DO OUR ASPIRATIONS MATCH OUR ABILITIES? SYSTEMATIC CHALLENGES FACING THE TRAFFIC AND TRANSPORT PROFESSION

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ABSTRACT

World-class transport systems require world-class traffic and transport professionals. But do our professional aspirations match our professional abilities? This paper analyses the practices of the traffic and transport profession in New Zealand and finds the answer is “perhaps not”.

Four inter-related challenges are considered, namely: 1) the lack of scientific rigour that characterises common professional practices; 2) the limited degree to which professional practices consider economic concepts of value; 3) the relative incompleteness of key performance indicators and associated outcomes; and 4) the apparent misalignment between professional practices and stated professional values.

These challenges are often inter-related and tend to have cumulative impacts; together they seem likely to compromise the profession’s ability to make a positive contribution to society. To finish, the paper identifies possible options for addressing these challenges. The significance of the challenges, and the relatively slow pace of progress to date, indicates major changes may be required.

INTRODUCTION

World-class transport systems require world-class traffic and transport professionals. This paper considers whether the aspirations of the traffic and transport profession match our abilities, and finds that the answer is "perhaps not". Four inter-related challenges are presented and discussed:

1) The lack of scientific rigour that characterises common professional practices;
2) The limited degree to which professional practices consider economic concepts of value;
3) The relative incompleteness of key performance indicators and associated outcomes; and
4) The apparent misalignment between professional practices and stated professional values.

Evidence is presented to show these challenges are inter-related and together seem likely to compromise the profession's ability to make a positive contribution to society. To finish, the paper identifies possible options for addressing these challenges. The significance of the challenges, and the relatively slow pace of progress to date, indicates major changes may be required.

CHALLENGE 1: SCIENTIFIC RIGOUR

This section considers the level of scientific rigour that underpins common professional practices. Theoretical issues are presented first, before evidence is presented to show the implications of these issues for the robustness of the profession's quantitative predictions.

Demand equations form the basis for many of the profession's quantitative predictions and, in turn, inform many of its recommendations. These equations typically assume the following form, where demand is assumed to be a linear function of development size[1]:

$$Demand = f(Size) = \beta.Size$$

These demand-prediction equations appear to be vulnerable to several theoretical challenges.

First, there is evidence the equations **omit causal variables**. Litman (2014) argues demand is a function of numerous characteristics other than development size, including but not limited to 1) *locational attributes*, such as land use density; 2) *aspects of site design*, such as internal layouts; and 3) *travel demand management policies*, such as pay parking and home delivery.

These omitted causal variables seem likely to be positively correlated with each other, as well as with the size of the development. For this reasons, the profession is likely to overestimate the value of β,[2] i.e. the use of a single explanatory variable introduces systematic bias into demand equations that are commonly used by the traffic and transport profession.

Second, there is evidence to suggest the equations are sensitive to issues with **simultaneous causality.** This issue arises because the structure of the equations and their interpretation implicitly assumes demand is independent of the supply. Estimates of parking demand, for example, typically assume the following causal relationships:

$$Size\ of\ development \rightarrow Demand\ for\ parking \rightarrow Supply\ of\ parking$$

[1] Where "Demand" denotes vehicle trips and/or parking associated with an individual development; "Size" denotes the physical size of the development (often measured in terms of gross floor area, or "GFA"); and β denotes the coefficient to be estimated. "Size" is hypothesized to have a positive causal impact on demand (i.e. $H_0: \beta > 0$).

[2] This issue is only partly overcome by the tendency to segment developments into categories, or types. It is, for example, common practice to estimate trip generation and parking demands for smaller dwellings, such as one bed-room apartments, using different rates from larger dwellings. This segmentation implicitly accounts for some of the omitted causal variables, insofar as the types of development may also be correlated with the omitted causal variables. However, the omitted causal variable issue remains within individual types. For example, smaller dwellings in central locations will typically be assumed to be the same as smaller dwellings developed in peripheral urban areas. So while segmentation of development types mitigates some of the bias introduced by omitted causal variables, the issue remains largely unresolved. Efforts to categorise sites also creates issues with sample size.

A large body of research, however, shows a strong positive causal relationship actually operates in the other direction, i.e. an increase in the supply of parking will cause an increase in the demand for parking (TRB, 2003). This is especially true when the parking supply is unpriced. This implies a two-way causal relationship between demand and supply is more appropriate, as shown below.

$$Size\ of\ development \rightarrow Demand\ for\ parking\ \Leftrightarrow Supply\ of\ parking$$

Techniques to control for the presence of simultaneous causality, such the use of instrumented variables, are commonly used in other fields such as econometrics. By failing to make use of these techniques, and thereby control for simultaneous causality between demand and supply, estimates of the coefficient β are likely to be positively biased.

Third, demand equations seem to be sensitive to **sample selection bias.** The data used to estimate values of β are sourced from traffic surveys of individual sites. Such surveys, however, are usually undertaken in a random fashion, but are instead selected in response to an external pressure, e.g. when required by a regulatory authority as a condition of development.

This is likely to introduce sample selection bias in at least two ways: First, surveys are more likely to be undertaken for new developments in peripheral urban areas characterised by high levels of vehicle use. Second, surveys are more likely to be undertaken for developments where vehicle demands are expected to be an issue. Both factors are likely to positively bias estimates of β.

Fourth, the demand equations used by the profession tend to downplay issues with **statistical dispersion**, or variability. Measures of statistical dispersion simply seek to quantify variation between data points within a data set. Statistical dispersion affects the level of confidence that can be attached to inferences drawn from the data. The table below, for example, is adapted from Douglass and Abley (2011). It summarises trip generation rates derived for 33 supermarkets and shopping centres, as well as some measures of statistical dispersion derived by the author.

