Reducing Congestion and Improving our Environment Through Route Optimisation

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Abstract
There are significant financial and environmental benefits to reducing urban congestion in New Zealand.

Route Optimisation through traffic signal coordination is a technique that reduces congestion without the need for new and expensive infrastructure. Benefits of existing traffic signal coordination techniques are well known. However new methods are able to balance the needs of public transport, freight, vulnerable road users and private cars based on predefined performance indicators reflecting national and local policy.

GHD has undertaken a number of pilot studies in the Auckland area assessing costs and benefits and is developing a Route Optimisation methodology.

The results of these studies, along with research into other studies undertaken overseas show very high benefit cost ratios, and ongoing reductions in fuel use and emissions. The purpose of this paper is to demonstrate the benefits of these studies, and to promote the use of Route Optimisation, not just as a congestion reduction tool, but also as a practical tool for reducing transport emissions in urban areas. With the future introduction of carbon trading schemes, urban local authorities will be required to monitor and minimise carbon emissions. A well planned Route Optimisation programme could contribute to carbon reduction against a background of stable or rising vehicle travel by road

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1. INTRODUCTION

1.1 Background

Where other emission and congestion reduction programmes seek to influence travel behaviour by providing incentives or disincentives, Route Optimisation requires only passive participation from road users and can be used as an effective tool in the drive to reduce fuel consumption and CO_2 emissions.

Improvements to the coordination of adjacent traffic signals can benefit private vehicles, buses, commercial vehicles and cycles alike through reduced congestion, reduced idling time, lowered fine particle and carbon dioxide emissions. Traffic accidents would also be expected to reduce due to less red light running, and through reduced driver frustration and delays. Benefits also accrue to pedestrians since reviewing the operation and coordination of traffic signals incorporates safety reviews for pedestrian crossing phases.

Traffic congestion in Auckland is estimated to cost the local and national economy approximately $700 million a year [Ref: Ministry of Transport, Surface Costs and Charges study, 2005]. Urban traffic congestion is the largest part of this and results in unnecessary energy consumption, and increased vehicle emissions, and accidents.

The aim of this paper is to examine the benefits of Route Optimisation in a strategic context for the Auckland region and to present the case for a centrally managed and funded programme to enable a cost effective and strategic approach within an overall transport planning framework.

The proposed programme is designed to be flexible and non-prescriptive such that individual councils can implement individual transport policies with regards to their LTCCP's and choose to prioritise buses, general traffic, cycles pedestrians as per local policy preferences and remains open to change as new transport planning and traffic demand management techniques are implemented.

1.2 Strategic Context

The benefits achieved from Route Optimisation complement the objectives of a number of strategic documents including the NZ Transport Strategy.

As an aspiration, the vision in this Strategy stated that by 2010 New Zealand would have, "an affordable, integrated, safe, responsive and sustainable transport system".
It also introduced five key objectives:

- ***Assisting economic development***
- ***Assisting safety and personal security***
- ***Improving access and mobility***
- ***Protecting and promoting public health***
- ***Ensuring environmental sustainability.***

Route Optimisation achieves all of these objectives highlighted in the New Zealand Transport Strategy and should be considered as a key tool for the improvement of the NZ Transport system.

2. CONTROL AND COORDINATION OF TRAFFIC SIGNALS

2.1 What is SCATS?

Traffic signals in the 19 largest urban areas in New Zealand are coordinated by a system known as SCATS, which was originally developed in Australia. SCATS (Sydney Coordinated Adaptive Traffic System) is classed as a "real-time route traffic management system" and automatically adapts to trends in traffic movement, adjusting signal times in response to detected traffic demand.

SCATS works by adjusting the cycle times and phase splits to achieve equal saturation on all approaches to an intersection and also coordinates groups of intersections in order to manage traffic along a route. It is designed to improve the overall flow of traffic, resulting in less waiting time and fewer stops for road users, and reduced vehicle emissions.

2.2 What is Route Optimisation?

Route optimisation is the review and modification of the inputs into a traffic signal coordination program to ensure the most coordinated, efficient and safe operation of a group or corridor of traffic signals.

