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Surveying Customer Perceptions of Road Infrastructure Comfort

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Abstract

This paper continues an exploration of the relationship between strategic performance setting and operational measures in infrastructure management. The overarching study considers the use of road smoothness within the New Zealand context and its relationship to the strategic objective of improving customer comfort. The paper highlights the complexity of comfort when viewed from the customer's perspective, and the importance of customer engagement in informing technical decisions. In addition, the study has wider infrastructure management implications and highlights a broader issue with the alignment of strategic intent and the tactical reality of day to day infrastructure operations.

Key words: Roads & highways, management, social impact

Introduction

Infrastructure performance can be measured by defined levels of service across a range of factors including reliability, availability, capacity, and cost efficiency. Whilst they may also be measures of performance, customer demand and need are also underlying objectives that are ultimately reflected in infrastructure strategy and service delivery (Controller and Auditor General, 2014; NAMS, 2008-2015; New Zealand Asset Management Support (NAMS), 2007). The importance of integrating customer need into infrastructure management is being reinvigorated as infrastructure providers reorient from a technical or project structured organisation to service led delivery. This is further underlined as infrastructure managers seek to do more with existing assets.

This paper presents the second stage of a case study of customer perceptions of the surface of road infrastructure. The overarching study explores the relationship between strategic outcomes set by the New Zealand Transport Agency (the organisation accountable for managing New Zealand's State highway network), and its operational measures; in this instance the key area of customer comfort, measured by road smoothness. One of the study aims was to "*assist the integration of customer feedback within decision making and prioritisation processes so that the services provided could be better aligned to* ***customer need***" (Blom, De Marco, & Guthrie, 2015, p. 1; emphasis added).

The first stage of the study, which is detailed in Blom et al. (2015), consisted of a series of customer focus groups to:

- Elucidate the language specific to, and the needs of each mode and user group; and
- Pilot a questionnaire aimed at enabling a more extensive appraisal of individual need.

The subsequent questionnaire, and the subject of this paper, took the form of a comprehensive online survey. It is distinctive by being developed in conjunction with customer groups; a lesson derived from cultural safety practice in New Zealand healthcare (Koptie, 2009; Ramsden & Spoonley, 1993). In so doing, it sought to approach the underlying question from the customer perspective rather than that of a technical paradigm.

A second distinctive element of the overarching study methodology relates to its scope and New Zealand's jurisdictional boundaries. The New Zealand Transport Agency (NZTA) manages the State highway network including maintenance, improvements, renewals, and operations activities. The network ranges from roads with motorway status through to connecting rural highways. It also includes highways that pass through urban areas; paths are however typically managed by local government along with the local road network. The NZTA also administers central government funding contributions towards most local government road infrastructure. Funding and jurisdictional boundaries are not however discernible (nor relevant) to customers (Blom et al., 2015, p. 8). The inclusion of urban highways and both paths and roads within the scope of this study is therefore unusual within this context. The broadened scope (which included all roads and paths, including 'share with care' and cycling paths, but not off road tracks), was aimed at being more inclusive to enable interface issues (if any) to be explored.

This paper details the survey and discusses the wider study implications for infrastructure practice. The study has revealed a richness of information and has found two key dimensions to customer interactions with road infrastructure. How well infrastructure organisations address both dimensions is germane not only to a measure such as road smoothness and customer comfort, but to the alignment (or otherwise) of other strategic objectives and their tactical or operational measures.

Survey development and management

The survey was developed in conjunction with customer focus groups and a piloting process (Blom et al., 2015). Although originally designed to enable people using non-vehicular modes to comment on roads, limitations required some modal segregation. Pedestrians and those using non-vehicular modes are however road users, so this is an important issue yet one not often addressed in surveys of road use. The survey sought to recognise this incongruence within path related questions. It also treated cyclists and bus passengers as hybrid categories that may use either roads or paths (the latter because getting to a bus stop is integral to their journey). Road and path use are therefore generalised terms used for convenience, and of course should not be taken to mean that pedestrians and other path users are not road users also.

The NZTA hosted the survey on its webpage, project websites, and promoted it via all of its electronic media channels. Links were also sent to earlier workshop participants and various interest groups. The survey was available for two months, and a total of 1,648 responses were volunteered across this period. A single manual response was entered into the dataset prior to validation and analysis. Data was also screened to check for issues using a defined set of criteria (e.g. eliminating responses where only basic ethnographic data had been completed); this gave a total of 1,619 usable responses.

Results

Survey representativeness

Bryman (2001, p. 94) records that social research typically aims for a 95% level of confidence (with an associated margin of error of 1.96%). The survey achieves this as a subset of the New Zealand population (4,355,739 (Statistics New Zealand, 2013)). Basic ethnographic data (age, gender, geographic distribution) were also compared with the 2013 New Zealand Census (Statistics New Zealand, 2013)). Regression analysis across all three factors gave a relatively good correlation between survey and Census ($r = 0.87$). Overall it is considered that the survey is statistically significant and is reasonably representative of the wider New Zealand population.

