**RESEARCH PAPER**

**DEVELOPING A PUBLIC TRANSPORT PREDICTABILITY MEASURE**

**Authors**

**Dr Lorelei Schmitt** (presenter). BA MPlan (Distinction) PhD (Civil Eng) Init.NZPI, *Member of the IPENZ Transportation Group.* Senior Sustainable Transport Consultant, WSP | Opus International Consultants. (Contact: Lorelei.Schmitt@opus.co.nz)

**Dr Soroush Rashidi**. BEng (Civil) MEng (Infrastructure) PhD (Traffic and transportation engineering)*.* Traffic engineer -Data scientist, WSP | Opus International Consultants. (Contact: Soroush.rashidi@opus.co.nz)

**Louise Baker**.BSc (Hons) MSc PMP. Market Sector Lead – Smart Mobility & Advisory Services, WSP | Opus International Consultants. (Contact: Louise.Baker@opus.co.nz)

**ABSTRACT**

The ability to reliably predict public transport journey times is critical for network operators and transport authorities to measure, monitor, and target improvements to the public transport network, with flow-on effects for customers. Public transport performance monitoring is important to understand the ‘then’ and ‘now’ in order to make improvements for ‘tomorrow’. While a sophisticated measure of road ‘predictability’ is already in use in New Zealand, there is not an equivalent predictability measure used to monitor public transport. This research therefore aimed to identify and develop an optimal measure for public transport predictability. This was achieved by undertaking a local and international review of literature and practice of predictability/reliability measures used for public transport or private vehicle travel, and evaluating measures. From this review, and consideration of the potential for inter-modal and inter-regional aggregation, a shortlist of three preferred measures was developed including: Buffer Index, Modified Buffer Index, and Planning Time Index. These shortlisted measures were applied to a nationally aggregated set of public transport travel data from across regions and public transport modes. This data testing helped assess ‘fit’ to the NZTA [Road] Index, modification potential, and revealed that the shortlisted measures are all linearly related and there is not a strong case for one particular measure to be used. Validation workshops were then undertaken with key stakeholders to present and discuss the research. This paper documents this research the resulting conclusions and recommendations for future public transport predictability monitoring in terms of: measures to use, data preparation, consideration of customer perceptions of public transport reliability and potential future directions for public transport monitoring research, particularly in relation to emerging opportunities enabled by advanced technology.

**INTRODUCTION**

The ability to reliably predict public transport journey times is critical for network operators and transport authorities to measure, monitor, and target improvements to the public transport network, with flow-on effects for customers. Customers regularly identify public transport reliability as a key issue (Beirão & Sarsfield Cabral 2007), however, it is not measured in a consistent way across New Zealand. Currently, a range of reliability, or predictability-related measures for public transport are used in different parts of New Zealand, without one uniform measure deployed. Likewise, the NZ Transport Agency has a measure of travel time predictability for roads but does not have a comparable measure for public transport. While it might be desirable to compare reliability, or predictability, across travel modes, the characteristics of the NZ Transport Agency road-based measure mean that it may not be easily transferable to public transport. The research documented in this paper sought to address these issues and develop a measure for predictability performance that can be used across different transport modes and in different parts of the country. In summary, the research aimed to identify and develop the best measure for public transport travel time predictability based on

* + A review of literature and practice to ascertain the benefits and limitations of measures
	+ To develop a nationally aggregated set of travel time predictability information across regions, travel modes and times of day to ‘trial’ shortlisted measures
	+ To present and discuss research outcomes to key users of such measures including public transport operators and management agencies

It is important to note that the aim of this research was limited to a focus on ‘in-vehicle’ travel time. It is acknowledged that public transport journeys include multiple stages of travel including: ‘first mile’ travel to a stop or station, sometimes purchasing of fares, wait times for services, sometimes transfers (and additional wait times), in-vehicle travel, and finally ‘last mile’ travel to one’s final destination. The sole emphasis of this research was ‘in-vehicle’ travel time, including dwell time, because the research aimed to develop a measure which can be used to compare travel across modes, including private vehicle travel. In-vehicle time does have flow-on effects for wait times and transfers too though.