Size (m^2 GFA)	n	Mean	Std. dev.	95% C.I.	
				Low	High
0-2,000	9	17.4	7.32	3.1	31.7
2,001-4,000	13	16.3	4.38	7.7	24.9
4,001-6,000	3	15.04	4.35	6.5	23.6
6,001-10,000	8	8.42	6.43	-4.2[3]	21.0

Table 1. Trip generation rates for 33 supermarket and shopping centres in New Zealand

The statistical dispersion present in the above data casts doubts on two common professional assumptions: 1) that vehicle trip generation rates are strongly and positively related to the floor area of a development and 2) that trip generation rates tend to decline as the scale of development increases. In this case, the levels of statistical dispersion present in the data, as well as the small sample sizes, do not provide statistical evidence to support either inference.

Where statistical dispersion is acknowledged by the profession, then it tends to be managed in a curiously biased fashion. It is common practice, for example, to design for "the peak hour" and/or "the 80-90th percentile" event (see, for example, Douglass and Abley (2011)). A review of the literature found no scientific or economic justification for the adoption of such a design standard, aside from the circular reasoning that it is 'common practice'.

The question remains, however, as to whether these alleged theoretical issues actually affect the robustness of the profession's predictions of demand?

[3] It is assumed the data follows a normal distribution, which gives rise to negative values. If this assumption is correct, then the result implies there is no statistical evidence to support the hypothesis that GFA impacts on trip generation for this type of development.

The magnitude of the positive bias introduced by theoretical issues becomes obvious when one compare the trip generation rates commonly used by the profession to those derived from other sources. Site surveys in the Trips Database Bureau ("TDB"), which is a common basis for professional demand estimates, implies the average New Zealand household generates an average of 10 vehicle movements per day. In contrast, data from the Ministry of Transport's (MOT) Household Travel Survey (MOT, 2014), which is a random sample of approximately 2,000 households, finds an average of only 5.2 vehicle trips per day[4]. In this case, trip generation rates used by the profession are 100% higher than that derived from more scientifically rigorous sources.

Strikingly similar findings are reported in a 30 year old study into the vehicle trip generation rates specified by the Institute of Transportation Engineers ("ITE") in the U.S. (Reid, 1982):

> *The commonly used household vehicle trip rates from the Institute of Transportation Engineers' Informational Report, Trip Generation, are nearly twice as large as equivalent data from survey-based sources … ITE data are claimed to lead to excessive local road capacity decisions. Survey-based rates are more consistent with other national accounts and observations of travel.*

Despite major methodological issues and errors with trip generation and parking rates being identified over 30 years ago, their application remains largely unchanged today.

These issues are compounded by **inadequate validation**. The scientific process of validation simply seeks to compare predicted and observed demands so as to identify causes of systematic variance and improve the accuracy of predictions. The aforementioned theoretical issues, for example, could be mitigated by adequate validation.

The business case for the Additional Waitemata Harbour Crossing (AWHC) provides a contemporary local example of inadequate validation. Figure 1 compares observed vehicle demands in the period from 1990-2013 (solid black line) with the level of vehicle demand assumed in the business case (dashed black line) (NZ Transport Agency, 2010).

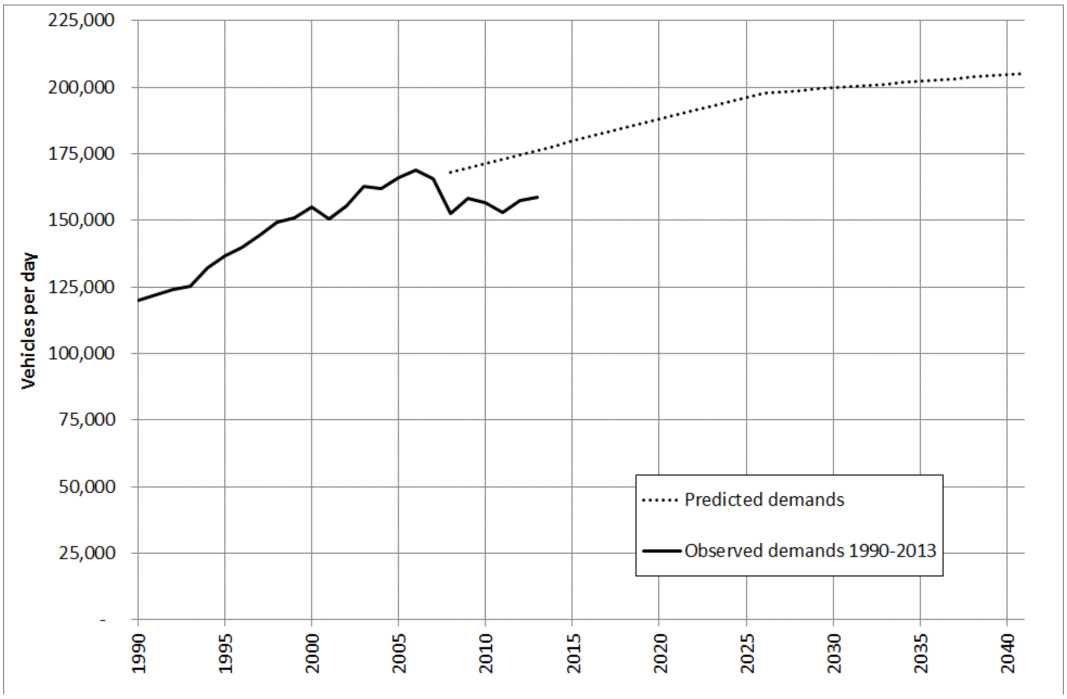

Figure 1. Comparison of observed and predicted demands in the AWHC business case

This reveals a large discrepancy between actual and predicted demands, with the latter being

4 (5.2 = 699 private vehicle trips per year per capita x 2.71 people per household / 365 days per year)

approximately 8.5% higher than the former in the base year (2008). It is important to note 1) the AWHC business case was developed in 2010, by which time vehicle count data from 2008 and 2009 is likely to have been available and 2) the non-linear nature of vehicle delays means this discrepancy is likely to have significant implications for benefits attributed to the project.