Mode use

Respondents were asked to indicate the forms of transport they currently use to travel on roads or footpaths, and were then asked to indicate the modes they would like to use but do not do so currently (Table 1). Potential customers do not appear to be approached often in infrastructure satisfaction surveys, and the question was included after workshop feedback. More than one mode was able to be selected in each case.

Table 1: Mode use

Mode or User Group	Current mode use	Additional mode use sought
Road Modes		
Car driver	87%	5%
Car passenger	60%	2%
Motorcyclist /scooter	10%	7%
Light commercial vehicle	5%	<1%
Truck	3%	1%
Bus driver	1%	1%
Both Road and Path Modes		
Bus passenger	37%	17%
Cyclist	43%	19%
Path Modes		
Pedestrian	84%	3%
Pedestrian with pram or pushchair	11%	1%
Wheel chair or mobility scooter	6%	2%
Skateboard / long board / push scooter	3%	<1%
Horse	1%	2%
Other	1%	3%

Car travel dominated current mode use, with car drivers and passengers accounting for 42% of total mode usage. However pedestrians were also dominant. Five of the 13 defined mode or user groups accounted for some 89% of the total current modal use.

Some 54% of the survey indicated that they would like to augment their current mode (1.4 additional modes sought on average). A strong preference was expressed for cycling or bus patronage, which accounted for 57% of all additional mode usage sought. This is not necessarily latent demand however, as respondents noted a range of scenarios, including modes that were:

- Used previously but which had been given up; and
- Currently used but which the customer would like to use more than at present.

Barriers to mode augmentation

Respondents were also given the opportunity to comment on the barriers affecting their use of other modes (Table 2). Approximately 40% elected to do so, giving rise to 59 factors. The two most sought additional modes (cycling and bus patronage) identified the widest range of barrier factors.

Table 2: Key Barrier Factors to the Uptake of Additional Modes

Mode or User Group	Range of Individual Issues Identified *(n=59)*	Proportion of the Total Number of Barriers Identified (n=1,199)	Top Ranked Barrier Issues *(1= top ranked)*
Road Modes			
Car driver	14%	1%	1. Traffic environment 1. Cost of service / relative cost 1. Technology gap
Car passenger	17%	2%	1. No facilitated provision for carpooling 2. Cost of service / relative cost 2. Trip duration, time
Motorcyclist /scooter	29%	4%	1. Safety 2. Cost of service / relative cost 3. Weather
Light commercial vehicle	0%	0%	Not applicable
Truck	0%	0%	Not applicable
Bus driver	3%	<1%	1. Scared or frightened 1. Confidence
Both Road and Path Modes			
Bus passenger	64%	35%	1. Accessibility of mode 2. Timetabling of service 2. Cost of service / relative cost
Cyclist	71%	43%	1. Safety 2. No or few separate assets 3. Shared space issues 3. Lack of width, narrow spaces
Path Modes			
Pedestrian	41%	6%	1. No or limited asset 1. Safety 1. Poor condition, quality of asset
Pedestrian with pram or pushchair	27%	2%	1. Speed environment 2. No or limited asset 2. Safety 2. Obstructions 2. Pollution
Wheel chair or mobility scooter	25%	2%	1. Rough or uneven surfaces 1. Accessibility of mode 2. Shared space issues 2. Interface between paths and road
Skateboard / long board / push scooter	22%	2%	1. Rough or uneven surfaces 2. Safety 3. Shared space issues
Horse	12%	1%	1. Safety 2. Shared space issues 3. No or few separate assets 3. Design issues 3. Accessibility of mode 3. Trip duration, time 3. Rule clarity

Mode or User Group	Range of Individual Issues Identified *(n=59)*	Proportion of the Total Number of Barriers Identified (n=1,199)	Top Ranked Barrier Issues *(1= top ranked)*
Segway	14%	1%	1. Rule clarity 2. Safety 2. Rough or uneven surfaces 2. Trip duration, time
Other	10%	1%	1. Current technology gap 2. Accessibility of mode 2. Pollution

The main modes concerned with the issue of surface roughness and unevenness were path users and in particular, skateboarders / push scooters, followed by pedestrians and wheelchair or mobility scooter users. However the issue only accounted for 2% of the total number of barrier issues raised.

By contrast, 'accessibility', which affected an equally diverse number of modes or user groups, was identified more frequently as a barrier. 'Accessibility' was most significantly a barrier to the uptake of bus patronage (both generally and for those with mobility constraints), and to a lesser extent, for cyclists also. Whilst accessibility itself is often managed in transportation operations through simplified metrics such as travel time, feedback from this survey tends to support research which highlights the complexity of this factor and in particular the role of *usability* (Geurs & van Wee, 2004; e.g. Iwarsson & Ståhl, 2003), for example the ability to manoeuvre wheelchairs or prams on to (or off) a bus.

