D'ARTAGNAN CONSULTING

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Review of international road pricing initiatives, previous reports and technologies for demand management purposes

For Ministry of Transport

Appendices

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[1] Appendix R, which contained raw interview notes with people involved in developing congestion pricing schemes, has been redacted to protect the confidentiality of those interviewed.

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APPENDIX A – Detailed review of ARPES scheme options

- ## Review of selected options

Five options were selected in the ARPES study for detailed appraisal. These are briefly reviewed below:

Single cordon

The **single cordon scheme (**Figure 1) was designed on the basis that the size and shape of the isthmus and the "large proportion of traffic within it" made it a logical choice for a cordon. Although locating a cordon across the isthmus has superficial appeal on geographical grounds (and it does minimise the number of charging points to sixteen), it is far from clear that it makes sense on traffic grounds. The function of a cordon is solely to charge vehicles that cross it. The claim that it is justified because of "a large proportion of traffic within it" is difficult to sustain, when the cordon would *not* charge any traffic circulating within it. For example, a car commuter from Remuera to the Viaduct Basin would pay nothing, but a commuter from Otara to Southdown or Titirangi to Rosebank would pay. The proposed geographic scale of the single cordon scheme is akin to the *outer* cordon proposals for Edinburgh and Manchester, and larger than that of those in Singapore, London and Stockholm. The larger a cordon design, the more likely it is to charge roads that are not congested (particularly those in the west) and so create negative economic and social impacts. By effectively overcharging short trips over the cordon and undercharging longer trips within it, it creates its own distortions, particularly affecting residents and businesses located close to it.

The main impact of the cordon is to charge all major motorways through Auckland, and so those benefiting the most would be those travelling through Auckland by road and willing to pay (as they have the greatest travel time saving). However, the greatest *net* beneficiaries would be those *only* driving within the cordon who benefit from travel time savings without paying for them. The greatest net losers are those making trips that only just cross cordon boundaries, some of which are not currently congested and for which there may not be reasonable alternatives. ARPES does not identify the distributional impacts by location of different charging scheme options. However, it does identify that this option would require considerable mitigation to offset some of the likely localised impacts of the cordon. It is noted that the single cordon option charged entry from the Auckland Harbour Bridge at twice the price of other crossings, which will produce different results than a flat single charge (but raise issues of public acceptability). Not noted in ARPES was the longer term implication of this option, which would be to encourage further development in Auckland outside the isthmus (outside the cordon).

Figure 1 - Single cordon scheme from ARPES

In conclusion, the single cordon, on the geographic scale proposed in ARPES, is blunt and relatively arbitrary in its application. It has a net negative NPV due to the mitigation measures required to offset the impact of the cordon through residential areas and separating major locations of employment from residential areas. The proposal was larger than any cordon that has been implemented elsewhere. The larger the cordon, the more likely it is to distort route and trip choices, and lead to consequential negative economic and social impacts. Although the network benefits of the option are considerable, this is primary due to the imposition of charges on all four major motorway routes (and parallel alternatives), and is offset by the localised impacts of the cordon crossing residential areas. The concept of a single cordon still has merit, but not on the scale proposed in ARPES.

Double cordon

The **double cordon scheme** (Figure 25) appears to be designed to capture trips towards inner Auckland as well as those captured by the single cordon. In addition, the single cordon has been adjusted to use SH20 as a boundary although it also charges vehicles using that route. It is not clear why the single cordon option didn't also follow this boundary, as SH20 as a boundary creates less community severance than the single cordon design, although it still retains many of the same boundary issues seen in the single cordon design.

Figure 2 - Double cordon scheme from ARPES

The scheme design retains elements that may be difficult to justify both in policy terms and to the general public. It is unclear why trips from Hillsborough to Three Kings, or between Point Chevalier and Westmere should be charged yet trips from Epsom to the CBD are not. Notwithstanding this, by allowing for two sets of charges, it allows for a finer degree of charging to be introduced over time (each cordon and each charging point on each cordon could have a different price if desirable), and for a greater proportion of traffic benefiting from the scheme to pay for it. It has fifty charging points and would be more effective in reducing congestion than the single cordon, simply because it captures more trips, but would be more expensive to build and operate. The claim of a lower mitigation cost compared to the single cordon may not be justified, as there are likely to be boundary effects on the inner cordon that would need to be addressed.

This option has some parallels to the double cordon proposal rejected in Manchester (although the Manchester proposal did not charge use of the outer ring motorway). Edinburgh's double cordon was also rejected although its inner cordon was much smaller than the scheme proposed in ARPES. One issue for both schemes was the perception that a border was being placed in the outer suburbs when congestion across that cordon varied considerably (although the price for the outer cordon in Manchester was deliberately much cheaper than the inner cordon, to reflect this). Copenhagen also considered and rejected such a scheme.

The double cordon remains a blunt scheme, charging for roads that are both congested and uncongested, and not capturing a lot of traffic movements within the cordons that could be substitutable by public transport (particularly car trips from inner suburbs to the CBD, where public transport and active mode options are most likely to be feasible). It is notable that no city has implemented a double cordon system to date, primarily because the negative effects of a large outer cordon on outer residential and business premises are seen to outweigh the benefit gained from reduced congestion. This is likely to significantly affect public acceptability, as businesses located just within the boundaries of the cordon would perceive negative impacts from their employees and customers facing a cordon to access them, especially if competitors were located outside the cordon. Some residents also would perceive that they may live on "the wrong side" of a cordon, effectively taxing them for trips in one direction only. Although this effect is minimised when there are already significant natural boundaries (e.g. harbour or river) in built up areas it is difficult to justify, particularly for routes that are not severely congested.

In effect, the double cordon is a more refined version of the single cordon, but retains many of the latter's negative effects, primarily because the outer cordon is very similar to the single cordon option. It would be reasonably effective at reducing congestion in the isthmus, but would charge roads that are relatively uncongested and for short trips crossing the outer cordon. Meanwhile, residents of inner Auckland suburbs would retain uncharged access to the CBD by car during the peak times (despite having the greatest choice of modes for such trips of any Aucklanders). A longer term impact of the double cordon may be to encourage businesses to locate outside the double cordon to avoid the direct and indirect costs of the charge.

If Auckland introduced a small inner city cordon, reconsideration of a second cordon at a later date may be justified. This could be an alternative option alongside a more comprehensive network pricing scheme, for users who are unable or unwilling to fit the in-vehicle equipment required for the latter.[2]

Area Charge

Following on from the double cordon, the **area charge scheme** (Figure 26) used the inner cordon but charged all movements within it. This option removes the free rider problem with the cordon proposals, in that no one living within the area could drive without paying, much like those originating trips from outside the area. It retains boundary issues given the area's size is around six times that of the Auckland CBD. This means that trips to locations just inside the area would be charged as much as those to the CBD, even though there are likely to be a wider range of options to access the CBD by other modes.

One of the issues an area charge raises is that local residents are charged for *all* trips within the area during charging hours. This could be mitigated by restricting charging to peak hours, or granting residents a discount to enable some essential trips to be undertaken without excessive penalty (e.g. taking a car for a Warrant of Fitness).

An area charge does not have the potential flexibility of a cordon to vary charges by individual crossing point. Any charge would be a single rate, even if some routes into the area were much more congested than others. Only London has an area charge scheme, and its current zone is around two-thirds the size of the proposal here (and London has a much larger CBD than Auckland). This suggests that the size of the proposed zone

[2] If Auckland provided a network charging option, visitors to Auckland may be charged for crossing two or more cordons as an alternative to having an account with an in-vehicle GNSS system for network charging, but not as a core scheme.

in ARPES is larger than optimal. A smaller area, akin to the CBD cordon area identified in the ATAP report, may be more appropriate and reduce the boundary effects of the ARPES proposal.

Figure 3 - Area charge scheme from ARPES

The evaluation of the area charge scheme indicates it would be effective in managing congestion within the area, but would have diversionary effects for trips seeking to avoid the area. In particular, trips using the Southern and North Western motorways to cross the Isthmus may divert onto St Lukes/Balmoral/Green Lane rather than pass through the area charge zone.

In conclusion, the area charge scheme in ARPES covers an excessively large area, and so would capture short local suburban trips in inner suburbs as much as longer distance commutes to the CBD. Yet the area charge concept may still have some merit. As an option for just the CBD, this would avoid the impact of charging largely residential areas and restrict the boundary effects to business premises in certain areas. However, this should be balanced against the inherent inflexibility of an area charge compared with a cordon in a similar location. It is not clear whether the additional traffic movements captured by a small area charge would justify it over a cordon.

Strategic Network Charge

The **Strategic Network Charge scheme** (Figure 27) was designed to impose a charge at motorway interchanges where congestion occurs. By only charging for motorway use at such locations, it was arguably better targeted at congestion than the cordon and area charge schemes. However, as it would not charge parallel arterial routes, the primary impact would be to encourage those on shorter trips to use routes such as the Great North Road and Great South Road, to avoid paying. It would have a significant positive impact on motorway congestion, but this would be more than offset by greatly increasing congestion on local routes.

Although there is some merit in encouraging more optimal use of the network for short trips, the evaluation in ARPES indicated the net effect would be highly negative. It is the only option in ARPES that would *reduce* average travel speeds and has minimal impact on travel times for public transport (not least because improved motorway times are offset by congestion in local streets). It is also likely to have a negative environmental impact by increasing exposure to emissions for residential properties, pedestrians and cyclists. It is the only option that generates a Benefit Cost Ratio below 1. The main negative effects could perhaps be mitigated by significant capital investment in new capacity on the local road network (including grade separation at major intersections), but this could mean that revenue generated from users of the motorways would be used to improve conditions for those using parallel routes without charge.

No other city has implemented such a scheme (although Dubai's scheme has some parallels). Many cities have tolled motorways (e.g. Sydney), but in general such tolls were introduced concurrently with the motorway capacity to pay for the infrastructure rather than manage congestion. Transport impacts are quite different when new capacity is built and tolled selectively, not least because tolled urban motorways have few entry and exit points to minimise the cost of tolling points and minimise the risk of traffic diversion. This also justifies higher tolls for longer trips. The advantages for public acceptability in retaining parallel uncharged routes are offset by the poorer conditions for motorists using those routes, as well as those who live, walk or bike on them. This could generate a perception that the motorways are there for "the rich", whereas "the poor" experience slower more congested conditions and a degraded street environment.

The main advantage of this option over the others is the lack of need for mitigation measures to address *local access concerns*, but this is significantly offset by the diversion of traffic onto local roads. It would be possible to reduce this impact by reducing charges on the motorway network, but this would clearly reduce the effectiveness of the charge in managing congestion on the motorways. The other alternative of significantly increasing capacity on those routes would erode the net benefits of the charge, and raise the question of the value of a demand management measure that increases demands on roads to justify additional capacity to function efficiently.

It may be possible to vary this option to only charge for trips on the motorways that pass points where the local road alternative would be so much slower that diversion would be a low risk. The North Western Motorway between Patiki Road and Te Atatu, the Auckland Harbour Bridge and Mangere Bridge are obvious examples; but this would only be useful to target congestion at these points. Charging specific parts of the network may have merit to target specific locations of congestion, but could not be a wider solution to congestion in Auckland.

Figure 4 - Strategic Network Charge scheme from ARPES

Parking Charge

The parking levy proposal in ARPES was focused on taxing car parks in the four Auckland central business districts (figure 28). This is unlikely to have a major impact on congestion as it would target car trips to relatively small areas. t is difficult to scale this proposal beyond the locations identified and the concerns around enforcement and complexity remain valid, as it would require a new regulatory regime for all parking (public and private) for the parking cordons. It is also unclear why such a levy should be restricted to Auckland, Takapuna, Henderson and Manukau. The trend emerging in London of significant growth in on-demand taxi traffic (such as provided by Uber) would not be constrained by such an option, as such vehicles do not park. Nottingham notably has a Workplace Parking Levy, which applies to car park spaces at employers' premises across Nottingham. A study into the effects of that policy has indicated that there has been a negligible impact on congestion.[3] Given this, there does not seem to be a case tor further consideration of this option as a tool to manage congestion in Auckland.

[3] Source: *Evaluating the impacts for traffic congestion and business behaviour following the introduction of a Workplace Parking Levy (WPL) and associated public transport improvements*, Nottingham City Council, Loughborough University, 2013.

Figure 5 - Parking levy ARPES scheme

Discussion of unselected options

As discussed above, two pricing options were initially considered but ultimately not selected for full evaluation in ARPES. These two pricing options are tolling specified lanes on multi-lane facilities, and full network pricing. This section provides a brief overview of these pricing options, and discusses the reasons they were not included in ARPES.

Toll lanes

Toll lanes are where one or more individual lanes on a limited access highway/motorway are subject to a toll, parallel to other lanes which remain available for general use without a toll. They are only introduced on limited access highways/motorways so that access to the lanes can be easily controlled and traffic flow can be better managed without intersections or traffic queuing to turn off both sides of a roadway.

Other requirements for toll lanes are:

- More than two lanes in each direction (for motorways to function safely and effectively they need at least two untolled lanes in each direction);
- Limited numbers of entry and exit points to ensure traffic flow is well managed;

- Sufficient corridor width to physically segregate the priced lane from unpriced lanes (even if only by a thicker painted line), so that users of the lane cannot easily cross into other lanes to avoid toll points located on the lane. Toll lanes are always located on the innermost lane, so as to not interfere with traffic needing to exit and enter the motorway that does not wish to use the toll lanes; and

- Congestion that is sufficiently severe and recurrant for road users to be willing to pay for the priced lane.

The primary policy purpose of tolled lanes is to offer an *option to bypass congestion*, rather than to address the fundamental congestion itself. It is often referred to as congestion pricing in the United States because it exposes road users to the value of pricing in delivering free flow traffic compared to unpriced lanes. However, there is little sign that the presence of such systems across the US (there are more than 50 such lanes in operation) has encouraged the further evolution of congestion pricing options on existing roads. Furthermore, they are not offered as an option on at-grade streets.

ARPES rejected toll lanes for detailed evaluation because the option was considered incompatible with objectives to reduce congestion across Auckland. Toll lanes require either *new* lanes to be built (so use tolls to help pay for new capacity and to manage demand on that capacity) or for existing lanes to be restricted for toll access only.

Tolling new capacity is the use of supply to ease congestion, rather than manage demand of existing road space. This is possible under existing legislation, so may already be considered as new lanes are added. However, the ability to do this is restricted by the practical conditions under which toll lanes can be implemented as explained above.

To convert existing capacity to tolled lanes is effectively a partial implementation of charging on the motorways (the "Strategic Network" charge). As such, it would be likely to have a similar impact, by relieving the tolled lanes, but transferring congestion onto the untolled lanes (and in some cases the parallel local network). However, it is more complex and difficult to implement than simply charging all lanes (or the on and off ramps) on motorways.

Toll lanes are widely used only in the United States. In some cases (e.g. 91 Express Lanes in Orange County, California) new capacity is built and tolled (but typically with untolled access for buses and high occupancy vehicles). In others tolls have been introduced on existing lanes, but only those that *already have restricted access.* For these lanes (often called High Occupancy Toll or HOT lanes), the primary objective is to get better use out of lanes which were previously only available for buses and high occupancy vehicles by expanding the scope of vehicles that can use them.

For toll lanes to deliver sufficient travel time savings for users to be willing to pay, they have to provide for faster trips over a considerable distance. In Auckland, given the conditions outlined above, it would only be practical on motorways with at least three lanes in any one direction. As entry and exit to toll lanes needs to be restricted, and distances between interchanges on Auckland motorways are short by international standards, entry and exit could not be allowed at all of the interchanges along the motorway. This would limit their utility to only those motorway users travelling longer distances, or accessing the motorway at specific interchanges.

There would be further challenges in convincing the public of the merits of taking one or more lanes out of general use to be tolled, particularly if such lanes become unavailable to some motorway users because of restrictions on entry and exit points. As no other city has converted general purpose lanes to toll lanes, it seems reasonable that toll lanes were excluded from further consideration in ARPES, although the option should not be ruled out completely as there may be limited conditions whereby such lanes could generate net benefits. For example, it is conceivable that spare capacity on the Northern Busway (or any similar future infrastructure) could be made available to general traffic paying a toll to ensure that the conditions on the route are sustained for buses (although bus stations do not offer a bypass route for any vehicles using the Busway). Allowing access to tolled vehicles on dedicated lanes that would otherwise be underutilised may have merit in isolated cases, but this is not going to effectively manage congestion across Auckland.

Full network pricing

Full network pricing is when charges apply to *all* road use, and may vary by vehicle type, road and time of day. This offers the capability to price congestion across the network by targeting pricing on individual road segments, and to vary pricing according to changes in demand. It is distinct from other forms of congestion charging in that it charges for the full consumption of road use by distance (or time), rather than having a charge triggered by passing a particular point. As distance can be charged differentially based on time, location and even the amount of distance used (e.g. a minimum amount or a cap may be introduced), the distortions that arise from cordon charging or motorway only charging can be avoided.

To enable full network pricing, vehicles have to be equipped (either as part of in-vehicle telematics systems or a dedicated on-board unit) with GNSS systems to enable the vehicle's movements on the road network to be measured by road and time of day, reconciled against a map with varying charges. This effectively would meter road use against the price of specific roads at specific times. A key distinction between this type of pricing and the existing New Zealand RUC system is that the total charges payable by a vehicle operator can only be determined after road use has occurred (RUC prepays future distance travelled).

Several countries (notably the UK and the Netherlands) have discussed moving towards full network national road pricing in recent years, although the political will to proceed was not sustained. With challenges to the long-term sustainability of fuel tax as a means of charging for road use (because of growing fuel efficiency and emerging trends to hybrid and electric vehicles), it may yet evolve out of programmes to reform national charging. Australia is starting a national debate about such a reform and will embark on a study to move light vehicle charges towards such a system (there is already a policy to move heavy vehicles onto a weight, distance, location based charging system that would be a more sophisticated version of New Zealand's existing RUC system).

For Auckland, it is fairly clear that *if* full network pricing could be implemented easily and with sufficient public acceptability, it would provide a powerful tool to ease congestion and to encourage shifts in demand by mode, time of day and route, as well as generating significant revenue that could be used to tactically increase transport network supply where required.

However, full network pricing was rejected in ARPES because "appropriate technology is currently not proven for a scheme focused on management of congestion in an urban environment".[4] At that time, only Germany had a GNSS based road charging system, for heavy vehicles largely on motorways only. However, since ARPES, four other countries have implemented major national GNSS based charging systems, and New Zealand has allowed such a system to be used for RUC collection. Concerns around urban canyoning effects and the accuracy of GNSS systems have been ameliorated by improvements in the accuracy of such systems (and the introduction of new systems such as Galileo) and the increased use of maps to match GNSS signals to trips. It is increasingly accepted that technology is no longer a technical barrier for urban road pricing in most locations in the developed world. Singapore is to implement a system with this capability by 2020 and Transport for London no longer considers that there are major technical barriers to the implementation of full

[4] pg.20, Chapter 2: Road Pricing Schemes Evaluated, ARPES, 2006.

network charging. In New Zealand the accuracy and integrity of GNSS does not yet match that in Europe and North America, but there are means to address this using map matching to GNSS signals. Network pricing using GNSS should therefore be considered as a technically feasible option for Auckland.

The main challenges of implementing such a system are not in fact technical, but rather the logistical and administrative complexity of deploying a system that would potentially require equipping up to a million vehicles with devices, and for all of those vehicles to have accounts opened for them. There are particular challenges in public acceptability of such an all-pervasive form of road pricing when there is little experience of pricing to date. However, steps can still be taken that may help enable the option of full network pricing to be implemented at a later stage, either specifically for Auckland or as an evolution of the existing electronic options for RUC.

APPENDIX B - Detailed review of ARPS option

Congestion reduction scheme

The congestion reduction scheme considered was a variant on the area charge scheme considered in ARPES. The primary reason for that is the effectiveness of that scheme (compared to others in ARPES) in reducing congestion.

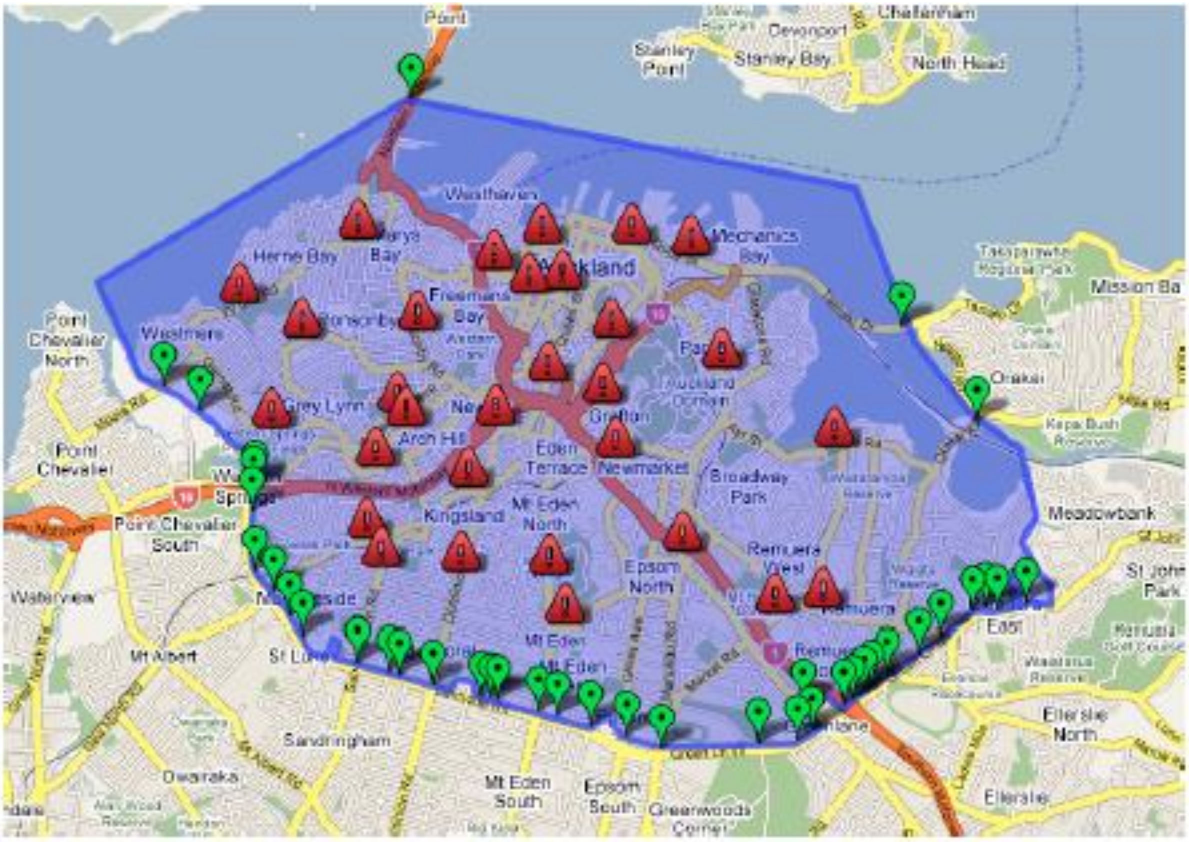

Figure 6 - ARPS congestion reduction scheme

As it was not considerably different from the ARPES scheme, the key findings of ARPS were also not considerably different. The scheme was found to reduce car trips by around 10% and increase mode share for public transport and active modes in the area. The economic impacts were seen to be mixed, no doubt dependent on whether businesses are more or less reliant on employees or customers accessing them by car or public transport.

ARPS was largely positive about the impacts of the scheme, and since ARPS the cost of implementing such a scheme will have reduced because the need for DSRC to supplement ANPR technology no longer exists.

However, ARPS also found considerable boundary traffic impacts, particularly on St Lukes/Balmoral/Green Lane as the "bypass" route for east-west traffic. This impact might be reduced by exempting through trips on SH1/SH16, but targeted capacity improvements such as lane widening or grade separation could also be needed. There may be a reasonable case for allowing through traffic on the motorways to be exempt from the charge, because of the lack of reasonable alternatives, although as with Stockholm, future application of a lower charge on those trips may be desirable to manage congestion on those routes. Exempting through trips on the motorways would only reduce the number of trips affected by 3-4%.

The key limitations of this scheme are:

- Lack of flexibility to vary charges by entry point, as an area charge by definition sets a single rate for all movements within the area. This cannot be addressed easily without replacing the scheme with some form of full network pricing varying by location;
- Bluntness of the area charge in charging short trips across the boundary the same price as vehicles circulating extensively within it. For example, a taxi undertaking many trips during the charging period would face a similar charge to a vehicle just crossing the boundary (e.g. an employee accessing Westfield St Lukes from outside the area). This creates negative impacts for those just across the boundary, but also raises equity questions;
- Charging all trips once encourages greater use by those who pay. The experience in London of an area charge scheme is that once a road user decides to drive in the area, that user may enter and exit multiple times without there being any cost to them, even though it contributes to congestion. In London, this means that after the initial effect of suppressing road trips from introducing the charge, those that pay face no incentives to reduce their driving in the area.
- Impact on residents within the area is likely to be a source of concern. For residents within the area travelling towards the CBD, the density of available public transport options is expected to be reasonable. However, for other trips the area charge may be seen as excessively punitive. For example, a resident in Grey Lynn driving to Manukau may not have a reasonable alternative and would be charged, but may feel unjustly penalised compared to a resident from St Heliers making a trip of similar length who is not charged. An alternative would be to make residents' vehicles exempt or grant a discount, but this would also affect trips to the CBD for those best able to make a modal shift; and
- Options for scaling the scheme are limited. Expanding the charging area would exacerbate the bluntness of the charge geographically.