International research finds errors in the profession's quantitative predictions are systematically biased in directions that tend to favour the profession – at least in the short run (see, for example (Flyvbjerg, 2013; BITRE, 2011). Analysis suggests these biases may also be present in New Zealand (Nunns, forthcoming). Figure 2, for example, shows the variance in costs for 69 transport projects reviewed by the NZ Transport Agency from 2008 to 2012.

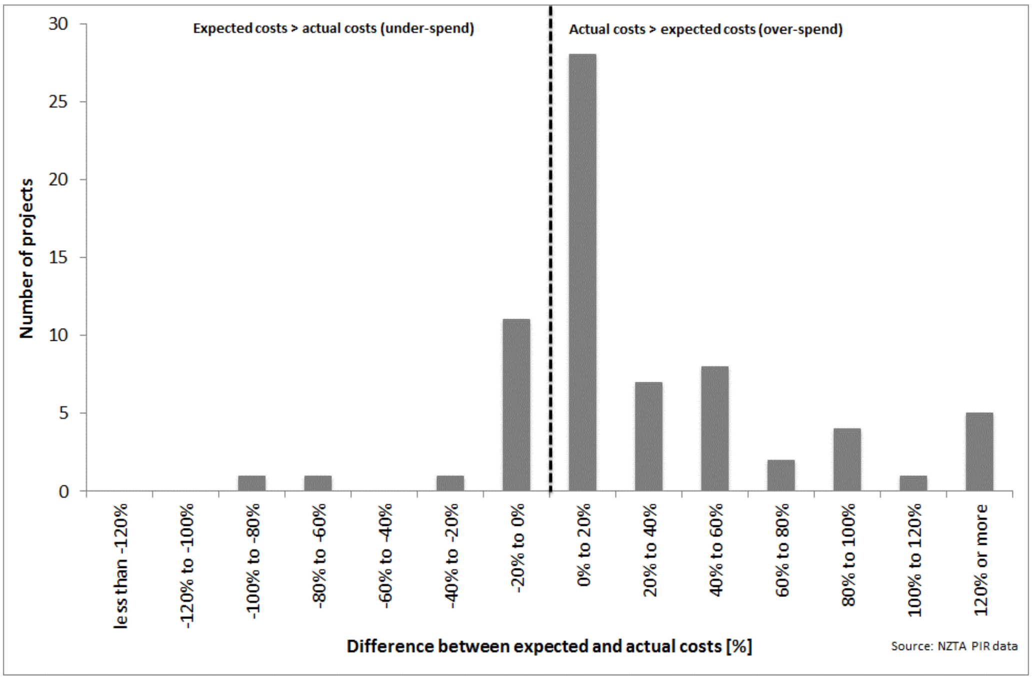

Figure 2. Difference between expected and actual construction costs

The difference between predicted and actual costs illustrated in this figure is statistically significant (p-value < 0.01), which implies project costs are systematically under-estimated by the profession[5]. Flyvbjerg (2008) attributes systematic errors in the profession's quantitative predictions (i.e. where demands are over-estimated and costs are under-estimated) to two biases: "optimism bias", which is a subconscious bias that results in optimistic assumptions, and "strategic misrepresentation", which is a conscious bias that results in facts being omitted, misreported, or even ignored.

CHALLENGE 2: ECONOMIC CONSIDERATIONS OF VALUE

This section considers the degree to which professional practices reflect economic considerations of value. Robbins (1932) defines economics as a social science ("studies human behaviour") that considers how people allocate scarce resources ("means") between potential alternative uses, and in turn how different allocations of these resources impact on people's well-being.

Many common professional practices do not appear to have been subject to the most rudimentary economic analysis. Such an analysis would logically attempt to compare the *transport benefits* derived from a particular practice with its *economic costs*, e.g. land and construction costs. Where the transport benefits exceeded the economic costs, then the practice could be considered to make a positive contribution to economic outcomes, and vice versa. Such a comparison explicitly recognises potential alternative uses for many resources.

[5] It is not clear how these projects were selected. If, for example, NZ Transport Agency conducted post-implementation reviews on only problematic projects, this analysis will be subject to sample selection bias and so overstate the magnitude of cost overruns.

The following sections first consider the economic value of two common professional practices, specifically minimum parking requirements and design standards for road geometry. This section concludes with some discussion on the economic duty of the traffic and transport profession.

THE ECONOMIC VALUE OF MINIMUM PARKING REQUIREMENTS

The first example of professional practices that appear to have developed without consideration of their economic value is minimum parking requirements ("MPRs").

MPRs specify the minimum amount of off-street parking that is to be provided with new developments, and are often based on numbers supplied by traffic and transport professionals. In New Zealand MPRs are often codified into district plans. From an economic perspective MPRs require some developments to supply more on-site parking than demanded by the market, which in turn increases the supply of parking. In situations where parking is priced, then MPRs can be expected to reduce the price of parking – all other factors being equal.

Recent research undertaken by the author for Auckland Council considered the economic impacts of MPRs (Donovan, 2014). This research includes a review of the literature on MPRs, which identified no credible studies supporting MPRs[6]. The author then quantifies the economic costs and benefits of MPRs, and finds that removing MPRs is likely to be beneficial in all but the most peripheral areas. Based on the results of this research, it seems likely that the application of MPRs, aided and abetted by the traffic and transport profession, has reduced society's well-being.[7]

THE ECONOMIC VALUE OF ROAD GEOMETRY DESIGN STANDARDS

A second example of professional practices that appear to have developed with little consideration of their economic value is design standards for road geometry. While a variety of standards exist, they typically involve setting minimum/maximum dimensions to facilitate the movement of vehicles.