Overall however, the most frequent barrier issue was identified as safety (15% of all issues) and that the group most concerned with this are potential cycling customers. The second most prevalent barrier relates to where there are '*no or few separate assets or ability to access a separate facility*' (7% of the overall issues; or 11% when combined with the interlinked issue of shared space).

Levels of satisfaction

A common strategy in general customer surveys is to assess the degree of satisfaction with a given outcome or asset, and then to ask customers to rank or provide feedback on a range of given parameters. Respondents were generally satisfied with both roads and paths (Figure 1). This is important to recall when considering other feedback; indeed responses were sometimes prefaced 'generally good, but…'. Furthermore, whilst satisfaction surveys may enable comparison over time, there may be an element of 'expectation adjustment'. Consequently satisfaction aligns with a given context, defined level of service and other conditioning factors (for example vehicle condition or suspension).

The general satisfaction question also provides a degree of benchmarking with past NZTA surveys and the context for subsequent questions on the relevance and attributes of comfort. The NZTA currently surveys 1,000 customers every quarter to assess their satisfaction with the State highway network. Comparison with this survey (Figure 1) shows that whilst the proportions of average performance are similar, customers were slightly more satisfied with the State highway network than New Zealand's roads and paths more generally. This might infer that customers are less

satisfied with local roads, which could indeed be the case (and was suggested by some of the feedback to this survey). However this may not be the singular reason and we make the following observations in this regard:

- The State highway surveys specifically excluded local roads, and could be interpreted as also excluding urban sections of the State highway. In smaller rural towns, the highway may have adjacent paths, and customers are not necessarily aware of, nor cared for, administrative boundaries (survey responses; Blom et al., 2015).

- The State highway surveys also focus on driver or vehicular experience (e.g. "*Maintaining the road surface so that it is safe to drive on*"). Whilst non-drivers are recorded, wording inclines towards vehicle passengers (e.g. "*Please select the frequency in which you use (as a passenger or driver) State Highways*"). The highway survey does however ask how well the NZTA recognises and responds to the needs of different types of highway users such as cyclists and pedestrians. Responses to that question show a much closer alignment with this survey (Figure 1). This may suggest a higher proportion of non-vehicular customers responding to this survey (perhaps as a consequence of distribution to interest groups), or respondents taking a broad approach (e.g. "*Roads are built excellent (1) for being a car driver/passenger, but are built to very poor (5) for cyclists.*").

A range of factors may therefore have contributed to the differences in satisfaction, and may not be as simple as the inclusion of local road infrastructure. This is an area for further exploration.

Customers were also given the opportunity to clarify their general satisfaction responses in an open ended question; some 59% (roads) and 45% (paths) elected to do so. Comments were coded, giving rise to a large range of issues which provided a richness of detail otherwise not apparent at the higher level. These have been summarised in Figure 2.

At the summary level, by far the most significant road-related category related to provisions for mode diversity, followed by issues around maintenance, surface treatments, and customers' experiences and behavioural factors. Interestingly, traffic conditions such as congestion, which is often a transportation sector focal point, ranked 5th.

Of the 79 individual road-related concerns identified (not plotted but integrated within Figure 2), 'maintenance responses and strategies' attracted the largest number of comments. The general tenor of comments expressed a sense of frustration at the level of rework occurring on New Zealand roads. There were two dominant aspects to this:

- The reworking of roads where the customer did not perceive a need for maintenance (leaving 'worse' areas untouched); and

- The current strategy of patching. Customers consider this creates rough edges and bumps, does not last, and results in more disruption and a degraded outcome overall.

The next two highest individual issues relate to a perceived lack of provision for cyclists and the closely related matter of cycle lane connectivity and quality. Comments relating to these highlighted issues with a singular approach given the breadth of cycling user groups: commuters, children or families, disabled users (e.g. using hand bikes), and recreational cyclists of various levels (from those just wanting to do a bit of exercise, to others who indicated more extensive cycling usage).

With respect to road surfacing (which underlies this research programme), general road surface conditions accounted for 3% of the issues raised. Customers were however also concerned with a range of other factors which could arguably contribute to a generic question on road surface conditions. These include:

- Maintenance strategies and practice (including the quality of repairs and utility works);
- No or inadequate shoulders (extent of road surface or seal);
- Other surfaces (e.g. loose gravel, metal covers);
- Surface treatments (e.g. slippery cobblestones);
- Bumps around manholes and the edge of repairs;
- Interfaces between areas (path to road, train tracks etc.);
- Corrugations, undulating or generally bumpy surfaces;
- Tar melts, bleeds and flushing (where "*new layers of chip seal are rapidly embedded into the underlying layer*" creating smooth or 'flush' surfaces; New Zealand Transport Agency (2000));
- Issues in the ride line or corners; and
- Issues that force users to swerve (into a live lane, or to move off the road).