It is also worth explaining the terminology: the research was commissioned to identify an appropriate ‘predictability’ measure comparable to the NZ Transport Agency road-based measure; however, the dominant term used for this type of performance measure in literature is ‘reliability’. For this reason, the terms are used somewhat interchangeably in this paper.

The research methods employed to achieve this aim are documented in the next section.

**METHODOLOGY**

The research was conducted in New Zealand between August 2016-2017 and involved three research methods:

1. Secondary research involved apractice review of measures used locally and internationally and documented literature. To yield the best results, the ‘net was cast wide’ and measures available for either public transport or private vehicle travel were reviewed. This included evaluating the benefits and limitations of existing reliability measures and comparing available measures with the current NZTA road-based measure. Measures were evaluated in terms of their ability to meet the overarching aims of the research and consideration was given to the fact that, ideally, effective performance measures should be: applicable to users, easy to calculate, accurate and able to be clearly and consistently interpreted. From this review, and with consideration of the potential for inter-modal and inter-regional aggregation, a shortlist of three preferred measures was developed.
2. **Assessing modification potential of measures using NZ public transport data:** The shortlisted measures were applied to a nationally aggregated set of public transport travel data from across regions and public transport modes. This research stage involved: obtaining NZ public transport datasets, preparing data, applying shortlisted measures to data alongside the NZTA Index, undertaking threshold sensitivity testing, and interpreting the outcomes.
3. **Validation testing – workshops:** The outcomes of these research stages were then then presented to key stakeholders (public transport management authorities and operators) through interactive workshops in Auckland, Wellington and Christchurch. Attendees were asked to provide feedback on their understanding of shortlisted measures, whether they preferred any of the measures or thought they were useful, and what they thought the implications of adopting the measures might be.

The outcomes of these research methods then led to a number of considered conclusions and recommendations as are summarised at the end of this paper.

**LITERATURE AND PRACTICE REVIEW**

The literature and practice review covered: NZ Transport Agency road measures, public transport measures used in New Zealand and internationally, and international measures from either road or public transport captured in academic literature and other documentation, like manuals by transport authorities (e.g. the Federal Highway Administration 2009). Initially the literature review did not reveal any reliability or predictability measures being applied to both transit services and private cars by one agency.

Some authors argue that travel time reliability is the most important factor affecting public transport rider satisfaction (Gaffney 2006). Travel time reliability is generally defined as a measure of trip consistency during a specific time and location. It is meant to account for more than daily congestion and consider route inconsistencies due to unexpected delay (Kimley Horn and Associates 2011). Chen et al 2009 argues that in the case of public transport reliability is the consistency of travel times and the ability of the system to maintain regular headways and adhere to a schedule. Meanwhile, Mazloumi et al (2008) have distinguished between travel time reliability and variability definitions. Travel time variability is variation in travel time while travel time reliability is the level of trip consistency to expected arrival time.

Public transport reliability can be measured from the perspective of the operator or passenger. Currie et al (2012) offers an excellent review of customer-centric indicators of urban bus service reliability. Customer-centric measures tend to be relatively straight-forward to understand so that they are meaningful to passengers. However, operational reliability measures can be more sophisticated, potentially more accurately measuring inconsistency of travel times albeit in ways that may be less meaningful if directly communicated to customers. The research commission documented in the present paper was intended to look at predictability from a more operational point of view.

