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Professional Practice Papers – Multi Metric Network Operating Plans

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Abstract

Evaluating multiple metrics in the assessment of network wide Level of Service Operating Gaps is highly complex and time consuming – but through the application of geospatial modelling, network wide operational investment programmes can be optimised to address strategic objectives.

Abley delivered a Network Operating Plan (NOP) for the Tauranga Area, in the North Island of New Zealand. The methodology differed from prior evaluations, by incorporating Austroads research into multi-metric operating gap evaluations, including mobility, safety, accessibility and amenity across all modes and various timeframes. This revealed challenges in determining what data and values were robust, but produced comprehensive and meaningful outcomes. The team also identified an opportunity to efficiently produce Network Operating Frameworks(NOF) with qualitative outcomes that support long term planning.

The current process uses extensive stakeholder input focusing on congestion alone. Though critical as a step in the development of a NOF, this is very time consuming for all involved. This paper details how geospatial data was applied across multiple metric measures to make the stakeholder engagement process more efficient, and how data driven inputs enable broader application of the SmartRoads tool.

The outcome of the Tauranga NOP was productive in determining the correct focus areas and interventions to achieve the long-term plan for mode choice, safety and an efficient and sustainable transport system, enabling continued economic growth and more liveable environments.

1. Introduction

The Framework (Hewitt, S, 2013, p.i) approach to managing competing interests for road space has been in use since 2009. The SmartRoads process is a methodology developed by VicRoads and adopted by Austroads for best practice in this Framework approach. It compares the impacts of interventions on the use of road space to move people, goods and services through adjusting measures of Throughput and Levels of Service (LOS).

Initially, LOS was based on capacity or delay. However, since 2015 research has been published that considers multiple factors including Mobility, Safety, Accessibility, Amenity and Information (Green, D & Espada, I, 2015, p.4).

This paper discusses our experience in applying the full suite of metrics available from the Austroads Research into multi-metrics to a city network, in this case Tauranga, in the North Island of New Zealand, using available spatial data and stakeholder knowledge.

2. Network operating plans

A Network Operating Framework (NOF) approach looks at the movement of different modes of transport (people and goods) by time of day, in a land use or "Place" context. It is a process for allocating limited road space across a network in a way which is consistent with defined longer term strategic objectives, such as mode shift.

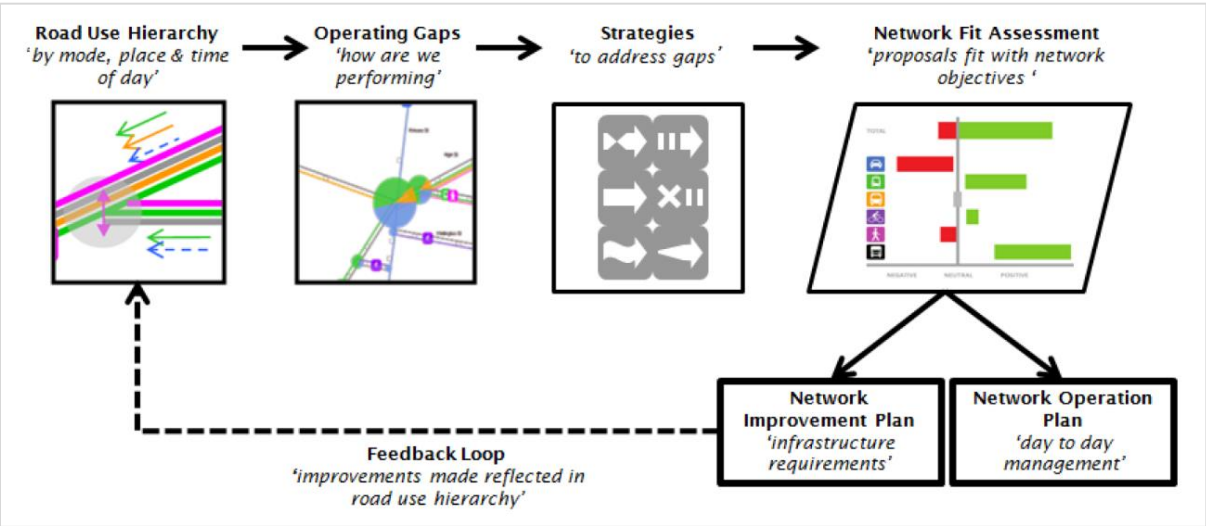
The process for developing the NOF informs decision makers of the trade-offs between alternative strategies in a constrained network. The decision makers are the stakeholders who control the network and operate public services, and for this project included NZ Transport Agency, Tauranga City Council and Bay of Plenty Regional Council. In developing the NOF together, they ensure a "One Network" approach that optimises the network and provides a more consistent Level of Service (LOS) across a range of modes. This in turn gives customers better choices as to how and when they travel, and further strengthens the links between land use and transport planning.