One important and commonly applied concept in road geometry is that of the "design vehicle" (see, for example, LTNZ (2006)). The design vehicle is typically the 90th or 99th percentile vehicle in the vehicle fleet, or the largest vehicle that is expected to use a particular road, based on physical size or weight. The design vehicle is typically less manoeuvrable and, by extension, tends to have a significant influence on overall road geometry, especially at intersections.

Auckland Transport's (AT's) draft Code of Practice contains the following edict (AT, 2014a; p. 12):

> "*All intersections on major arterial roads should be designed to accommodate a semi-trailer.*"

The effect of designing for a semi-trailer is shown in Figure 3 below, which compares the intersection footprint required for a standard car versus a standard semi-trailer.

For the same design speed of 5-15km/h, the standard car requires 3.0m lanes and a turning radius of 7m. The semi-trailer, in contrast, requires 3.5m lanes and a turning radius of 15m, which increases the area of this particular intersection by 37% - from 2,973m^2 to 4,086m^2.

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[6] This is concerning given 1) MPRs have been applied across much of the developed world since the 1950s; 2) in this time parking has become one of the largest urban land uses; and 3) the sustained growth of cities is causing urban land to become increasingly valuable. The simple fact that a public policy intervention as significant as MPRs has not been subject to economic analysis illustrates the degree to which the profession has hitherto escaped scrutiny commonly applied to other professions, e.g. planning.

[7] This is not equivalent to suggesting that MPRs have no benefit; indeed MPRs certainly benefit motorists. What it does imply is that the benefits MPRs provide to motorists is outweighed by the costs they impose on others.

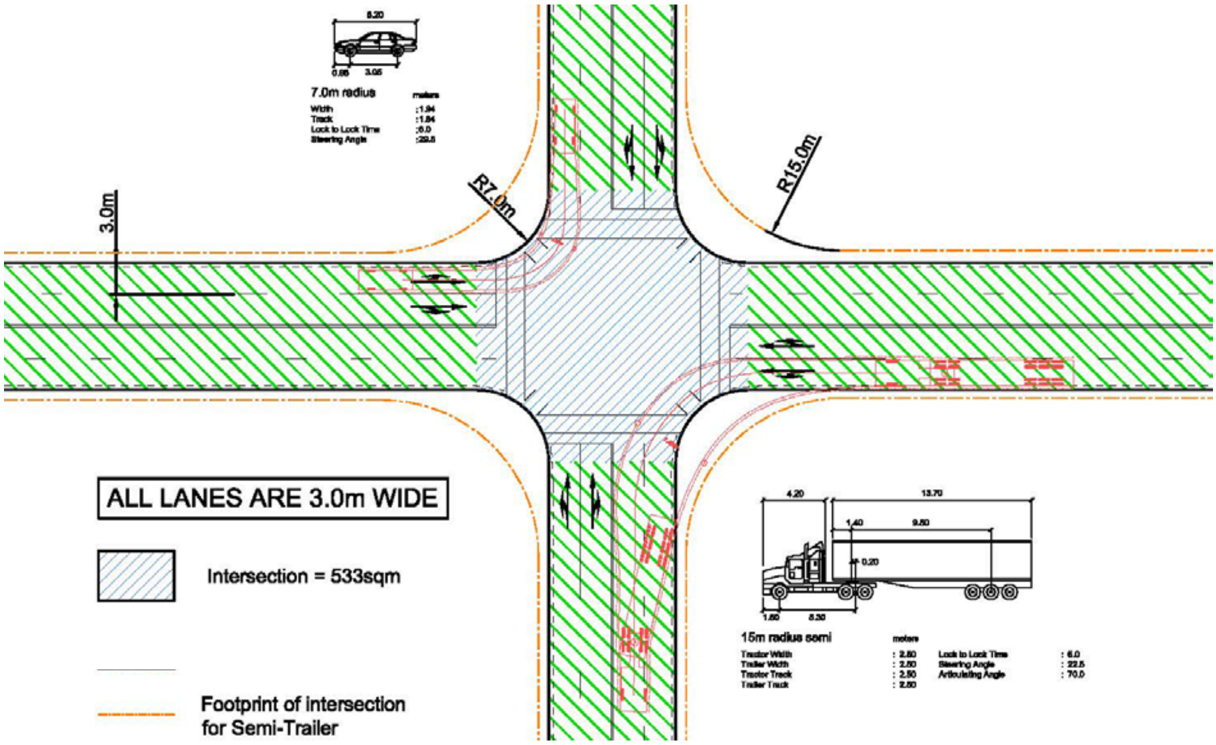

Figure 3. Simulating the effect of design vehicle selection on the physical footprint of an intersection.

The incremental cost of the larger intersection has been calculated and is shown in Table 2. This considers the costs of the larger intersection for a range of different land values (NB: The range of land values is representative of values found across the Auckland region).[8]

Land value ($ per m^2)	Incremental cost		
	Land capital value ($)[9]	**Annual cost ($ p.a.)**[10]	**Per semitrailer ($ per veh.)**[11]
$100	$111,300	$6,678	$0.08
$500	$556,500	$33,390	$0.38
$1,000	$1,113,000	$66,780	$0.76
$1,500	$1,669,500	$100,170	$1.14
$2,000	$2,226,000	$133,566	$1.52

Table 2. Calculating the incremental land costs attributable to a larger design vehicle

This suggests the incremental cost of land associated with accommodating semi-trailers ranges from $0.08 - $1.52 per vehicle per intersection. The economic benefits derived from this primarily accrues to trucking companies and their customers. This raises the following important question: Would beneficiaries be willing-to-pay a toll of this amount for every intersection they used?