As noted earlier in the paper, an objective of the research was to identify a measure that could be compared with the NZ Transport Agency *road-based* predictability measure. This measure and can be defined:

*‘measures whether a time period exceeds this threshold or is under this threshold. The threshold is referred to as the “buffer”, and this approach may be called the ‘buffer measure’. Currently, the threshold is defined as the rolling 12-month average (average over last 12 months from current month) plus 5%.* (CTOC, 2015)

To calculate “predictability”, each peak hour per day during a monthly period (in 15-minute intervals) is assessed against this buffer and then allocated a value of ‘zero’ if the observed travel time exceeds this buffer or ‘one’ if it is below. Predictability is then expressed as a percentage and is equal to the average of the sum of the ones and zeros in the peak hour period of that month. The percentage is directly proportional to ‘predictability’, so a lower percentage indicates a lower predictability. Percentage outcomes can then be compared against the previous months for performance reporting purposes. For the remainder of this paper, we refer to this NZTA predictability measure as the ‘NZTA Index’. This measure, in its present use, is solely intended for performance reporting from an operator perspective rather than for direct customer information; but there are certainly implications for customers. The NZ Transport Agency uses several other measures to evaluate travel time performance, as summarised in the full NZTA research report.[[1]](#footnote-2)

The NZTA Index measure is a ‘buffer time’ measure, one category of reliability performance measures. There are three other main categories of performance measures: schedule adherence measures; statistical ranges; and tardy trip indicators. Table 1 shows a summary of measures reviewed. The three measures that were shortlisted for further investigation are denoted with asterisks and measures are discussed in more detail shortly.

**Table 1: Summary of measures reviewed**

| **Measure** | **Type** | **Description** |
| --- | --- | --- |
| **Punctuality****(includes: on-time performance, early arrival, late arrival,)** | Schedule adherence | Based on alignment of actual service running with scheduled service running. For instance, the proportion of buses that are not more than 1 minute early and no more than 5 minutes late (Chen et al 2009) |
| **Standard deviation** | Statistical range | Measures the spread of data. The more concentrated the data is around the mean, the smaller the standard deviation will be. It is generally represented by sigma (σ)

|  |  |
| --- | --- |
| $$σ=\sqrt{\frac{\sum\_{i=1}^{N}(X-\overbar{X)}}{N-1}}$$ |   |

where *X* is individual measurement of travel time,  is mean travel time and N is sample size  |
| **Coefficient of variation** | Statistical range | The ratio of the standard deviation to the mean |
| **Percentile travel time** | Statistical range | Simple and straightforward. Wakabayashi (2010) identifies commonly used percentile travel time measures (e.g. TT95: The 95th percentile travel time is a measure representing the first worst travel time)  |
| **Skew statistic** | Statistical range | The ratio of the difference between the 90th percentile travel time and the median and the difference between the median and the 10th percentile (Margiotta et al 2008) |
| **Frequency of congestion** | Statistical range | Percent of time that travel times exceed a threshold (FHWA 2008). Assumes conditions are considered congested when speed is less than or equal to 50% of the free-flow speed, or, equivalently, travel time is equal to or larger than two times the free-flow travel time (INRIX 2011) |
| **Travel time index** | Buffer time | The ratio of actual average travel time to free-flow travel time. Technically a congestion intensity measure rather than a reliability measure |
| **Failure rate** | Schedule adherence | 100% − percent of on-time arrival (Pu 2011) |
| **Misery Index** | Tardy trips | How the average of the worst set of trips (i.e. 20 worst) exceeds the average of all trips

|  |  |
| --- | --- |
| $$Misery Index (MT)=\frac{ATT\_{20 }}{ATT}$$ |   |

where ATT20 is the average travel time for the longest 20% of the trips and ATT is the average travel time |
| **\*Buffer index\*** | Buffer time | The extra time travellers must add to average travel time when planning trips to ensure on-time arrival.

|  |  |
| --- | --- |
| $$BI=\frac{TT\_{95^{th} }-TT\_{mean}}{TT\_{mean}}$$ |  |

 |
| **\*Modified buffer index\*** | Buffer time | A median-based variation of Buffer Index using 85th percentile travel time. Used by members of the Auckland Motorways Alliance and Auckland Transport$$MBI= \frac{TT\_{85th}-TT\_{Median}}{TT\_{Median}} $$ |
| **\*Planning time index\*** | Buffer time | Ratio of the 95th percentile travel time over free flow travel time

|  |  |
| --- | --- |
| $$Planning Time Index=\frac{TT\_{95th }}{TT\_{f }}$$ |   |