Revenue Scheme

The ARPS revenue scheme was very similar geographically to the congestion reduction scheme, except that instead of being an area charge it is a cordon and instead of operating in the AM peak only, it would operate all day at a lower charge rate than the congestion reduction scheme. This scheme is notable in comparison only for having lower impacts on congestion and having more concentrated impacts on the scheme boundaries. Because it was planned to operate all day, it would affect non-commuter trips more significantly, some of which would be less amenable to mode shift (e.g. medical appointments) with no reasonable option for time shifting trips. As it lacks a rationale in terms of congestion, it is not considered further in this report.

APPENDIX C - Detailed review of FATF option

Motorway user charge

The proposed motorway user charge is similar only to the Dubai scheme, which is only imposed on a few such routes. It was accepted in FATF that there would be some shift of traffic onto the local road network, but to mitigate this, capacity improvements were proposed on some local roads to address congestion. It was also proposed to have no charge after 1900 (or 2000 in the peak charging variant) to give some an alternative time of day to travel, although it is also not clear how those who usually travel between 0600 and 2000 could readily delay their trips till night time. Charges were assumed to range from $1.30 off peak to $2.80 peak, or a flat rate of $2 per trip.

The proposed technology to identify vehicles was ANPR; it is likely the costs for such systems have reduced since the time of this report (2014). The assumed operating costs of around NZ$0.24 per transaction (defined as a single chargeable event) seem reasonable, although these are dependent on volume. The description of potential channels and means of payment was reasonable for 2014, but the emergence of smart phone apps could now provide more automated options for charging users, or notifying them of the need to pay for the use of the motorway network.

The impact of doing nothing was analysed relative to the introduction of the two variants on the motorway user charge (flat and peak rates) and the alternative revenue raising option. However, it is not clear to what extent the improved travel times of any of the options beyond the base case are due to charging, or to the investment in new capacity funded by charging revenues. As the motorway user charge options perform moderately better than rates/fuel tax, it is assumed that the demand management impacts were positive, although no measure of the impact on the local road network is presented. Given the findings of ARPES on a similar proposal, it is likely that these impacts would be considerable in some locations.

Experience from Sydney suggests that a modest difference between peak and off-peak charging is not likely to make a meaningful difference to congestion. Sydney Harbour Bridge and Tunnel both had peak charging introduced in 2009, of A$4 in the morning peak, compared to A$3 in the inter-peak. The result was an incremental improvement in conditions in the short term (reductions in delays of <5 minutes), but this has been eroded over time. That would suggest that a modest charge that only applies *once* is unlikely to have a sustained impact on demand without regular adjustments for inflation and the incomes of those using the charged roads.

The social impacts of the scheme were noted in terms of the proportion of households that would pay. The average impact per household per annum was $345-$371 and up to 3.9% of low income households would have a high financial impact because of a lack of choices as to how and when to travel.

APPENDIX D - Detailed review of ATAP options

CBD only cordon

Modelling indicates that the CBD-only cordon option reduces traffic flows in the CBD, although some routes at the boundary of the CBD had increased flows. Traffic management and careful design of the cordon boundaries could address this. Travel times improved modestly for most trips, except those affected by diversion around the boundary. There were modest positive impacts on accessibility to jobs in most areas. In summary, the impacts reflect the scale of the cordon, and this option does not have significant negative boundary impacts or distortions because it does not divide residential areas. It is particularly effective in reducing car trips to the CBD and increasing public transport mode share and has the best benefit to cost ratio of the three options.

The option includes charging in the inter-peak and the PM peak inbound, neither of which appear to be justified in terms of reducing congestion, although there may be merits in applying the cordon outbound in the PM peak, and inter-peak charging (on weekdays) could have merit if congestion levels justified it. However, as with other charging schemes, the benefits to users in travel time and vehicle operating cost savings are lower than the net revenues collected from them, suggesting the need to either use the revenues for transport improvements that will benefit users, or to offset other charges.

As an option in itself, it appears to have considerable merit in changing behaviour for trips to the CBD, particularly because public transport provision in Auckland is focused on access to the CBD from across Auckland. Unlike other boundary schemes like cordon and area charges, it would appear to create few distortions for short trips crossing the cordon as public transport or active modes could provide a reasonable substitute for many of those trips. In short, it offers an option to introduce pricing in Auckland, with few negative impacts. The main criticism of the option is its limited scope. It could improve conditions approaching the CBD, but would be less likely to reduce congestion on major arterials or motorways some distance away from the CBD. Yet if implemented, it would have the advantage of demonstrating how road pricing could work to ease congestion, even on a modest scale.

Motorway charge

The motorway-only charge has parallels to the original Strategic Network charge in ARPES, but is a single access charge that would be much higher at peak times ($5) than at the inter-peak ($1.25). The primary effect (as with the ARPES proposal) is to move congestion from the motorways to the parallel local network (although this effect is much more modest for routes parallel to SH20, no doubt in part because there is no reasonable alternative to the Mangere Bridge for much of that traffic). Travel times would reduce for longer distance trips on the motorway, but increase for shorter trips off the motorway network, particularly in the isthmus. The net impact on freight was forecast to be positive, although this may vary by freight industry segment. Line haul freight would be likely to benefit considerably, whereas local delivery traffic may be negatively affected by the diversion onto the local network. The impact on access to employment varies considerably, improving access for those originating from the North Shore and West Auckland but restricting access for those affected by congested local roads.

This appears to be the poorest performing of the three options under ATAP, primarily because of the negative impact on local roads and because it is more likely to encourage shift of route than mode, thereby moving congestion from one route to another. These negative impacts are in alignment with those identified in ARPES, and neither report suggests that a motorway-only charge would accrue net congestion-reduction benefits for motorists.

Full network pricing

ATAP modelled full network pricing based on replacing existing fuel tax and road user charges, (which average 6c/km at present for light vehicles paying either way). This would have a different demand response from introducing an additional charge (similar to introducing a charge 6c/km lower). The key opportunity this presents is to enable off-peak charges to be lower than the current fuel excise/RUC charges. That approach was not modelled, but could have interesting distributional and social impacts, particularly for those accessing employment, education and healthcare outside peak periods.

It is critical to note the limitations of a strategic model in being able to adequately reflect the network wide impacts of distance charges that may vary by time of day. It is also highly unlikely that all roads in Auckland would have the same charge during the peak. It is expected charges would be higher on congested segments and that all charges would be carefully calibrated to discourage diversion onto routes where the local impacts would not justify significant increases in traffic. Consequently, the option modelled here is not likely to represent the best option for Auckland and this is acknowledged in the ATAP Demand Management Pricing Report.

However, the findings of the evaluation are still worthy of consideration. Network pricing reduces traffic and congestion across the network as a whole, but still sees some congestion on parts of the network. This could indicate a need for additional capacity due to underlying demand, or for a more sophisticated charging scheme (such as targeted charging) than was modelled. Network pricing also improves access to employment across Auckland. Compared to the other two options, the scale of revenue this option can collect results in greater disparity between user benefits and charges paid. This disparity may be reduced if charging is targeted by location, and graduated to offer lower than current charges at off-peak periods such as evenings and some periods in weekends, or if revenue raised was linked to expenditure on roads.

It is clear from this report that in the longer term full network pricing offers the potential to transform the management of roads in Auckland, encouraging changes in modal choices and helping to better inform expenditure on new road capacity. The primary challenge will be whether it is introduced as a replacement for existing nationally collected taxes on road use, or as an increment on top of them.

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APPENDIX E - Additional details of Singapore Electronic Road Pricing

CATEGORY	DESCRIPTION
System name	ERP
Year operation commenced	1998 as ERP, 1975 as Area Licensing Scheme
Contracting authority	Singapore Land Transport Authority
Type of scheme	Major highway point charging with central cordon charged per crossing
Number of charging points	77
Vehicle categories charged	All vehicles
Elements of charge	Vehicle type (PCU basis), location, time of day, direction of travel
Impact on other charges/taxes	ERP replaced ALS which was introduced on top of other charges
Procurement approach	LTA contract with supplier to design, build and maintain
Primary charging technology	DSRC with integrated payment stored value smartcard inserted in on board unit
Basis for charge calculation	Performance based to ensure minimum speed range at charging points (20km/h-30km/h in urban streets, 45km/h-65 km/h on expressways)
Discounts and exemptions	Emergency vehicles
Estimated gross revenue	NZ$154m per annum
Use of revenues	General government revenue
Estimated capital costs	NZ$200m (1998 prices)
Estimated operating costs	NZ$16.2m per annum
Range of charge rates	NZ$0.51 to NZ$4.05 per charging point crossed, with no cap
Occasional user product	None, DSRC based account is compulsory or fine issued
Modal share	Cars are used for 48% of all trips, 35% of employment trips
Violation rate	0.5% of crossings of charging points

Table 1 - Summary of Singapore ERP

Objectives

On 22 November 2011, Mrs Josephine Teo, Minister of State, Ministry of Finance and Ministry of Transport stated in an answer to a Parliamentary Question about ERP:[5]

Traffic congestion at any time leads to a sub-optimal utilisation of our road network. It undermines our quality of life, the environment, and the overall efficiency of the economy. Congestion therefore needs to be kept in check. Where possible, traffic engineering methods, such as road widening, have been implemented to

[5] Source: https://www.mot.gov.sg/News-Centre/News/2011/Oral-Answer-to-Question-on-ERP-charges/

relieve congestion. However, where such solutions are not available or have been exhausted, Electronic Road Pricing (ERP) has been introduced.

Development and implementation timeframe

Singapore starting investigating options to manage traffic congestion and urban transport in the early 1970s, culminating in a high-level ministerial committee that was established in 1973 that recommended a series of options to constrain the growth of private car traffic. The concept of the Area Licensing Scheme (ALS) arose from that committee meaning Singapore became the first city to introduce some form of price based demand management of road use with the introduction of ALS in 1975. The ALS required motorists to purchase and display a paper licence to access a CBD cordon. Licences were purchased for a month or a day of access, and would allow unlimited access during the operating hours of the licensing scheme (0730-0930, later extended to 1015 weekdays). The charge was S$3 per day and initially buses, taxis, goods vehicles, emergency vehicles and high occupancy (four or more people) vehicles were exempt. In 1989 this exemption was constrained only to scheduled buses and emergency vehicles, in part because private motorists were touting for bus passengers to meet the high occupancy target to avoid payment.

The initial demand response was a 50% reduction in vehicle trips at the morning peak. In order to sustain these gains, the evening peak was also subject to licensing from 1989, and in 1994 the ALS applied all day (0730-1830). Enforcement was carried out by police officers observing vehicles crossing the cordon (which encircled an area of $6km^2$ later extended to $7.2km^2$) and fining vehicles that did not display a licence by recording their number plates and posting a violation notice to the vehicle owner's address. Revenue from the ALS was treated as general government revenue, with no hypothecation for transport purposes.

The ALS evolved in the 1990s to require licences to use three major expressways and at that point was called the Road Pricing Scheme (RPS). A licence for the ALS would also be valid for passage along two expressways, but a separate one was required for the third. The expansion of the paper based system in the 1990s was the precursor to technical demonstrations to see how a new automated system could be developed to replace the ALS and RPS.

The success of the ALS/RPS in reducing congestion was clear, but the administrative efficiency of manual inspections of vehicles was growing costly (over 100 officers were employed in the 1990s in the enforcement role) and Singapore sought to develop a more flexible system that would be more scalable and efficient. Singapore started investigating the use of electronic road pricing technology in 1989, when the emergence of the first tag and beacon type systems appeared (albeit at the time only to provide an automated trigger for toll booth barrier). A lengthy and complex process was undertaken with bidders and revising the functional design.[6] A series of technical trials were undertaken with various systems and vendors, until the Land Transport Authority was convinced that it would technically viable and economically feasible to replace the ALS/RPS with what was coined Electronic Road Pricing (ERP). The functional specifications for Singapore's ERP system were outlined by Professor Gopinath Menon and Dr Sarath Guttikunda in their paper *Electronic Road Pricing: Experience & Lessons from Singapore* and seen in Figure 7 below[7].

It started operating in September 1998 replacing both ALS and RPS, and over the following years the inner city cordon was expanded and the number of expressway/highway charging points has increased in number significantly.

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[6] See http://eresources.nlb.gov.sg/infopedia/articles/SIP_832__2009-01-05.html for details.
[7] SIM-air Working Paper Series 33-2010, January 2010.

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One of the key advantages ERP offered was for charging rates to be developed independently for each charging point, including hours of operation and direction of travel for charging. This now means Singapore has by far the most sophisticated road pricing system anywhere in the world, as each charging point has its own price schedule based on time of day, direction of travel and even day of the week (some operate on Saturdays).

Notable innovations since ERP was introduced were:

- 2003: Introduction of 5 minute interval variations in charging, to enable prices to step up gradually over a period (e.g 0730-0735 $1, 0735-0740 $1.20, 0740-0745 $1.40) to minimise behaviour to avoid significant increases in charges;
- 2005: Saturday operation of ERP commenced for part of the CBD;
- 2008: Rate changes to be in increments of S$1 instead of 50c and the 85th percentile of speeds instead of average speed used to measure congestion performance to inform rate changes;
- 2012: 18 month technical trial undertaken on GNSS technologies to determine suitability for replacement of current system.
- 2016: Contract awarded for GNSS based ERP system (next generation).

The next generation ERP system will be implemented in 2020 using GNSS technology at a cost of around NZ$523m. This will comprise replacement on-board units, with all existing users of ERP able to switch to the new units with GNSS technology free of charge over an 18 month transition period. This has followed some years of testing of GNSS technology in Singapore.

Key factors affecting development of scheme

Core to the ability of the Singapore Government to introduce its charging schemes has been high levels of public trust in the government to act in the wider interests of the public and the economy.

Singapore's Government has long focused on economic development and on innovation and technology. It also has a long standing series of transport policy objectives:

- Making public transport a mode of choice (encouraging greater use of public transport, given the population density and size of Singapore);
- Manage road usage (balancing the desire to own a car and drive, with the need to maintain free flowing traffic conditions);
- Meet the diverse needs of the public (recognising the social role of transport and the need to ensure access for those on lower incomes).

Within this policy context, the Singapore Government has taken a series of measures to constrain car ownership and driving. This includes the Certificate of Entitlement (CoE) programme to restrict car ownership, that is an auction system to grant people a right to legally own a car for a period of ten years. The price of a CoE is typically similar to the retail price of a new car, severely constraining the affordability of car ownership. Furthermore, car owners need to ensure they have a car park space at their residence. This may not necessarily be the case. Such a policy and cultural context of restricting car ownership makes it much easier to introduce urban road pricing to constrain car use. Singapore has a per capita vehicle ownership rate lower than all other developed countries and many developing countries such as Brazil and South Africa. There has been relatively little political challenge in Singapore to this policy approach, although some media criticism and debate has occurred.

Undoubtedly, it has proven much easier for Singapore to develop and evolve its ERP system after successfully operating the ALS system for over twenty years. Not only did ALS prove that pricing can effectively constrain road traffic growth, but that the system existed for congestion management, not revenue. With the introduction of ERP, this was proven further, as the policy of varying rates based on performance (both up and down) demonstrated the policy commitment to optimising traffic flow, not taxing road users. ERP itself is a bespoke system, with few parallels to DSRC based free flow toll systems elsewhere. This demonstrates Singapore's willingness to develop a solution that suits its needs and to take technical and developmental risks, rather than await others to prove that a technology or approach works.

The decision to develop the GNSS based system follows on from the success of ERP, but is also an attempt to move beyond the limitations and criticisms of the ERP system. The two main problems with ERP are:

- Lack of flexibility at reasonable cost (it is costly to install a large gantry to expand charging to another section of road);
- Public opposition to new gantries (ERP gantries are considered large and unsightly, particularly on residential and commercial streets).

The GNSS based system will enable gantries to be reduced in number and scaled down in size (as they will retain ANPR cameras for enforcement purposes), but also allow for charging to evolve to charge by distance on expressways and highways, and for parallel routes to also be subject to a charge.

Evaluation framework

Singapore's focus on evaluation of ERP has been on traffic performance and system performance.

Traffic performance measurement is based on measuring traffic speeds on charged roads to determine if they are within the 85th percentile of a specified range (of 45km/h-65km/h for expressways and 20km/h-30km/h for local streets). This is used to directly inform rate setting that is undertaken every three months. If traffic at a charging point is below the range specified for that type of road within at least 85% of the period sampled, the charge rate will be increased. Similarly, if it is above that range, the charge rate will be decreased. Charge rate changes will be implemented by S$1 increments. This is seen by LTA as providing a reliable and efficient measure of how well ERP is managing traffic demand and performance of the road network.

LTA does not evaluate the economic, social or environmental impacts of ERP. It is assumed that as ERP optimises traffic speeds and is not priced to deter road use when traffic is free flowing above the speeds indicated, that it is optimal in economic terms and this has consequential environmental benefits (congested traffic generates higher emissions per km), and that the high provision of public transport adequately addresses social concerns around access.

Although there have been academic surveys and studies undertaken around wider impacts, none of these have been officially endorsed and no data is provided by the LTA to support such analysis. The LTA is unwilling to provide data about usage of the ERP system because of legal constraints on its ability to share data that could compromise the privacy of ERP users.

Methodology for choosing scheme design

The locations of the ERP charging points were originally based on the ALS/RPS charging points, and have since focused on corridors with severe congestion. New charging points were selected based on regular congestion levels dropping below the target range. This also had to take into account the effect and practicality of installing a charging point, so that an ERP gantry would not be likely to encourage diversion of traffic (so any alternative routes would have to either be charged or be sufficiently inferior that most road users would not change routes). The time of operation and pricing applied have been dependent on the temporal conditions of congestion at the chosen charging point.

The choice of technology and system was based on the need to achieve very high levels of reliability (which only tag and beacon technology could achieve in the mid to late 1990s). The choice of the system of using prepaid smartcards (and now credit cards) inserted into on-board units was to enable automated payment (in an age before e-commerce and internet payments had developed) and to help protect user anonymity. The concept was that a road user could use a stored-value card to pay ERP, without the ERP system needing to know anything *except* that a valid payment had been taken from the card. This helped to address concerns that ERP was to track vehicle movements. The on-board unit design was also intended to enable motorists to visibly see the value of their stored-value cards with a LCD display screen, for ease of use and understanding. By directly associating identification of a vehicle at a charging point, with instant receipt of payment, the system was seen as being easy to understand and also avoiding extensive use of back-office processes for billing or processing of accounts (with the primary back-office function being to reconcile number-plate images for the small proportion of vehicles for which payment was not received).

However, the decision to develop a bespoke DSRC system which takes payment through the gantries has meant Singapore has some of the largest and most elaborate road pricing gantries seen anywhere. The gantries take up 11m of road length and are comprised of three gantries to locate camera, OBU controllers and antennas to enable the reading of OBUs and the collection and writing of data for the collection of money from OBUs. The size and scale of these structures has undoubtedly contributed to opposition in recent years towards the installation of more such gantries in built up areas. Although technology has advanced since the original system was installed, if it were to be replaced with a similar type of system, gantries would still have to be larger and more elaborate than used today for DSRC based systems.

The choice of target vehicles was intended to provide an equitable basis for charging, in that all vehicles except emergency vehicles would have to pay without exemptions, with the rate for payment directly related to road space occupancy (using the Passenger Car Unit equivalent measurement). Buses were not made exempt in part out of concern that if they were, taxis would lobby for an exemption. As the system was designed to manage congestion, it was seen as most equitable to charge as many vehicles as possible, to incentivise changes in behaviour by mode or time of day.

Enforcement is undertaken using ANPR cameras identifying vehicles with no valid on-board unit or insufficient payment in their ERP smartcards/accounts, with vehicle owners fined accordingly.

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Box 2: Functional requirements for ERP in Singapore

- It should be a multi-lane system with no toll booths.
- There would be no manual payment.
- There would be no need to slow down at the ERP entry points.
- Provision to accommodate
  - When more than one vehicle passing simultaneously under the entry point.
  - Vehicles may straddle lanes as they pass under the gantry.
  - Vehicles could travel at speeds of up to 120kph.
- The In-vehicle-Unit (IU) should do a self-check and a check of the CashcCard before the journey starts. The self-diagnostics include icons and sounds to alert the driver of any faults in the IU.
  - The IU should warn the driver when the cash balance in the CashCard become low.
  - The IU should preferably draw its power from the vehicle battery.
  - The IU should be permanently fixed to the vehicle and the fitting exercise should be simple and not take more than 20 mins.
  - The IU should carry a five-year warranty against manufacturing defects.
- Audible signals on the IU are to complement the visual displays.
- The enforcement photographs should be transmitted back to the control centre within 15 mins and initially checked by an optical character recognition system.

Figure 7 - Functional requirements for Singapore ERP in advance of procurement

Public engagement and consultation

The development of ALS, RPS and ERP have all been subject to public consultation and engagement, as with other public policy initiatives in Singapore and transport policy measures implemented by the LTA. Stakeholders including road freight companies, fleet operators and motor vehicle associations were consulted. A large scale public engagement exercise was undertaken in advance of the introduction of all three schemes, so that the public understood when and where the systems would operate and how they could pay and be compliant.

A trial operation of ERP was undertaken in advance of operation to demonstrate how the system would work and to help with familiarisation of the system. This greatly helped in ensuring that non-compliance was minimised when the system was introduced.

Acceptability was also enhanced by allowing taxis and commercial vehicles to have a brief concessionary period of operation at a discount, to help with them familiarising themselves with the operation and to absorb any costs. A key element to increase acceptability was the reduction in vehicle taxation, transferring charges from owning a vehicle to using a vehicle.

Since the introduction of ERP, consultation is undertaken for the installation of each location for new gantries. As a result, not every proposal has been implemented in some cases due to public opposition.

Review of scheme outcomes and longer term effects

The ALS originally reduced morning peak traffic volumes by 60%, and when it was extended to the evening peak in 1989, it reduced volumes at that time by 40%, both indicating a very high elasticity of demand. It is notable that ALS applied to only taxis and private cars. t was expanded to goods vehicles, non-scheduled buses and motorcycles in 1989. ERP continued with this, but charges all buses.

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ERP reduced traffic volumes by an average of 7% and this has been sustained since its introduction during the times of operation. ERP has enabled Singapore to grow and for vehicle numbers to increase, but without congestion worsening at the places and times where it operates. Overall traffic volumes have reduced by between 17% and 4% depending on the charging point. However, traffic volumes have increased in non-charging periods. For example, in the CBD, evening traffic volumes increased 28% (during a non-charged period), but this was still well within the capacity of the road network to handle efficiently.

Complementary measures

Extensive improvements to public transport were undertaken during the period of the ALS and since the ERP was introduced. New metro lines, additional bus services and bus lanes were added, with real time information systems for public transport. Air conditioned bus interchanges also helped to integrate the overall policy message that road users were offered reasonable alternatives to driving.

Applicability to Auckland

Singapore is an example of a mature successful urban congestion pricing scheme that has delivered sustainable management of congestion in Singapore. Furthermore, it will almost certainly be the first city to evolve urban congestion pricing to a even more variable time-location-distance based system after 2020. It is important to note that both the urban form/geography and political culture of Singapore are significantly different to that of Auckland. Housing in Singapore is typically of a much higher density and concentration than in Auckland, with car ownership levels well below half that seen in Auckland (and commensurate intensive provision of public transport, with very low operating subsidies). Although it is easy to characterise Singapore's political culture as being much more trusting of government with fewer opportunities to vigorously oppose or protest policy measures, it still has a media and political discourse that challenges government. There has been regular coverage of concerns and scepticism about ERP in the Singapore media. It has not been possible for new ERP gantries to be installed wherever LTA believes it to be appropriate, so Singapore's government has had to be aware of ensuring public support for the development of ERP.

The key positive lessons from Singapore come from what it does well:

- Performance management based approach to price setting;
- Targeting pricing by vehicle type, route, time of day and direction of travel;
- Evolving system building on success and confidence building.

The approach of setting and reviewing prices based on measurement of traffic speeds on the network ensures that the system actually delivers on its intentions, in managing congestion. By not allowing speeds to drop too low, it means that those who pay are effectively guaranteed a level of service is going to be maintained. By reducing prices if speeds are consistently higher, then the system also minimises the risk of *overcharging* for travel time savings, so that the network is not overpriced and underutilised. Although there is little direct economic evidence for the impacts of this, taking this approach would undoubtedly reduce any negative impacts of charging being too blunt.

The high refinement of charging rates by location, time of day and direction of travel has also avoided charging that disproportionately affects road users that are not contributing equivalently to congestion. Simply by minimising exemptions, and charging both motorcycles and trucks at levels equivalent to road space occupancy, has meant Singapore has the most *economically efficient* levels of pricing. This has helped to promote equity, fairness and public acceptability. It is difficult to argue against prices that are refined to reflect congestion by vehicle size at a particular location and time of day. However, Singapore did not get to this point of sophistication quickly. The original cordon ALS charged a flat rate for access and as each additional charging point was added under RPS and ERP, the charges for that location (and charging times) were developed independently, so that the price could be effective in managing congestion and demonstrating that congestion management is *the* objective.