When complete, the NOF enables informed decision making and ensures that proposed actions are consistent with the stakeholders' collective strategic objectives. The process includes:

- setting strategic objectives
- determining the priority networks for each mode
- place-based information
- measuring network performance by time of day
- then developing and testing interventions.

The outputs of this process are a Network Operating Plan (NOP) and Network Improvement Plans (NIP). NOPs identify simpler interventions for delivery within a five-year period, with larger more complex improvement interventions identified in the NIP and considered further under Programme Business Cases. Figure 1 illustrates how the Austroads SmartRoads process results in the development of both plans.

Figure 1: SmartRoads Process Map[1]



[1] Vicroads, 2015, Smartroads Guidelines

3. Strategic objectives

The land use and transport strategy objectives for a Local Authority are set in advance of the NOP objectives. The current Austroads process focuses predominantly on measuring congestion, which limits the ability to consider wider objectives. For the Tauranga NOP, the stakeholders desired a set of metrics to incorporate safety, accessibility and amenity that more comprehensively encompass customer values.

In Tauranga's case, stakeholders report that growth pressures and development constraints have led to dispersed population and car dominance with a poor safety record which threatens the future viability of the region. Reliance on car travel must be reduced to enable Tauranga to continue to grow in a sustainable way, without severe traffic congestion and increasing risk to travellers that compromise its liveability and economic vitality. Stakeholders determined the overarching objective for this NOP was:

> *To identify a 0-5 year programme of interventions that can provide an optimal balance in addressing existing modal LOS gaps whilst continuing to enable growth over a 30-50 year horizon, based on the Optimised Transport System approach.*

This was to be achieved by:

- making journeys safer
- increasing mode choice
- developing a freight priority network; and
- investing in high-quality bus networks integrated with other modes.

It is noted that many of these objectives are increasingly in conflict.

4. Road use hierarchy

The road use hierarchy is developed by identifying mode priorities along links, place values and throughputs of traffic. To aid stakeholders in determining these factors, a GIS model was built with a comprehensive and visual appreciation of the land use activities and networks in the study area. The GIS model brought together the various sets of available information into a single place and included: crash and risk mapping data, traffic count data, traffic signals locations, cycleway routes, bus routes, stops and shelters, the road hierarchy, school locations, retirement village locations and sizes, planning zones and other council data.

4.1. Priority networks

Stakeholders agreed that the network to be used for the Tauranga NOP should consist of the State highway network, with the addition of local arterial and collector roads, totalling approximately 600km in length. The network was expanded to include future infrastructure planned to be implemented in the next 5 years, and selected existing local roads and off-road paths to provide a complete strategic network for busses, cyclists and pedestrians. From this network specific links were identified as contributing to the priority movement of each mode.

The Pedestrian Priority Network identified where pedestrian movement is of highest priority, and generally correlated with the 'Place' significance. The Tauranga Cycling Priority Network was primarily based on the routes with higher volumes of cyclists in the published Tauranga Cycling Network. The Stakeholders agreed that the Tauranga Freight Priority Network would be limited to the State Highways.

4.2. Place definition

Place importance determines, in part, the priority given to each mode. By way of an example, pedestrians get the highest priority in the city centre. An unforeseen difficulty in applying Place into the SmartRoads tool was that the attribute is assigned to network links rather than any true spatial form: for example, a 2km long road link including a local shopping centre of say 100m length would either have all its length assigned as a Place or the shopping area would have to be omitted. This was resolved by sub-dividing links into smaller segments to ensure Place was adequately represented.