Where *TTf* is free flow travel time |
| **Lost customer hours**  | Tardy trips | The total extra journey time, measured in hours, experienced by Underground customers (based on patronage) as a result of all service disruptions with durations of two minutes or more |
| **Excess journey time** | Buffer time | Time in minutes to complete an average journey on the network over and above the scheduled journey time, weighted by (perceived) customer time values. Used on London Underground to account for all journey elements from entering to exiting station |

\*Shortlisted measure\*

The practice review revealed that *schedule adherence* measures are the most common type of predictability, or reliability’ measure currently used by public transport authorities in New Zealand and abroad. For example, Auckland Transport measures public transport punctuality as the percentage of total services leaving their origin stop no more than one minute early or five minutes late. Schedule adherence reliability is sometimes reported on websites, (e.g. in Boston the MBTA publishes reliability information on their dashboard) or at transit stations (e.g. rail stations in Melbourne). The punctuality thresholds often vary by service frequency or public transport mode.

Schedule adherence measures can be understood by customers relatively easily and are particularly useful for assessing operators as Key Performance Indicators. Unfortunately, this type of reliability measure is unsuitable for comparison with existing road-based reliability because the road-based measures are not based on a prescriptive schedule. Instead, measures that measure variability in travel times (for example Buffer Index), but which do not rely on scheduled departure times, are therefore inherently better suited for cross-modal comparisons of predictability. Another disadvantage of schedule adherence measures is that they can incentivise slower speeds in timetabling (and thus lengthen journey times) in an effort to improve schedule adherence. This can lead to services waiting at timing points and thus increasing journey times, a poorer outcome for customers.

Statistical range measures such as standard deviation or percentile travel time are more appropriate for inter-modal comparisons but can be associated with difficulties in aggregation from route level to regional levels. For example, standard deviation cannot be used to compare variability between routes of different route lengths since standard deviation increases with route length. Percentile travel times are often used as part of other measures, like buffer time measures, which have formula structures that make them more appropriate for aggregation. The US’s Federal Highway Administration (FHWA 2009) discourages use of standard deviation as a reliability performance measure because it is not easily understood or related to by non-technical audiences.

The tardy trip measures are used across a variety of travel modes. ‘Lost customer hours’ is a sophisticated measure used by Transport for London which includes perceived travel time and weights delays based on the associated public transport patronage. It is thus not overly easy to calculate. Misery index is focused on ‘the worst’ trips and thus not appropriate for evaluating wider performance.

The NZTA Index is a buffer time measure. Buffer time measures are generally popular in operations the United States among network planners in operations. Some are easy to understand, customer-focussed metrics and can utilise the worst-case percentiles travel time to highlight the expected delay on top of “normal” travel conditions. There is flexibility in the formula in terms of which percentile to use and the measures are flexible for aggregation. Mazloumi et al (2008) applied different percentile-based measures including Buffer Index to investigate travel time variability/reliability using Automatic Vehicle Location (AVL) data and found Buffer Index and Coefficient of Variation preferable due to their perception that they provide more information to users and planners. Buffer Index is not a preferred measure when the travel time distribution is heavily right-skewed and median should be used instead of the mean (Pu 2011).

The three buffer-time measures of Buffer Index, Modified Buffer Index (Figure 1) and Planning Time Index (Figure 2) were shortlisted and applied to aggregated public transport data alongside the NZTA Index to evaluate the ‘closeness of fit’.

|  |  |
| --- | --- |
| **Figure 1: Example of Modified Buffer Index reporting by Auckland Transport who now use the indicator to measure reliability and call the measure ‘Reliability’** | **Figure 2: Example of Auckland Transport reporting of what they refer to as ‘Delay’ - a variant of Planning Time Index (with 85th percentile travel time)**  |