The objective of the route optimisation is a reduction in actual travel time along an optimised route, reduced stop-starts, and reduced idling time. All these factors have an effect on vehicle fuel consumption, CO_2 emissions and safety and reductions would contribute positively to economic development, accessibility and mobility without major infrastructure works and at a greatly reduced cost.

Other minor physical works are often recommended to improve travel times along the route such as:

- Lane reallocation – often traffic flows and queuing is uneven and changing the lane allocation through remarking lanes and associated signal changes can improve efficiency greatly. With the continued development of the Auckland Region many lane layouts may be out of date since they would have been based on old traffic flows and turning movements.
- Local widening
- Left-turn free lanes
- Clearways and rationalisation of parking close to traffic signals
- Relocation of bus stops to reduce obstruction of traffic lanes and improve safety
- Relocation of traffic signal and street lighting poles for improved visibility

2.3 Why Doesn't SCATS Automatically Perform the Functions of Route Optimisation?

Since SCATS is an adaptive system the temptation in the past has been to install the system and leave it to control signals with minimal review of the inputs and factors it requires for coordination. Studies worldwide have shown that an on-going review of the SCATS system, labelled 'Route Optimisation' is required to fully achieve the benefits SCATS provides.

Physical maintenance of SCATS is undertaken, through fault reporting and upgrades of intersections and software. Reviewing the functionality of SCATS operation along strategic routes is commonly undertaken in other countries but rarely in NZ; many Australian cities, for example, perform a review of the whole SCATS network once every three years in order to identify and optimise key routes in the network and reduce delays, congestion, fuel consumption and emissions.

2.4 Who Benefits from Route Optimisation?

Route optimisation benefits road users as follows:

- Private vehicles – coordinating the traffic signals reduces stops, delays and congestion for private cars and improves journey times
- Buses - bus priority measures such as bus lanes and bus priority at signals are not effective if the buses are caught in congestion. Route optimisation can be focussed on bus routes as required. For example this may be effective as part of the bus feeder strategy for the North Shore busway.
- Cycles – route optimisation reduces queuing at traffic signals. The route optimisation process can incorporate measures for cycles including installing cycle lanes, cycle advanced boxes, cycle crossings and other facilities.
- Pedestrians – optimising traffic signals can allow for a review of pedestrian crossing times, crossing locations and other pedestrian facilities such as barriers, drop kerbs, tactile paving and the improved location of pedestrian phase call buttons. Route optimisation commonly results in reduced cycle time at signals, which reduces pedestrian wait times.
- Commercial vehicles – in industrial areas the stopping and starting of HCV's can add to fuel and maintenance costs and add to the cost of transporting goods. Coordinating closely associated signals can reduce these costs and delays.
- Local residents – reducing stops, delays and congestion reduces noise pollution and emissions. Within the region as a whole the carbon footprint of the transport system will be reduced due to reduced fuel consumption.

The optimisation of traffic signals can also defer the need for new roads due to the gaining of greater efficiencies from the existing road network. Pilot studies have shown that non-priority flow road users using the intersections along the route i.e. side roads and routes crossing the optimised route can experience a marginal reduction in level of service. However this has been shown to be minimal since any re-evaluation of traffic signals on a regular basis often improves the optimisation and benefits all users. Given that Route Optimisation can be tailored to the particular needs of the local community, optimisation can be designed to benefit buses, pedestrians / cycles and other roads users etc and is not a technique only for the improvements in flow for general traffic.

2.5 Route Optimisation Costs and Benefits

2.5.1 Indicative Costs of Route Optimisation

The cost elements associated with route optimisation are made up of a number of elements as follows:

- Data Collection and Analysis
- Traffic Signal optimisation and Coordination
- Traffic Signal Software
- Traffic Signal Controller Upgrades
- Minor Physical Works
- Before and After Studies
- Reporting

2.5.2 Indicative Benefits

The benefits associated with route optimisation are made up of a number of elements as follows:

- Time Savings
- Vehicle Operating Cost Savings
- Accident Savings
- Emissions and Carbon Footprint
- Noise and other Environmental Benefits