Together these account for another 18% of the total number of issues, and begin to highlight the complexity of road surface issues when considered from the customer's perspective.

Aligning with the feedback for roads, provision for mode diversity (or the range of modes and user groups competing for path space, and the relative priority these are given when interfacing with the road) was by far the most significant path category at the summary level (Figure 2). Whilst maintenance was not within the top four path categories, 'customers' experiences and behavioural factors' and 'surface treatments' (both within the top four for roads) placed second and third respectively. Safety was the fourth ranked category (and was closely aligned with the crossing and intersection categories, which collectively account for some 17% of the total issues raised).

Of the individual concerns identified (not plotted but integrated within Figure 2), the three top issues were as follows:

- ***The broken or generally bumpy condition of paths:***
  Whilst maintenance and the poor condition of paths did attract a significant number of comments, a great many of the issues related to the design of the paths themselves. Bumpy and undulating conditions were noted from the design of vehicle accessways, path depressions at crossing points, the transitions with the road and traffic islands, for example. Customers noted that this made it difficult for path users; particularly the very young (or those pushing prams), those using mobility devices, or the less mobile and elderly. These issues were often exacerbated by other factors such as overhanging vegetation or parked cars, which reduced customer choice, experience, and frequently forced customers on to grassed verges or the road.

- ***Safety issues:***
  The broken and bumpy condition of paths was one of the important factors contributing to perceived or actual safety issues through the risk of getting stuck, tripping, tipping over, or breaking mobility devices. Another key issue was the lack of paths, or the practice of installing paths only on one side of a road as this either forced customers on to the road (where often busy roads or inadequate shoulders then became an issue), or forced the customer to cross the road. However the most commonly identified safety issue related to the frequency and design of crossing points and the nature of intersections. Customers indicated that they would avoid crossing points they perceived (or had experienced) as being dangerous. Roundabouts were often cited as problematic along with driver behaviour, vehicle dominance, and the design of kerb depressions (frequency, location, width, steepness, paving transition etc.). A number of people noted that they used their car more as a consequence.

- ***Narrow or inadequate space:***
  Narrow paths were considered to be especially difficult to use if you wished to walk side by side, needed to manage small children, or were in a mobility device. Whilst there was an interface with path obstruction issues, often paths were identified as inappropriately narrow by design.

Path surface conditions do not contribute to the measure of road smoothness (the focus of the wider research programme). However this highlights the importance of physical and behavioural interfaces with paths, and the condition of roads to those who may be crossing the road or are otherwise forced to walk on or alongside the road due to other factors.

Relative importance of comfort

The next survey question looked at how customers see the relative importance of a range of given high level factors. The purpose was to contextualise the importance of comfort (as a high level concept) within a range of typical transportation indicators used by industry. Whilst listed as separate or discrete concepts, the previous workshops indicated that the issues were in fact intertwined.

Of all the issues, comfort was closest to being neutrally ranked (i.e. 55% of customers' ranked comfort within the top 6; 45% in the bottom 6), and was ranked 7th of the 12 given issues (Figure 3). Safety and accessibility were seen as the two most important issues; comments again underlined the value of looking beyond an assumed or technical interpretation of these terms, and indeed in engaging with the community.

Overall journey comfort

Figure 4 presents the results of how customers view their overall journey comfort. Of the thirteen mode or user groups, all but one of the seven most comfortable mode or user groups are vehicular; car drivers and passengers being the most comfortable overall. The most comfortable of the non-vehicular modes are pedestrians (5th). The least comfortable are those customers in wheelchairs or users of mobility scooters, closely followed by horse riders. The remainder of this paper explores comfort in more detail.

Road comfort factors

A range of road related comfort factors were identified and developed as part of previous customer workshops and piloting of the questionnaire (Blom et al., 2015). Customers were asked to identify those affecting their comfort (Table 3).

Table 3: Comparison of Most Frequent Road Comfort Factors

Mode or User Group	Three Most Frequent Road Comfort Factors		
	1st	2nd	3rd
All modes / user groups	Appropriate speeds	Road roughness and defects	Other's behaviour
Car driver	Appropriate speeds	Other's behaviour	Traffic conditions
Car passenger	Appropriate speeds	Road roughness and defects	Other's behaviour
Cyclist	Other's behaviour	Road roughness and defects (2nd=) | Safety issues (2nd=)	Road surface texture (2nd=)
Motorcyclist / scooter	Potholes	Slippery surfaces	Road roughness and defects
Light commercial vehicle	Appropriate speeds	Road roughness and defects	Other's behaviour
Truck	Appropriate speeds	Road roughness and defects	Potholes
Bus driver	Appropriate speeds	Traffic conditions	Road roughness and defects
Bus passenger	Connectivity and accessibility	Appropriate speeds	Clear and logical information

Overall, 'appropriate speeds' was most the frequently identified factor affecting road mode or user group comfort; appearing within the three most frequently identified factors for all road modes or user groups with the exception of cyclists and motorcyclists / scooters. Customers were given the opportunity to clarify their answers and this gave rise to a range of sometimes conflicting views (e.g. speed limits are too high or too low) and issues with a perceived 'one size fits all' or formulaic approach. Responses also highlighted a behavioural component, such as bus drivers speeding up near bus stops or traffic lights.