**APPLYING THE MEASURES TO DATA: TESTING MODIFICATION POTENTIAL**

In order to assess the modification potential of measures, the following four-step process was used to test the measures:

1. Obtain New Zealand public transport datasets:
2. Prepare data: evaluate data format, address missing values, ensure data consistency
3. Apply measures to data and examine results: identify any emerging limitations of each measure
4. Threshold sensitive testing

In order to best understand the implications of the data testing the shortlisted measures were applied to the data along with the measures currently used for measuring road predictability (the “NZTA Index’) and public transport reliability (‘punctuality’ and ‘early’ and ‘late arrival’). The latter measures were solely included as a frame of reference to examine the shortlisted measures as they are currently commonly used to evaluate public transport reliability in New Zealand and overseas.

Public transport management agencies in Wellington, Auckland, and Christchurch were contacted to obtain data. With negotiation, four complete datasets for March 2016 were obtained: bus data for Auckland, Wellington and Christchurch; and rail information for Wellington. No ferry data was provided. The data then required significant ‘cleaning’ to prepare it for aggregation and analysis. Once ready, data were aggregated and the measures were applied to the AM peak period (7:00 AM to 9:00AM) March 2016 aggregate datasets. An example of the output of this analysis at the aggregate level is provided in Figure 3. (Route-by-route analysis using the measures was also undertaken but is commercially sensitive.) Results were colour- based on the performance against the thresholds. At this stage, the private-vehicle thresholds for the shortlisted measures were applied without adjustment. Green colouring indicates ‘Reliable’ predictability performance, amber ‘Moderately Reliable’ performance and red ‘Unreliable’ performance. It is clear that under the NZTA Index, the Buffer Index, Modified Buffer Index and Planning Index there was little differentiation in performance between cities. Conversely, using the schedule adherence measures, there was more variation with Auckland generally performing better than the other two cities.



**Figure 3: An example of composite results for all bus routes in each city based on median**

It was found that mean is a good measure of central tendency if the data are symmetrically distributed, but it can be affected by extreme observations. The median, on the other hand is the preferred method when the data are not symmetrically distributed and there are rare events or extreme observations in the dataset. Both mean and median were applied to data to test this issue.

Further investigation of a route, corridor or a section of a route is recommended when a significant difference between the mean and the median is found.

The outcomes of the data testing indicated that the shortlisted measures were comparable to the NZTA Index (all being linearly related) as the results of the performance analysis produced comparable results across different measures. This suggested that there was not a compelling case for one particular measure to be used, although mean-based measures were more sensitive to extreme observations in the data than median-based measures. The reliance of the NZTA Index to 15-minute time intervals meant that that the measure is only potentially appropriate for high frequency transit routes. The road-based thresholds initially applied did not provide much differentiation in performance outcomes. For this reason, some sensitivity analysis applying the measures using different thresholds was also undertaken. The results of this exercise suggested that use of any of the shortlisted measures will require careful consideration of which thresholds to use.

**VALIDATION WORKSHOPS**

When presented with the results of the research in the three validation workshops held in each of New Zealand’s main centres, key stakeholders had a range of reactions and feedback. Some workshop attendees were more confident in understanding and interpreting the measures than others. Generally, there was a sense that the measures may be appropriate for network planning but would require some translation for the outcomes to be meaningful for customers and other parties. Some attendees expressed concern about trying to ‘fit’ a predictability measure to the NZTA Index measure as many found that that measure to be complicated and non-intuitive.

The workshops further revealed that stakeholders felt that selection of any shortlisted measures depended on what aspect of reliability one wanted to examine and that care needed to be taken in comparing modes and developing thresholds. In terms of evaluating the shortlisted measures, many attendees wanted to better understand the context – which measure to use depended on how it would be used. Operators stated that they really only cared about measures that were written into their contracts. Some saw potential for the shortlisted measures to be useful for network planning but suggested that such measures are becoming less relevant to customers as advanced technology provides more intuitive and personalised travel reliability information.