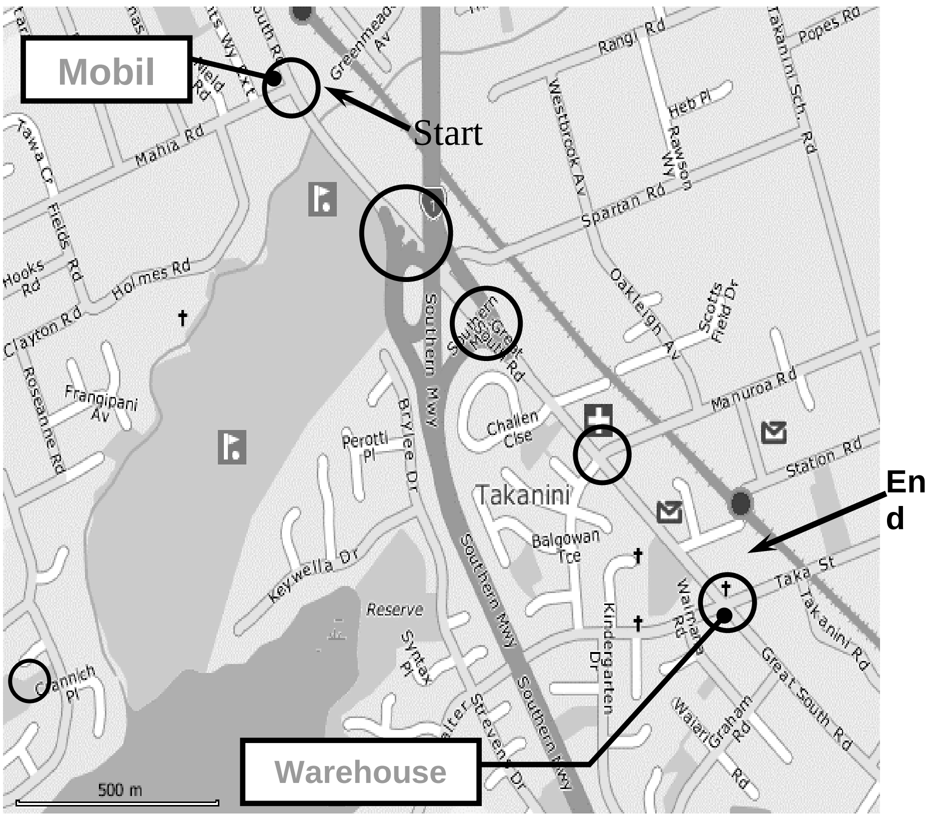
3. AUCKLAND ROUTE OPTIMISATION STUDIES

3.1 Takanini Great South Road Route Optimisation Study

3.1.1 Description

In December 2006, GHD Ltd were commissioned by the Energy Efficiency and Conservation Authority (EECA) to undertake a pilot study on five adjacent congested intersections on a route carrying 25,000 vehicles every day, in Takanini, Auckland. The objective was to assess the potential costs and benefits of a route optimisation programme for Auckland.

Figure 1 – Great South Road, Takanini Traffic Signals Optimised



3.1.2 Costs and Benefits of the Pilot Study

The cost of the Study was $50k and the calculated benefits to road users of the pilot study were as follows:

- Fuel savings of **214,660 litres** in the first year (10% reduction).
- CO_2 reduction of **547 tonnes** in the first year (10% reduction).
- Average time savings of **17 seconds per vehicle** per trip along the route.
- Total time savings to road users of **63,453 hours** in the first year (13.5 % reduction).
- Financial benefits of **$1,161,598** in the first year
- A benefit cost ratio of **17.0** in the first year alone growing to 31.0 in three years.

These benefits continue to accrue in following years until traffic growth or changing traffic patterns require a review of the route optimisation, which is normally considered to be 3 years for developing urban areas and will only be required due to new local development in less urban areas. Further benefits accrue in accident reduction, and also in health benefits.