'Road roughness and defects' was also a frequently identified issue for most modes; the exceptions being car drivers and bus passengers. This is interesting given the focus on the drive line of four wheeled vehicles inherent within the methods for measuring road smoothness (Blom et al., 2015). Comments related to road roughness and defects reinforced both its general importance and also the observations from the earlier focus groups, such as the importance of road shoulders, surface debris and its location, loss of grip / ultra-smooth surfaces, kerb transitions (kerb height and pavement interface), and user preference. Maintenance practices (quality of workmanship and responsiveness) were also often identified within this theme.

Other frequently identified issues included 'other's behaviour', 'traffic conditions', 'safety', 'potholes', 'slippery surfaces', and 'road surface texture'. The latter three being closely related to the issue of 'road roughness and defects', however the interplay between these issues, and the preferences or needs of different modes is an area for potential conflict. Bus passengers also

commonly identified 'connectivity and accessibility' and the need for 'clear and logical information' as comfort factors. Many of the associated comments noted that road conditions were 'generally good, but…'. Few new issues were raised; the two more frequent ones being enforcement and issues forcing users into the live lane, off the road, or onto another mode.

After identifying the range of factors that affected their comfort on the road, customers were then asked to select the three most important, and then to rank these (Figure 5). This shows a clear segregation of the top issues. Again, 'safety issues' was most frequently and singularly identified as one of the 'three most important road comfort issues' for Customers. Less notable were 'others' behaviour', 'appropriate speeds', and 'road roughness and defects'. All four were however relatively dominant by comparison to the other issues.

Path comfort factors

As for roads, a range of path related comfort factors were identified and developed as part of the previous customer workshops (Blom et al., 2015). Customers were asked to identify those affecting their comfort (Table 4).

Table 4: Comparison of Most Frequent Path Comfort Factors

Mode or User Group	Three Most Frequent Path Comfort Factors		
	1st	2nd	3rd
All modes / user groups	Kerbs / transitions with the road / between surfaces	Path roughness, unevenness, and defects	Path width (being able to travel side by side) (3rd=); Other's behaviour (3rd=)
Bus passenger	Connectivity and accessibility	Clear and logical information	Safety issues
Cyclist	Traffic separation	Kerbs / transitions with the road / between surfaces	Path width (being able to travel side by side)
Pedestrian	Path width (being able to travel side by side)	Path roughness, unevenness, and defects	Kerbs / transitions with the road / between surfaces
Pedestrian with Pram or Pushchair	Kerbs / transitions with the road / between surfaces	Path width (being able to travel side by side)	Path roughness, unevenness, and defects
Wheel Chair or Mobility Scooter	Path roughness, unevenness, and defects	Kerbs / transitions with the road / between surfaces	Path steepness
Horse	Other's behaviour	Safety issues (2nd=); Over-hanging vegeta-tion / obstruc-tions (2nd=)	Traffic separa-tion (2nd=); Con-sistency and pre-dictabil-ity (2nd=); Free-dom, flexibil-ity and choice (2nd=)
Skateboard / Long Board / Push Scooter	Path roughness, unevenness, and defects	Kerbs / transitions with the road / between surfaces (2nd=)	Other's behaviour (2nd=); Potholes (2nd=)

'Kerbs / transitions with the road / between surfaces' was most the frequently identified factor affecting path mode or user group comfort. This issue appeared within the three most frequently identified factors for all path modes or user groups with the exception of bus passengers and people riding horses. Customers were given the opportunity to clarify their answers or to comment further and many elected to do so, for example:

> *"Even, wide surfaces are important. Need to consider good access free of barriers/obstacles for prams, wheelchairs and other people with mobility impairments as a priority issue. Currently there are a number of areas… which have issues for these users at present, which would be relatively low cost to fix. For example, the pedestrian crossing in* [location] *does not have a smooth transition from road to kerb … and just the other day I witnessed a wheelchair user having immense difficulty here. This would be a very easy issue to fix."*

'Path roughness, unevenness, and defects' was also a frequently identified category for many modes; the exceptions being bus passengers, cyclists, and those riding horses. Current NZTA measures of comfort and smoothness do not of course consider paths (Blom et al., 2015).