5. Throughput

With the road hierarchy defined, throughput was added to determine the relative value of each link by mode. Traffic volumes sourced from RAMM data, and modelled flows from the 2016 Tauranga Traffic Model were compared to provide Throughput values. The model flows were selected as they provide more consistently reliable data and have recently been validated. Similarly, heavy vehicle volumes were extracted from the same model. Utilising this direct data connection was more efficient and provided more robust analysis than manual application.

Bus service routes and frequencies were primarily based on existing bus schedule information. Application of bus GPS data to provide this information was not utilised in this project but is being incorporated into the Auckland NOP currently under development.

The availability of reliable pedestrian and cycle count data was limited but was supplemented by school transport mode choice data supplied by stakeholders. The stakeholders then refined these volumes using local knowledge and consideration of Place function. While a Place-based approach helped in setting representative numbers, the process required user judgement and remains a weakness of the process.

6. Level of service

Levels of Service (LOS) are the final base model input that measure the network's performance in the present day. The stakeholders desired a more comprehensive approach comprising the recommendations of research by Green, D & Espada, I, (2015, p.14-15). This initially included 61 metrics to measure mobility, safety, accessibility, amenity and information.

However, detailed evaluation of each suggested metric concluded that many either lacked meaningful impact on the LOS or were substantially incomplete. For example, the pavement ride quality measure of amenity was removed since the range of quality was not significant enough to influence outcomes. Instead, amenity was measured qualitatively through the overall quality of the facilities, including the aesthetics.

The outcome was the development of comprehensive yet simplified LOS Measurement Matrices including both descriptive and illustrative measures, see Figure 2 for an example of this development. The matrices proved to be especially useful when later considering the impact of interventions on the LOS and provided a full range of values that can be implemented across any network ensuring that future assessments and comparisons are well aligned.

Once the metrics were revised, existing GIS data (including Travel Speed, Speed Efficiency, Volume Capacity Ratio, Crash and Risk maps for each mode and time period) could be applied to better inform the qualitative evaluation of each link's LOS..

Figure 2: Current versus simplified metrics (PT only example)

Current

LOS need	LOS measure	Data Set (TCC/WBOPRC/NZTA)
Mobility	Service schedule reliability	Both these criteria are functions of the operating environment of the road link concerned. A bus operating on a congested road without any bus priority measures would have poor reliability and a low operating speed.
	Operating speed	
Safety	Crash risk	Personal Risk Category from previous risk analysis mapping.
	Crash risk of transit users while accessing/ egressing transit vehicle	This should not vary by road link assuming that bus stops are provided in appropriate locations. Also no reliable data available.
Accessibility	Service availability (urban services only)	This is a function of the service frequency and service routes along the road or link concerned.
	Level of disability access	This can be expected to be relatively consistent throughout the network, and should not vary by road or link.
	Access to transit user stops/stations from key origins and destinations	Again, this is a network function not a road link function
Information	Traveller information available	The availability of traveller information does not vary by link, but is a function of the quality of information available at interchanges, stops and over the internet.
Amenity	Pedestrian environment (also refer to pedestrian LOS)	Dealt with under pedestrian amenity
	On-board congestion	On-board congestion and seat availability are a function of the service frequency (dealt with under access criteria), demand and funding. Of these only service frequency is relevant at the individual road link level.
	Seat availability	
	Security	Security perception can be influenced by several factors including the surrounding development, lighting, walk distances, the design of interchanges/stations, on board CCTV etc. It is very difficult to calibrate, is predominantly a system attribute and would require a lot of data capture / analysis.
	Comfort and convenience features	Comfort and ride quality are based primarily on the quality of the vehicles and PT infrastructure. Convenience is influenced by vehicle design and service frequency and reliability. Service frequency is included under access criteria. The aesthetics of the public transport system is not expected to vary significantly across the network.
	Aesthetics	
	Ride quality	