3.1.3 Conclusions

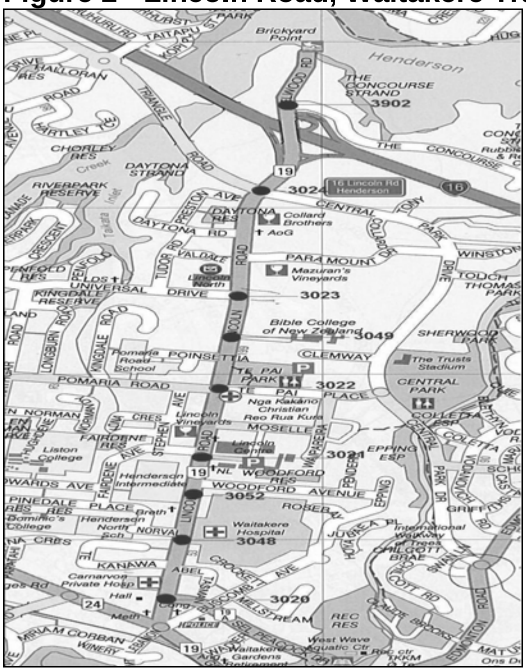
This was a ground breaking study as prior to this Route Optimisation of signals tended to be carried out in NZ without undertaking a 'before and after study' that measured benefits. When the benefits were first calculated it was assumed that a mistake had been made, as they were very high. Subsequent checking and a review of similar studies internationally revealed that the results were well within the range of cost benefit reported, with some studies recording benefit costs of up to 200, but the majority recording a cost benefit of around 30 to 50 over 5 years.

3.2 Waitakere Lincoln Road Optimisation Project

3.2.1 Description

In August 2007, GHD were commissioned to undertake Route Optimisation of 9 intersections along Lincoln Road in Waitakere.

Figure 2 - Lincoln Road, Waitakere Traffic Signals Optimised



3.2.2 Costs and Benefits of the Route Optimisation Work

The cost of the Study was $45k, and the benefits of the project were as follows:

- AM Peak journey time reduction of between 9% and 27%
- IP Peak journey time reduction of between 4% and 18%
- PM Peak journey time reduction of between 0% and -4%

In this case the PM benefits were lower than expected due to queuing and interference from the SH16 motorway on ramps, but overall benefits in terms of travel times and emissions were substantial in line with previous studies.

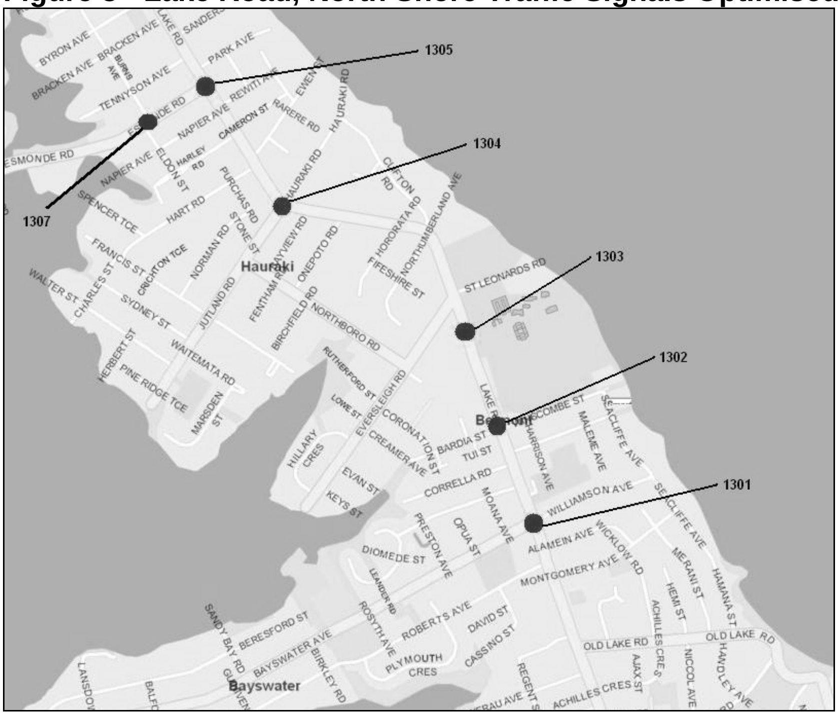
3.3 North Shore Lake Road Route Optimisation Project

3.3.1 Description

North Shore City Council commissioned the Traffic Management Unit (TMU) to optimise six traffic signals along the Lake Road corridor from Esmonde/Lake to Bayswater/Lake in February 2008.
The Lake Road corridor is the only point of access into and out of the Devonport Peninsula other than the passenger ferries. During peak periods, Lake Road is over capacity, resulting in significant delays at all major intersections along the corridor, including Esmonde Road, Jutland Road, Winscombe Street and Bayswater Avenue.