Auckland is unlikely to be able to replicate Singapore's neutrality as to the use of net revenues from ERP (which are all treated as general government revenue), and similarly it is neither going to be acceptable, nor necessary for Auckland to acquire a system with the physical urban footprint of ERP (with large, visually obvious gantries). The desirability of a payment option with anonymous smartcards to protect privacy is notable, but for Auckland such a system would be bespoke and significantly add costs. Given the public acceptability to date of the existing tolling system for Northern Gateway, this would appear to be excessive. However, Auckland should be able to develop a system that incrementally evolves to have a level of sophistication akin to Singapore. Different roads should have prices that vary by time of day and location to reflect congestion, and if prices are reviewed regularly to track both up *and down*, this could be expected to improve public acceptability as well as minimise negative impacts on access and equity.

Finally, as the first city to adopt GNSS based pricing, Singapore should be carefully observed to see what lessons Auckland could embrace from its deployment of a platform that could allow full network pricing. It would be challenging for Auckland could advance such pricing initially, but the experiences from Singapore would be useful in informing future steps towards full network charging. Singapore intends to use its new GNSS system initially to replicate what it does now, gather data on traffic movements and then to evolve its system incrementally.

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APPENDIX F - Additional details of London Congestion Charge

CATEGORY	DESCRIPTION
System name	Congestion Charge
Year operation commenced	2003
Contracting authority	Transport for London
Type of scheme	Area Charge one charge for all day
Number of charging points	174 locations across 21km^2
Vehicle categories charged	Private cars, light and heavy goods vehicles
Elements of charge	Flat rate for all vehicles between 0700-1800 weekdays except public holidays
Impact on other charges/taxes	None
Procurement approach	Design, build, maintain contract
Primary charging technology	Declaration based system enforced by ANPR, evolved to detection based system for account holders
Basis for charge calculation	Policy judgment
Discounts and exemptions	Emergency vehicles, all buses and coaches, all taxis have exemption or 100% discount. Residents of the area 90% discount. Ultra low emission vehicles, Holders of disabled blue badge have a 100% discount, recovery/breakdown vehicles 100% discount. 50% of all trips recorded are of vehicles with discounts or exemptions
Estimated gross revenue	NZ$410m
Use of revenues	Hypothecated transport fund
Estimated capital costs	NZ$415m five year design, build, maintain contract
Estimated operating costs	NZ$164m
Range of charge rates	NZ$20.75 (NZ$18.95 if registered for autopay or fleet operators, NZ$25.30 if paid the next day)
Occasional user product	None, core product is declaration of future or past trips
Modal share	Cars used for 32% of all trips in Greater London (10% to central London)
Violation rate	6% in 3 months ended 31 March 2017

Table 2 - Summary of London Congestion Charge

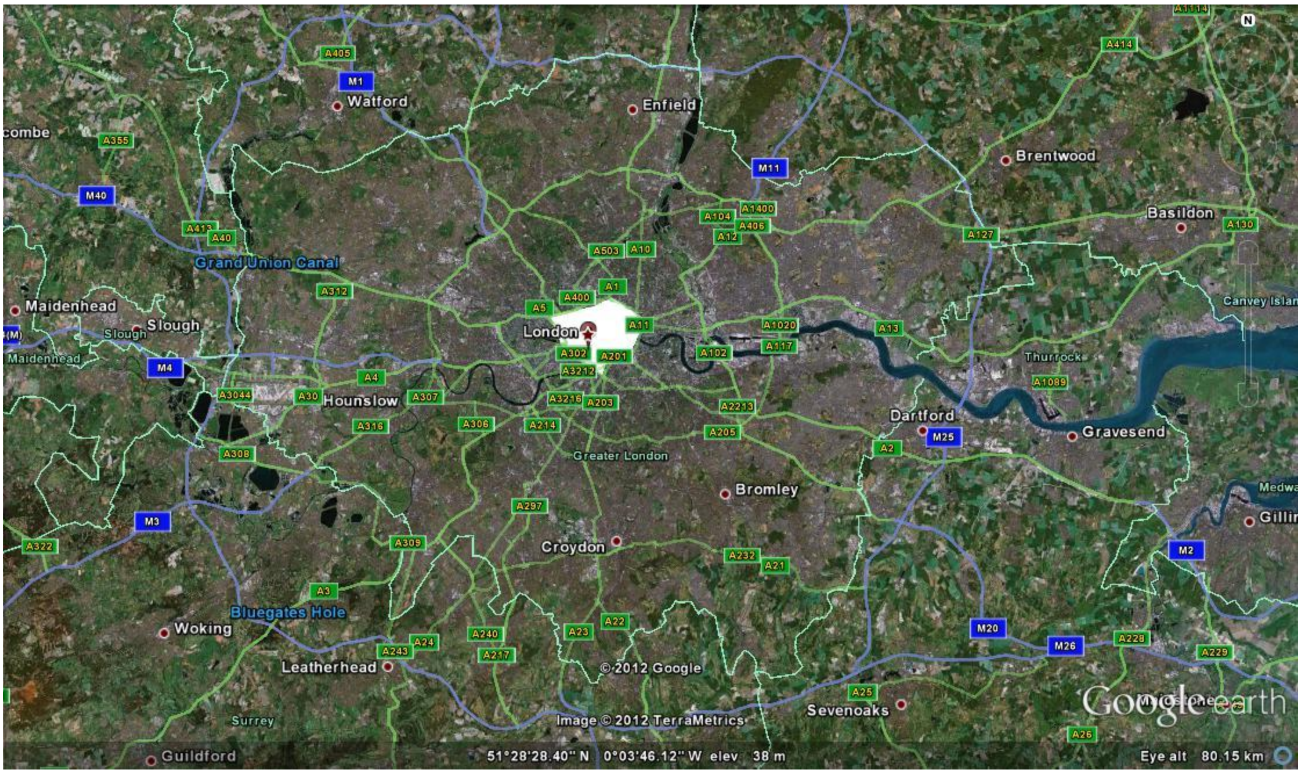

Figure 8 - London congestion charge area within the M25

The Western Extension and other attempts to expand the charge

From 19 February 2007 until 4 January 2011, London's congestion charge scheme was double the size it is today and was originally. This was due to introduction of the Western Extension, which expanded the size of the charging area westwards across Kensington & Chelsea bounded by the Thames at the south, the A3220 arterial to the west and Harrow Road to the north. The policies for vehicles entering the Western Extension were identical to those for the central zone, and one charge covered entry into both zones. The boundary between the zones (a north-south major route from Edgware Road through Park Lane, Victoria to Vauxhall Bridge) was a bypass route for traffic to pass through the zone without paying (see Figure 9). In addition, the Westway (a motorway standard route connecting the A40 highway from the West to central London) was also excluded from the charging zone, because it contributed towards providing an efficient orbital bypass route.

The fact of both zones being treated as one created a key inequity with the extension. As residents of both zones could apply for a 90% discount to the charge for using their vehicles, this meant that residents of both central the western zones could now enter each others' zones for a significant discount. Kensington & Chelsea is one of the wealthiest boroughs in London, and in effect the extension gave its residents a 90% discount on driving into central London, even though there is no shortage of public transport options for them (four underground lines and many bus services).

The Western Extension was developed and subsequently cancelled largely for political reasons. Ken Livingstone expanded the congestion charge to Kensington & Chelsea in part because he believed that it was politically acceptable to place one of London's wealthiest suburban areas within a congestion charge zone. There was no particular traffic or transport merit in choosing that location over other adjacent ones to the central zone. The Western Extension cost £125m to install (NZ$219m) primarily involving ANPR cameras and communications infrastructure, and cost an additional £33m (NZ$96m) to operate. The impact was a 13% reduction in numbers of vehicles entering the Western zone.

The Western Extension was controversial and in the 2008 Mayoral Election, Boris Johnson campaigned on reviewing the Western Extension. He won the election and proceeded to consult on the future of the scheme. Consultation indicated 62% opposition (from surveys and submissions) to retaining the scheme, although (in confidence) the Mayor was interested in retaining it for revenue purposes. Ultimately, the Mayor cancelled the extension primarily for political reasons.

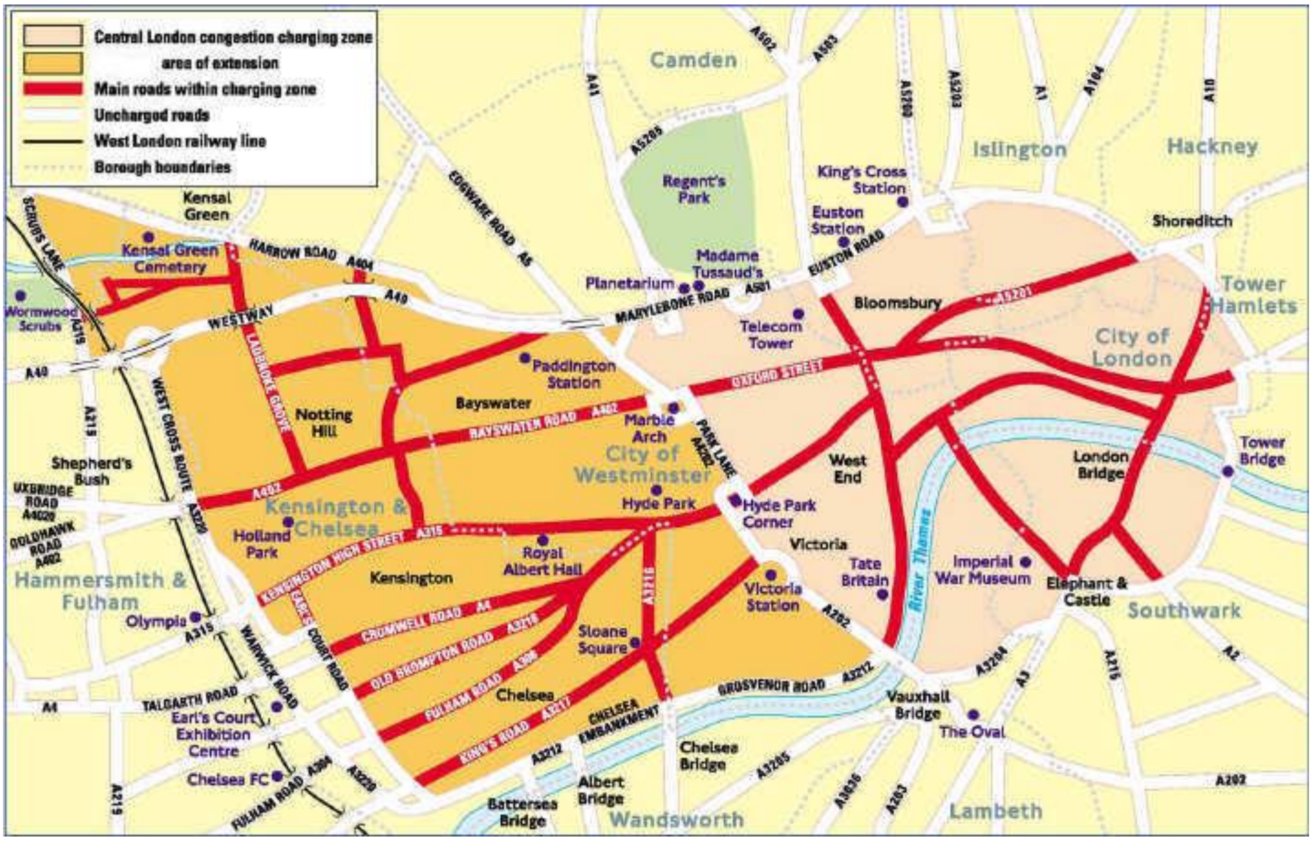

Figure 9 - London congestion charge zone with Western extension

Cancellation of the scheme cost TfL on average £55m in net revenue per annum. Traffic increased into the zone by 8% on average after the Western Extension was closed, with a 6% increase in traffic circulating in the zone and a 3% reduction in average speeds (TfL forecast an 8-15% increase in traffic volumes and a 6-21% reduction in speed). There was no impact on pollution from removing the extension.

There have been no subsequent attempts to expand the congestion charging zone. A previous study into implementing a congestion charge at Heathrow Airport (2002) did not result in any progress for several reasons:

- The Mayor's lack of authority over many of the roads at the airport (being on airport land);
- The lack of reasonable alternatives for car users travelling from outside London to Heathrow, include employees;
- Modelling indicating the proposal would have minimal impact on air quality, given the impact of aircraft and ground vehicles at the airport and the high traffic volumes on the adjacent M25 and M4 motorways that were primarily unrelated to the airport.

One view is that any expansion of the congestion charge should be concentric, and apply equally to neighbouring areas around the existing zone. The next likely expansion of charging in London will be on the Blackwall Tunnel, one of London's most congested routes, which will have a toll introduced in parallel to the opening of a new river crossing to the east of it, which will also be tolled. These tolls are intended to pay for the new tunnel, but also sustainably manage demand for new road capacity. The new tunnel is expected to improve access to areas of development, but also assist with the need for connections between south and east London, particularly for commercial and freight traffic, and create opportunities for new bus routes.

Low emission zone

On 4 February 2008, the Low Emission Zone (LEZ) was launched. It applies a minimum emissions standard for all heavy vehicles and specific light commercial vehicles entering London and applies almost to the entire territory of the Greater London Authority. The only routes exempt from the Low Emission Zone are the M25 orbital motorway and motorways that enter London (although traffic exiting those motorways towards London are all subject to the zone. The LEZ applies on all days and at all times and requires heavy vehicles to meet the Euro IV standard and light commercial vehicles the Euro III standard respectively. Those that do not face a daily fine of £100 (NZ$175) or £200 (NZ$350) depending on the vehicle category. The LEZ cost £49m to implement as it uses the back office and enforcement systems of the congestion charge. However, one study indicated the impacts of the zone on air quality in London were insignificant.[8]

Changes to the Congestion Charge

Changes to the scheme over the years have focused on reducing costs for Transport for London and for users. Autopay was introduced so that regular users (in particular commercial vehicles and trucks) need not have someone manually pay a charge for every trip. Whereas payment through retail outlets was closed because of the costs of maintaining it (and the very low use of retail outlets for payment after five years of the charge commencing).

Contract values

Initial contract to implement and manage the scheme from 2003 to 2008 was £280m (Capita). Around £10m a year was considered by Capita to be profit.

Latest contract from 2015 till 2020 is worth £145m (Capita) to operate and manage the scheme along with the Low Emission Zone.[9]

Ultra Low Emission Zone

The current Mayor of London is focused on implementing a two stage Ultra Low Emission Zone (ULEZ). Ths first will effectively be a surcharge on top of the existing congestion charge for vehicles that do not comply with criteria defining ultra low emission vehicles. This will apply from April 2019 and require vehicles to be at least Euro 3 for motorcycles, Euro 4 for petrol cars, vans and minibuses, Euro 6 for diesel cars, vans, buses, trucks and coaches, or face a £12.50 surcharge (on top of the congestion charge if applicable) or a £100 surcharge for heavy vehicles.

The second will be a much larger implementation, effectively creating an environmental area charge located at London's "middle" orbital routes (North and South Circular Roads). Vehicles that do not comply with the

[8] Source: Wood HE, Marlin N, Mudway IS, Bremner SA, Cross L, Dundas I, et al. (2015) Effects of Air Pollution and the Introduction of the London Low Emission Zone on the Prevalence of Respiratory and Allergic Symptoms in Schoolchildren in East London: A Sequential Cross-Sectional Study. PLoS ONE 10(8): e0109121. https://doi.org/10.1371/journal.pone.0109121

[9] Source: https://tfl.gov.uk/info-for/media/press-releases/2014/january/transport-for-london-announces-new-congestion-charge-and-low-emission-zone-service-provider

ULEZ criteria that enter these zones, will face a fine. The Mayor seeks to extend the scheme to these roads by 2021. By expanding the geography to this large an area, there will effectively be a form of urban road charging scheme in London that applies across all of inner London encompassing many suburbs. However, TfL does not believe these schemes will have a significant impact on traffic congestion, as only a "small minority" of vehicles will be subject to the charge. One concern is that although most of the North Circular Road is a multi-lane grade-separated highway, the South Circular Road is mostly a signposted series of local streets, some passing though the middle of local shopping areas. It is unclear how the possible impacts of the scheme on those communities will be addressed at this stage.

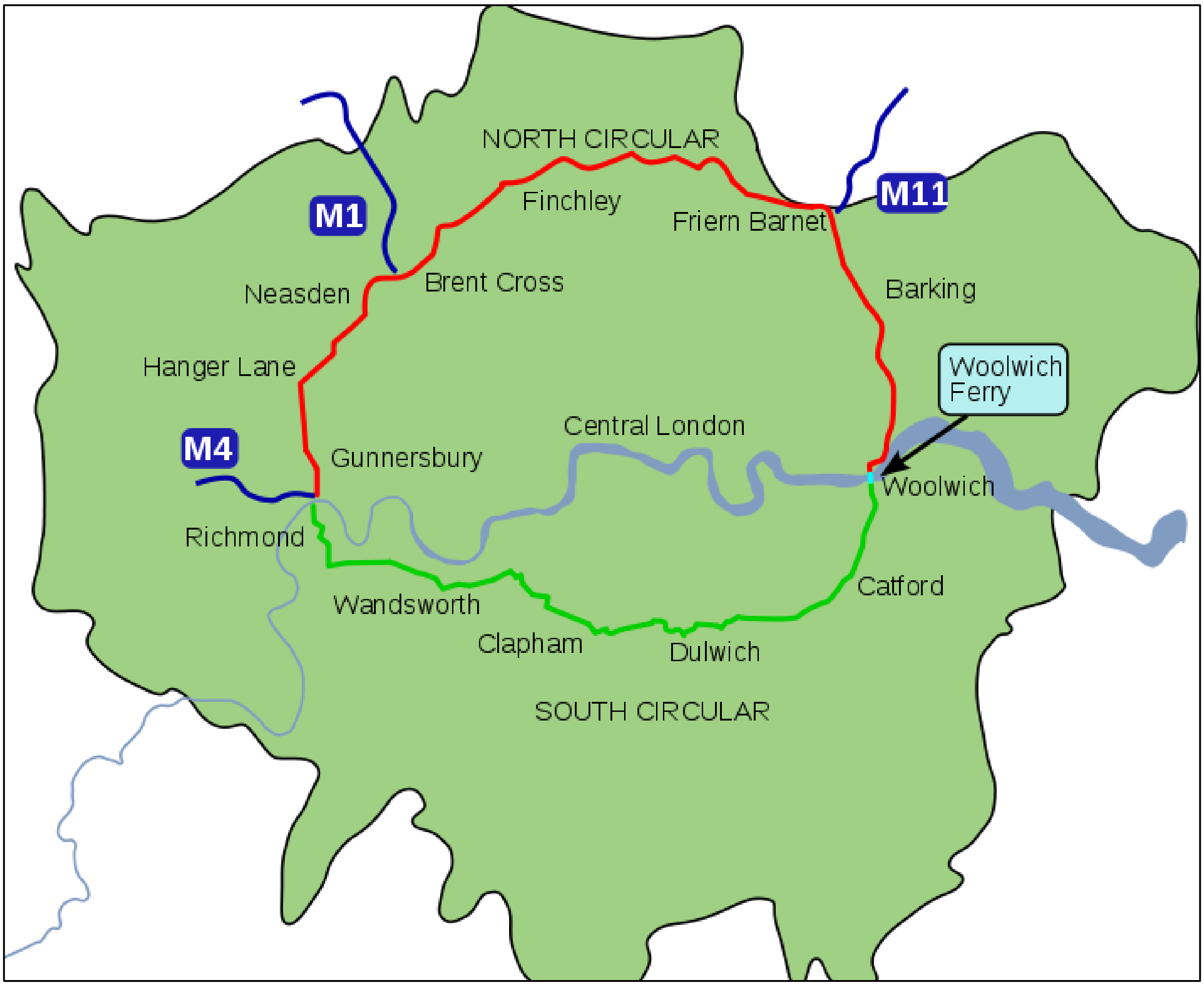

Figure 10 - London's north and south circular roads, which will be the boundary of the cordon for the Ultra Low Emission Zone

Future of Congestion Charge

In February 2017, the Transport Committee of the London Assembly released a report on London congestion.[10] It made a number of conclusions about the congestion charging scheme:

- The flat rate charging structure is not a disincentive to limit driving once it is paid. It does not meter usage of roads within the area;
- The charge does not vary across the charging period, so does not target congestion effectively.

The report noted the Stockholm example positively and that a survey of 1,000 Londoners saw 60% support for moving away from the congestion charge to a road pricing scheme based on paying by road usage. It concluded that a comprehensive road pricing scheme (using GNSS technology) would be the best way forward, which did not necessarily mean charging all motorists more than at present, but targeting charges where and when congestion is concentrated. TfL no longer believes that the technology for full network charging is a major barrier to implementation, but rather that political will and public acceptability are the key issues. The current Mayor of London has not expressed a view on further evolution of the congestion charge. Current policy is focused on implementing the ULEZ (which TfL says has a much higher level of public acceptability than the introduction of the congestion charge did in 2003, indicating much more public support for environmental rather than congestion charging).

One reason for hesitation in expanding congestion charging is concern about being seen as "anti-car", with perceptions that implementing the ULEZ is sufficient for now. However, there is significant lobbying from business, motoring and environmental groups for a new feasibility study to be commissioned for network road pricing in London. The Mayor would like London to have devolved responsibility for revenue from Vehicle Excise Duty (equivalent to motor vehicle registration and licensing fees in New Zealand). It is considered by TfL that this could offer an option to introduce full network charging in exchange for providing London vehicle owners a refund in Vehicle Excise Duty.

The Mayor released his draft Transport Strategy on 21 June 2017.[11] It contains a vision to reduce the modeshare for cars from 36% of trips to 20% of trips by 2041, with a reduction in absolute terms of one-third of trips by car or taxi. He also seeks to reduce the number of freight trips in the morning peak by 10%. To do this, he wants to consider the introduction of full network road user charging, by distance, time of day, location and emissions type. Neither technical feasibility nor cost, are seen as serious barriers. TfL's view is that introduction of the ULEZ in combination with the LEZ that already exists effectively provides much of the enforcement infrastructure needed.