A review of the literature found no studies analysing this trade-off in detail. The only study which appears to have indirectly considered the economic values of larger road geometry found they significantly reduced the viability of new residential development (Bertaud and Malpezzi, 2001). Hence, the risk exists that the transport benefits associated with the choice of a larger design

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[8] The incremental cost is expected to be conservative, insofar as it is likely to understate the costs imposed by larger design vehicles. Additional pavement construction costs, for example, are not considered.

[9] Total land costs is estimated as (4,086 – 2,973) x Land value.

[10] Annual land costs are estimated by multiplying the total land cost by 6%. This, which yields an annual economic return on the additional capital cost that is incurred by the decision to design for larger vehicles.

[11] Each approach to the intersection is assumed to cater for 5-day annual average daily traffic (AADT) of 5,000 vehicles per day, i.e. 20,000 vehicles per day in total. An annualisation factor of 220 days p.a. was used to estimate annual volumes. Vehicles of semi-trailer size, or larger, are assumed to represent 2% of total vehicle volumes.

vehicle are outweighed by the economic costs involved in designing for such a vehicle.

It might be argued the choice of a larger design vehicle is warranted on safety grounds (see, for example, Andreassen, 2003). This is, however, a moot point; evidence also exists that large road geometry results in higher vehicle speeds, which increases the probability and severity of crashes, especially for vulnerable road users. Ewing and Dumbaugh (2009), for example, conclude:

> *First, the traffic environments of dense urban areas appear to be safer than the lower-volume environments of the suburbs. The reason is that many fewer miles are driven on a per capita basis, and the driving that is done is at lower speeds that are less likely to produce fatal crashes. Second, at least in dense urban areas, less-"forgiving" design treatments—such as narrow lanes, traffic-calming measures, and street trees close to the roadway—appear to enhance a roadway's safety performance when compared to more conventional roadway designs … less-forgiving designs provide drivers with clear information on safe and appropriate operating speeds … Considered broadly, the fundamental shortcoming of conventional traffic safety theory is that it fails to account for the moderating role of human behavior on crash incidence. Decisions to ... widen specific roadways to make them more forgiving are based on the assumption that in so doing, human behavior will remain unchanged. And it is precisely this assumption … that accounts for the failure of conventional safety practice.*

Finally, it is worth noting that even if there were positive safety benefits choosing a larger design vehicle, then these benefits could be incorporated within a general economic analysis.

THE IMPORTANCE OF ECONOMICS TO THE TRANSPORT PROFESSION

The examples of minimum parking requirements and design standards for geometry indicate that common professional practices have developed without adequate consideration of economic value. This seems likely to result in over-investment in the transport network.

Greater scrutiny of the economic value of the practices of the traffic and transport profession would seem to be warranted for at least three reasons.

First, the transport network is the recipient of significant public investment. New Zealand currently invests approximately $4.0 billion p.a. – or 1.5% of GDP – in transport infrastructure and services, of which the majority is invested in roads. This figure is well in excess of the OECD average of 1.0% p.a. The relatively large public investment in the road network makes the economic value of professional practices a matter of significant public interest.

Second, the road network has a significant opportunity cost. Government accounts record the state highway network as having a "book value" of $26 billion (NZ Transport Agency, 2014). While the local road network does not appear to have been valued, its larger physical extent – especially in urban areas characterised by high land values – suggests it would have an even higher value. Together, the state highway and local road networks are likely to represent the single largest public asset in New Zealand by a considerable margin. Hence, the profession would seem to have a duty to ensure this asset is managed in a manner that considers its economic value.

Third, professional practices are often codified into documents that have statutory weight, such as district plans and development codes. Often compliance with such documents is not optional. Enshrining professional practices in statutory documents takes them out of the "technical domain" and places them squarely into the category of "public policy". Economic considerations of value should therefore play a key role in the application of professional practices.

CHALLENGE 3: COMPLETENESS

This section considers the relative "completeness" of the profession's chosen key performance indicators (KPIs) and the outcomes they lead to, especially for non-car modes. Table 3 summarises some commonly used KPIs, the scale of application, and typical dimensions.[12]

Performance indicator	Scale of application	Dimensions
Travel-time	Network, intersections	Vehicle-hours
Speeds	Network, intersections, movements, links	Vehicle kilometres per hour
Travel-time indices	Networks	Ratio of peak / off-peak speeds
Delay (congestion)	Network, intersections, movements, links	Seconds per vehicle
Queues	Movements, links	Metres or vehicles
Degree of saturation (DOS)	Movements, links	Vehicle density
Level of service (LOS)	Intersections, movements, links	Vehicle density (categorised)

Table 3. Summary of key performance indicators frequently used by the traffic and transport profession

Most of these indicators measure either vehicle speed or throughput[13], or the consequences of low speeds/throughput, e.g. delays and queues[14]. In almost all cases, professional practice interpret higher vehicle speeds/throughput as being a positive, or worthy, objective – and vice versa. Figure 4, for example, categorises arterial roads in Auckland based on their LoS in the morning peak.