The aim of the optimisation project was to ensure the traffic signal operating system (SCATS) and all traffic signal controllers were configured to provide the most efficient traffic flow along Lake Road, without penalising side road traffic.

Figure 3 - Lake Road, North Shore Traffic Signals Optimised



3.3.2 Costs and Benefits of the Route Optimisation Work

The cost of the Project was $40k and benefits were as follows:

Northbound Delay:

- **54**% reduction in the average delay was achieved for northbound traffic during the morning peak
- **7**% reduction was achieved during the evening peak.

Southbound Delay:

- **27**% reduction in the average delay was achieved for northbound traffic during the morning peak
- **1**% increase was recorded during the evening peak.

Northbound Navy Shift Change Peak Delay

- **35**% reduction in the average delay was achieved for northbound traffic Bayswater/Lake intersection during the 4:00pm (Navy) peak relating to the movements of Navy personnel.

3.4 Other New Zealand Cities

The 19 largest cities in New Zealand also use the SCATS system for traffic coordination covering a large proportion of trips undertaken by road in New Zealand. Similar levels of benefits could be anticipated in these cities relative to the number of suitable routes to be optimised and the level of congestion currently experienced. These have not been assessed as part of this study but together would amount to an appreciable saving in urban traffic energy consumption in NZ.

4. INTERNATIONAL ROUTE OPTIMISATION STUDIES

4.1 Comparison With Other Australasian Cities

Discussions with traffic engineers in Sydney, Melbourne and Adelaide show that Australian transport departments are investing heavily in this technique as a congestion, energy consumption and emissions reduction method. These three major Australian cities set annual budgets for route optimisation and employ a dedicated team of engineers for implementation. The main justification for doing so has been the low relative cost of implementation compared to the high benefits received. Table 1 shows the relative investment of the three cities compared to Auckland.

Table 1 overleaf shows that annual resources committed for route optimisation are much higher in equivalent traffic control centres in Australia, with budgets of over A$1 million in all cases and a target of 30 to 50% of the network being reviewed annually. A route optimisation programme for Auckland has been created but is still funded on an ad hoc basis with no agreed priority or ongoing funding.

Approximately $150K was spent on route optimisation in Auckland in the 2005/2006 financial year. Approximately 30 signals were optimised - only 5% of Auckland's signals. In comparison, traffic control centres in Australia have identified the large benefits associated with route optimisation and currently undertake route optimisation on 30% to 50% of their networks every year amounting around 650 signals per year in many cases.

Table 1 Resource Commitment to Route Optimisation

City	No of traffic signal controlled intersections	Annual Route Optimisation Budget	Number of Route Optimisation Staff (FTE)	Dollar Spend per Traffic Signal
Melbourne	2700	A$1.2 million	12	$ 444.00
Sydney/New South Wales	2000	A$1.0 million	12	$ 500.00
Adelaide/South Australia	700	A$1.0 million	14	$1,428.00
Auckland TMU	690	NZ$0.15 million	1.5	$ 217.00

4.2 Portland Route Optimisation Study

A City of Portland review of 150 intersections. [*Ref:http://www.springsgov.com/units/traffic/SignalCoordinationPlan.pdf*]

The cost of the Study was US$ 533K and the study produced savings of:

- US$ 3 million per year; and
- 169,000 tons of CO_2 per year.