[10] *London stalling. Reducing traffic congestion in London*, Transport Committee, London Assembly, February 2017. Available at https://www.london.gov.uk/about-us/london-assembly/london-assembly-publications/london-stalling-reducing-traffic-congestion
[11] Full text available at https://consultations.tfl.gov.uk/policy/mayors-transport-strategy/user_uploads/mts_main.pdf

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APPENDIX G - Summary of Stockholm Congestion Tax

CATEGORY	DESCRIPTION
System name	Congestion Tax
Year operation commenced	2007
Contracting authority	Swedish Transport Agency
Type of scheme	Cordon Charge
Number of charging points	26
Vehicle categories charged	All vehicles except buses and motorcycles
Elements of charge	Rate that varies by time of day for entry/exit of charging zone
Impact on other charges/taxes	None
Procurement approach	Design, build, maintain contract
Primary charging technology	Detection/declaration based system using ANPR
Basis for charge calculation	Demand modelling for target percentage of traffic reduction
Discounts and exemptions	Buses over 14 tonnes, emergency vehicles, motorcycles, military vehicles and vehicles with disabled parking permits all exempt
Estimated gross revenue	NZ$138m (2013)
Use of revenues	Hypothecated transport fund for roads and public transport
Estimated capital costs	NZ$309m (including first year of operation and pilot trial)
Estimated operating costs	NZ$41m (2013) includes Gothenburg
Range of charge rates	NZ$5.68-NZ$1.79
Occasional user product	None, core product is billing of trips
Modal share	Cars used for 40% of trips to CBD (20% during peak)
Violation rate	3.8%

APPENDIX H - Summary of Gothenburg Congestion Tax

CATEGORY	DESCRIPTION
System name	Congestion Tax
Year operation commenced	2013
Contracting authority	Swedish Transport Agency
Type of scheme	Cordon Charge, with two corridor charges
Number of charging points	36 locations
Vehicle categories charged	All vehicles except buses and motorcycles
Elements of charge	Rate that varies by time of day
Impact on other charges/taxes	None
Procurement approach	Design, build, maintain contract
Primary charging technology	Detection/declaration based system using ANPR
Basis for charge calculation	Demand modelling aimed at minimum revenue forecasts
Discounts and exemptions	Buses over 14 tonnes, emergency vehicles, motorcycles, military vehicles and vehicles with disabled parking permits all exempt
Estimated gross revenue	NZ$16.6m per annum
Use of revenues	Hypothecated transport fund for West of Sweden package of railway and road improvements
Estimated capital costs	NZ$12m
Estimated operating costs	NZ$2m (increment on top of Stockholm)
Range of charge rates	NZ$3.57-NZ$1.46
Occasional user product	None, core product is billing of trips
Modal share	Cars used for 74% of trips to CBD
Violation rate	2.6%

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APPENDIX I - Summary of Dubai Salik scheme

CATEGORY	DESCRIPTION
System name	Salik
Year operation commenced	2013
Contracting authority	Dubai Road Transport Authority
Type of scheme	Corridor charges per crossing
Number of charging points	7 locations
Vehicle categories charged	All vehicles except buses
Elements of charge	Flat rate applies at specific times
Impact on other charges/taxes	None
Procurement approach	Design, build, maintain contract
Primary charging technology	DSRC tag
Basis for charge calculation	Target reduction of demand at charging points
Discounts and exemptions	Military, emergency vehicles, buses or vehicles with disabled owners
Estimated gross revenue	NZ$305m
Use of revenues	General government revenue
Estimated capital costs	Unspecified
Estimated operating costs	Unspecified
Range of charge rates	NZ$1.52
Occasional user product	None, tags compulsory
Modal share	<5% public transport for all trips
Violation rate	Unknown

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APPENDIX J - Additional details of Milan Area C

CATEGORY	DESCRIPTION
System name	Area C
Year operation commenced	2012
Contracting authority	Municipality of Milan
Type of scheme	Cordon unlimited trips in one day in historical center of Milan (Cerchia dei Bastioni) a 8.2 km^2 area
Number of charging points	43 gates
Vehicle categories charged	All vehicles except motorcycles
Elements of charge	Flat rate applies at specific times (0730-1930 weekdays, 0730-1800 Thursday)
Impact on other charges/taxes	Replaced Ecopass environmental charge which operated similarly During the activation time, the access in "Area C" is forbidden to "Euro 0" petrol vehicles and to "Euro 0, 1, 2, 3" diesel vehicles with a length of more than 7.5 metres
Procurement approach	Unknown
Primary charging technology	ANPR
Basis for charge calculation	Target reduction in traffic
Discounts and exemptions	Emergency vehicles, motorcycles, registered disabled. Electric, natural gas, LPG and bi-fuel vehicles through 15 October 2019 Temporarily: Residents' vehicles have 40 free entrances per year, after which it is discounted
Estimated gross revenue	NZ$47m
Use of revenues	Fund for public transport (fleet renewal and increased frequency), active transport mode infrastructure (bike sharing program), new park and ride
Estimated capital costs	NZ$11m
Estimated operating costs	NZ$22m
Range of charge rates	NZ$7.91 (NZ$3.17 residents, NZ$4.75 commercial)
Occasional user product	To enter in "Area C" user must purchase and activate a ticket. The ticket can be purchased at the parking meters, newsagents, tobacconists, ATM points (Milan Transport Company), at the ATMs of Intesa Sanpaolo, online, or calling the call centre and in conventioned garages The ticket must be activated no later than midnight of the next day access, by sending an SMS message, calling the Call centre, by visiting the website or in the municipal offices
Modal share	7 of 43 access gates exclusively for transit
Violation rate	Unknown

		Ecopass				Area C	
Year	**2007**(4)	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Average number of vehicles entering	90,582 (of which 77,540 passenger)	71,729 (of which 62,120 passenger)	75,097 (of which 65,332 passenger)	73,103 (of which 64,072 passenger)	80,799 (of which 72,378 passenger)	55,670 (1)	56,478 (1)
Charged	*38,081*	*16,322*	*12,255*	*12,224*	*11,431*	*n.a.*	*n.a*
Not charged	*52,501*	*55,407*	*62,842*	*60,879*	*69,368*	*n.a.*	*n.a.*
Average number of accesses (2)	159,328	136,136	n.a.	n.a.	131,898	90,849	92,175
Traffic inside Area. Variation compared to 2007 (3)		-20.8% -19.8% for passenger cars	-17% -15.7% for passenger cars	-19.3% -17.4% for passenger cars	-10.8% -6.7% for passenger cars	-38.8% (1) -31.1% compared to 2011	-37.6% (1) -30.1% compared to 2011

(1) Our estimate applying the same variation as number of accesses.
(2) Notice that the total number of entrances differs from the number of individual vehicles entering (they may enter more than once in the area).
(3) Excluding exempt vehicles.
(4) average of 10 days period 26-30 October and 12-16 November 2007.
(5) Provisional data

Table 3 - Impact of Milan ECOPASS and Area C[12]

Objectives: Improving the life conditions of those who live, work, study and visit the city is the goal of the Congestion Charge - Area C. Its objectives are:

- Decreasing road traffic in "Cerchia dei Bastioni" (city centre);
- Improving public transport networks;
- Raising funds for "soft" mobility infrastructure: cycle lanes, pedestrian zones, 30kph zones; and
- Improving the quality of life by reducing the number of accidents, uncontrolled parking, noise and air pollution.

Timeframes for pricing schemes and initiatives, from investigation and conception, design and implementation:

- 2006: local government of Milan established a working group comprising academics and city officials to evaluate all the possible options for cordon pricing in Milan
- 1 January 2008: Launched Ecopass, a pollution charge as a one-year trial period and was later extended for the years 2009 and 2010. Tariffs were proportional to vehicles' PM10 emissions. Long-term prospective to gradually implement a congestion charge that would be equal for all vehicles.
    - Resulted in modal shift to transit, but as newer vehicles replaced older ones, Ecopass scheme was no longer able to accomplish the main objective of reducing PM10 below EU legislation limits.
- January 2012 – April 2013: Intended trial period for Area C
- July 2012 – Sept 2012 Area C suspended by Italian court due to protests by parking owners in the centre of Milan
- March 2013: Municipal council permanently adopted the Area C congestion charge

[12] Source: Urban road pricing: the experience of MIlan, Croci. E, Ravazzi D., IEFE/Bocconi University/ Italian Ministry of Environment, Rome, 2015 http://ic-sd.org/wp-content/uploads/sites/4/2016/06/Milan-Urban-Road-Pricing_07.08.15.pdf

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The relevant and determining factors in the environments in which the systems/schemes were investigated, developed and (as relevant) implemented, and how these factors shaped and influenced the outcomes:

- Local politicians have been strongly supportive of the need to address congestion.”[13]
- The most polluting vehicles were no longer circulating in the city centre anymore, so most of the emissions were derived from friction sources and at congested locations.

Evaluation framework(s), transport and traffic modelling and any other analytical tools used to analyse and assess pricing options, including assessments prior to and after implementation, and the practical limitations of these:

- Data on environmental pollution is obtained from Environmental Monitoring Stations deployed in the city.

Description of the methodology for choosing scheme design including: scope; technology; target vehicles; exemptions; privacy; data security; payment system; interoperability with tolls and fuel tax collection; enforcement methods; use of revenues, and a critical analysis of their success/drawbacks:

- Payment is required for entry into the zone, the amount dependent on the vehicles emissions. You have until midnight the following day to pay. Penalty for non-payment is subject to a civil penalty €70-285. Police penalties are €70 plus a €11 investigation fee within 60 days.[14]

What was undertaken for public engagement and consultation, and the extent of market and customer analysis and how this contributed to/affected the success of the scheme/system; this should include when in the process public engagement was commenced, how public engagement and consultation was phased, including any post-implementation engagement undertaken:

- Citizens were directly involved in developing Area C. In June 2011, they were asked to vote in a public referendum on limiting traffic and increasing the uptake of low-emission vehicles in the city centre. A 79% majority voted in favour.
- Make the utilisation of revenues clear from the outset. Milan’s local government developed a revenue utilisation plan for the Area C scheme that has increased public transport services and enhanced cycle networks;
- Came with much criticism, especially from right-wing politicians. Demonstrations were held against Area C. A referendum to stop the program was promoted by opponents. However, promoters of the referendum failed to reach the minimum number of signatures to propose it.

The extent and nature of practical development and implementation timeframes of any system and technology pilots or demonstrations, and how that information informed future work:

- The full magnitude of driver responses emerges immediately the first day of a suspension of Area C (with only 1 day’s notice).

[13] Source: http://www.eltis.org/discover/case-studies/area-c-milan-pollution-charge-congestion-charge-italy
[14] Source: http://urbanaccessregulations.eu/countries-mainmenu-147/italy-mainmenu-81/milan-area-c-charging-scheme

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Review of scheme/system outcomes (including how actual outcomes compare to forecast outcomes) including impacts on traffic, economic, social and environmental outcomes:

- Area C has contributed to a reduction of the following pollutants:
  - Total PM10: -18% (above Ecopass, Ecopass improvement was 15%)
  - Exhaust PM10: -10%
  - Ammonia: -42%
  - Nitrogen Oxides: -18%
  - Carbon Dioxide: -35%
- “Overall, Area C has provided great benefits to the city: less congestion, traffic, pollution, noise, and more space for walking and cycling. The reduction of cars circulating in the city centre has enabled public space once reserved for parking to be reclaimed by pedestrians. Moreover, thanks to the reduction in traffic from Area C, the city’s whole transport system has benefited. According to a statement of AICAI (Courier Aircraft Association), Area C has resulted in a 10% increase in productivity of freight deliveries in the city centre.[15]
- Under Ecopass, revenue from initial penalty payments may have been higher than the toll revenues.[16]
- Interactive website that provides data and indicators related to Area C (access to Area C, access by time of day, emissions in Area C): https://areac.amat-mi.it/it/areac/
- Traffic inside the charging zone was reduced by 16.2% with Ecopass and a further 30.7% with Area C.
- Road accidents reduced by 21.3% with Ecopass and a further 20.8% with Area C.
- Buses and trams increased their velocity by 11.8% with Ecopass and a further 5% between 8:00 and 18:00. Outside the Area C the velocity of buses and trams increased by only 2-3% in the same period. [17]

Effect (shorter and longer term) of implemented schemes/systems on transport user experience and public reaction, and a critical analysis of what insight this provides as to likely outcomes.

- Commuter routes adjacent to public transport saw smaller traffic changes than those without similar access. In other words, many of the people who took public transport to work continued to do so even once the cordon price was suspended. This finding suggests that people are more than happy shifting out of cars if they can find homes with good transit access to work.[18]
- Minutes just after the priced period ends each day, at 7:30 p.m., drivers flood the zone. The change in behaviour without pricing is immediate.[19] This is illustrated in Figure 11.

[15] Source: http://www.c40.org/case_studies/milan-s-area-c-reduces-traffic-pollution-and-transforms-the-city-center
[16] Source: http://www2.units.it/danielis/wp/wp122.pdf
[17] Source: http://www.academia.edu/10359496/The_Ecopass_pollution_charge_and_Area_C_congestion_charge_-_comparing_experiences_with_cordon_pricing_over_time
[18] Source: https://www.citylab.com/transportation/2015/09/milan-abruptly-suspended-congestion-pricing-and-traffic-immediately-soared/404521/
[19] Source: https://www.citylab.com/transportation/2015/09/milan-abruptly-suspended-congestion-pricing-and-traffic-immediately-soared/404521/

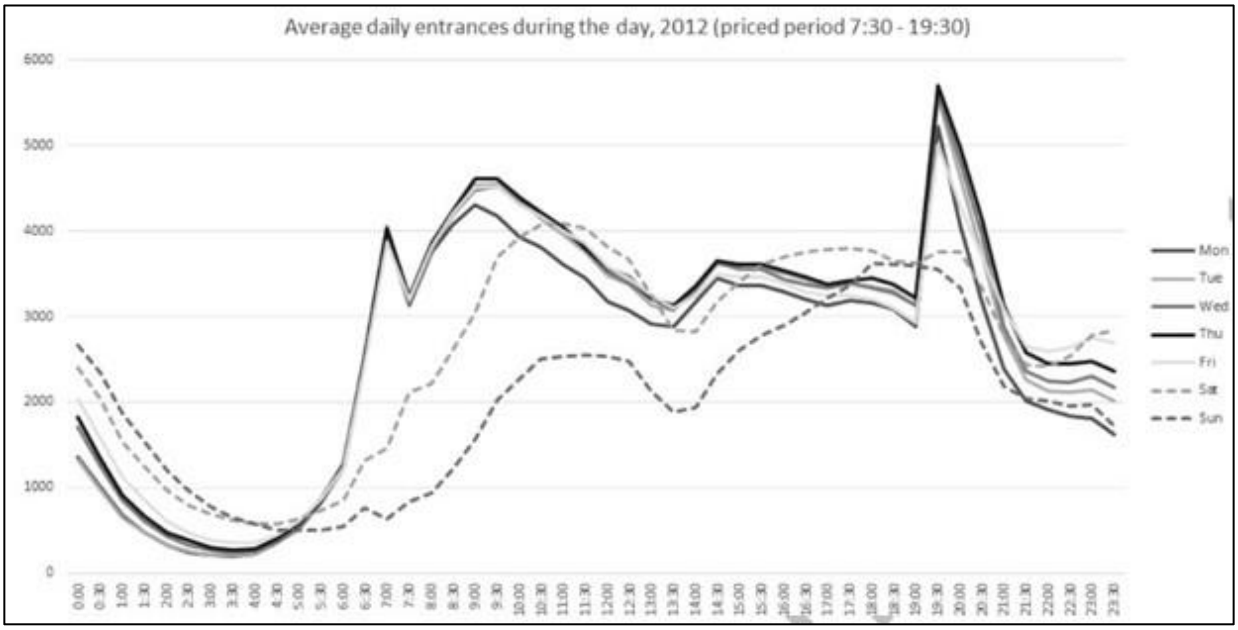

Figure 11 - Demand impact of Milan Area C

Local business and property values were not influenced by the congestion charge.[20]

Future plans

Milan is considering extending Area C to a second cordon and introducing a specific Low Emission Zone in parallel. There is also interest in using the scheme to manage the number of tourist coaches.[21]

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[20] Source: http://www.academia.edu/10359496/The_Ecopass_pollution_charge_and_Area_C_congestion_charge_-_comparing_experiences_with_cordon_pricing_over_time

[21] Source: Source: http://www.c40.org/case_studies/milan-s-area-c-reduces-traffic-pollution-and-transforms-the-city-center

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APPENDIX K - Additional details of Oslo toll ring

CATEGORY	DESCRIPTION
System name	Toll Ring
Year operation commenced	1990 (as manual system) 2007 (fully electronic free flow)
Contracting authority	Norwegian Public Roads Administration
Type of scheme	Cordon inbound only
Number of charging points	19
Vehicle categories charged	All vehicles except motorcycles
Elements of charge	Flat rate varying by vehicle type (higher for heavy vehicles)
Impact on other charges/taxes	None
Procurement approach	Design, build, maintain contract
Primary charging technology	DSRC (fully free flow since 2007)
Basis for charge calculation	Revenue to recover transport package costs
Discounts and exemptions	Emergency vehicles, electric vehicles, buses and registered disabled
Estimated gross revenue	NZ$216m per annum
Use of revenues	Three packages of road, public and active transport improvements
Estimated capital costs	NZ$43m (1990) values
Estimated operating costs	NZ$21.6m per annum
Range of charge rates	NZ$16.70-NZ$5.60 (zero for zero emissions)
Occasional user product	Non tag users are invoiced after trip taken within one month unless accumulated travel is to a value under NZ$89 (three months)
Modal share	Total trips: 36% car, 30% public transport, 29% foot, 5% bicycle (2013)[22]. 37% car, 29% foot, 27% public transport, 5% bicycle (2008). 47% car, 28% foot, 17% public transport, 6% bicycle (1992)
Violation rate	2-5%

Demand response of scheme and future changes

Oslo undertook a panel study October-November 1989 3 months before the toll was introduced. This was followed up one year later with a questionnaire and travel diary. 40,000 surveys sent in the first tranch with 46% response, second tranch of 22,000 was sent to respondents. Total net response was 34%. The study surveyed a random sample of Oslo residents between 15 and 75.

[22] Source: http://oslo.miljobarometern.se/state-of-the-environment-oslo/transport-and-mobility/distribution-of-transport-modes-daily-journeys/bil/

Panel responded indicating an 11% reduction in trips. Predominantly social trips reduced in frequency (down 23%) followed by shopping/private trips (17%). Business trips only down 4% and work trips by 9%. However total retail sales were down only 1%, indicating that shopping trips either were consolidated or trips changed by mode. The methodology was criticised because of a reported tendency to under-report and the attrition of survey participants.[23]

54.8% of employment is located within the toll ring. There has been no indication of significant change in home and work choices due to the toll ring, but there were minor variations in destinations for discretionary travel.

Figure 13 depicts the long-term trend of traffic crossing the toll ring. This is attributed not only to the toll ring (which has increased in price periodically to reflect inflation), but also growth in the mode share for public transport trips.

[23] Road pricing and toll financing, Farideh Ramjerdi, Institute of Transport Economics, Oslo, 1995.

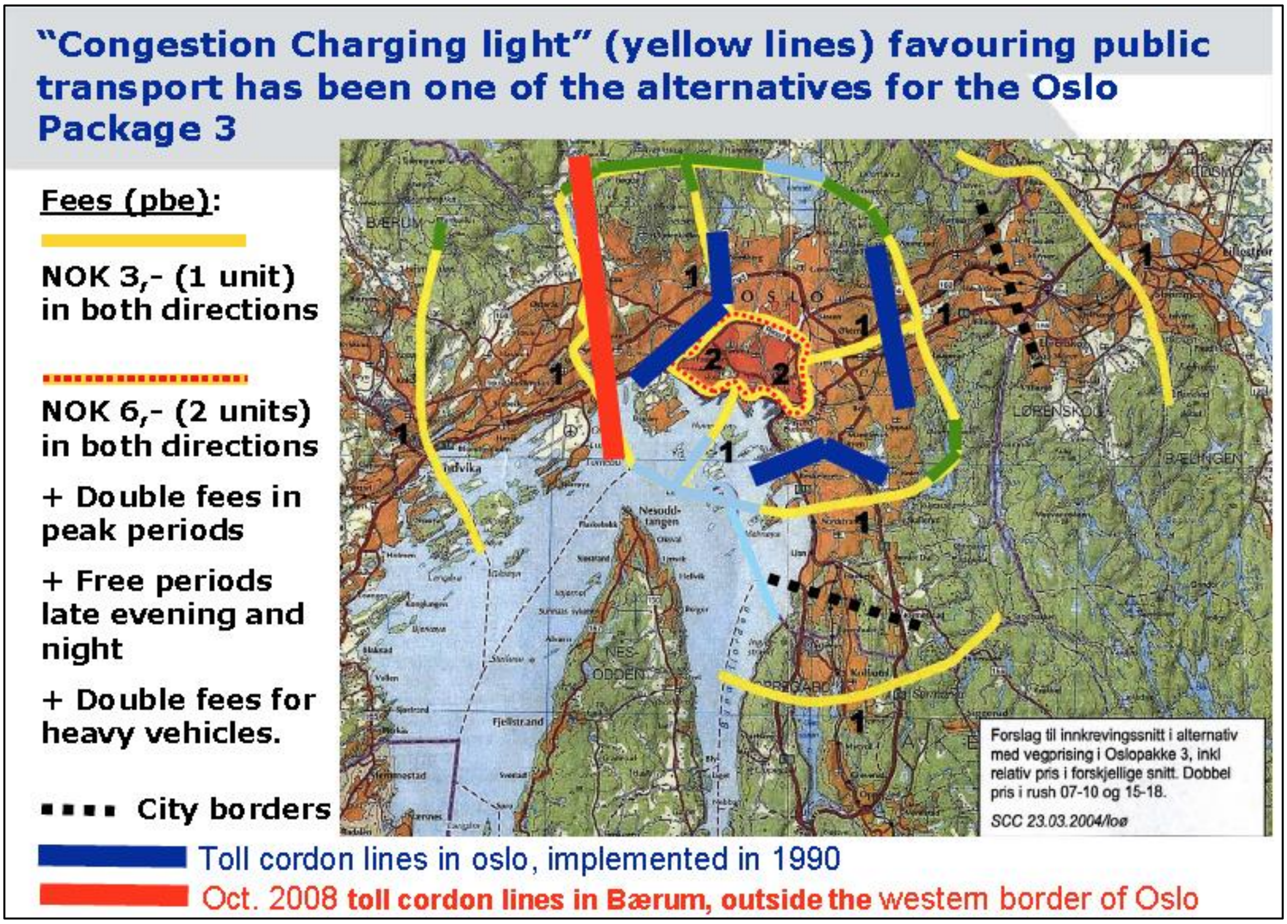

Figure 12 - Oslo abandoned plan to convert toll rings to congestion charging

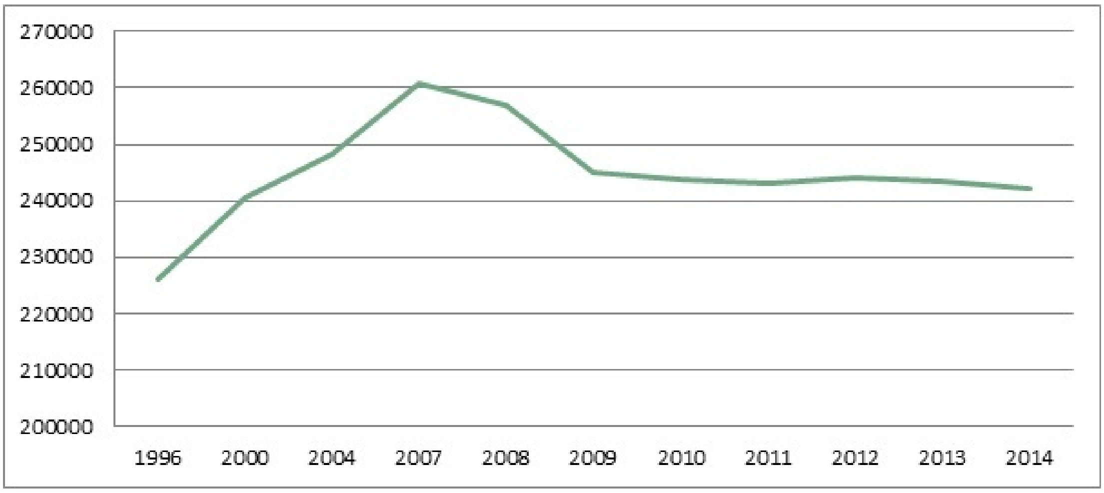

Figure 13 - Average number of vehicles crossing toll ring per day[24]

[24] Source: City of Oslo, https://www.oslo.kommune.no/english/politics-and-administration/green-oslo/best-practices/the-toll-ring

Future plans

Attempts to convert the toll ring scheme to a congestion charge failed in 2008, due to public opposition and political concern over the impacts. Centre-right parties are opposed to charging simply to restrain traffic (rather than fund transport improvements), whilst centre-left parties are opposed to applying market principles to the management of roads. Figure 12 depicts the original toll ring position in blue, the proposed multiple cordon congestion charging scheme in yellow (rejected) and the final additional charging points in red introduced with Package 3.

Although the Oslo toll ring is not a congestion charge, it was decided to reform the toll rates to include time of day charging to manage peak demand. An emissions element was also added, to contribute to Oslo's goal of reducing noxious emissions.

Table 4 depicts the current and future Oslo toll ring charge schedule in current NZ$ values for the next three years.

Revised Oslo Package 3 charges						
	Light duty vehicles -diesel	**Light duty vehicles - petrol and hybrid**	**Light duty vehicles - zero emission**	**Heavy duty vehicles - Euro V and older**	**Heavy duty vehicles - Euro VI**	**Heavy duty vehicles - zero emission**
Stage 1: 01/03/2017 - 31/12/2017	NZ$8 (+ NZ$1.70 peak)	NZ$7.30 (+ NZ$1.70 peak)	0	NZ$26.90 (+ NZ$5.10 peak)	NZ$16.90 (+ NZ$5.10 peak)	0
Stage 2: 01/01/2018, - 31/12/2019	NZ$8 (+ NZ$1.70 peak)	NZ$7.30 (+ NZ$1.70 peak)	NZ$1.70 (+ NZ$1.70 peak)	NZ$26.90 (+ NZ$5.10 peak)	NZ$16.90 (+ NZ$5.10 peak)	0
Stage 3: 01/01/2020	NZ$8 (+ NZ$1.70 peak)	NZ$7.30 (+ NZ$1.70 peak)	NZ$3.40 (+ NZ$1.70 peak)	NZ$26.90 (+ NZ$5.10 peak)	NZ$16.90 (+ NZ$5.10 peak)	0

Table 4 - Future charges for Oslo

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APPENDIX L - Additional details of Hong Kong Electronic Road Pricing studies

Background

Hong Kong started investigating congestion pricing in the 1980s and has undertaken four sets of investigations into congestion pricing:

1. Hong Kong Road Pricing Study 1983-1987;
2. Hong Kong Electronic Road Pricing Feasibility Study 1997-2000;
3. Hong Kong Electronic Road Pricing Modelling and Technology Update 2005-2009; and
4. Hong Kong Electronic Road Pricing Pilot Scheme Development 2015-

In 1983, Transport Secretary Alan Scott committed to Hong Kong being the first city to test the technical, economic and administrative feasibility of electronic road pricing. Hong Kong had previously trebled annual vehicle licensing fees, doubled registration tax and doubled fuel duty to try to stem the growth in car reduce private car use by 10%, and average speeds increased between 1979 and 1984 by 40% as a result, although only one in ten households had access to a private car.[25] However, the concern was that this would not be sustainable over the medium to longer term and other steps would be needed (with a particular interest in moving away from taxing car ownership and towards usage).

Hong Kong Electronic Road Pricing Study (1983-1987)

From July 1983 until March 1985, Hong Kong embarked on a 21 month demonstration of technology for road pricing. It consisted of electronic number plates mounted under vehicles, the size of VHS video cassettes that would be read by an under-road loop connected to a roadside computer. It would be matched with a camera that would take images to be manually read of vehicles that were not installed with such a system. 2500 vehicles were equipped with the system called AVI (Automatic Vehicle Identification). The technical trial demonstrated 99.7% reliability in effectively identifying vehicles for charging purposes.

Three schemes were considered, one that would operate weekdays 0730-1930, with five charging period during the day (shoulder-peak-interpeak-peak-shoulder), with five zones that vehicles would have to pay to cross, with no bypass routes. The second had a bypass route, but charged in only inbound or outbound peak directions. The third had thirteen zones. Modelling indicated significant net benefits if cars and taxis were charged only, with a reduction of 20-24% reduction in private car trips. In economic terms the benefits ranged from NZ$131m to NZ$165m in annual savings (1985 values). Annual costs (amortised capital and operating costs) were estimated at around NZ$9m a year (1985 values), so it appeared to have a high benefit to cost ratio at the time. However, the proposal to introduce a simplified version of the scheme in one zone did not proceed.