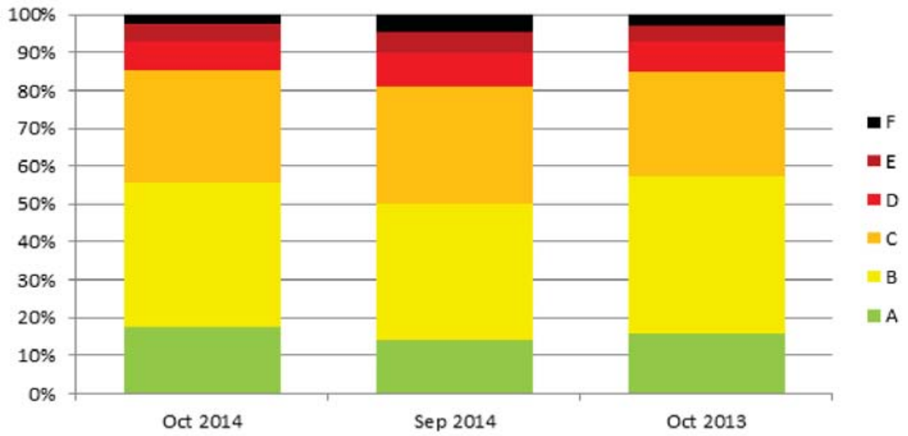

Figure 4. Auckland Transport Level of Service on Arterial Roads in the Morning Peak period (AT, 2014b)

The fact that only 15% of Auckland's arterials roads operate at LoS D, E, or F is usually interpreted as a positive result. An alternative, less positive, interpretation is that Auckland's arterial road network is so over-designed that it has considerable spare capacity, even during peak periods.

The contrasting nature of these interpretations stem from underlying differences in the way "performance" is defined.

The first interpretation reflects the predominant professional view, i.e. increased transport output is always a positive outcome. In contrast, the second interpretation implies that in making such a judgment one needs to consider output and input, i.e. *productivity*. The importance of productivity is widely recognised; Nobel Prize-winning economist Paul Krugman opined that "productivity isn't everything, but in the long run it is almost everything" (Krugman, 1997).

Productivity is a ratio of output to input. In a transport context, output could be defined as the

12 This list is indicative of the types of KPIs that are commonly used by the profession. Indicators used in strategic transport models are not listed, although many of these are derivatives of those listed here.

13 High LoS is not equivalent to high throughput. Research by Wallis and Lupton (2013) found that throughout is maximised at intermediate speeds, rather than free-flow speeds (where vehicle speed is generally analogous to LoS).

14 While "delays" could in principle be used to measure delays to non-car modes, this is rarely done in practise.

desired outcome, e.g. trips completed or kilometres travelled (by any transport mode), while input could be defined as the costs of public investment (capital and operating), minus any revenue generated from users. These definitions lead to the following functional form:

$$Transport\ productivity = \frac{Output}{Input} = \frac{Transport\ outcome}{Public\ investment} = \frac{Transport\ outcome}{Costs - Revenues}$$

Productivity indicators, such as that shown above, seem to provide a more robust basis for evaluating transport system performance.[15] Such indicators are not necessarily more complex than the KPIs that are currently used by the profession; all that is required is that output and input are evaluated contemporaneously. Appendix A uses the above indicator, for example, to evaluate the productivity of Balmoral and Dominion Roads in Auckland.

Evaluating performance in terms of productivity, rather than vehicle speeds, throughput, or delays, would tend to shift the focus of the profession from "*how do we maximise transport system output*" to "*how do we maximise transport system efficiency*"?

Answers to the latter question seem more likely to support well-being.

Issues with KPIs should not be construed as "academic"; KPIs often conceal important value-judgements about the desirability of different transport outcomes, which can have a major influence on the nature of the solutions that are delivered. Stated differently, incomplete KPIs create the conditions in which the profession is more likely to deliver incomplete solutions.

AustRoads (2012) p42, for example, suggests "the design of a new or upgraded development-related intersection should also be assessed for safety … for road users other than cars". While the guide encourages designers to ensure "pedestrians do not experience excessive delays", it does not subsequently define "excessive" pedestrian delays. This omission is particularly telling given that the guide provides specific "limits of operation" in terms of DoS for vehicles.

Figure 5 shows a four-way signalised intersection in Auckland where pedestrian crossings have been dropped from the two approaches marked with arrows. While this arrangement would improve the aforementioned car-oriented KPIs, such as DoS, in doing so it has become practically impossible for pedestrians to travel to/from the north-east corner of the intersection. It does not seem unreasonable to suggest that "impossible" meets the AustRoads definition of "excessive".

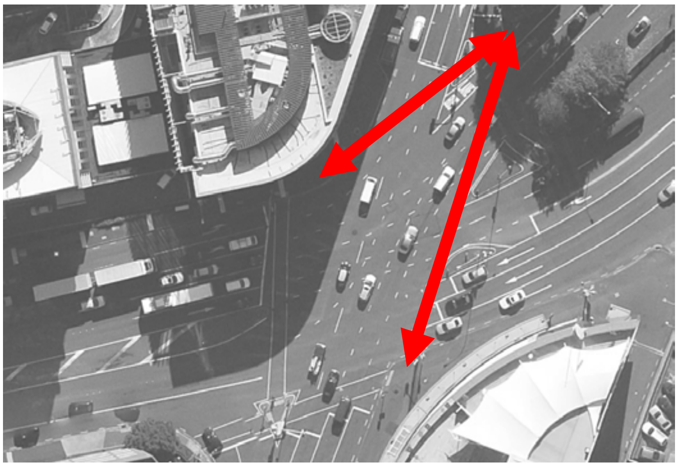

Figure 5. Intersection of Fanshawe Street and Nelson Street, Auckland.

Some might argue that the profession is increasingly aware of issues with completeness. While this may be the case, it is also true that highly incomplete transport solutions continue to be

15 This definition of productivity assumes gross costs exceed revenues, i.e. the denominator is positive. In situations where the denominator is negative, then the investment is defined to be "profitable". An important corollary of this functional form is that if costs appreciate faster (in absolute terms) than revenues, then productivity will tend to decrease – all other factors remaining equal.

delivered with concerning regularity. It remains common professional practice, for example, to remove pedestrian crossings on approaches to signalised intersections. The recently re-configured intersection of Fanshawe and Halsey Streets in Auckland is one such example.