4.3 Colorado Springs Route Optimisation Study

Route optimisation on key arterial routes reported a saving of US $40 of fuel for every US$ 1 spent on signal coordination (i.e. a cost / benefit ratio of 40 excluding other health and value of time benefits) *[Ref:http://www.springsgov.com/units/traffic/SignalCoordinationPlan.pdf]*

4.4 Other Route Optimisation Studies

A review of results of improved network traffic signal coordination from other countries gives a range of results as follows:

- 20 - 30% reduction in peak hour delays
- 5 - 10% reduction in fuel consumption
- 15% reduction in vehicle stops
- 4 % reduction in hydrocarbons
- 5% reduction in carbon monoxide
- 5 - 10% reduction in energy consumption

5. A REGIONAL ROUTE OPTIMISATION PROGRAMME

5.1 Costs

5.1.1 Implementation Programme

Currently, Route Optimisation work is completed on an ad hoc basis in New Zealand. This has meant that skilled practitioners have left the industry or relocated to other countries. There are current programmes in place to train future technicians and recruitment plan to attract engineers back into this field. The proposed implementation programme takes into account these up-skilling and recruitment issues. The programme would be required to run at full capacity for 4 years to alleviate the backlog of route optimisation required in the Auckland Region. In the 5th and consecutive years, work could be reduced as many of the critical issues would have been addressed and to achieve the desired 30% to 50% review of the network each year, less funding would be required.

5.1.2 Estimated Resourcing Required For Auckland

The Auckland TMU estimates that an initial commitment of $2.5 million per year would enable an Auckland-wide program to be set up. This amount would be reduced after a number of years when the programme was established and procedures and a skilled dedicated team were put in place.

Table 2 Implementation Time Table

Year	Costs	Systems	Training	Resources (FTE's)	Route optimisation
Year 1	$1.5m	System Setup, QA, funding mechanisms,	Hire/Train Resources,	4	Review 10% of sites
Year 2	$2.5m	Database development, standardise procedures	Continue training	5	Review 20% of sites.
Year 3	$2.5m	Standardised offline modelling capability	Continue training	6	Priority 30% of network reviewed.
Year 4	$2.3m	Maintain and develop systems.	Update and maintain skill levels	5	Priority 30% of network reviewed
Year 5	$2.0m	Maintain and develop systems.	Update and maintain skill levels	4	Priority 30% of network reviewed

5.2 Funding Options

The intention is to capitalise this project such that it will be subject to an average LTNZ subsidy of 53%. Route Optimisation work covers a wide spectrum of benefits and budgets and other funding sources are being explored including:

- Energy Efficiency
- Sustainability
- Carbon Reduction

5.3 Prioritising Routes

Route prioritisation will be decided through discussions with local authorities. A number of Route Optimisations are to be undertaken each year.
The prioritisation of routes will be based on a number of factors including:

- Perceived benefits to the region
- Opportunity to coordinate with other traffic signal work along the route that can be more cost effectively tied in with the route optimisation work
- Urgent requests
- New developments
- New infrastructure
- Special events (e.g. Rugby World Cup)

Criteria for Route Optimisation need to be developed further with local authorities to ensure that the benefits are spread fairly across the region. This will be undertaken in the next stages of this project including consultation with relevant parties.

6. SUMMARY AND RECOMMENDATIONS

6.1 Summary

- Cost of implementation is low compared to the benefits. This results in a benefit cost ration (BCR) of approximately 30 to 1. These results are in line with other studies undertaken in Europe and North America and Australia;
- Disruption to existing traffic is minimal, with little or no on-street roadworks required;
- No consents or changes to district plans are required;
- No land purchase is required;
- Benefits are high, in terms of financial benefits, energy consumption, emissions reduction, air quality and health;
- Accidents are reduced due to reduced driver frustration and delays;
- Improvements to pedestrian crossing times and coordination are also implemented with a view to reducing waiting and crossing times;
- Benefits accrue to all modes of transport, buses, private cars, commercial vehicles, cyclists and pedestrians;
- Route optimisation can defer the need for intersection improvements and road widening, thereby releasing funds for other transport network improvements.

6.2 Recommendations

Recommendations following the studies undertaken are as follows:

- It is recommended that appropriate on going funding for route optimisation in NZ is identified and provided to reduce traffic congestion and energy use in the transport sector.
- In order to take advantage of the potential benefits, funding for route optimisation should be at a level similar to Australian cities to enable the Auckland Traffic Management Unit to undertake route optimisation on 30% of identified routes per year.

7. REFERENCES

Report on Route Optimisation Pilot Study - Urban Transport Energy Reduction
EECA, May 2007

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