Academic Timothy Hau gave a series of reasons[26] as to why it did not proceed:

[25] Timothy D. Hau (1990), "Electronic Road Pricing: Developments in Hong Kong 1983-89", Journal of Transport Economics and Policy, Vol. 24, No. 2, May 1990, p 204..
[26] Ibid.

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- A new metro line on Hong Kong Island and a new highway on the eastern north coast of the island had relieved congestion, reducing pressure for more radical solutions;
- Hong Kong was still reeling from the effect of stock and property market crashes, with a general suppression of traffic corresponding to a reduction in economic activity;
- Tax increases on registration, licensing and fuel had had a noticeable effect and private motorists were unhappy that they were "singled out", whereas the ERP proposal had notably excluding taxis (due to a large scale taxi protest a few years earlier about licensing fees that saw Hong Kong turn to gridlock). Public acceptability was challenged as a result;
- Some believed the cost of introducing ERP to be unnecessarily expensive;
- Privacy concerns over the use of CCTV cameras, as the discussion paralleled the signing of the Sino-British declaration to hand over Hong Kong to China in 1997 (raising fears of a surveillance state);
- Failure to sell the benefits of ERP to the public, in part due to a lack of information supplied and distributed to inform the public about how it would work and how effective it would be;
- Public disbelief that the government would cut licencing and registration fees in exchange for introducing ERP.

The idea was shelved for some years, but as incomes rose, so did car ownership and road traffic. Public transport mode share started to decline in the early 1990s, which was in part attributed to the increasing delays experienced by buses in congested traffic.

Hong Kong Electronic Road Pricing Feasibility Study (1997-2001)

A second study was launched in the late 1990s as congestion grew, with the following goal:

The Goal of Road Pricing in HK is to improve the mobility of people and goods. Adoption of the "user-pays" principle offers a more efficient, equitable and flexible way of managing road use. Road pricing could be implemented in conjunction with other measures for easing traffic congestion.

The study was carried out over three years with core tasks as follows:

- Demand modelling
- Assessment of the need for ERP and alternatives
- Initial evaluation of technology options and field testing of technology options
- Development of a conceptual design
- Public Relations
- Preferred strategy

The study considered options to first manage demand in the Hong Kong CBD, but then to scale the system to include Hong Kong Island between the Western and Eastern Harbour Tunnels and southern Kowloon.

The proposed scheme would have been a single cordon in the CBD and was modelled to reduce traffic counts by 24%. It would have applied to all vehicles except those of emergency services. The modelling indicated that to achieve optimal results, there needed to be inclusion of taxis and buses, although the initial proposal was to charge both of them 50% the intended rate in the first year, escalating to full charges in three years.

Following the second study, it was decided again, not to proceed, because of public concern with the economic slowdown after the handover of Hong Kong to the People's Republic of China. This slowdown had reduced traffic volumes and consequentially eased congestion.

Hong Kong ERP demonstration

As part of the 1997-2000 study, Hong Kong embarked on a full technical demonstration of both DSRC and GNSS technologies. The demonstrations were undertaken in two phases:

- Controlled tests at the former Kai Tak Airport site, to prove technical effectiveness; and
- On street testing, with a vendor for each technology using 24 vehicles installed with the equipment and an on-street "network" designated to prove capabilities.

The demonstrations tested the reliability and accuracy of the technologies, in different conditions for climate and different vehicle types (heavy and light). Tests were to identify if both systems were useful for recording entry and exit to a zone, and time or distance elapsed in the zone during set periods. Both DSRC and GNSS proved reliable for such applications. The conclusion of the report on technology was:

Hence, taking into account various aspects such as adaptability, flexibility and better integration with ITS, VPS (Vehicle Positioning System) *technology offers the best-balanced choice for ERP in the longer term.*[27]

In other words, the key conclusion from Hong Kong, *as early as 2000*, was that GNSS technology offered the best long term prospects for urban congestion pricing. This was *before* any country had implemented any use of GNSS for charging (which happened the following year in Switzerland, where GPS was used to assist the measurement of distance for its network wide heavy vehicle RUC system).

Hong Kong Electronic Road Pricing Modelling and Technology Update

As the decision around the 2001 study was to defer future consideration until 2006, an update of the previous study was commissioned in that year. A new transport model was commissioned and a technology update obtained to further refine the analysis from the previous report.

The main change in modelling terms was to replace the WAYS traffic model used previously with the CUBE model, which included sub-model forecasts for freight, public transport and overall passenger demand. A single cordon scheme was modelled in the Central-Wan Chai area (which was identified as having the slowest traffic conditions in Hong Kong) and once again considered the preferred approach operating between 0730-2000 weekdays. It was modelled with all vehicles being charged, at prices ranging between HK$10 (NZ$1.78)-HK$20 (NZ$3.86) resulting in a modelled reduction in all road vehicle trips inside the cordon of between 10%-20%. Car and taxi trips were seen to reduce by 20-30%, with the response largely due to a shift towards public transport or to off-peak trip periods. Only a small proportion of freight trips retimed to avoid charges. Traffic speeds were modelled to increase to an acceptable range of 17-20km/h on average in the local network. Public transport trips were modelled to increase by 2-4%, whilst emissions were modelled to reduce by 2-8% in the charged area.

[27] Paragraph xii, Executive Summary.

Proposed complementary measures included increases in public transport (especially buses), traffic management measures to cater for trips avoiding the cordon. Enhanced public transport interchanges and pedestrian facilities were also proposed, along with a new transport information/incident management system.

Scalability was considered, with options identified such as further cordon schemes (e.g. Tsim Sha Tsui), charging the strategic network (albeit that cross harbour tunnels are already tolled) and full network charging.

However, the conclusion of the report was that "there are no strong arguments for introducing congestion charging in Hong Kong at present" because of adverse economic conditions that indicated traffic growth would be lower than forecast. It also stated that until a free bypass route was made available around the charging zone (the Central-Wan Chai Bypass) it would not be effective. The report recommended that if it is decided to implement charging, there should be an extensive public engagement programme consulting a wide range of stakeholders and the public.

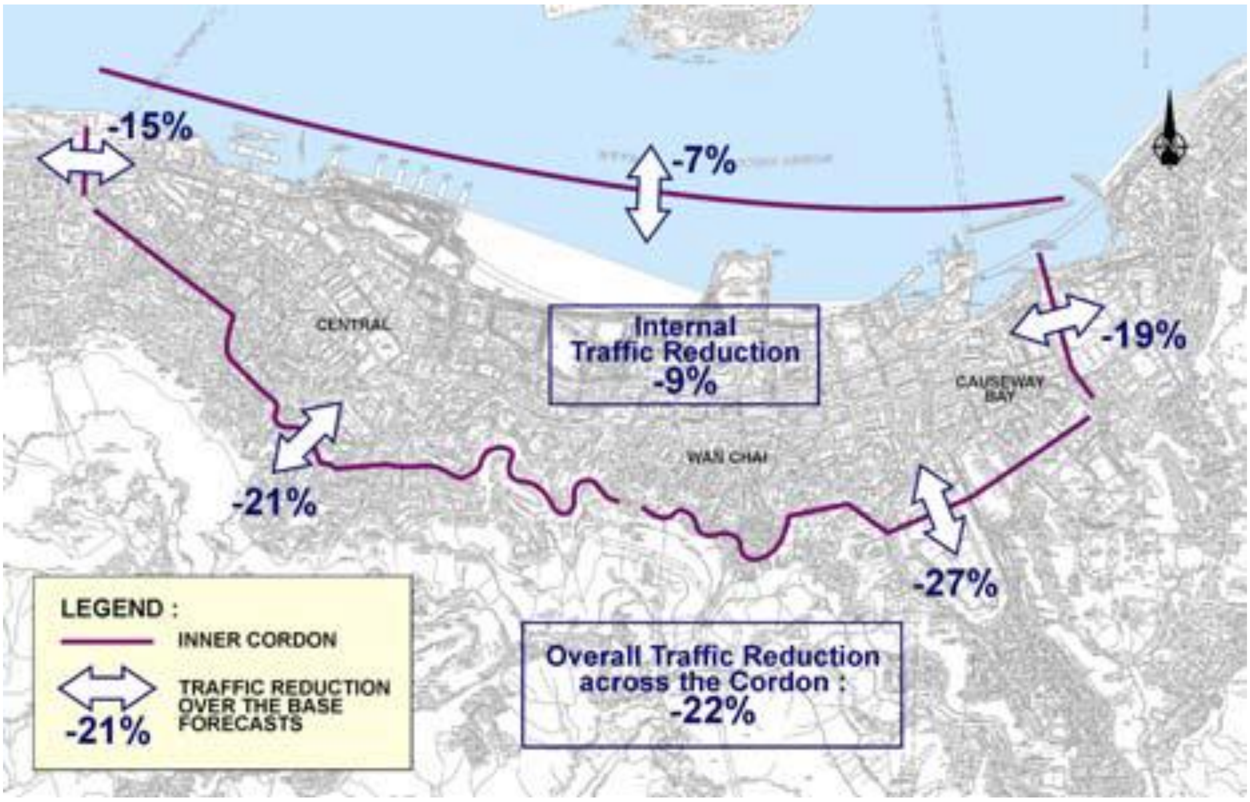

Figure 14 - 2006 proposed Hong Kong scheme boundaries and expected impacts

Hong Kong Electronic Road Pricing Pilot Scheme Development

In 2014 a Transport Advisory Committee report recommended that road pricing be considered again given growing congestion. A study on congestion in Hong Kong found that traffic speeds had dropped by 11% in ten years, and that it was physically impossible to grow road capacity to meet demand. It recommended that a diesel tax be introduced (there was tax on petrol but not diesel), parking meter charges should be increased (they had not been in 20 years) and that a pilot congestion charge should be implemented once the Central-Wan Chai Bypass had been opened.

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A survey that was part of the study indicated over 60% supported the concept of road pricing, although among vehicle drivers this number dropped to around 52%. Taxi and truck drivers were most opposed, bus drivers most supportive (even though it was not indicated that buses would be exempt).

A more detailed public engagement exercise was commenced from December 2015 until March 2016. A report on this exercise was published in January 2017. That exercise consulted on six basic elements of charging:

- Charging area;
- Charging mechanism;
- Charging period;
- Charging level;
- Discounts and exemptions; and
- Technology.

The consultation focused on three key concerns, privacy, effectiveness and complementary measures. A dedicated website was set up (http://www.td.gov.hk/mini_site/erphk/en/home/index.html) for the consultation which includes materials and reports for public consumption. TV, radio, leaflets and posters were all used to engage the public. 20 events were hosted for major stakeholders groups, such as professional bodies, academics, transport industry, business groups and environmental organisations. A District Council forum was held, and separate meetings had with various elements of the transport industry (freight, bus and taxi sectors). Detailed responses and feedback were received about the scheme design elements.[28]This included views on discounts and exemptions that ranged from having none, through to a long list of categories that seemed "justified", although in one case (taxis) it would mean exempting 35% of vehicle movements in the planned charging area. Full details on the consultation are available online at (http://www.td.gov.hk/mini_site/erphk/en/document/index.html).

The Hong Kong Government is now commissioning a feasibility study to undertake detailed design of what is now called the Central District ERP Pilot Scheme. It is determined to proceed and believes that the public consultation exercise has helped to boost understanding and support for the concept.

Conclusions on Hong Kong

Hong Kong's various studies and demonstrations of urban road pricing have always been focused on management of congestion. Indeed, it has been times of economic slowdown and reducing congestion problems that have been one of the key reasons why Hong Kong has suspended further development of the programme on several occasions. Nevertheless, Hong Kong's urban environment has conditions that would appear to ideally suit the introduction of road pricing, with very high urban density and 78% of motorised trips undertaken by public transport (not just commuter trips, or trips to the CBD), and only 11% undertaken by private vehicle. Hong Kong public transport is largely financially self sufficient, with almost all bus services operating commercially without subsidy, as well as the Hong Kong Island tram and the metro. With dense public transport, and no opportunities to expand road capacity easily (the most recent major project is a tunnel under a reclamation to build a bypass to Wan Chai), it is clear Hong Kong has few alternatives to manage congestion.

Hong Kong has not proceeded on several previous occasions for various reasons, including concern around the economic impact at times of recession, early concerns about privacy (although design options to include anonymous payment systems are intended to address this) and a significant degree of scepticism about the

[28] Full text of the consultation report is available at http://www.td.gov.hk/filemanager/en/content_4838/eng_td_pe1report_main.pdf

effectiveness of the concept. However, the most recent exercise in public consultation has been extensive, thorough, consistent and very focused. The likelihood is that Hong Kong will proceed towards introducing a cordon scheme, as a pilot, by 2020.

Lessons for Auckland

Hong Kong has conditions that would appear to ideally suit the introduction of road pricing. 78% of motorised trips are undertaken by public transport, with only 11% by private vehicle (11% by taxi). Car ownership is lower than in Singapore (at less than half the rate of Singapore).

Yet the political power and the public concern around road pricing has hindered implementation of road pricing, in part because those who drive are influential, but also the importance of the taxi industry to Hong Kong (people use taxis extensively to cover gaps in public transport service, or convenience for several people travelling together).

Although Hong Kong's conditions contrast with Auckland, the most important success of Hong Kong has been with the most recent public engagement exercise. That exercise was based on taking a single concept, clearly explained through all basic relevant components, and seeking opinion on a range of core policy and design elements. The effectiveness of the public engagement is demonstrated in how thorough it was, in seeking to formally approach a large number of interested bodies, and to actively facilitate input from the public. The exercise maintained a consistent and clear set of messages that were carried through to the media and on Transport Department Hong Kong's website.

Finally, Hong Kong identified *as early as 2000*, that GNSS technology offered the best long-term prospects for urban congestion pricing. This was *before GNSS was used for charging* (which happened the following year in Switzerland, where GPS was used to assist the measurement of distance for its network wide heavy vehicle RUC system).

APPENDIX M - Additional details of Jakarta Electronic Road Pricing project

Figure 15 - Jakarta ERP proposed first phase

Background

To help ease congestion, a high-occupancy vehicle rule was applied to a series of main roads, making it illegal for cars to enter those streets during weekday peak periods with fewer than three occupants. This policy was widely criticised, as wealthier motorists would pay very poor residents near the entry points to these roads to ride with them, to avoid being fined for low occupancy. Media reports about young children being "rented" to wealthy motorists to comply caused a significant backlash and accelerated a decision to abandon the rule (called "3 in 1") in 2006.

A truck ban has been introduced on one major inner city highway in 2011 between 0500 and 2200 to attempt to control congestion, but this has been widely criticised as imposing high costs on business.

Development of system

In 2010, it was announced that a regulation would be passed to authorise "Electronic Road Pricing" in Jakarta, following the model of Singapore. In 2011, the Indonesian President signed Regulation No. 32/2011, which would allow for bylaws to be made by cities to allow road pricing on existing roads in Indonesia only if congestion conditions would justify it.

In 2013 the Jakarta Transportation Agency announced that it would be proceeding with designing a scheme with intended implementation in 2014, with the first step being a series of technology trials for vendors to prove the technology concept. Singapore's LTA has been assisting Jakarta with development.

In Jakarta, the problem of congestion is so severe that there is not organised public opposition to "ERP", but rather some scepticism that it would be effective. Around 30% of people in Jakarta own a passenger vehicle (car or motorcycle), about the same level as Tokyo and five times the ownership rate of Indonesia as a whole.[29] This indicates that congestion pricing in Jakarta does need to bear in mind the opinions of the population. However, until it is actually implemented as a pilot on one or more sections of road, it will be difficult to convince people that it works (given their experience of previous demand management polices).

In 2014 a technology demonstration was held with three toll system suppliers (Kapsch, Q-Free and WatchData) using 50 vehicles at one site in Jakarta. The technology tested was DSRC systems with ANPR. This was followed with a second demonstration using Kapsch and Q-Free equipment only, including prepaid smartcards inserted into the on-board units, similar to the Singaporean system. The intention following those trials was to hold a tender to introduce the first phase of the system.

In 2015, the strategy seemed to change with the Mayor of Jakarta interested in considering GNSS based charging, in part because of concern over the physical impact and the cost of installing gantries (quoted at around NZ$110,000 per site). Procurement was delayed as that option was investigated and ultimately rejected because of the need to build gantries in any case for enforcement. By early 2016 the proposed charging scheme was subject to further scrutiny, out of concern that only charging the main roads would divert congestion onto smaller local streets (the main problem with the Dubai system). The response to this by the Jakarta provincial government was that this would not be a problem, because those streets are just as badly congested now, so there would be a significant penalty in time from seeking to bypass the main routes.

In 2016, it was reported that the High Occupancy Vehicle rule (known as 3 in 1) would be replaced with a new restriction on traffic, limiting vehicles with odd or even number plates on the associated dates of the calendar. Subsequently, development of the ERP system has stalled. Officially this was considered a "simpler" solution first (involving sticker passes for monthly or annual access to the city centre), but unofficially the fundamental problem is that the number plates and the database of motor vehicle ownership in Indonesia are too difficult to work reliably with ANPR. Indonesia does not use a standard font for number plates, with number plates produced by hand by independent vendors. This is proving an almost impossible barrier to overcome, and is likely to require a wholesale change in regulations and issuance of number plates to enable enforcement. It is notable that none of Jakarta's toll road concessions has shown much interest in replacing manual tolls with fully electronic free flow tolls, which would provide an obvious first step to prove such a system.

For all of the political rhetoric and interest, Jakarta has not been open about not having one of the key enablers for road pricing, number plates that can be reliably read by ANPR systems. Until Indonesia (or at least Jakarta and the other five provinces on the island of Java) standardise and reform the issuance and database of number plates (or mandate the presence of DSRC tags or other systems of electronic vehicle identification as in Brazil), it simply wont be possible to introduce congestion pricing in Indonesia. It is likely that a programme of around 2-3 years would be needed to address this issue.

The odd/even number plate based rationing system started operation in August 2016. In five months over 6500 vehicles were fined (fine of NZ$26) for breaching the rule, but reports indicate that motorists do not believe it has made much difference to congestion. The trial one month before it was introduced reportedly reduced travel times in the restricted area by 9-27%.[30] It operates between 0700-1000 and 1600-2000 every

[29] Extrapolated from: Study on energy efficiency improvement in the transport sector through transport improvement and smart community development in the urban area Working Group (2013), 'An Overview of Urban Transport Situation in Asia', in Kutani, I. (ed.), Study on energy efficiency improvement in the transport sector through transport improvement and smart community development in the urban area. ERIA Research Project Report 2012-29, pp.5-14.
[30] Source: https://www.pressreader.com/indonesia/the-jakarta-post/20170215/281741269173483

weekday. It is enforced by manual means, with police stopping vehicles visually identified as crossing the zone boundaries with the wrong number plate. Concern has emerged that it will encourage a new black market in fake number plates.

Latest position

Procurement for ERP was halted in February 2017, as the national competition authority deemed the regulation specifying the technology that is to be used for ERP to be anti-competitive (as it limited technological solutions for the scheme). The date for introducing ERP has since been deferred until 2019 due to the need to change that law. However, there is little indication of any steps that are to be taken to address the issue of number plate reliability.

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APPENDIX N - Additional details of Edinburgh congestion charge programme

Edinburgh

Enforcement

Fines of £60 (NZ$106) were proposed for those who did not pay up. It was expected that the scheme would earn in the region of £761m (NZ$1.34b net of set-up, operating and financing costs) to be used for investment in public transport improvements over a 20-year period.

The significant additional transport improvements that were forecast to be funded from this revenue included:

- Around £200 million (NZ$352m) for additional bus services;
- £154 million (NZ$271m) for a tram line to southeast Edinburgh (since partially completed);
- £111 million (NZ$196m) for additional road maintenance;
- £147 million (NZ$259m) for regional rail improvements;
- £17 million (NZ$30m) for additional accessible transport; and
- £24 million (NZ$42m) for road safety projects.

The cost for setting up the congestion charge was initially estimated at £11million (NZ$19m) for the double cordon option later reduced to £8.1 million (NZ$14m). This appears excessively conservative given the estimated costs only a few years later for the similar Manchester scheme are many times that cost, and do not include any risk and optimism bias premiums.

Timeframe: from investigation and conception, design and implementation.

1999: Edinburgh's Transport Choices" (Local Transport Strategy consultation).

2000: Preparatory Market Research.

2001: Regional Market Research.

2002: "Have Your Say" (Strategic Regional Consultation) introduced charging scheme formally.

September 2002: Council confirmed the initial proposals with some variations.

2003: Detailed Scheme Design Consultation (Local Consultation).

April 2004: Public enquiry opened and lasted ten weeks.

February 2005: Referendum rejecting the proposal.

2006: The charge would have commenced operation followed by planned Post-Implementation Market Research

The relevant and determining factors in the environments in which the systems/schemes were investigated, developed and (as relevant) implemented, and how these factors shaped and influenced the outcomes

In 1999, there was approximately 60% support and 30% opposition for the charge according to the Loughborough University Institutional Repository paper. Support fell through each phase. Ultimately, the plan was rejected by city residents with 74% of those who voted rejecting the council's plan out of a turnout of 69%.[31]

- Concern was expressed that 1 in 12 of those not paying would not be traceable.
- Some political parties and central city traders were sceptical of the projected economic impacts, claiming that shoppers would drive to other out of town destinations, shifting business away from Edinburgh. Some called for reduced charging hours in the city centre to reduce the impact on retail shops. Some requested that all commercial vehicles be exempted, arguing that businesses would have to pass on their increased costs to consumers or leave the city altogether.
- Concern about fairness on the residents of neighbouring areas who contributed to the Edinburgh economy, but had been priced out of the city by the high cost of living, now having to contribute to the transport within the city centre.
- There were calls for improvements to the public transport system before the charge began and scepticism about the likelihood that proposed public transport improvements would be implemented.[32]

Evaluation framework(s), transport and traffic modelling and any other analytical tools used to analyse and assess pricing options, including assessments prior to and after implementation, and the practical limitations of these.

Given the lack of experience of implementing congestion charging schemes, it is perhaps unsurprising that there was great uncertainty surrounding the model outputs - the modelled predictions for the central London scheme significantly underestimated the actual impacts of that scheme.

The modelled predictions also forecast the following benefits, by 2011, compared with the do-nothing situation:

- 21% reduction in city centre traffic delays.
- 9% reduction in traffic delays city wide.
- 30% reduction in vehicles entering the city centre on a typical weekday, and an 8% reduction across the outer cordon.
- Increases of 22 and 8% in numbers of people entering the city centre and the city as a whole (respectively) by public transport on a typical weekday.

[31] Source: https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/2756/3/Paper_to_Transport_Policy_-_final_submission_7-05_-_to_IR_4-07.pdf
[32] Source: http://www.manchestereveningnews.co.uk/news/greater-manchester-news/why-edinburgh-said-no-to-c-charge-975262

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Numbers provided by Edinburgh City Council were met with scepticism including:

- There was a constant distrust of the motives of the authority – "experts claimed congestion was costing Edinburgh £20bn a year. People who live in the city are sceptical about that" [33]
- Estimates of projected effect on businesses (expectations were negative)
- Amount collected that would end up going towards public transport (belief that the system would cost more or that revenue would be diverted).

In developing and promoting the scheme, the City of Edinburgh Council was under a legal obligation to demonstrate that it would reduce congestion. The normal response in UK transport planning to such an obligation is to spend a large amount of money on modelling, and the Edinburgh case was no different. Considerable sums were spent in the period 2000-2004 on modelling the possible effects of the scheme. Nonetheless, the modellers involved did admit under cross-examination at the public inquiry that their model outputs were accurate to within +/-20-30% [34]

Description of the methodology for choosing scheme design including: scope; technology; target vehicles; exemptions; privacy; data security; payment system; interoperability with tolls and fuel tax collection; enforcement methods; use of revenues, and a critical analysis of their success/drawbacks.

The reasons for the choice of a twin cordon rather than an area scheme were complex.

Qualitative appraisal work carried out in 1999 found that multiple cordon, screenline or area schemes would be more effective in traffic reduction terms than simple single cordon schemes, but scored them low in relation to their public acceptability and ease of implementation. Modelling work carried out in 2001 and 2002 considered variations on only two basic options: a city centre cordon, and a city centre plus outer cordon. In congestion management and traffic reduction terms, the outer cordon had a somewhat greater predicted impact than a single inner cordon and it was predicted to generate twice as much revenue (Transport Initiatives Edinburgh, 2002).

Perhaps, for the above reasons, as the plans for the scheme progressed, they were expanded to include outer as well as a city centre cordon - although the commitment to an outer cordon was not finalised until after the initial Application in Principle for approval to the Scottish Executive, first submitted in 2001 (City of Edinburgh Council, 2001).

The choice of technology was influenced by considerations of cost and practicality, and by what was to be used in London. Similar to London, automatic number plate recognition systems to record vehicles passing the cordon boundaries, and fines issued to those who had not paid using the Driver and Vehicle Licensing Agency database to trace vehicles. A simpler paper-based scheme was ruled out at an early stage because of the problems of enforcing it effectively.

Vehicle exemptions included emergency service vehicles, motorcycles, local buses, Blue Badge holders (disabled) and City Car Club vehicles. City of Edinburgh Council area residents living outside the outer cordon were exempted from paying to cross the outer cordon.