There was not an overwhelmingly strong preference for any of the shortlisted measures but when pressed, some respondents from the Wellington workshop suggested just looking at absolute travel times (with a range to show variability). Everyone seemed to understand and like punctuality measures, with which they are familiar, but given the non-applicability to the objective of comparability with private vehicle measures, their next preference of the shortlisted measures presented seemed to be Planning Time Index and Modified Buffer Index. The Wellington workshop contingent thought the Planning Time Index seemed flexible in its applicability to convert into useful measures for both network planners and customers. In the Auckland workshop, we learned that since the initial literature and practice reviews had been conducted, Auckland Transport (AT) had begun using Modified Buffer Index referring to this as ‘Reliability’, and a measure similar to the Planning Time Index which they refer to as ‘Delay’ for inter-modal reliability analysis. The organisation provided some examples of the dashboard outputs they have produced using these measures, some excerpts of which were provided above in Figure 1 and Figure 2.

**CONCLUSIONS AND RECOMMENDATIONS**

Overall, the research largely achieved the overarching aims. A review of literature and practice review identified which reliability measures were in use in New Zealand and internationally for both public transport and private vehicle travel and included some evaluation of measures. The resulting shortlist of measures was applied to a nationally aggregated set of public transport travel data across regions and public transport modes in New Zealand. The results of this ‘trial’ suggested that any of the three shortlisted measures would be appropriate to use for aggregate comparisons of reliability across modes. However, it is recommended that different predictability measures be used depending on what aspect of public transport reliability one wishes to understand. A summary of the evaluation of key reliability performance measures is provided in Table 2 below.

**Table 2: Summary of evaluation of key reliability measures**

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure** | **Better for measuring** | **Less optimal contexts** | **Explanation and additional comments** |
| **NZTA Index** | * Road reliability
* Detailed data analysis
 | Public transport generally but especially low frequency routesGeneral public reporting | The NZTA Index’s current use of 15-minute interval readings makes it inappropriate to use for lower frequency public transport services.Feedback from the workshops was that the NZTA Index is very difficult to understand and there would be a strong preference not to use this measure. |
| **Buffer Index** | Typically used for private vehicle travel  | Reliance on mean makes this measure less optimal when there are extreme observations | This measure can be used across modes and provides similar results to the NZTA Index but thresholds need to be considered |
| **Modified Buffer Index** | Good for measuring all modes | Thresholds may need adapting across modes/regionsPresentation to the public would benefit from a more intuitive name and an easy explanation of the measure | This measure can be used across modes and provides similar results to the NZTA Index but thresholds need to be considered. Already in use by AT.  |
| **Planning Index** | Good for measuring all modes | Thresholds may need adapting across modes/regionsPresentation to the public would benefit from a more intuitive name and a simple explanation of the measure | Research demonstrates that this can be used across modes and provides similar results to the NZTA Index but thresholds need to be considered. A variant of this measure is already used by AT under the name ‘Delay’ |
| **Lost Customer Hours (TfL)** | Currently used for public transport in London | Less optimal for quick and easy calculations, requires sophisticated data capture | Not currently used for private vehicle travel but with some modifications could be used. Time intensive to calculate |
| **Punctuality (schedule adherence measures)** | * Public transport arrival and departure times
* to detect early and late running
 | Not appropriate to use for private vehicle travel which lacks specific schedules | Private vehicles lack specific scheduled arrival and departure times so punctuality is not appropriate to use for multi-modal comparisons |

Different measures can show variability from slightly different perspectives:

* With their reliance on average rather than median, the NZTA Index and Buffer Index are more sensitive to extreme observations than median-based measures like Modified Buffer Index
* Buffer Index can be useful for looking at how much fluctuation occurs on average along a route
* The Planning Time Index can be relatively easily converted to total journey times, offers an absolute minimum and maximum (considered most understandable for customers)
* Punctuality is a common and easily understood measure used to evaluate reliability for public transport but does not meet the objective of being comparable to private vehicle travel.
* The fact that AT is already using two of the shortlisted measures (or variants of) across multiple modes suggests that both Modified Buffer Index and Planning Index are appropriate for comparing reliability aspects across modes (and regions). However, it may be useful to present performance outcomes under more easily-understood terms and using colour-coding. AT’s ‘dashboard example of performance reporting provides a useful example. The appropriate thresholds to use for different measures require more consideration and may vary by region or mode.