Simplified

	Public Transport	
A	**Mobility:** Congestion - VCR < 0.05% (of operational lane) **Safety –** As Pedestrian and no crashes. **Accessibility –** Number of routes (not buses/hr) = 6 or more. **Amenity –**Stop quality/security/seat availability (as above.)	
B	**Mobility –** VCR = 0.06-0.15% **Safety –** As Pedestrian with only a one crash in 10 yrs. **Accessibility –** Number of routes (not buses/hr) **= 5.** **Amenity –**Stop quality/security/seat availability (as above.)	
C	**Mobility –** VCR = 0.16-0.30% **Safety –** As Pedestrian **Accessibility –** Number of routes (not buses/hr) = 4. **Amenity –**Stop quality/security/seat availability (as above.)	
D	**Mobility –** VCR = 0.31-0.45% **Safety –** As Pedestrian **Accessibility –** Number of routes (not buses/hr) = 3. **Amenity –**Stop quality/security/seat availability (as above.)	
E	**Mobility –** VCR = 0.45-0.60% **Safety –** As Pedestrian **Accessibility –** Number of routes (not buses/hr) = 2. **Amenity –**Stop quality/security/seat availability (as above).	
F	**Mobility –** VCR = 0.61-1.00% **Safety –** As Pedestrian **Accessibility –** Number of routes (not buses/hr) = 1. **Amenity –**Stop quality/security/seat availability (as above).	

7. Strategic encouragement factors

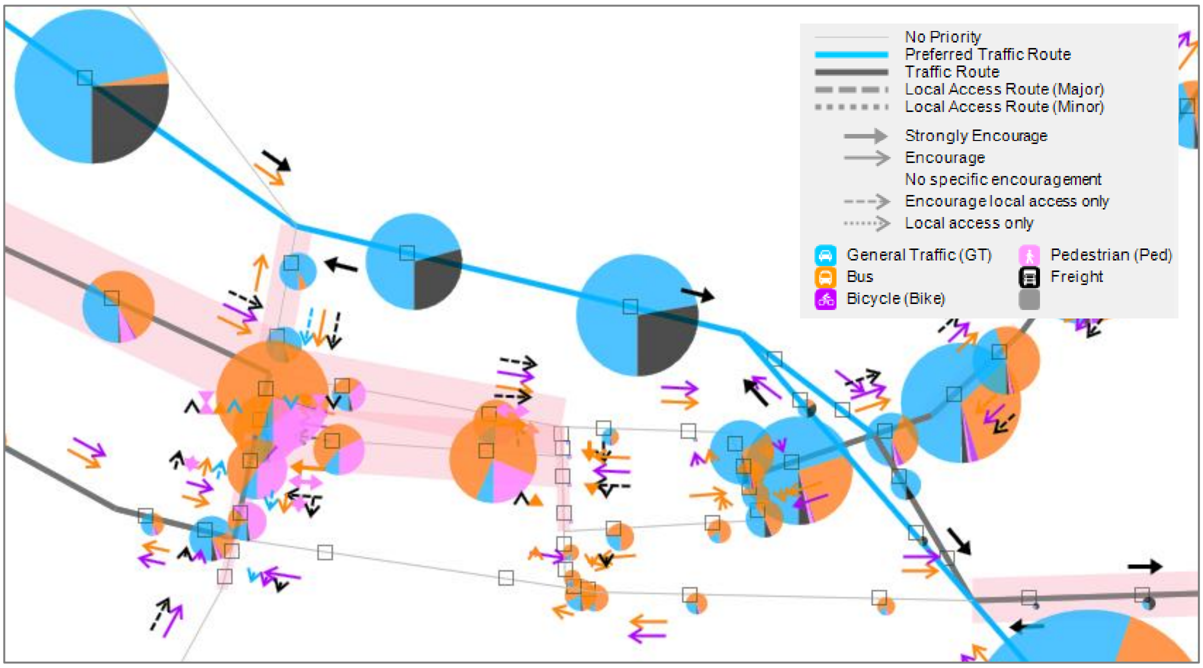
With the base model completed, the target LOS can be calculated through consideration of the place, network priorities, throughput and four strategic factors which are determined by stakeholders:

1) Levels of Encouragement or Relative Priority Factor which is determined by Place and Road User Hierarchy giving more encouragement to the modes most desired in any given Place.
2) Mode Shift Factor or Relative Growth Factor is a strategic network wide factor which can be thought of as the probability of a mode shift from cars to the alternative mode. In Tauranga, the Stakeholders allocated a high growth factor to public transport and cycling. Walking was given a medium growth factor which in part reflects an aging population.
3) Period Weighting Factor was applied only to buses and represents the aspirational LOS for peak travel times in terms of average bus occupancy.
4) Relative Efficiency Factor represents the relative value of each mode in moving people or goods and services.