[33] Source: ibid

[34] See transcript of afternoon of 29 April 2004 inquiry proceedings available at http:// www.ititime.com

·What was undertaken for public engagement and consultation, and the extent of market and customer analysis and how this contributed to/affected the success of the scheme/system; this should include when in the process public engagement was commenced, how public engagement and consultation was phased, including any post-implementation engagement undertaken.

The major steps in the consultation process are outlined below, taken from the Council's Statement of Case for the Public Inquiry on congestion charging:

'A major consultation exercise was undertaken in Edinburgh in 1999/2000 on the principles for future transport strategy, as part of the development of the LTS. The public were presented with three future scenarios based on:

(1) a continuation of the status quo;

(2) a strategy based on the introduction of a workplace parking levy; and

(3) a strategy based on some form of congestion charging.

Public response was substantial, and was overwhelmingly supportive of the options (2) and particularly (3). The Council's conclusion was that road user ('congestion') charging was therefore the only strategy available to meet the key congestion reduction and transport improvement objectives. Key requirements were set out and remained part of the core thinking on the scheme design and public acceptance:

- The revenue raised must be ring-fenced for transport and environmental improvement;
- The revenue raised must be treated as additional, with no claw-back of existing sources of funding for transport; and
- Substantial improvements will have to be in place before the introduction of charges.

In 2003 extensive consultation was then undertaken in developing the Council's next *Local Transport Strategy (*LTS) and the transport investment package, to be part funded from congestion charging. This included market research, focus groups, meetings with key interest groups and a mail-in questionnaire and comment sheet. The key points from this consultation were:

- There was a consistent level of public support for the concept of a transport investment package based on congestion charging;
- support was greater within Edinburgh than in the surrounding areas;
- responses become more mixed (less supportive) when detailed scheme suggestions were put forward; and
- stakeholder responses (e.g. from the retail community) were cautious, and highlight the importance of continuing engagement throughout the development of the 'Investing in Travel Improvements' (ITI).[35]

A consultation was initially sent to over 250,000 people in the city and surrounding areas. A public enquiry opened on 27 April 2004 and lasted ten weeks. The enquiry report broadly supported the Edinburgh council's proposals, but recommended removing some of the exemptions proposed for Edinburgh residents living outside the outer cordon. In most other respects, in spite of the uncertainties surrounding the possible

35 (City of Edinburgh Council, 2004b, pp. 38-40)

impacts of the scheme, the enquiry felt it to be a timely, reasonable and well-structured response to impending congestion problems. [36]

It also expressed concern at the implementation timetable along with the likelihood of receiving the required public transport improvements.

Press launches (at the start of Consultation phases) and press releases were used by the City of Edinburgh Council to inform the media.

A commitment to a popular referendum and the weight the Scottish Executive placed on the demonstration of clear public support for the scheme prior to implementation and the need to win a public referendum could have been considered a mistake. Public opinion for congestion pricing usually decreases over time during design and then recovers after implementation.

Some of the opposition political parties, in particular the Conservative Party and the Scottish Nationalist Party (SNP), staged their own publicity stunts and photo-calls to present negative messages against the congestion charging proposals.

Some of the material produced was not as clear as could be in setting out the benefits. Including concern that the referendum forms were confusing.

Preparatory market research was also conducted.

Schemes were adjusted in response to all of these inputs.

Conclusions on consultation

In conclusion to this section of the paper, it can be argued that in the Edinburgh case there was no lack of consultation, except perhaps on the issue of the retail impact, where detailed research and active engagement with the city centre retail community only really took place in the final year of scheme planning. As noted by the Council Officer, the run-up to the scheme coincided with a decline in the relative fortunes of retailing in central Edinburgh and consequently the City Council was criticised by an already-sensitive retail community for failing to engage with them earlier on the retail impacts of the scheme and how they could be ameliorated.

The other key issues that were thrown up by the consultation process, aside from the retail impact, included:

- The impact of traffic displaced by the inner cordon rat-running through residential areas (a key issue for at least one opposition lobby group).
- Whether or not the level of congestion in Edinburgh actually merited a Congestion Charging scheme. The Council Officer, Labour Politician and pro-congestion charge lobby group co-ordinator - as well as the Reporters at the Public Inquiry - were all unanimous that indeed congestion was serious enough, but this issue continued to be raised, for example in the press.
- Whether sufficient alternatives to driving would have been put in place prior to the scheme's introduction - partly related to a significant lack of public trust in the Council.
- Equity impacts - that the rich could continue driving whilst poorer drivers would be priced off the road.
- More general issues, such as that the scheme was an additional burden on an already over-taxed motorist (the largest number of objections was received on this theme).

[36] The full report on the Inquiry can be found online at 'Investing in Travel Improvements' at www.ititime.com

As noted above, some of these consultation issues were difficult to resolve within the existing transport governance structure in Edinburgh: large scale improvements to the bus network prior to the introduction of congestion charging were not possible. Equity impacts are almost impossible to resolve in an implementable congestion charging scheme, and revenue-neutrality (the response to the 'over-taxed motorist' argument) requires control over vehicle and fuel taxation, which is a UK government matter (outside the scope of Edinburgh and the Scottish Governments).

Forecast scheme/system outcomes including impacts on traffic, economic, social and environmental outcomes

A critical issue for the Edinburgh congestion charge was the proposed transport projects identified that were to be put in place before the congestion charging scheme was due to start, that is, prior to April 2006.

Such projects were required in order to satisfy the Scottish Executive's policy guidance. Between 2002 and 2006, the City Council spent £100 million on projects in an attempt to meet this requirement - the vast bulk of it funded directly by the Scottish Executive, and not directly linked to the plans for congestion charging, although it is a disproportionate share of total Scottish local transport spending over that period.

The new investments included a new bus station, three new rail stations and a cross-city rail service, real-time bus information, a short section of guided bus way, four park and ride sites, and extensive bus priority on most radial road corridors including the addition of a bus-only lane on the Forth Road Bridge. Critically, however, it was not possible for the City Council to fund additional bus services prior to the introduction of congestion charging, since (without congestion charging) it is dependent on the Scottish Executive for transport funding. Most additional funding for transport from the Scottish Executive was at the time in the form of capital money, for infrastructure investment, and not revenue for the subsidy of additional services. Therefore, the Council was limited in what it could do to put public transport improvements in place prior to the introduction of congestion charging, and was open to criticisms from many residents that the £100 million of improvements were of little use to them. In many of these cases, it was geographically specific. Had revenue funding been available, the Council could have improved bus services on a regional basis as it was in London by the Mayor.

The City Council planned to put in place additional bus services from Day 1 of charging, funded from the revenues, but these could not be started any earlier than that, and remained rather poorly specified right up to the time of the referendum, as development work on them was still in progress at that time. A member of the executive committee argued that part of their opposition voiced was because the public wanted to see much bigger public transport improvements (rail and tram) in place before any congestion charging scheme. As a result, future plans for expansion of the Forth Road Bridge or any new facility would need to be a "multi-modal" facility to be acceptable.

Review of any planned complementary measures to mitigate any adverse outcomes particularly for providing alternatives to driving in peak hours and addressing income and spatial equity impacts

- It was proposed to introduce traffic calming measures including speed humps, road closures, and one way roads to stop drivers trying to avoid the congestion charge.
- Promised to be completed prior to 2006: bus improvements, rail improvements, Park & rides, interchange facilities, city centre environmental improvements, cycleways, 20mph zones
- The City considered reopening freight railway lines, to carry new passenger trains, and a new tram line in South East Edinburgh.

- Transport Initiatives Edinburgh announced £435million for public transport schemes outside of the Edinburgh council area.
- There was a difference in perception between the 'transport professionals' and the stakeholders. Edinburgh's scheme designers were attempting to introduce a road pricing mechanism as a proxy for making road users pay the full marginal cost for their journeys, while public opinion was that congestion came about because the alternatives to car travel were not viable, yet the public believed there was **no commitment to investment in alternatives before road pricing would start.**
- The Council believed it had adopted an approach that could be delivered in practical terms. This is that transport improvements within the city, benefiting primarily (but not solely) city residents, will be funded from the proportion of the congestion charging revenue originating from city residents. Conversely, regional transport investments, benefiting primarily residents of the surrounding areas would be funded from charges raised from this group on the basis of priorities determined by the local authorities concerned. This principle has been maintained throughout the development of the initiative. In spite of this, neighbouring authorities have maintained their objections.[37]

Consideration of applicability of key lessons to Auckland given context of local situations including population, topography, urban form, traffic characteristics, level of car use relative to public transport use and any other relevant factors.

The Edinburgh scheme provides many useful lessons that can be summarised as follows, and are listed in order of priority:

Firstly, agreement on objectives and a political champion are key to a successful scheme. In Edinburgh these elements were lacking. There was disagreement on the objectives for the scheme and whether it would achieve them, which was without doubt one of the most important reasons for the scheme's rejection. It is also probable that such disagreements, within the ruling Labour group on the City Council, led to the decision to hold a referendum that was the ultimate death knell of the scheme. Because there were two levels of government responsible for scheme approval, this added to the problems of disagreement on objectives, since there was a greater number of parties who could disagree.

The Edinburgh scheme was relatively complex, as public (mis-)understanding of how it was supposed to function showed. A complex scheme gives more grounds for disagreements about its ability to achieve objectives, and more grounds for objections. The inclusion of the outer cordon in the Edinburgh scheme was a contributor to the scheme's rejection because it increased the numbers of opponents.

As noted earlier, in Edinburgh there was one implementing agency but two approving bodies and, in addition, neither of these had sufficient control of bus services in order to improve these before the proposed charge was implemented. The public transport improvements that could be implemented were of insufficient benefit to a large proportion of the population, because they were limited to specific corridors and locations.

Opposition to the cordons was expressed from surrounding Local Authorities relating to the fairness of the cordons.[38] Such opposition increased after September 2003 (and the time period of the content analysis), when exemptions were given to City of Edinburgh Council residents living outside the outer cordon. Equity,

[37] Source: http://www.starconference.org.uk/star/2005/kirsty_lewin.pdf
[38] Source: Edinburgh Evening News, 29th November 2001; Scotsman, 12th June 2002)

in terms of the effect of congestion charging on low-income groups, was not a major issue in the media. Equity, as reported in the newspapers, related to the fairness of cordon location, particularly the outer cordon.

Public acceptability problems were compounded by the approach taken by the scheme's promoters. Newspapers played a big role. "Newspaper coverage had been highly politicised and increasingly negative over the time period leading up to the referendum," and had a role in reinforcing the negative arguments. This was countered by the scheme's promoters more with consultation material than with the active promotion of the scheme's benefits. Approximately half of the stakeholders represented in the newspaper articles were politicians, while other stakeholders (public opinion, business opinion, interest groups) were represented and tended to be more negative than positive. The majority of the media failed to give a balanced view about the issues surrounding the introduction of the Edinburgh scheme although the same could be said of the coverage in London. This is likely to have exacerbated the negative referendum result.

The public did not believe that congestion was a sufficiently serious problem nor believed that it would be impossible to manage in the future.[39] There was public belief that improvement of public transport will on its own reduce car use.

Consideration of applicability of key lessons to Auckland given context of rapid charging technology advancements, including technology used, collection and enforcement processes.

- The technology was the most straightforward portion of the project.
- There was an absence of a powerful champion for the scheme, which is helpful to successful implement of a congestion charging scheme
- There was a need for an effective communications plan that works with the media to understand the purpose and intent in the scheme. This includes a strategic engagement plan and open debate on critical issues by leaders of the scheme and not over relying on published and disseminated scheme materials.
- Value in having a single implementing steering committee or council to provide one voice for guidance, procurement, policy and to show unity to the public on the scheme design.

[39] Source: Source: http://www.iapsc.org.uk/assets/document/0606_John_Saunders_IASPC_2006.pdf

APPENDIX O - Additional details of Copenhagen congestion charge programme

Sources

- Traffic in Copenhagen report 2009 (published in 2010)
- Traffic and Environment report 2004-2009
- OECD Economic Surveys 2012: Denmark http://transportpolicy2013.blogspot.com/2013/05/copenhagens-failed-congestion-charge.html
- http://cphpost.dk/news/local-news/congestion-charge-is-not-perfect-but-its-coming-anyway.html
- http://cphpost.dk/news/national/odense-turns-to-technology-to-fight-congestion.html
- http://cphpost.dk/news/politics/light-rails-trains-and-fewer-automobiles.html
- http://cphpost.dk/news/politics/transport-minister-dismisses-road-pricing.html
- http://cphpost.dk/news/national/congestion-worsening-in-copenhagen.html

Biking culture

Copenhagen aims to become the best cycling city in 2015.The City of Copenhagen has therefore set out three ambitious targets in The Environmental Metropolis:

• At least 50% cycle to their place of work or education in Copenhagen

• The number of seriously injured cyclists has more than halved by comparison with 2005

• At least 80% of Copenhagen cyclists feel safe in the traffic

The bicycle is the form of transport most widely used for work and study, measured in trips. The bicycle's market share has been roughly stable for the past five years (36% in 2004 and 2006, 37% in 2008 and 2009).

Objective(s) and goal(s) of systems/schemes.

The Forum of Municipalities commissioned to study congestion pricing for Copenhagen believed congestion pricing could contribute towards meeting the following objectives:

- reduce congestion,
- increase productivity,
- improve air quality,
- reduce noise pollution, and
- contribute to reducing climate change overall.

Timeframes for pricing schemes and initiatives, from investigation and conception, design and implementation.

- **2006 - Investigation and recommendations:** In 2006, the Forum of Municipalities (a grouping of 16 municipalities near Copenhagen) released a report on the possible implementation of congestion pricing in the greater Copenhagen area. According to the Forum, the average speed of traffic during rush hour was down to 20 km/h. This resulted in more than 130,000 hours of wasted time, or the equivalent of about $1 billion in lost productivity. The Forum suggested implementing congestion pricing to reduce or eliminate congestion and to spend the net revenues directly in public transport.
- **2011 – All set to start implementation:** In 2011, a congestion charge in Copenhagen looked all but inevitable.
- **2012 - Project halted:**
  - **February 2012 - Opposition demanded study on congestion charge effects:** In an admitted move to stall the government's proposed congestion charge scheme, a unified opposition demanded a more comprehensive study of its environmental impact on the city and surrounding towns. Venstre, Konservative, Danske Folkeparti and Liberal Alliance demanded an official Environmental Impact Assessment on the effects of the proposed cordon as a preliminary groundwork for its presentation to parliament for a vote.
  - The mayor of Gentofte council, which borders Copenhagen and the proposed cordon, announced that his town was filing a legal challenge against the government for failing to provide the environmental study with its proposal.
  - The government countered that an Environmental Impact Assessment would be redundant, as the proposal is based on several alternative environmental impact studies, including a traffic study by the Technical University of Denmark (DTU), an air-pollution study by Aarhus University and an environmental impact study by the state roads and highways authority, Vejdirektoratet.
  - Ministers in Denmark cancelled the proposed congestion charge in 2012.

The relevant and determining factors in the environments in which the systems/schemes were investigated, developed and (as relevant) implemented, and how these factors shaped and influenced the outcomes

Experience from neighbouring countries

Experience from other countries shows that for congestion charging to bring some net benefits, road congestion needs to be severe and public transport congestion should be low (OECD, 2011a). While road congestion may be lower in Copenhagen than in several other large cities, it has increased substantially over the recent years.

Pledge to become carbon neutral by 2025

Copenhagen is already a low CO^2 emitting city, but plans to do even more to become the first carbon neutral capital by 2025. Meanwhile the city targets to cut CO^2 emissions by 20% between 2005 and 2015. Copenhagen's strategy rests on plans and policies very similar to national ones, but also includes some more ambitious ones including the following on transport:

- The transport sector would account for 10% of the cut. This would be achieved by favouring walking and bicycling even more. In 2010, already 35% of all trips to work or for education in the city of Copenhagen were made by bicycle with this share rising to 50% of trips for people working and living in Copenhagen. The municipality also planned to improve the quality of public transport and to promote car-sharing. Stringent performance standards concerning CO^2 emissions from buses were gradually being introduced and the city was experimenting with electric buses and cars. **A congestion charge was to be introduced after a consultation phase. Its revenues would have been used to improve public transport.**

Vehicle kms travelled

The overall development in vehicle kms travelled in Copenhagen shows an increase of about 20% from 1990 to 2009.

Increase in car ownership

Over the past 15 years, car ownership has risen among Copenhageners. The number of private passenger cars was approx. 50% higher in 2009 than in 1995. Nationwide, the equivalent figure is approx. 60% higher. Thus Copenhagen still has far fewer cars per inhabitant than the rest of the country, but the number is rising.

Evaluation framework(s), transport and traffic modelling and any other analytical tools used to analyse and assess pricing options, including assessments prior to and after implementation, and the practical limitations of these.

The Forum of Municipalities recommended that a boundary be set up around Copenhagen's centre and that all those entering the centre be charged a daily fee.

- They suggested charging 25 DKK (NZ$5.25) during morning and evening rush hour;
- 10 DKK (NZ$2.10) during the rest of the day; and
- no charge for entering the city centre at night.

What was undertaken for public engagement and consultation, and the extent of market and customer analysis and how this contributed to/affected the success of the scheme/system; this should include when in the process public engagement was commenced, how public engagement and consultation was phased, including any post-implementation engagement undertaken.

- **On 28 April 2005** the Copenhagen City Council adopted the **2004 Transport and Environmental Action Plan** for the City authority. The plan was worked out in a dialogue with the citizens and includes the City authority's vision of the way traffic and traffic development can be planned and influenced in the years ahead so as to achieve a smooth-functioning and healthy city.
- The Transport and Environmental Action Plan's overriding objective is to assure a fully functional transport system to service the city while creating substantially less environmental impact than today.

This means that it will be attempted to cater for the increase in traffic activity by increasing use of public transport and bicycles, and to minimise environmental problems.

- The Transport and Environmental Action Plan contains an action plan on 20 initiatives. These were to be implemented within the existing economic framework of the administration, possibly supplemented with extra appropriations. A progress report was given on what has been happening in these areas of commitment in 2009.
- The Transport and Environmental Action Plan contains an action plan on 20 initiatives including the following to **help clarify how congestion problems in the metropolitan region can be solved:**
    - On the basis of the Danish Association of Municipalities' report entitled "Congestion Charging in the Greater Copenhagen Area", the Danish Board of Technology arranged a consultation, at which one of the conclusions was that a vital contribution to solving the capital's road congestion problems could be made by introducing a cordon charge. In the longer term the problems could best be solved by adopting a multi-pronged approach, e.g. both a satellite-based GPS system, including all cars and all roads, changes in taxes and rates, and investments in public transport as an alternative to the car.

Review of any planned complementary measures to mitigate any adverse outcomes particularly for providing alternatives to driving in peak hours and addressing income and spatial equity impacts.

Source: Traffic in Copenhagen report 2009 (published in 2010)

- **New Parking Strategy in 2009 to limit congestion problems:** The increase in car ownership has put great pressure on street parking. Partly for this reason the City of Copenhagen has adopted a new parking strategy in 2009, which is intended to limit the congestion problems in Copenhagen and simultaneously improve parking conditions for residents in the Blue Parking Zone, where three fully automated underground parking installations were to open in 2010.
- The aim is still for the parking strategy to limit congestion and environmental problems in Copenhagen, as well as to ensure that Copenhageners' car ownership can grow in step with the general increase in prosperity in Denmark.
- **February 2012 - After the project was halted:** Instead of the congestion pricing scheme, the government promised to spend a billion kroner (NZ$210m) to cut ticket prices and raise public transport standards nationwide – but, crucially, without any penalty on those who drive cars into the city. The financing would come from higher taxes on leased vehicles.
- As part of its new plan, the government also created a special commission to study Copenhagen's traffic and air-pollution problems. Their findings, due on 1 January 2013, will supplement several earlier traffic and air-pollution studies that went into the congestion charge proposal.

Consideration of applicability of key lessons to Auckland given context of rapid charging technology advancements, including technology used, collection and enforcement processes.

Main reasons for failure:

- **Lack of communication on alternatives explored:**

- The opposition delayed and ultimately rejected the proposal, in part due to the lack of Environmental Impact Assessments.
- Impatience that the government had not yet managed to publish a report showing how public transport would be improved or how income from the new tolls would be spent.
- Government admitted that the solution of a congestion charge was pursued without investigating other alternatives, such as GPS-based road pricing.

- **Opposition from Mayors (re borders):**
  - Some mayors have been vocal about criticism of the cordon. They have questioned the proposed borders, and have insisted that the capacity and quality of public transport must improve before a congestion charge is implemented.
  - One of the remaining key details about the congestion zones– its size– fell into place after the publication yesterday of an environmental assessment report that appeared to find nothing to undermine the government's position that the zone's border should be congruous with Copenhagen's city limits. That position has caused rancour among mayors of towns bordering Copenhagen – including some members of Socialdemokraterne – who charge that their roads would suddenly be overwhelmed by cars seeking to avoid the congestion zone.
- **Communicating on benefits:**
  - "Given the initial lack of popular backing, supporters of road pricing would need to do a better job of explaining its benefits. People are sceptical towards the idea of paying more, but at the same time they don't want traffic jams".
- **Approach seen as punitive:**
  - The plan fell short because it punished those who wanted – or needed – to drive anyway.
  - The government continued to improve public transport, and it will do so without the charge, but any plan to encourage more people to take the bus and train needs to look at the way car ownership is taxed
- **Weak leadership**:
  - The conflict between parties (S and SF) culminated in 2012 what the media was billing as a "crisis meeting", with commentators noting that their apparent inability to solve their differences behind closed doors exposed a lack of cohesion and weak leadership. "Every Dane now knows there is internal friction inside this government,"
  - Berlingske's political commentator Thomas Larsen said. "First and foremost, Helle Thorning-Schmidt has failed as the prime minister to contain this conflict and lay the groundwork for an internal compromise". "The government itself is to blame for this circus, because all the politicians in the cabinet have been willing to comment on it," he told Politiken newspaper.
- **Support for alternative proposal :**

- Opposition parties Venstre and Konservative had already expressed their support for full network pricing using GNSS technology.

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APPENDIX P - Additional details of Netherlands road pricing programmes

Background

The Netherlands funds its roads from sales taxes, fuel taxes, and annual ownership taxes based on vehicle weight and fuel consumption. Road pricing and road usage charging proposals have been made six times since 1988, but none of them were ultimately implemented.

The core purpose of the Netherlands' road charge proposals was to reorganise an existing mix of taxes to be simpler and more cost-effective. However, the stated objectives also include reduction of congestion, improved environmental outcomes and encouraging greater use of other modes. A key focus was to simplify charges to maintain net revenues.

The objectives of each road charging proposal are covered in the following sections.

Objective(s) and goal(s) of systems/schemes.

A little bit of history…

Early Stages: Investigations into road pricing

- Road pricing was already put forward in 1965 by Dutch transport engineers as a promising policy instrument, inspired by the English Smeed report (Smeed, 1964: https://en.wikipedia.org/wiki/Smeed_Report). Around 1970 the government asked two scientific committees to develop future transport policies. Both committees suggested congestion charging or road pricing as possible effective future transport policies. The first notion of pricing incentives in road transport in the Netherlands was found in a policy document from 1977 (Structuurschema Verkeer en Vervoer – SVV).

1988: Rekening Rijden I. Proposed distance-based road charge system.

- **Context (Relevant determining factors)**: The first concrete proposal for road pricing was introduced in a policy document from 1988 (Tweede Structuurschema Verkeer en Vervoer – SVV2). The proposal to introduce a time and place differentiated cost increase for passenger transport (rekeningrijden) was fiercely debated and not considered socially or politically feasible. In 1990, the Cabinet decided, on the basis of the SVV2, to introduce the a toll charge to enter cities. The Dutch government proposed the introduction of a large multiple cordon-based road pricing system called rekening rijden ("road pricing") for the Randstad region (including Amsterdam, Rotter- dam, The Hague, and Utrecht, plus part of the province of Noord-Brabant).

- **Objectives:** The main objective of this proposed scheme was to manage travel demand and hence to reduce congestion. Other objectives were to decrease environmental pollution and generate funds to finance new infrastructure.

- **Main reason for failure:** Because of public opposition and opposition from provinces, municipalities and political parties, the proposal was not pursued.

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- **Alternative:** In 1991 fuel tax was increased and a congestion supplement to the vehicle registration taxes was proposed.

1992: Spitsvignet. Proposed peak period charges in urban areas.

- **Context:** In 1992, a proposal of reduced scope, which involved a system of supplementary licensing for motorists using the main road network during peak periods (spitsvignet), was discussed. Peak-hour motorists would have been charged a fixed toll to travel during peak hours regardless of the area. The charge would be about $2.85 per day (1992 prices) applied during the morning peak period, 6 to 10 a.m.

- **Objective:** Raise money for road infrastructure and manage congestion.

- **Main reason for failure:** Although this time an agreement was reached with the four large cities and some pilot projects were executed, the plan failed in 1993 due to the lack of political support. The proposal was not approved after a new government was elected in 1994.

1994: Rekening Rijden II. Proposed AM peak period cordon charges around four cities: Amsterdam, Rotterdam, The Hague, and Utrecht.

- **Context:** In October 1994, the Dutch parliament agreed in principle and proposed the implementation of a revised form of rekening rijden (referred to as "congestion charging"), which would be a system of electronic toll cordons around the four main cities in the Randstad area starting in 2001 (Dutch Ministry of Transport 1995). The charge would be in operation during the morning peak hour (7 to 9 a.m.) on weekdays.

- **Objective:** Improve accessibility of the economic centres.

- **Relevant determining factors:** Growing congestion levels initiated new research into the possibilities of electronic road pricing using cordons (again referred to as rekeningrijden).