There were other lessons learned as well. One, aggregating data across regions and modes is time-intensive and complex. Another issue is that while the focus of the research was on in-vehicle travel time, in the context of ‘real-world’ perceptions of public transport reliability, waiting time is very important to customers and their perceptions of public transport reliability (Douglas et al. 2006). Transport for London’s sophisticated ‘Lost Customer Hours’ is excellent at capturing this but is time-intensive to calculate and is not necessarily directly transferable to private vehicle travel. It is worth considering also that reliability may be less relevant to customers using high frequency services.

Thirdly, advanced technology may be changing the opportunities for public transport predictability analysis and also customer expectations. Customers have a growing expectation for real time travel information and communication about disruptions. Big data is emerging and enabling real-time responsiveness and better data for monitoring our transport networks. New technology-enabled transportation services are increasingly providing a ‘first/last mile’ connection to public transport for customers. Some transport agencies overseas have entered formal partnerships to provide a connecting service. These new services include bikeshare, transportation network companies (e.g. Uber), carshare, dynamic carpooling and demand responsive or pop-up transit e.g. Via. The increasing diversity in shared-use transport services is driving more multi-modal trips; reliability is important to customers across all trip legs. What does predictability monitoring look like for these sorts of services and who is responsible for it? It would be useful to consider these three trends in the decision of a preferred multi-modal reliability performance monitoring path into the future.

A summary of recommendations and suggestions for the direction of future research include:

* For network planning it is recommended that either (or both) Modified Buffer Index and Planning Index be used for analysis, both of which are statistically buffered from data outliers
* Undertake further research applying each of the shortlisted measures to private vehicle travel, ideally this should be done for the same reporting period as for public transport data.
* Undertake further research to determine ideal thresholds for the shortlisted measures
* In New Zealand, set up a regular public transport monitoring workstream. To do so will require determining appropriate thresholds, streamlining data acquisition and preparation, and developing software to undertake regular monitoring (perhaps quarterly).
* It is recommended that for customers’, simple travel times or a range of absolute travel times simply be provided. Alternatively, Modified Buffer Index and Planning Index outcomes can be presented using more easily understandable names and outputs, modelled on what AT currently produces.
* Finally, in considering the future of aggregating to compare modes, there is potential to weight modes based on the number of people being moved (similar to Transport for London’s Lost Customer Hours) which may be useful to consider. However, this matter requires further consideration and research.

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**ACKNOWLEDGEMENTS**

The authors wish to acknowledge the wider project team including Vivienne Ivory, Prakash Ranjitkar, Thanura Rabel, Shifani Sood, and Hoda Rezaie. We would also like to thank NZ Transport Agency for funding this research, Steering Group members: Paul Clark, Ernest Albuquerque, Ellen Cox (NZTA), Wayne Hastie (GWRC), Shannon Boorer (ECan), Edward Wright (ECan); Peer Reviewers: Professor Graham Currie (Monash University), Professor Hesham A. Rakha (Virginia Polytechnic & State University). We would also like to thank those who gave their time to attend the industry workshops in Auckland, Wellington and Christchurch.

**AN IMPORTANT NOTE FOR THE READER**

The NZ Transport Agency is a Crown entity established under the Land Transport Management Act 2003. The objective of the Agency is to undertake its functions in a way that contributes to an efficient, effective and safe land transport system in the public interest. Each year, the NZ Transport Agency funds innovative and relevant research that contributes to this objective.

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1. Soon to be available via: <https://www.nzta.govt.nz/resources/research/> [↑](#footnote-ref-2)