Bus passengers identified similar comfort factors for the path segment of their journey. By contrast, cyclists identified a different suite of key issues including traffic separation, transitions with the road, and path width. Modal separation was also important to other path users and included intertwined issues such as behaviour, relative speeds, awareness and responsiveness (ability to see or hear approaching cyclists), and adequate space.

Other frequently identified issues included 'other's behaviour', 'path width (being able to travel side by side)', 'path steepness', 'safety', and 'potholes'. Customers riding horses also identified 'overhanging vegetation', traffic separation', 'consistency and predictability', and 'freedom, flexibility and choice' as key issues. Many of these were also issues for other mode or user groups but fell outside the three most frequent issues.

Additional comments again largely clarified existing issues with few new issues identified. As for roads, issues that forced users off paths and on to the road were also raised. New issues included shared space, and issues at intersections or crossings, one respondent observing:

> *"Lack of pedestrian priority in street design in general is the greatest source of 'discomfort'. There is no greater lack of comfort than being killed or injured by drivers taking the cue given to them by the physical environment that they have total right of way over all more vulnerable users."*

After identifying the range of factors that affected their comfort on paths, customers were then asked to select the three most important, and then to rank these (Figure 6). By comparison with road comfort, there is less separation of the top issues. In this instance the category 'path roughness, unevenness, and defects' was most often identified within the top three path comfort issues and was relatively clear of the next most frequent issue.

Complexity of comfort

Another way of looking at comfort data is directly in relation to its complexity, or the frequency that customers identified a given number of issues, and in particular the number of times comfort was captured by a single indicator or factor. The analysis reinforced the point that wheelchair or mobility scooter users in particular, and to a lesser extent cyclists (on the road) and car drivers have the most

complex or diverse range of comfort issues. Very few customers identified only a single factor affecting their comfort (Table 5).

Table 5: Occurrence of 'Path Roughness, Unevenness, and Defects' and / or 'Potholes' as the Sole Comfort Factor

Mode or User Group	Percentage Occurrence of Roughness or Potholes as the Sole Issue	Percentage of Current Mode Use
Roads		
Car driver	4%	<1%
Car passenger	6%	<1%
Cyclist	1%	<1%
Motorcyclist /scooter	1%	<1%
Light commercial vehicle	0%	0%
Truck	0%	0%
Bus driver	1%	3%
Bus passenger	4%	<1%
Paths		
Bus passenger	<1%	37%
Cyclist	<1%	43%
Pedestrian	<1%	84%
Pedestrian with Pram or Pushchair	0%	11%
Wheel Chair or Mobility Scooter	1%	6%
Horse	0%	1%
Skateboard / Long Board / Push Scooter	3%	3%

The role of comfort in mode augmentation and general satisfaction

The survey design also enables some consideration of the role of comfort in barriers to the uptake of other modes, and general satisfaction. In essence, given comfort complexity, most barriers and comments pertaining to general satisfaction relate to comfort in some way. Consequently whilst 'comfort' as a singular term might not rank highly in customers' minds, the individual attributes that contribute to the notion of comfort:

- Are closely intertwined and often inseparable as comfort factors; and
- Contribute to a range of other high level performance areas (e.g. safety).

Discussion and conclusions

The NZTA has adopted road smoothness as an indicator of customer comfort, technical conditions (e.g. surface and / or subsurface condition; Brown, Liu, and Henning (2010, p. 9)), and road user costs. This survey is part of a broader study into customer comfort, which, as a whole, has provided a rich source of information and insight into customer needs, and how this interfaces with

organisational drivers and technical performance. Whilst New Zealand specific, it is expected that the findings will also be of general relevance and use elsewhere.

The survey has reinforced messages from earlier customer workshops that roads are generally good from the perspective of car users, but that more significant issues arise from the perspective of other modes and user groups, and in particular those that are more vulnerable. The survey also reinforced the importance of considering paths, interfaces between users, and also the interfaces between roads and paths. For example, there are many parts of the network without paths (or with paths provided on only one side of the road). In such instances, and on occasions when obstructions or other users blocked passage, the road became the sole means of access. In any event, as one customer observed, a pedestrian's journey does not stop at the edge of the road (and conversely car drivers need to move from their cars to the side of the road). A much more holistic view of asset use, design, and management is therefore required.

Indeed, the survey reinforced much of the feedback from the earlier focus group workshops and underlines the value and importance of liaising with customers directly and face to face. Both the workshop discussions and the open ended survey questions enabled customers to explain:

- How they were interpreting terminology (which may be different to what engineers and others that manage the system may assume); and
- Which modal or user group 'hat' they were wearing to answer.

It also gave customers the opportunity to give further detail or to explain why a given issue was important to them.