Such configurations can impose 5 minute delays on some pedestrian movements. Assuming a walking speed of 1.4m/s, then this delay is equivalent to adding 420 metres to a trip (e.g. from Cathedral Square to north of the Avon; or from the Beehive to the waterfront; or from Britomart to Wyndham St. By extension. It seems clear that such practices greatly limit pedestrian accessibility.

General dissatisfaction with professional practices appears to have prompted some jurisdictions, such as New York and San Francisco, to replace road design guidelines, such as AustRoads, with urban street design guides. NACTO is an example of such a guide, which has been developed by the National Association of City Transportation Officials (NACTO, 2014).

In this context, it seems prudent for the traffic and transport profession in New Zealand to reconsider the completeness of its KPIs and the practices they support, if only to safe-guard its own professional relevance. This issue is explored in more detail in the following section.

CHALLENGE 4: PRACTICES VERSUS VALUES

Previous sections have outlined three general challenges facing the traffic and transport profession in New Zealand. These challenges have cast doubt on the robustness, value, and completeness of professional practices. This section now considers the degree to which these practices might cause the profession to act in ways that contravene its own stated values.

Professional engineering values are codified in the IPENZ Code of Ethics Parts 1 and 2 (IPENZ, 2015a and IPENZ 2015b); these ethical guidelines are used as the reference point for subsequent analysis in this section. Table 4 summarises professional ethical values and guidelines that are most at risk from the challenges identified in previous sections of this paper.

Values	**Guidelines**
Protection of life and safe-guarding people	1.1 Giving priority to the safety and well-being of the community …
	1.2 Ensuring that reasonable steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.
	1.4 Assessing and taking reasonable steps to minimise potential dangers involved in the construction, manufacture and use of outcomes of your engineering activities.
Commitment to Community well-being	3.1 Applying your engineering skill, judgement and initiative to contribute positively to the well-being of society.
	3.5 Endeavouring to be fully informed about relevant public policies, community needs, and perceptions, which affect your work.
Sustainable management and care for the environment	4.1 Using resources efficiently.
	4.3 Recognising adverse impacts of your engineering activities on the environment and seeking to avoid or mitigate them.

Table 4. Ethical values and guidelines for the Institute of Professional Engineers New Zealand

Previous sections of this paper presented evidence to suggest commonly used quantitative techniques lack scientific rigour and give inadequate consideration to economic value. Several of these quantitative techniques have been codified into statutory documents (in apparent contravention of guideline 3.5).

Common professional practices also seem likely to undermine efficient use of resources (in apparent contravention of guideline 4.1) in several ways:

- By leading to over-investment in road infrastructure,
- By leading to the inefficient allocation of scarce capital,
- By contributing to increased driving and increased consumption of energy/resources, and

- By contributing to the development of a road network that is physically larger than it needs to be, which is especially problematic in urban areas where land is most scarce.

The evidence presented in Sections 2 and 3 of this paper tend to suggest that common professional practices risk negatively impacting on well-being (guidelines 1.1 and 3.1). This risk seems especially prevalent for members of the community who cannot, or do not, drive. Many of the common professional practices discussed in this paper could be construed to directly and indirectly undermine community safety (guidelines 1.1, 1.2, and 1.4), e.g. the removal of pedestrian crossings from intersections and designs which lead directly to higher vehicle speeds.

Is it a major problem if professional practices do not align with the profession's own stated values?

Individual readers will of course have to answer this question for themselves, based on their own values. In the author's opinion, however, such a conflict would seem likely to erode the profession's credibility in the long run. This is particularly true for the esteem with which the profession is held by related professions, such as planners, urban designers, and economists.

IPENZ's ethical guideline 3.5 includes specific reference to the need for engineers to be "fully informed about … perceptions, which affect your work".

If perceptions are indeed important, then the traffic and transport profession would seem to have a serious problem. The article titled "With fat lanes[16], traffic engineers kill in the name of safety" provide an example of how related professionals currently perceive the traffic and transport profession (Speck, 2012). It observes:

> *… in the bizarre parallel universe of the traffic engineer, no such relationship exists. Motorists will drive at the speed limit, or slightly above, no matter what sort of drag strip we lay in their path … the engineers have once again failed to comprehend that the way they design streets will have any impact on the way that people use them …*

The language used by Speck to describe the traffic and transport profession is a cause for concern. And this article is not unusual: A quick internet search reveals numerous articles criticising the practices of the traffic and transport profession (see, for example, CityLab, 2012).

Based on this evidence, there appears to be an urgent need for the traffic and transport profession to address damage being caused to its credibility through the application of common professional practices. If these negative perceptions are unfounded, then the profession needs to communicate reasons why. On the other hand, if the negative perceptions are found to have some basis, then there is an even more urgent need for the profession to take corrective action.

CONCLUSIONS

This paper identifies four systematic challenges confronting the traffic and transport profession.

First, common professional practices appear to be critically lacking in scientific rigour. These issues seem likely to result in demands being systematically over-estimated, while costs are systematically under-estimated. The persistent presence of many of these issues casts serious doubt on the ability of the traffic and transport profession to "self- regulate".

Second, professional practices were also found to have developed without adequate consideration of their economic value. Evidence was presented to suggest this may result in an allocation of resources that is inconsistent with people's values and is likely to result in over-investment in the road network. The economic value of the transport network suggests this is an important issue.

Third, the profession's chosen KPIs were found to be incomplete insofar as they focus almost

[16] "Fat lanes" refers to vehicle lanes that are wider than 10 feet, or 3.05m.

universally on measuring vehicle speeds and throughput (or a lack of speed/throughput, e.g. delays and queues). The incompleteness of KPIs seems likely to contribute to conditions in which non-car transport modes are more likely to be treated inequitably and/or unsafely.

