne)		
1.8 Multiplier for Trade Price/tonne x 1.8	$54 ($30 x 1.8)	$90 ($50 x 1.8)	$180 ($100 x 1.8)
AKL Motorway Price/tonne x 161,920tn	$8.7M	$14.5M	$29M
AKL Roads Price/tonne x 2,082,903tn	$112.4M	$187.4M	$375M

Table 5 - Possible economic savings for offshore mitigation used to meet an enhanced NDC

Meeting New Zealand's Nationally Determined Contribution for Climate Change

The potential 2 Mt $CO_{2\text{-}e}$ (2,082,903 Tonnes $CO_{2\text{-}e}$ /Year) saved from Auckland's total road network emissions reduction in Table 3 would meet nearly a third of the 6.3 Mt $CO_{2\text{-}e}$ emission (Climate Change Commission 2021 Draft Advice for Consultation, 2021) shortfall for New Zealand to meet its Nationally Determined Contribution.

CONCLUSION

This think piece paper has identified significant capital works required to reduce congestion and presented the microCAR EV Micro Mobility mode of transport as an effective measure to both decarbonise transport and reduce congestion on Auckland's motorway under one scenario and the entire Auckland road network under a second scenario.

A mass deployment of motorcycle sized microCAR EVs reduces the carbon footprint two-fold. Firstly from the modal shift of Internal Combustion Engine Vehicles to Electric Vehicles which removes 4.6 tonnes of $CO_{2\text{-}e}$ emissions per vehicle per year. Secondly from reduced congestion which removes another 60% of $CO_{2\text{-}e}$ emissions in total per year.

Carbon emissions across the Auckland road network would reduce by 2 Mt $CO_{2\text{-}e}$ per year and save as much as $375M in annual overseas Carbon Credit purchases. The reduction of 2 Mt $CO_{2\text{-}e}$ would account for nearly a third of the 6.3 Mt $CO_{2\text{-}e}$ (Climate Change Commission 2021 Draft Advice for Consultation, 2021) emissions shortfall which makes this a significant measure for New Zealand to reach its Nationally Determined Contribution for climate change.

There are a number of other social, health and financial benefits to reducing congestion in Auckland's road network and the mass deployment of microCAR EVs is potentially a significant measure that is recommended for further research and development.

REFERENCES

Internet

ANCAP (n.d). *Smart Fortwo*, viewed 19 April 2021, <https://www.ancap.com.au/safety-ratings/smart/fortwo/5f4d5f>

Auckland Council (n.d.). *Auckland's capacity for growth*, viewed 19 April 2021, <https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/auckland-plan/development-strategy/Pages/aucklands-capacity-for-growth.aspx>

Auckland Council (2020). *COVID-19 Financial Update,* viewed 20 April 2021, <https://ourauckland.aucklandcouncil.govt.nz/media/34282/covid-19-financial-update.pdf>

Austroads (2020). *Guide to Traffic Management part 3: Transport Study and Analysis Methods,* viewed 19 April 2021, <https://austroads.com.au/__data/assets/pdf_file/0021/342750/AGTM03-20_Part_3_Transport_Study_and_Analysis_Methods.pdf - pg 42>

Barth M. and Boriboonsomsin K. (2010). *Real-World Carbon Dioxide Impacts of Traffic Congestion*, viewed 16 February 2021,<https://escholarship.org/uc/item/07n946vd>

Climate Commission (2021). *Climate Change Commission 2021 Draft Advice for Consultation,* viewed 17 February 2021, <https://haveyoursay.climatecommission.govt.nz/comms-and-engagement/future-climate-action-for-aotearoa/supporting_documents/CCCADVICETOGOVT31JAN2021pdf.pdf - pg 10, 158>

Driving Tests (n.d.). *What is the formation in which you ride called*, viewed 20 April 2021, <https://www.drivingtests.co.nz/roadcode-questions/motorbike/all/when-riding-in-groups-what-is-the-format/>

FYI (2017), *Exemption Letter*, viewed 19 April 2021, <https://fyi.org.nz/request/5516/response/18547/attach/html/5/NZTA%20Exemption%20Letter.pdf.html>

Lowrie M. (2012). *Reaction to the leaking of the CCFAS*, viewed 15 February 2021, <https://www.greaterauckland.org.nz/2012/11/24/reaction-to-the-leaking-of-the-ccfas/>

Maerivoet S (2011). *Commuting by Motorcycle*, viewed 15 February 2021, <https://www.tmleuven.be/en/project/motorcyclesandcommuting>

Ministry of Transport (n.d.). *Fleet Statistics*, viewed 17 February 2021, <https://www.transport.govt.nz/statistics-and-insights/fleet-statistics/sheet/vehicle-fleet>

Stuff (2013). *$60b plan for Auckland transport*, viewed 19 April 2021, <http://www.stuff.co.nz/auckland/local-news/8480391/60b-plan-for-Auckland-transport>

Stuff (2021). *Driver-less shuttles may be built in Christchurch*, viewed 19 April 2021, <https://www.stuff.co.nz/business/industries/124831565/driverless-shuttles-may-be-built-in-christchurch--a-20-million-boon-to-city>

US Environmental Protection Agency (n.d.). *Greenhouse Gas Emissions from a Typical Passenger Vehicle*, viewed 16 February 2021, <https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle>

Wallis I. and Lupton D. (2013). *The costs of congestion reappraised*, viewed 19 April 2021, <https://www.nzta.govt.nz/assets/resources/research/reports/489/docs/489.pdf - pg 63>

Waka Kotahi NZTA (2013). *State Highway Traffic Volumes*, viewed 16 February 2021, <http://nzta.govt.nz/resources/state-highway-traffic-volumes/shtv-2008-2012-by-region.xls>

Wikipedia (n.d.). *Microcar*, viewed 15 February 2021, <http://en.wikipedia.org/wiki/Microcar>

Wikipedia (n.d.). *Micromobility*, viewed 21 April 2021, <https://en.wikipedia.org/wiki/Micromobility>

Wikipedia (n.d.). *Neighborhood Electric Vehicle*, viewed 19 April 2021, <https://en.wikipedia.org/wiki/Neighborhood_Electric_Vehicle>