The NZTA, in line with general international practice, has adopted road smoothness as an indicator of customer comfort, technical conditions, and road user costs. By asking customers what comfort actually means to them, the NZTA should be better placed to re-examine the notion in all of its complexity and how best to improve outcomes for its customers; for the survey confirmed that comfort is complex. A customer workshop had previously identified comfort as comprising both emotional and physical attributes. This was reinforced through the survey with customers using emotive terms such as 'scary', 'wish', 'frustration', as well as commenting on a range of physical issues. However one aspect to emerge more rigorously from the detail of the survey is that customer comfort on roads and paths appears to have two further dimensions to it, each with a physical and emotive component:

- How comfortable I am on the asset (I have a pleasant experience, and I don't feel unsafe or vulnerable); and
- How I live my life comfortably (I can get where I want to, when I want to, and don't feel excluded).

We note that under s.94 of the Land Transport Management Act, "Land Transport Management Act" 2003), the defined objective of the NZTA is to "*undertake its functions in a way that contributes to an effective, efficient, and safe land transport system* ***in the public interest***" (emphasis added). The inclusion of 'public interest' moves the transport system beyond artefacts and assets, to social outcomes, and this is reflected in the NZTA's strategic objectives. Presently the comfort key result area is only partially served by the road smoothness measure by targeting roads and some users only. An asset based approach is arguably a narrow view of what constitutes infrastructure, and may

now be at odds with the organisation's recent strategic focus on customer outcomes. As Blom et al. (2015) observe:

> *"… whilst road smoothness is both a frequently identified and critical comfort factor, the notion of comfort is complex and cannot be considered in relation only to a single asset or mode if it is to have any real meaning to those the outcome is intended to benefit. Although the NZTA has a range of other performance indicators that might arguably address some of the wider comfort requirements, this case study has highlighted that there are limitations with taking these at face value or without considering the interplay between measures. … … All this is not to suggest that the IRI or road smoothness should be abandoned or is not an appropriate measure. Rather, there is an opportunity to consider whether there is a measure that is either 'mode agnostic' and / or better targets the vulnerable user, and in so doing provides more integrated and inclusive system level outcomes."*

The NZTA is unlikely to be alone in facing this issue, indeed as Moodley (2015) observes, this is a "*challenge for outcome-based infrastructure – a challenge the existing orthodoxy will have to overcome to deliver the desired outcomes*." Furthermore, it is arguable that whilst specific to the relationship between comfort and a measure of road smoothness, the study begins to explore a much wider issue of the alignment between strategic intent and the tactical (or operational) reality of infrastructure management.

In their overview of governance research, Daily, Dalton, and Cannella (2003) observe that "*in nearly all modern governance research, governance mechanisms are conceptualized as deterrents to managerial self-interest".* This points to an intrinsic conflict with both public administration and with the nature of infrastructure itself. A conflict that new public management and service oriented philosophies aim to reconcile for public sector organisations. The work by Kaplan and Norton, and their development of a balanced scorecard approach to reconciling strategy and operations, also attempts frame this issue (Kaplan & Norton, 1996, 2004). However as Norreklit (2000, p. 67) observes, this is focussed on the establishment of measures and, citing de Haas and Kleingeld, "*invalid assumptions in a feed-forward control system will cause anticipation of performance indicators which are faulty, resulting in dysfunctional organizational behaviour and sub-optimal performance*".

Whether or not the balanced score card, or indeed any other framework for strategic / operational alignment is appropriate, is however somewhat academic. This is because of the lack of feedback mechanisms that exist within infrastructure management (Busby, 1998; Flyvbjerg, Skamris Holm, & Buhl, 2003; Lenferink, Tillema, & Arts, 2008). Consequently tools, such as those proposed by Kaplan and Norton, and others such as Osterwalder (2004), whilst perhaps useful, arguably apply to the operation of infrastructure as a business unit, not the services derived from, and therefore the performance of, the infrastructure itself. This remains a continuing theme in infrastructure delivery (e.g. Controller and Auditor General, 2010, 2014; Dobbs et al., 2013; Institution of Professional Engineers New Zealand, 2010).

Additionally, if Ackoff (1971, p. 668) is correct in the assertion that complex systems (such as infrastructure) exhibit dynamic, goal seeking behaviour, the very relevance of output and outcome based performance measures is called into question. By contrast, assessing the *attributes* of services at the systems level of assets, networks, and social context may well provide a more suitable approach.

Although this study has usefully highlighted an immediate issue with one commonly used road infrastructure measure, it has also provided an insight into the wider alignment of infrastructure management with strategic intent. The complexity of the social: technical interface calls into question the applicability of current management approaches when applied to system level services (rather than the business unit of the infrastructure organisation itself). It is suggested that this is an important distinction and this broader system level issue remains an area where further infrastructure related research is required.