Finally, this paper observes an apparent misalignment between professional practices and stated professional values. This misalignment may partly explain the growing number of well-informed critiques of common professional practices, especially from other related professions.

RECOMMENDATIONS

The primary recommendation of this paper is fairly clear: The traffic and transport profession in New Zealand needs to seriously lift its game. The magnitude of the issues, and the slow pace of progress to date suggests major changes are required.

How might such changes be achieved?

First, in the author's experience many of the pitfalls identified in this paper are less prevalent in non-English speaking European jurisdictions, such as the Netherlands and Sweden. For this reason there could be merit in aligning professional practices in New Zealand with these countries, which tend to achieve best-practice outcomes in a number of areas, e.g. safety. Put simply, one solution may be for the profession to step out of the "English–speaking echo chamber".

Second, there seems to be a number of tangible steps that could be taken to improve the state of the traffic and transport profession in New Zealand, specifically:

- Openly acknowledging the profession is subject to political and commercial incentives and pressures which obviously influence the quality of the professional guidance that is delivered. Professionals should be made to be critically aware of these influences, while processes should be implemented to mitigate or minimise their impacts. Subsequent recommendations use this acknowledgement as a starting point.
- Convene an independent commission of inquiry into the state of the traffic and transport profession to be overseen by an eminent scientific or legal body. The purpose of such a commission would be to hear evidence from people working both inside and outside the traffic and transport profession and objectively identify and prioritise areas for reform.
- Completing comprehensive, independent, and randomly-selected post-implementation reviews of transport projects, from which the results are made publicly available. Such reviews would introduce an element of professional accountability, and would provide data with which the quality of professional work could be systematically monitored.
- Working with educational institutions to produce more well-rounded traffic and transport professionals. Traffic and transport professionals should be able to demonstrate knowledge in a wide range of not only scientific but also humanistic disciplines, including but not necessarily limited to geography, economics, statistics, psychology, and public policy.
- Funding independent research into:
    - Auditing the delivery of transport projects;
    - The accuracy of the profession's quantitative predictions;
    - The development of more complete KPIs; and
    - The economic value of common practices.
- Considering the replacement of road design guidelines, such as AustRoads, with street design guidelines, such as NACTO, especially in urban environments.

Finally, it is noted that many of these initiatives will encounter resistance from not only vested interests within the profession itself, but also from individual professionals for whom even acknowledging these issues could be interpreted as an admission of guilt. Providing appropriate (and potentially anonymous) mechanisms for professionals to highlight failings in past practices, without necessarily opening themselves to liability for the consequences of said practices, would seem to be an important practical step in enabling the profession to improve its practices.

APPENDIX A – PRODUCTIVITY CALCULATIONS

Figure 6 below illustrates the definitions of Dominion Road and Balmoral Roads as used in this analysis.

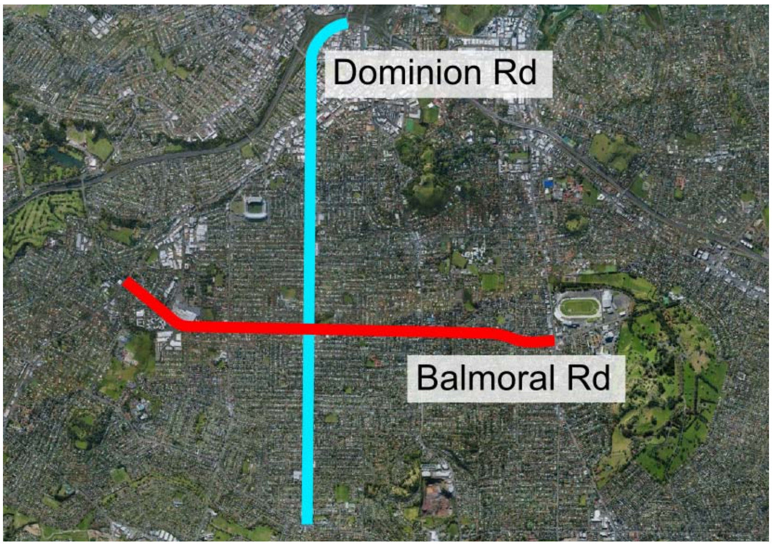

Figure 6. Definition of Dominion Road and Balmoral Road

Table 5 summarises the input assumptions and data sources for these calculations. A vehicle occupancy of 1.52 (from HTS) was assumed, and trip length was assumed to be the full road length.

Parameters		**Dominion Rd**	**Balmoral Rd**	**Dimensions / sources**
Output	AADT	24,698	26,438	vehicles per day (AADT)
	Annualisation factor	365.25	220	Estimated
	Passenger-km	72,847,191	40,614,963	km per year
Input	Road length	5,300	4,583	m (measured)
	Average road width	6.5	10.5	Assumed
	Lane-m	21,200	18,332	Road length x lanes (both directions)
	Area	34,450	48,122	Road length x road width
	Value	$1,250	1,000	per m^2
	Capital return	8%	8%	per year
	Opportunity cost	$3,445,000	$3,849,720	per year
	Local road network	14,400	14,400	lane km
	Maintenance costs	$190,005,205	$190,005,205	Total local road maintenance in 2014
		$13,195	$13,195	$ per lane km per year
		$279,730	$241,887	maintenance costs p.a.
	Fuel economy	10.00	10.00	litres fuel consumed per 100km
	Fuel excise duties	$0.57	$0.57	$ per litre
	Fuel tax revenues	0.06	$0.06	$ per vehicle-km
		$2,702,469	$1,506,725	$ revenue per year
	Net costs	$1,022,261	$2,584,882	$ costs per year
Productivity		71	16	passenger-km per net $

Table 5. Summarising input assumptions and data sources for productivity calculations

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