- **Main reasons for failure:**

  - The proposal of rekening rijden was opposed by several interest groups. The main objection was that the authorities failed to provide an alternative for those who were obliged to travel by car during the proposed charging period.

  - **(Source interview)** This tax collection system was too expensive as it required the installation of too many portals. It thus met with even more obstruction from the public.

1999: Spitstarief. Proposed cordon pricing with charging points in the Randstad conurbation.

- **Context:** In 1998 the decision to introduce road pricing based on cordons was included in the coalition agreement.

- **Main reason for failure:** In the summer of 1999 fierce opposition suddenly emerged from various interest groups, of which the ANWB2 (Algemene Nederlandse Wielrijders Bond - Dutch automobile association) was the most apparent, as well as a national newspaper. The proposal politically 'died' (the official reason claimed was the growing technical opportunities for the implementation of kilometre charging).

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2001: Kilometerheffing. Proposed a distance-based road charge system

Context: In 2001 congestion charging became a major political issue in the Netherlands. The government considered an alternative proposal for a Mobimeter ("kilometre charging") system. The cabinet announced a proposal for legislation on the kilometre charge by the end of 2003 and stated its intention to start implementing the system in 2004 (the system was expected to be fully operational by 2006). The system would be a non-differentiating kilometre charge first, but the possibilities of differentiating the charge in relation to location and time of day (to manage congestion) were to be discussed later.

Key determining factors: The idea was supported by the successful development of the technology for the kilometre charging system. In addition, the policy could well fit in with the European Commission white paper that proposed kilometre charging as a good instrument for transport pricing in Europe.

Objectives: The main objectives behind kilometre charging were the improvement of accessibility (reduction of congestion on motorways) and environmental quality. The replacement of the fixed vehicle taxes by a variable usage-based charge was considered fairer.

Main reason for failure (Source interview):

Technology: OBUs (On Board Units) were required, but the cost of technology was still too high as six million OBUs were needed; The Ministry of Finance could not find the sources to fund this OBU volume requirement. Private sector was unwilling to finance them either.

Many opponents: Users, the AMWB (Dutch automobile association) and employers strongly opposed the project. This massive opposition made it politically difficult to get the project off the ground.

Alternative solutions: Government decided that road improvements would be made, with new roads and road widening.

Change in status quo (Source interview): There was high support for the policy in government.

2005: Anders Betalen voor Mobiliteit (ABvM): "Paying Differently for Mobility"

- **Context / Key determining factors:** After a period of political silence, there was renewed interest in road pricing expressed in the 2004 policy document (Nota Mobiliteit). Contrary to earlier initiatives, this time the **importance of stakeholder support** was acknowledged and this resulted in the installation of the Nouwen committee, (named after their chairman). Also called the National Platform for Paying Differently for Mobility (Platform Anders Betalen voor Mobiliteit)), this committee consisted of representatives of governmental organisations, interest groups and societal organisations and was established to investigate the options for implementing road pricing. In 2005 this committee recommended nationwide kilometre charging (kilometerprijs) for all vehicles to replace the fixed vehicle ownership and registration taxes. This proposal was broadly supported, primarily because the 'pay for usage' principle was considered fair.

- **Objectives:** ABvM was proposed to simplify the many taxes paid by motorists into a single distance-based charge. Secondary objectives included reducing travel times, improving trip reliability, and supporting efficient distribution of economic activity. The government's Mobility Policy Document to 2020, published in September 2005, stated: "The cabinet considers the introduction of a kilometre fee in combination with a reduction in road taxes to be a workable alternative… The state will take all steps needed to introduce a system for levying a 'fast-track fee'. The proceeds will be used to expedite the resolution of existing bottlenecks.

- **Main reasons for failure:**
  - **Huge delay:** Although the new government in 2007 embraced the proposal for kilometre charging it started the implementation preparations to enable a *successor* cabinet to implement the policy instead of starting the implementation during its period of government (2006–2011). At the end of 2009, the Concept Kilometre Charging Act (Rijksoverheid, 2009b) was introduced to parliament and full implementation was considered feasible around 2018.
  - **Controversy:** Amid some political turmoil over the influence of the ANWB on the policy process, the government fell (19 February 2010). The Dutch parliament declared kilometre charging a politically controversial subject and halted the policy process until the formation of the new government (Rijksoverheid, 2010a). The new government (installed on 14 October 2010) decided not to implement kilometre charging (Rijksoverheid, 2010b).

(Source: interview)

  - **Political instability** with coalition government system: too many parties and no leading force to see the project through.
  - **Scoping:** The project was too ambitious given the time frame (4 years); it involved high volumes and important funds and was therefore too risky.
  - **Timeframe:** the project had to be implemented within 4 years, but within the given timeframe, the elections took place. It would have been a huge political risk for the coalition government to support such an unpopular measure. Unlike France (as seen with Ecotaxe), the implementation phase does not start until an agreement is reached. The enthusiasm that built up during the first year waned with such long delays before implementation.
  - **Communication:** It was difficult to communicate on a project that did not have the same benefits for all stakeholders; some people would pay less as they would drive less, but in other areas the cost of driving would inevitably increase. The costs of the system were also going to be higher: the system would have cost about 10 times more than levying a simple tax. The move from the current tax system to the new road pricing scheme would have represented an increase in the cost of collection from 1% to 5% (in the best case scenario) or even up to 10% (estimated to about €10 billion)

Current situation (Source: interview)

- **Shift in the mentality:** Employers, trade unions, the public can see that congestion is costing more and more to the economy and quality of life. Freight is enduring worsening congestion.
- **Rising awareness and support:** For many years, there was a push from government to implement new measures to improve traffic, but now there is also a push from employers, businesses, trade unions as awareness starts to rise. ANWB is one of the leading forces and has built a coalition with employers to push for a new road charging initiative. One political party supports the idea, the public is now expecting it, and there is a national goal to meet the EU commitments in the Paris Agreement on CO^2 emissions.
- **Learning from the neighbours:**

- **Belgium:** Netherlands is waiting to see how the VIAPASS heavy vehicle RUC scheme proceeds in Belgium, which has a comparatively more complex political system. The key to success in Belgium is that the project was deployed regionally.

- **Vignette system:** Netherlands could deploy a vignette system for passenger cars (meaning that there would be no need to change the tax system). The vignette could be a means to progressively introduce the bigger idea. There would be a smooth start with a flat rate, and then a second phase with congestion charge. The Netherlands is already a membe of the Eurovignette scheme for heavy goods vehicles.

- **One major obstruction:** There remains strong opposition to road pricing in some political circles. It is a purely political stance and the chances of road pricing moving forward with the current government are very slim.

Evaluation framework(s), transport and traffic modelling and any other analytical tools used to analyse and assess pricing options, including assessments prior to and after implementation, and the practical limitations of these.

Source: Cost and benefits of pricing for the Netherlands (Erna Schol)

Two relevant studies to assess pricing options:

- **In a 1997 study the Economic Institute of the Netherlands applied cost–benefit analysis to two variants of road pricing**: cordon-based area fees and fees levied on highways anticipated to be congested by 2001. Regardless of the variant, it was assumed that the tariff would be approiximately €2.25 and levied on both passenger and freight transport. The study concluded that given the assumptions, the cordon-based approach would yield greater net benefits.

- **In a Central Planning Bureau cost-benefit analysis conducted in 2001, two other scenarios were identified:**

  - a “variabilisation” of fixed costs through a per kilometre charge—essentially a flat rate based on the “pay as you drive” principle; and

  - a flat rate that included a congestion component—a surcharge of €0.10 per kilometre at times and locations of congestion.

- **Conclusions of second study conducted in 2001:**

Both scenarios make use of an onboard unit and GNSS, so no toll collection points were needed. According to the study:

  - The total effect of the flat rate scenario is around zero, meaning that the costs are comparable with the benefits.

  - The total effect of the congestion charge is positive and comes to a benefit of about €10 billion by 2020, on the assumption of nationwide implementation of road charges for both passenger and freight traffic.

- Strong evidence that a congestion charge is effective in lowering transport demand and thus congestion. However, even the flat rate can decrease congestion (though to a lesser extent) if simpler, less expensive technology is used.

- **Lessons learned**
  - Costs inevitably increase during the course of a project and benefits can vary markedly depending on the structure of the pricing scheme, including the tariff level, the potential to vary the charge in response to congestion levels, and the application of the scheme to an urban area generally or to highway travel.
  - The cost–benefit analysis can be a powerful tool for gaining insight into not only the advisability of a stated project but also the impacts of various refinements of a proposal.

Description of the methodology for choosing scheme design including: scope; technology; target vehicles; exemptions; privacy; data security; payment system; interoperability with tolls and fuel tax collection; enforcement methods; use of revenues, and a critical analysis of their success/drawbacks.

What was undertaken for public engagement and consultation, and the extent of market and customer analysis and how this contributed to/affected the success of the scheme/system; this should include when in the process public engagement was commenced, how public engagement and consultation was phased, including any post-implementation engagement undertaken.

After the failed attempt to proceed in 2001, initiation of a "Mobility Alliance" movement:

- A vital lesson learned from previous projects was that a broad consent of the public and the political sphere is necessary.
- Contrary to earlier initiatives, this time the **importance of stakeholder support** was acknowledged and this resulted in the establishment of the Nouwen committee, (named after their chairman). Also called the National Platform for Paying Differently for Mobility (Platform Anders Betalen voor Mobiliteit)), this committee consisted of representatives of governmental organisations, interest groups and societal organisations and was established to investigate the options for implementing road pricing. Furthermore, political parties together representing some 75% of the population gave their backing to the project.
- In 2005, this discussion platform sought an agreement and came to the conclusion that the best solution to improve the congestion problem was a distance charge for all vehicles and on all roads, with tariffs differentiated for time, place and type of vehicle. This solution was to be implemented as quickly as possible. **However, in order to achieve social acceptance, the overall tax burden on car users was to remain the same.**

Public engagement and consultation: Surveys

Population was surveyed regularly and useful information was gathered:

- Surveys of the population at large showed a high degree of approval and acceptance of the pricing concept as a necessary and sensible measure to reduce traffic congestion, particularly as there was the political pledge that the overall tax revenue should remain the same. In addition, the project was faced with the political requirement that the recording costs should amount to no more than 5% of the revenue. Though this turned out to be unrealistic, the estimated costs remained in this order of magnitude.

- According to the surveys, the population as a whole was interested in a simple, fully-automated technical system that did not require any special attention or service, that would protect personal data, treatment all users equally (no exceptions!), in an attractive OBU design and in the strict enforcement of payment by everyone. Moreover, it was desired that the system should be controlled by the public sector, not the private sector.

Consideration of applicability of key lessons to Auckland given context of local situations including population, topography, urban form, traffic characteristics, level of car use relative to public transport use and any other relevant factors.

KISS – "Keep It Simple Stupid." Despite the objective of simplicity, the road charging policy had too many objectives, making it a target for opposition. Proponents lost focus on the primary objectives as originally stated, which included the following:

- Pay for roads in a direct way based on usage rather than ownership
- Keep net revenues neutral with the existing tax regime
- Dedicate revenues to the transport sector

Detractors exploited weaknesses in the complex proposals to damage public relations.

A technology-centric approach led to reliance solely on GNSS-based measurement alternatives as the only option for deployment because of the multi-faceted objectives sought by the program.

Consideration of applicability of key lessons to Auckland given context of rapid charging technology advancements, including technology used, collection and enforcement processes.

Conclusions: The key barriers to successful implementation of a national road user charging scheme in the Netherlands have been political and technological. Even though the success of a kilometre charge will rely heavily on the reliability and capability of charging technology, the greatest barrier to further progress still appears to be political and closely linked to public acceptance. The change today is increased public awareness over the years and a clear leading force with the ANWB movement.

(Source: Interview)

- **Looking forward**
  - Schemes and policy have matured over the years, and the main objectives have not changed
  - There has been an enormous leap in technology, meaning that it would be much cheaper to use advanced technology
- **Recommendations:**
  - It is important to make choices. The project cannot aim to fill too many objectives.

- Project scope should be more focused and the timeframe should be shorter. With long implementation delays, support for such a project starts to wane. As technology keeps on moving amidst a context of political instability, it is important to choose the right time frame for a full deployment. Given the political context, there are only three years after each election to fully deploy and implement a project of this size and scale.

- It is important to specify requirements at the right level of detail to avoid endless discussions. Given the sums of money involved, the specifications were developed to a high level of detail to meet Dutch requirements. Private companies which have their own systems that cannot exactly fit the requirements. They have to invest considerable time and funds to adapt and alter their systems. It should be a win-win situation for the government and the market.

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APPENDIX Q - Additional details of Oregon Road User Charging Pilot Programme

Objectives and goals.

Oregon was motivated by three goals — a perceived need to replace the fuel tax for road funding, a desire to manage traffic congestion in the Portland Metropolitan area, and a preference for transparency in road funding. A legislatively created task force had recommended testing congestion pricing in the Portland Metropolitan Area. With minimal funding committed to the project and lacking authority to install infrastructure along local Portland streets, the Oregon Department of Transportation (ODOT) pursued the objectives of low implementation and operating costs, with increased potential for public acceptance by "piggybacking" onto a broader, statewide, road pricing technology pilot in 2006-07 that tested the concept of a basic, flat rate distance-based road usage fee (similar to light RUC in New Zealand).

The broader test involved the participation of volunteers with 300 vehicles paying NZ$0.01 per km for driving in Oregon from June 2006 through March 2007. Roughly a third of the vehicles transitioned into a congestion pricing demonstration in Portland that began midway in Fall 2006 and lasted through March 2007.

How the systems/scheme emerged

The idea of testing congestion pricing within a distance-based, road usage fee, technology pilot emerged during discussions between the ODOT and the U.S. Federal Highway Administration (FHWA) in 2001. ODOT sought and received approximately US$400,000 in federal grant funding to investigate testing of a distance-based road usage fee as a potential funding mechanism for Oregon's road system provided the investigation included a congestion pricing component.

This federal funding supported the road pricing investigatory work of the Road User Fee Task Force (RUFTF), an independent body created by the Oregon Legislative Assembly and appointed by the Oregon Governor, Senate President, House Speaker and the Chair of the Oregon Transportation Commission. Over a 15-month process to identify new road funding options, the RUFTF chose the distance-based, road usage fee as the best replacement option for the fuel tax but also found the following,

"Congestion pricing can be used to efficiently distribute motorists' use of congested facilities and provide additional revenue for modernization of the congested facility." [40]

The RUFTF also recommended that ODOT conduct a technology trial for a road usage fee that included a congestion pricing component. Specifically, the RUFTF recommended the following,

- A congestion pricing trial should be integrated with a distance-based road usage fee as a base-rate adjustment to the base fee by adding a "rush hour" rate;
- A GPS-based system should be trialled for congestion pricing through peak hour pricing by area, pricing primary routes and side roads and streets equally so as to minimise traffic diversion; and

[40] P. 47, Road User Fee Task Force Report to the 72nd Oregon Legislative Assembly (March 2003)

• Area charging should involve charging variable rates within a defined geography without specification or discrimination for a particular roadway or street with all routes priced the same per mile driven within the area during the same periods.

Analytical tools used

The small size of this demonstration obviated the use of traffic modelling for testing network or facility effects. Rather, pilot technicians tested the performance of technologies, and surveys were conducted of participant attitudes before, during and after the pilot. Users who volunteered to "pay" the rush hour rate operated with in vehicle equipment for a "control period" of five months without any nominal charge, to help to provide a basis for analysing any behaviour change, comparing uncharged road use with any response to the road user charge.

Methodology for choosing systems/scheme design

The scheme chosen for the demonstration was area pricing. The area priced was within a polygon, defined by GPS coordinates, at the edge of the legally defined Portland Metropolitan area, within which drivers would pay the higher congestion charge rate for driving during peak periods of 0700-0900 and 1600-1800 on weekdays. This was seen as being a simple, easy-to-understand variation on flat network charging.

The pilot recruited a random set of Oregonians for the broader pilot, but only residents of the Portland Metropolitan area participated in the congestion pricing component. Participation resulted from a process of self-selection and meeting pre-determined screening criteria.

The technology pilot deployed two methods of recording distance travelled, using thick client devices installed within participating vehicles for uploading data wirelessly at service stations. One method used GPS-only devices to identify location and distance travelled, while a second method used GPS for location only and accessed the vehicle speed sensor through the on-board diagnostic port (OBD-II) for calculating distance travelled. Participants were incentivised to change behaviour by the creation of accounts for their vehicles that would reward them at the end of the trial for reducing their driving behaviour (compared to driving during the control period). Their vehicles were nominally "charged" against an account for their usage (which was transparent to them throughout as an account online). Participating motorists "paid" both a flat distance travelled fee of NZ$0.01/km and a higher congestion charge of NZ$0.086/km as part of the commercial transaction to purchase fuel. The transaction included a reduction of fuel price by the amount of the state fuel tax as part of the trial. Service stations remitted the accumulated distance travelled fees and the congestion charges to Oregon DOT once a month.

Pilot design protected individual privacy by use of thick client in-vehicle GPS devices that erased detailed travel coordinates concurrently with measuring distance travelled. Only summary distance travelled data was uploaded for use in determining the congestion charge. Data security was outside the scope of this pilot demonstration. As only volunteers participated in this pilot demonstration, enforcement measures were not investigated nor was actual revenue generated. The devices proved accurate in differentiating zones for congestion pricing, although this was by no means a sophisticated form of network pricing.

More problematic was associating a vehicle equipped with an on-vehicle, distance-recording device with the fuel pump used to fuel the vehicle and where the data upload occurred. Overall, the percentage of vehicles correctly associated with a fuel pump was only 80%.

Public engagement and consultation

The RUFTF held three public hearings during the first year of investigations (prior to launch of the pilot) and accommodated public testimony during each of its meetings. ODOT accepted invitations to speak across the state at local clubs, business associations and chambers of commerce and gave 45 formal presentations to the Oregon Legislative Assembly as well as several presentations to the Oregon Transportation Commission before, during and after the pilot operations. There were regular and extensive engagements with local, state and national media of all types. ODOT gave many media interviews before, during and after the pilot.

All participants received detailed instruction about the pilot demonstration prior to agreeing to participate as well as during introduction. ODOT developed a detailed participant communication plan outlining each type of anticipated communication with participants during the pilot test and included written, spoken, and electronic communications. ODOT provided a pilot hotline that a participant could call for help or offer opinions at any time. The communications plan was a success in that all forms of communication were executed as planned.

Development and implementation

ODOT developed the congestion pricing demonstration from scratch, informed only by its own research and preliminary outcomes from the yet-to-be concluded pilot demonstration in the state of Washington by the Puget Sound Regional Council. ODOT worked with Oregon State University to develop the technologies to be tested. Development and testing of the equipment used in the pilot occurred from Spring 2003 to Spring 2006.

Outcomes

Evaluation of the entire effort combined the congestion charging demonstration with the distance-based road usage fee pilot test. The pilot used opinion surveys of volunteer participants pre-pilot, mid-pilot and post-pilot to evaluate results. Overall, the pilot test was successful in terms of acceptability to participants, achieving 91% satisfaction among participants, yet wider public attitudes towards congestion pricing were not assessed. Since the technology pilot demonstration only involved a few hundred participants, broader outcomes were not measurable.

User experience and public reaction

In the final survey, 96% of the volunteer participants said they were happy with communications from the ODOT project team. Ultimately, however, general public concern about the financial effects of congestion pricing on driving in urban areas and concern about protection of privacy using GPS reporting equipment has stalled the congestion pricing effort in Oregon. ODOT and the RUFTF decided to hold back development of congestion pricing in favour of a simple RUC system. Six years later, the Oregon Legislature enacted a voluntary per-mile road usage charging system that launched on July 1, 2015 and remains active today. There is no congestion pricing component in this programme but the system could accommodate congestion pricing should state and local authorities wish to do so.

Complementary mitigation measures

The scale of this technology pilot meant that complimentary mitigation measures were not necessary or undertaken.

Lessons for Auckland

Oregon's demonstration showed that in a demonstration setting, road users can respond to price signals (with a 22% reduction in distance travelled, even though the price signal was a future reward). User concerns around privacy can be addressed through design. Oregon has demonstrated that behaviour change can be seen from distance based charging focused.

APPENDIX S - GNSS coverage issues in New Zealand

GNSS accuracy is improving, but only the "gold class" units or higher are used for pinpoint accuracy for surveying and precise positioning. With today's GPS Satellite Block 3 changes and signal strengthening of satellite signals (L1, L2 and L5 control channels) greater positioning is achievable. However, with today's commercial units, a three-metre diameter error of probability is usually expected for a vehicle standing still. For a moving vehicle, that level of precision is closer to five metres. There are several techniques devised that can augment this accuracy.

Many GNSS systems use a suite of other sensors to assist in measuring chargeable events. Internal sensors for speed, acceleration, and azimuth are used to parallel the GNSS positioning in the internal computer. Comparisons are made and the vehicle azimuth and speed are used to further reduce the circular error of probability to an as small as possible arc. If the GNSS coordinates do not fall within the calculated arc, they are not used and the sensor positioning is used. In addition, the GNSS systems improve accuracy by analysing the past 25 to 100 calculated points and uses a sum of least squares calculation to smooth the vehicle path and use the internal sensors to cross reference the directional variations of the vehicle. Still another technique is using the calculated point of the vehicle and comparing it to a GIS representation of road network map. The vehicle is then "snapped" or placed on the road centreline of the GIS map representation. This "snap to map" approach is very common and provides a seven metre cross section for a single lane carriageway or a 20 metre cross sectional margin of error for a two-lane carriage way with safety verges.

For precise charging, the pricing areas are set in a GIS box that is 7.5m to 10m in cross sectional dimension. The charging system then uses multiple GNSS co-ordinates calculated every second or tenth of a second when approaching the designated price zones. It then uses a statistical routine to measure the coordinates falling inside the GIS box to gain 99.99% confidence that the specific vehicle with the GNSS device is at the specific charging point.

All of the above are active measures used today with commercial or smartphone GNSS devices to charge vehicles. Australian and New Zealand Governments are funding a A$12 million project implement a Satellite Based Augmentation System (SBAS) test bed to evaluate three positioning signals for improved accuracy and integrity. The three signals are current L1 legacy services, second-generation dual frequency multi-constellation signal to improve legacy signals (L1, L2 and L5), and high precision point corrections that will provide decimetre accuracies. In short, these augmentations or "pseudo-satellite" techniques will improve GNSS signals to less than 1 metre for a moving vehicle.

APPENDIX T - Review of Previous Auckland Road Pricing Studies – Economic Evaluation Aspects

INTRODUCTION

Scope of paper

This paper is a contribution to a consultancy assignment being undertaken by D'Artagnan Pacific (DP) for the Ministry of Transport titled "*Auckland Smarter Transport Pricing Project: Review of previous Auckland and international pricing initiatives for demand management purposes*".

The paper addresses one of the two major work areas of the project, being a review of previous Auckland road pricing studies.

Specifically, its scope is to:
"*Analyse and assess the strength and limitations of supporting methodologies used in previous Auckland road pricing studies by:*

- *Obtaining any further information available on the appraisal methodology applied in the previous studies; and*
- *Undertaking more in-depth assessment of the appraisal methods applied in previous studies, and prepare a draft paper*." [41]

The paper has been prepared by Ian Wallis Associates Ltd (IWA), sub-consultants to DP on the project.

The project ToR specifies four main previous studies relating to road pricing for Auckland that are to be covered in the review, ie (in date order):

- Auckland Road Pricing Evaluation Study (ARPES), MoT, 2005-06.
- Auckland Road Pricing Study (ARPS), MoT, 2008.
- Auckland Transport Funding Project (FATF), Auckland Council, 2014.
- Auckland Transport Alignment Project (ATAP), Central and regional government agencies, 2015-16.

This paper focuses primarily on the first and last of these four studies: ARPES was the first of the four studies and the most comprehensive in many respects, involving extensive methodology development; while ATAP is the most recent, with every opportunity to build on the previous study methodologies. ARPS explored in more detail some of the issues identified in ARPES, but did not involve any further economic appraisal work. The ATFP work was concerned primarily with transport system funding issues, but it did include some further economic appraisal work on the merits of motorway charging options as a means of raising revenue for additional transport investment, relative to raising revenues from increased petrol taxes and/or increased household rates.

The paper addresses the economic evaluation (appraisal) aspects of the previous work, which have applied an economic welfare framework using cost-benefit analysis (CBA) procedures:[42] it addresses the costs and benefits of various road pricing schemes on the main affected groups (principally transport system users and

[41] MoT clarified that this aspect of the work was not expected to address demand modelling aspects of the earlier studies, but to take the demand modelling inputs as a given and to review the subsequent steps involved in completing the economic appraisal.

[42] No attempt has been made to cover economic impact aspects (primarily concerned with the distribution of economic impacts), which were also covered in the major studies.

public authorities), leading to estimates of scheme total benefits, total costs, and hence net present value (NPV) and benefit: cost ratio (BCR) performance measures in economic terms. Some financial performance measures are also assessed.

The economic evaluations undertaken in the previous studies have generally been consistent with the principles and applied the unit parameter values specified in NZTA's Economic Evaluation Manual (EEM), so that (and subject to some caveats) the economic performance of these road pricing schemes can be compared with other transport initiatives evaluated by and for NZTA.