Acknowledgements

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Captions for Figures

Figure 1: Overall Road and Path Satisfaction (and Comparison with State Highway Satisfaction Surveys)
Source: Results from past NZTA surveys obtained with permission (NZ Transport Agency, 2015).
Note: Only recent NZTA data are presented as this was indicative of other past surveys.

Figure 2: Summary of Issues Arising from General Satisfaction with Roads and Paths
Note: Summarised from 79 individual road and 62 individual path issues.

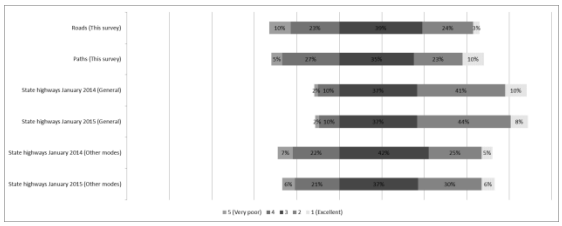
Figure 3: Relative Importance of Issues

Figure 4: Overall Journey Comfort

Figure 5: Frequency Distribution of the Top Three Comfort Factors: Roads

Figure 6: Frequency Distribution of the Top Three Comfort Factors: Paths

Crib Sheet for Figures *(Guidance only)*



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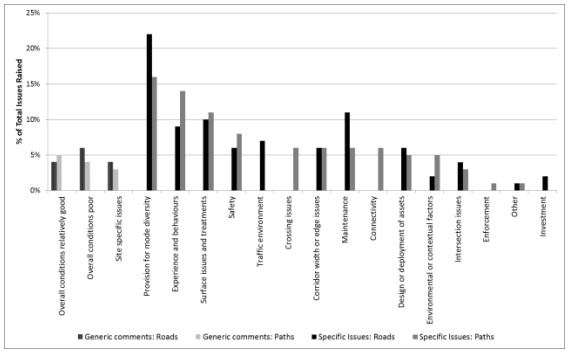

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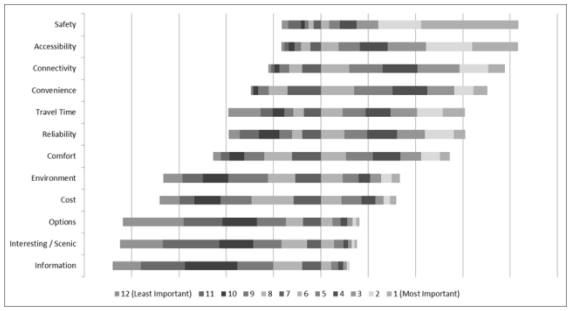

Figure 3: Relative Importance of Issues

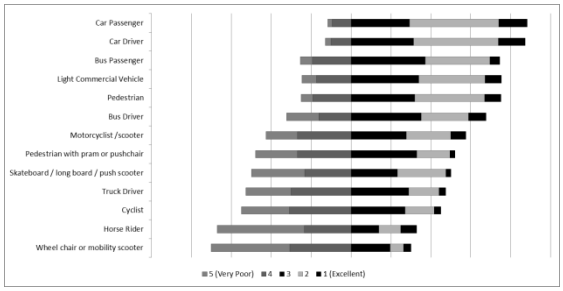

Figure 4: Overall Journey Comfort

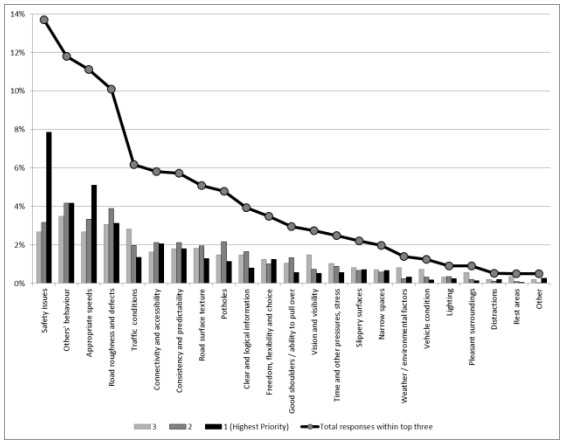

Figure 5: Frequency Distribution of the Top Three Comfort Factors: Roads

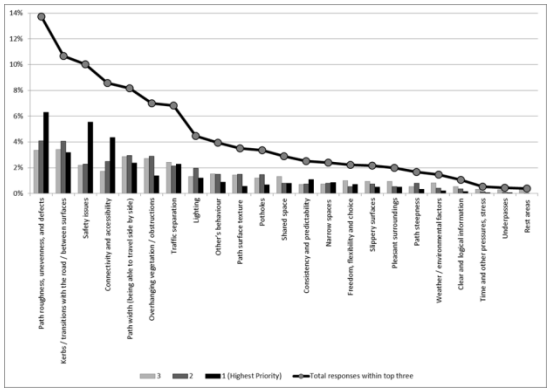

Figure 6: Frequency Distribution of the Top Three Comfort Factors: Paths