8. Operating gap identification and visualisation

Network performance is measured using Operating Gaps (OGs). OGs represent the difference between the existing and desired LOS for any mode for a specific time of day and place. The SmartRoads Network Fit Assessment (NFA) Tool is a tool supplied by Austroads to support their methodology for developing a NOF. It provides outputs that determine OGs in the form of a pie chart for each link, direction and period, see Figure 3.

Figure 3: SmartRoads Network Fit Assessment Operating Gap Output



Presenting the OG data spatially enabled the Stakeholders to identify which areas represented the greatest opportunities for investment. This proved valuable as some of the initial perceived focus areas did not align with the greatest opportunities to close the OG.

9. Intervention scenarios

For each focus area, a range of demand and supply interventions were combined into three scenarios aimed at providing a more balanced choice of modes to customers. The three scenarios describe progressively stronger mode shift interventions that addressed the OGs whilst continuing to enable growth over a 30-50 year horizon and are as follows:

- Business as Usual (BAU) – This scenario is the most aligned to accommodating general traffic growth and improves non-car based networks only where the improvements do not have an adverse effect on car based congestion.
- Low Mode Shift (LMS) – This builds on the BAU scenario by providing new pedestrian, cycle and bus connections, transit lanes, ramp metering and a city parking pricing strategy.
- High Mode Shift (HMS) – This builds further on the LMS scenario by providing bus lanes, a ferry service to the Mount, and variable roads pricing/ tolls.

Interventions where implementation was anticipated to occur beyond the 5-year period, were considered as part of NIPs and therefore were excluded from further assessment.

10. Results and Conclusions

The assessment identified the HMS scenario as the most effective in achieving the strategic objective. However, with the LMS scenario only marginally less effective, this was concluded to be preferential due to political and public acceptability factors. Principally the LMS scenario included high occupancy vehicle lanes which were anticipated to provide high levels of throughput in the short term, whilst not precluding the future HMS scenario in the longer term which incorporated dedicated bus lanes.

The result of the NOP development was to identify the location and types of operational investment that would most clearly align with the longer term strategic objectives. Demonstrable intervention alignment also occurred between stakeholders as a result of the collaborative multi-stakeholder One Network workshops held throughout.

Had this process not been followed, some investment would have likely occurred in less effective locations and been less effective in achieving the longer-term objectives.

11. Learnings and further considerations

The current NOF approach requires extensive stakeholder input to determine the impact of interventions on congestion-based LOS to optimise the use of the transport network. However, the approach presented in this paper has several advantages over the current recommended Austroads approach to support the development of a NOF:

- Using GIS allowed the collection and presentation of a large amount of data graphically. The easily understood visualisations assisted in demonstrating the effect of changed parameters to Stakeholders.
- The use of qualitative examples of various LOS for each mode made it easier for Stakeholders to assess current LOS and, particularly, to assign LOS to the alternative scenarios.
- Presenting OG across the network gave Stakeholders valuable insights which enabled them to focus on developing and applying scenarios which addressed a wider range of strategic objectives.
- The approach facilitates the development of future NOPs through alignment with long-term plans for mode choice, safety, and an efficient and sustainable transport system.

The new approach used in this paper enables future development opportunities as below:

- Further intervention testing could be used to demonstrate how individual interventions contribute to the selected scenario, enabling more refined programming.
- The scale of impact on the Level of Service Operating Gap for each intervention could also be utilised to identify which interventions offer the greatest change (and should therefore be programmed earlier); which interventions need to be packaged together to achieve collective benefits; and which interventions may be the most controversial, in terms of impact on customers.
- The overall impact across the network from each scenario can be evaluated to indicate the modelled mode shift, which in turn can be aligned and compared with other comparable networks and strategic targets.

12. References

Green, D & Espada, I, 2015, Level of service metrics (for network operations planning), *Austroads*, AP-R475-15.

Hewitt, S, 2013, The application of network operations planning framework to assist with congestion management and integrated land use and transport, *Austroads,* AP426-13