The economic evaluations reviewed have all involved the following two main stages of work:

- Demand modelling and forecasting – to assess the impacts on road traffic travel times, traffic volumes, modal changes, etc of specified road pricing schemes relative to a 'base case' (which assumes current pricing policies). This work stage has, in all cases, used the Auckland Regional Transport (ART) model or a variant of this, supplemented by the Auckland Public Transport (APT) model.
- Evaluation of economic benefits and costs – to apply economic parameter values to the demand modelling outputs, in order to derive scheme benefits and costs in economic terms over the scheme life.

This paper focuses on this second stage of assessment. However, it does recognise that the evaluation of the economic performance of any major transport initiative is as much dependent on the quality of the first (demand modelling) stage as the second (economic evaluation) stage of analysis – and the first stage is technically the more difficult. Some limited comments are provided in the paper on the first stage, and the interface between the two stages, given their importance to overall scheme assessment.

Within its economic evaluation focus, the paper is concerned primarily with the evaluation **methodology** used, more than with the numerical performance results or any comparison of scheme economic performance (whether between scheme options or between studies): such performance results are, of course, dependent on both the demand modelling/forecasting analyses as well as the economic analyses. However, we do draw out some broad conclusions from the performance results, on aspects where these conclusions are likely to be robust to plausible variations in the demand modelling/forecasting analyses.
In assessing the economic performance of road pricing schemes for Auckland, we have generally examined only those scheme assessments that have compared road pricing schemes on a 'stand-alone' basis (rather than as part of a wider package of initiatives) relative to a (non-priced) base case. This avoids the potential difficulties of trying to disentangle the impacts of road pricing per se from those of other initiatives being assessed in combination.

METHODOLOGY OVERVIEW

This section provides an overview of the evaluation methodologies adopted in the previous studies, principally in ATAP and, where it differs significantly, also in ARPES (and ATFP). As noted in the previous section, the main focus is on the economic evaluation **methodology**, starting from the demand modelling (ART) outputs. However, the first sub-section (immediately below) sets out key features and issues on the demand modelling aspects, given their critical importance in the overall scheme evaluation.

Travel demand modelling aspects

The ART (Auckland Regional Transport) strategic/region-wide multi-modal model has been used for all demand modelling work undertaken in the previous Auckland road pricing assessments. It has been supplemented by the APT (Auckland Public Transport) model, for assessing the impacts of transport options on the PT system (demand, operations, costs, etc).

Table 2.1 provides a summary of key features of the ART model, and identifies and comments on key issues relating to the application of the model (principally in the ATAP and ARPES applications) for assessing the demand effects and user 'generalised' costs of road pricing options.

In summary, our principal concerns about the limitations of the current ART/APT models for the assessment of road pricing options relate to the following aspects (which seem likely to account for the greatest uncertainties in the estimated use benefits):

- Lack of segmentation of the car traveller market in terms of its spread of values of time (we understand this deficiency is currently being addressed in the Auckland Transport Models 'Refresh' project[43]). With an appropriately segmented model, it is expected that the estimated benefits from road pricing would increase quite substantially (assuming that the segmented values of time savings are also applied in the economic appraisal).[44]
- The extent to which the ART model's current speed v flow functions for road traffic reflect hyper-congestion (ie situations where traffic demand on a route exceeds the road capacity, with stop/start traffic conditions resulting). This is a critical factor in benefit estimation, as the majority of the user benefits (principally time savings) from road pricing schemes result from traffic demand being reduced such that the road operates at near capacity rather than in a hyper-congested state.
- The evidence from various previous studies, that use of the ART model tends to result in much lower estimates of benefits (typically around one-third) for major infrastructure projects than result from more detailed/localised project-based models. It is unclear to what extent this conclusion may apply to road pricing schemes – to the extent that it does, the present benefit estimates may be too low by a substantial margin.

We note in this regard that the ART model is currently being 'refreshed', in part to enhance its suitability for the assessment of road pricing options. We are unclear (without further investigation, which is outside our ToR for this project) to what extent the current ART 'refresh' will overcome the above concerns.

Economic evaluation aspects

This section summarises the methodologies used in the economic evaluation of road pricing schemes in the ATAP and (where different) the ARPES projects, in both cases starting from the ART/APT demand model outputs and examining the procedures and processes used to derive key performance measures (such as benefit: cost ratios).

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Table 2.1: Demand modelling methodology and issues

Aspect/methodology	Issues and comments
Model type	
• ART (strategic, multi-all modal, region-wide) model used in all AKL RP studies. • APT (more detailed PT) model, linked to ART, used for estimating PT system benefits,	• No alternatives available to ART/APT in the short/medium term for assessment of region-wide policies and projects.. • Currently an ART upgrade programme and progress to enhance ART, to make more suitable for RP scheme modelling and other improvements.

43 Auckland Transport Models Refresh 2017 – Model Specification. Beca et al for AT, Jan 2017.
44 Refer further discussion on this point in section 3.3.

• ART validity for estimating scheme benefits has been questioned, as for major infrastructure schemes economic benefit estimates have been around one-third of those estimated using more detailed local models.	• It is unclear whether/to what extent this problem of under-estimation of benefits may apply to regional pricing schemes -- but it may indicate that benefit estimates for these schemes have been very significantly under-stated.
Model periods	
• Model years. Demand forecasts (trip matrices) available for 2016 (baseline), 2026, 2036, 2046.	• ATAP RP modelling used 2036 only (but other ATAP modelling used all 3 forecast years). • Earlier ARPES modelling used all 3 forecast years. [Check??]
• Model time periods. Separate trip matrices available for AM peak, interpeak only.	• ARPES RP modelling used AM peak only; assumed PM peak impacts 50% of AM peak (charging applied only to AM peak), off-peak impacts not significant.
Traffic modelling aspects	
• Speed-flow functions for links and intersections	• Unclear how well ART models the capacities of major intersections compared with link capacities -- further examination may be warranted (outside scope of this assignment).
• Speed-flow functions for hyper-congested conditions	• Unclear how well ART models traffic behaviour under hyper-congested conditions (eg with queueing on motorway links): this is critical, as the majority of benefits from road pricing arise from moving from hyper-congested situations to situations where traffic is flowing freely (but the route is near maximum capacity). Further examination may be warranted (outside scope of this assignment) -- it is not clear that this issue is being addressed in the current ART 'Refresh' work.
• Road traffic behavioural response to changes in travel 'generalised costs'	• Highly desirable that the ART model should reflect the following types of behavioural change in response to changes in the level of congestion: (i) trip frequency; (ii) trip lengths (changes in O-D patterns); (iii) mode switching (to PT, active modes of from driver to passenger); (iv) trip retiming (to/from off-peak or peak shoulder periods). May be desirable to review ART's inclusion of each of these responses and the sensitivity (cross-elasticity) of each response to changes in car generalised cost/congestion levels.
Market segmentation aspects	
• Car traveller values of time for modelling purposes	• Currently ART applies a single value of time (by trip purpose) to all car travellers in modelling behaviour, in particular in response to toll charges. EEM (4.7.3) specifies that "*Evaluation of toll roads (including tolling policies) must use a distribution of values of travel time consistent with users' willingness to pay (WTP) values established through SP surveys or other means. A consistent distribution of values of travel time must be used in both the traffic modelling and economic efficiency evaluation.*" It is also noted elsewhere that the use of a single value of time is likely to result in significant under-estimation of the benefits of tolling policies. We understand that this deficiency in the model is being addressed in the current ART 'Refresh' work.

Our focus has been on the methodology used for the evaluation of benefits, principally to travellers but also impacts on other parties (we have not attempted to review the costing basis or methodology).

Our understanding is that the benefit evaluation procedures applied were required to be consistent with those set out in the NZTA Economic Evaluation Manual (EEM), so we have reviewed them on this assumption. Appendix E sets out the relevant benefit categories that should be addressed, as specified in EEM. It also sets out key economic parameters specified in EEM and key 'value for money' measures.

In the context of the EEM requirements, Table 2.2 provides a summary of the economic evaluation methodology adopted in ATAP and ARPES for the evaluation of the 'stand-alone' road pricing options.[45]

At this stage, we have not been in a position to check in detail: (i) the benefit parameter values input to the evaluations as to their consistency with the relevant EEM values; or (ii) the formulae applied to derive benefit estimates from the ART/APT model outputs (eg to allow for 'resource cost corrections'). Subject to this caveat, we highlight the key findings from the table as follows:

- **Evaluation (analysis) period**. The ATAP road pricing scheme evaluations assess the economics for a single year only (2036), rather than over a typical (often 40 year) period. This is probably appropriate at this initial evaluation stage; but we note that no capital costs have been included in the evaluation whereas a preferred treatment would be to allow for an annualised equivalent capital charge reflecting the expected life of the dominant capital assets involved (which might be c. 10 years in this case).[46] The ARPES road pricing options were evaluated over a 25 year period, which we consider unreasonably long given the nature of the main assets involved: a 10-year operational period would seem more appropriate.
- **Adjustment of road traffic values of time for congested and unreliable conditions.** EEM includes procedures for adjusting (increasing) 'base' values of road user travel time savings to allow for the greater driver stress and dislike of travelling in congested conditions and/or with unreliable travel times. A typical uplift in base travel time values in such cases is around 20%: this uplift factor has been applied in the ARPES modelling and evaluation, but is not mentioned in the ATAP evaluation, thus potentially understating the travel time benefits.[47]
- **Estimation of benefits associated with PT**. The ARPES road pricing scheme evaluations include 'PT benefits' as one of the major benefit components. The ARPES report (App 19) explains this component as the result of deducting the fares paid (being a transfer payment rather than an economic cost) from the PT user generalised costs of travel (ie a 'resource cost correction'). Similarly, a substantial PT user benefit is included in the ATAP 'full package' evaluations. However, such an item is not evident in the ATAP road pricing evaluations (eg refer the Williamson report and the Paling spreadsheet). It is not clear whether this benefit has been omitted in these cases (which we suspect) or absorbed within other benefit categories. If the former, this suggests that total user economic benefits (excluding toll payments) may be understated by in the order of 50%).

Table 2.2 Road pricing options (ATAP & ARPES) evaluation coverage relative to EEM requirements

Item (EEM ref)	Evaluation coverage – ATAP/ARPES
Key economic input parameters	
Discount rate (2.5) -6% pa (real terms)	OK.
Analysis period (2.6) - 40 years (standard)	ATAP single year only (2036): arguably this is satisfactory for comparative purposes between pricing options at this stage -- but preferable to include annualised capital value in evaluation. ARPES 25 years: suggest better to match period to life of main assets, likely to be c10 years (EEM allows this).

[45] In ATAP, there were some differences in the methodology applied to evaluate 'package' options from that applied to stand-alone road pricing options.

[46] We note that the ATAP 'full package' evaluations have allowed for a 40-year evaluation period: while this is the default period specified in EEM, it seems inappropriate (too long) for road pricing schemes. We also note that the ATFP applied a 60 year evaluation period, on the basis that many of the schemes involved would be implemented only towards the end of the 30 year Auckland Plan period.

[47] If a 20% uplift factor were to be applied to the ATAP base VoT values for congested/unreliable conditions, then the increase in the time savings benefits could be expected to be substantially greater than 20% as road pricing schemes would be expected to reduce congestion and unreliability in greater proportions than the reductions in travel times.

Benefit categories	
Travel time ('base') benefits (A4)	Main component of benefits (both studies). Not specified whether unit value used was same as behavioural value used in modelling, or adjusted to an 'equity' value as specified in EEM
Road traffic congestion (A4.4)/ TT reliability (A4.5)	Included in ARPES, estimated as 20% addition on base travel time benefits. Not mentioned in ATAP, assume not included (a).
PT travel 'base' time adjustments (A18)	Not specified in documentation -- expect included for ARPES (which includes a PT user benefit item); may not be included for ATAP.
Vehicle operating costs (A5)	Included (both studies). ARPES specifies that resource cost correction (RCC) as included, but not clear in ATAP.
Crash (accident) costs (A6)	Not included (both studies) (b). Discussed in ARPES, considered that any net benefits likely to be small (+ve/-ve).
External (local envt etc) impacts (A7)	Not included, eg valuations for traffic noise (both studies)
Vehicle emissions (local, global) (A8)	Included in ARPES (CO_2 emissions valued, but not particulates); assume not included in ATAP (not mentioned)
Wider economic benefits	
Agglomeration economies (A10.3)	Not mentioned/included (both studies)(c).
Imperfect competition (A10.5)	
Increased labour supply (A10.6)	
National strategic factors (A10.7)	Not mentioned/included (both studies) - most likely not relevant.
Security of access (A10.8)	
Investment option values (A10.9)	
Key 'value for money' performance measures (2.8)	
BCR(N) = PV national economic benefits/PV national economic costs	Included (both studies). In both studies, the toll revenue raised has been omitted from both benefits and costs, reflecting that it is a transfer payment and therefore not relevant in economic terms.
BCR(G) = PV national economic benefits/PV govt (financial) costs.	Not included (both studies).

Notes:

(a) The ATAP 'full package' evaluations included an allowance for travel time reliability benefits (which was about 13% additional to car user, principally travel time, benefits).

(b) The ATAP 'full package' evaluations included an estimate of safety benefits (which was about 5% of total road user benefits, excluding toll payments).

(c) The ATAP 'full package' evaluations included an estimated agglomeration disbenefit (which was about 10% of total benefits to road and PT users). ATFP also provides an estimate of agglomeration benefits (positive, not negative).

Economic performance measures: treatment of user charges

The primary performance measure used by NZTA for ranking schemes nationally in terms of 'value for money' is the benefit: cost ratio from a national perspective, BCR(N). As defined in EEM:

$$BCR(N) = \frac{\text{PV national economic benefits}}{\text{PV national economic costs}}$$

The word 'economic' is fundamental to the understanding of this ratio. Its interpretation is that only costs and benefits that involve generation or consumption of real resources are relevant: transfer payments between parties (such as toll charges and fares) are not relevant, and should not appear in the BCR(N) formulation.

Thus, the formula numerator should comprise net economic benefits to transport system users (principally travel time changes) and external costs and benefits associated with use of the transport system (eg noise, emissions); while the denominator should comprise capital and operating costs associated with the transport scheme. Transfer payments are not included.

This matter was debated in both the ARPES project and the ATAP work, and the view confirmed in both cases was consistent with the above.

We note here that EEM also includes a second BCR measure, BCR(G), defined as:

$$BCR(G) = \frac{\text{PV national economic benefits}}{\text{PV government (financial) costs}}$$

In this case, the denominator is to cover the financial costs to government rather than just the economic costs, so for road pricing schemes the net revenues to government from road tolls (and fares), relative to the 'base case', should be included. Based on the ARPES and ATAP evaluations of road pricing as a stand-alone scheme, this would result in the denominator of BCR(G) being negative in both studies.[48]

Of course, in any financial appraisal of road pricing schemes, any toll (and fare) payments need to be included from the perspectives of the parties paying or receiving them.

[48] The BCR(G) definition in EEM appears to be somewhat loosely worded. We are awaiting clarification from NZTA that the above interpretation is what is intended.

ECONOMIC EVALUATION RESULTS AND COMMENTS

Review of ATAP and ARPES component results

This section summarises the results of the economic evaluations of the road pricing schemes (on a 'stand-alone' basis) examined in the ATAP and ARPES work, and comments on key features of and issues with these results. Our assessment uses the evaluation results as given in the relevant study reports, showing them on as comparable a basis as possible between the two studies: no attempt has been made to adjust the reported values, so some anomalies and inconsistencies most likely occur.

The benefit and cost components from the two studies are presented in Table 3.1, leading to BCR(N) estimates in the bottom row of the table.

We first note the differing bases of the evaluations for the two studies:

- The ATAP evaluation was for a single (representative) year (2036), in 2015$.
- The ARPES evaluation was for 25 years, in 2006/07$ and using a 10% pa discount rate.[49]

From inspection of the table, some inconsistencies between the two studies are immediately apparent, the most significant being:

- ***Capital costs.*** These are not included for ATAP. While the ATAP evaluation is only for a single representative year, we would have expected that an annualised value of the capex would have been included.
- ***'Mode switcher' benefits.*** These are included explicitly (as a disbenefit) in the ATAP evaluation: for the ARPES evaluation, we expect they are included in the road user time benefits, but this is uncertain (their treatment is discussed in the relevant ARPES report – App 19).
- ***PT benefits.*** In this case, these are included explicitly in the ARPES evaluation, where they comprise the second largest benefit category, but are not included (or not separately identified) in the ATAP evaluation. The basis for estimation of these benefits in ARPES is not clear (the documentation simply says "*The PT benefits are derived from the outputs from the APT model*"), but the values involved seem surprisingly large.

In terms of total benefits, we note that time benefits to road users are the largest component of the economic benefits for both studies: this is what we would expect. The only other benefit components of much significance in the total are the mode switcher benefits (from ATAP) and the PT benefits (from ARPES)[50]. While the ARPES documentation discusses the application of 'resource cost corrections' (RCC) for VOC and PT fares, there appears to be no discussion in either study of any 'RCC' to adjust behavioural values of time to the 'equity' values specified in the current EEM: this may be a significant issue, depending on the values of time used in the ART/APT modelling process.[51]

[49] To put the two evaluations on a more comparable basis, the ATAP results would need to be multiplied by a factor *to convert from a single year figure in 2015$ to 25 year figures in 2006/07$ using a 10% discount rate.*

[50] The ATFP study also separated benefits in a similar manner to the categories in table 3.1, but gave only graphical presentation of these. This indicates that travel time savings were the dominant category (c 70% of the total), followed by 'congestion' (15-20%) and vehicle operating costs (c10%).

[51] This need for an adjustment is likely to be greater in future evaluations, if segmented time values are to be adopted for modelling following the ART 'Refresh' project.

Table 3.1: Summary of road pricing scheme economic evaluation results – ATAP and ARPES[(1)]

	ATAP			ARPES				
Item	**Annual benefits (2036), 6% discount rate, 2015$M**			**25 year benefits (from 2010), 10% discount rate, 2006/07$M**				
	CBD cordon	**Motorway**	**Full network**	**CBD cordon**		**CBD area**	**Strategic network**	**Parking**
				Single	**Double**			
Capital costs[(2)]	--	--	--	60	69	72	68	9
Operations costs	10	79	97	298	350	307	416	182
Total costs	10	79	97	359	419	379	483	191
Road user benefits - time	35	130	301	929	871	636	196	550
Road user benefits – VOC	0	1	15	-16	-67	-72	1	10
Mode switcher benefits[(3)] (tolled-off traffic)	-14	-26	-160	--	--	--	--	--
PT benefits[(4)]	--	--	--	331	423	303	140	198
Accident benefits[(5)]	--	--	--	--	--	--	--	--
CO_2 benefits[(6)]	--	--	--	12	18	15	10	5
Total benefits (excl toll revs)	21	104	156	1256	1226	867	337	758
Total revenues (tolls)	97	298	1146	709	911	902	638	502
BCR(N)	2.1	1.3	1.6	3.5	2.9	2.3	0.7	4.0

Notes:

(1) Further details given in Tables A3, B3.
(2) No capital costs included in ATAP evaluation (single year only).
(3) Unclear how (if at all) mode switcher benefits have been treated in ARPES evaluations.
(4) No accident benefits included in ATAP and ARPES evaluations.
(5) No CO_2 benefits included ATAP evaluation.

Review of economic 'value for money' BCR(N) results

In relation to the BCR(N) estimates in the bottom line of Table 3.1, we note the following:

- With the exception of the ARPES Parking option (not discussed further), the best estimate BCR(N) results are in the range 1.3 to 2.1 for the three ATAP options and 0.7 to 3.5 for the four ARPES options.
- Examining the results for the options that are broadly comparable across the two studies, the ATAP CBD cordon option has a BCR of 2.1, while the ARPES CBD cordon options have BCRs of 3.5 (single cordon) and 2.9 (double cordon). Also, the ATAP Motorway option has a BCR of 1.3, while the broadly-comparable ARPES Strategic Network option has a BCR of 0.7[52]. So there appears to be a reasonably consistent ranking of options in BCR terms between the two studies – the cordon options rank highest in each case and the motorway/strategic network options rank lowest.
- Comparing the BCR figures between the two studies, it is evident that ratios for the CBD cordon schemes tend to be higher for the ARPES schemes (3.5, 2.9) than for the ATAP scheme (2.1), but the ratios for the motorway/strategic network are lower for ARPES (0.7) than for ATAP (1.3). The reasons for this apparent lack of a consistent pattern of results between ATAP and ARPES evaluations are unclear.
- In this context, we note that ARPES has included sensitivity tests on BCR(N) values – based on a capital cost range of ± 25% about the 'base' estimate and a benefit range of -15%/+40%. The result of applying these ranges (high cost with low benefits, and vice versa) is that the BCR range is approximately -32%/+86% of the 'base' estimate (refer Appendix A, Table A3 for further details). In our view, these ranges probably under-state the 'true' degree of uncertainty in the BCR estimates at this stage of scheme development, particularly because of the potential uncertainties in the ART/APT model output results.
- We also note here that the ARPES work includes some 'first pass' estimates of the impacts on economic performance of adding selected 'mitigation' measures to the base pricing options. The resulting BCR(N) estimates were between about 10% and 50% lower than the base BCR figures (Table A4). However, the ARPES report (App 19) comments that: *"It is expected that the further refinement of the mitigation scope through an iterative process that determines the optimal package of mitigation works will produce BCR results that fall somewhere between the two tabulations set out above"* (ie the unmitigated and mitigated BCR estimates).

Comments on the value of travel time savings

The current ART model adopts a single (average) value of travel time savings for car users for estimating behavioural responses. A single value is also adopted for economic appraisal purposes: we expect that this is the same value is used in the behavioural modelling, although this is not clear from the available documentation.

With the model enhancements being undertaken as part of the Auckland Transport Models 'Refresh' work, the model value of time for car users will be segmented, based on willingness to pay surveys. We assume that these new segmented values will be carried through to the appraisal stage, as EEM specifies that, for evaluating tolling policies, a consistent distribution of values of travel time must be used in both the traffic model and economic appraisal stages of project evaluation" (refer table E1).
Assuming this approach is to be adopted for future road pricing appraisals in Auckland, this should result in substantial increases in the level of benefits that have been reported in studies to date (e.g. as in table 3.1).

Comments on toll revenues

As noted earlier, the toll charges (revenues) are not directly included in the BCR(N) evaluations, although the economic benefits included in BCR(N) are all effectively 'driven' by the imposition of the tolls.
One important feature highlighted through Table 3.1 is that the magnitude of the toll revenues in ATAP exceeds the total economic benefits (ie excluding tolls) by factors of between 2.9 and 7.3 in the three options; while in the ARPES options the toll revenues are between 56% and 189% of the total economic benefits. (It

[52] the ATFP motorway charging options also have broadly similar BCR results, in the range 1.3 to 1.9.

is unclear why these ratios vary so much between the two studies and the various options – this would appear to warrant further investigation).

In all the ATAP options and most of the ARPES options, the toll revenues exceed the monetary values of other user benefits (time, VOC, etc), in the ATAP options by large margins. Thus it would be expected that road system users would consider themselves worse off as a result of tolling policies. This will inevitably influence public/road user attitudes towards such policies, if implemented on a 'stand-alone' basis.
All the foregoing discussion on the economic evaluation results and in particular the BCR(N) estimates is on the assumption that the toll revenues are, in effect, 'banked' by the public authorities (central or regional government authorities).

In such a case, the road pricing schemes may be regarded as 'just another tax on motorists', from which the motorists themselves would gain limited benefits.

This highlights the risks in wide public airing of 'stand-alone' road pricing options; and the importance of putting forward 'packages' of complementary policy measures (which may, but would not necessarily, involve expenditure on transport system improvements), outlining how the toll revenue is to be used.

CONCLUSIONS AND WAY FORWARD

The following proposals to further assess and where appropriate, enhance current/recent methods for the economic evaluation of road pricing schemes in the Auckland context are put forward on the basis that: (i) enhanced evaluation of schemes previously evaluated or alternative schemes will be required in the short/medium term; and (ii) much can be learned from more detailed review of some aspects of the modelling and evaluation work done to date, particularly for ATAP and ARPES, which could then provide a 'blueprint' (which could be progressively enhanced) as the starting point for subsequent evaluations.

On this basis, we suggest a 3-pronged work plan:

(A) Document and review the ATAP road pricing evaluation work in more detail, with a view to identifying areas of deficiency and potential enhancements to demand modelling and evaluation methods focused on road pricing evaluation requirements.

(B) In close liaison with the current Auckland Transport Models Refresh project, for the potential model-related enhancements focusing on road pricing evaluations, identity: (i) the extent and nature of current modelling weaknesses; (ii) the feasibility of enhancements to address these weaknesses; (iii) whether such enhancements are already included in the current 'Refresh' project; and (iv) where not already included, the specification of and priority for further work to implement the enhancements.

(C) For those economic evaluation deficiencies identified in (A), through a small working group (or otherwise): (i) secure agreement on methodology enhancements; (ii) determine priorities, personnel requirements and extent of work required; (iii) implement work plan progressively through agency staff and/or consultants; and (iv) ensure that all enhancements made are fully documented, through updating of the 'blueprint' suggested above.

Based on our work to date on this assignment, plus wider knowledge from our previous work, Table 4.1 presents a summary of what we see as higher priority work areas relating to items (B) and (C) above.

Table 4.1: Enhancements to economic evaluation methods for road pricing schemes – potential work areas

Item		**Comments**
(B)	**Travel Demand Modelling Aspects**	
B.1	Segmentation of car traveller market by values of time	• Understand included in current ART Refresh programme (refer section 2.1). • Based on EEM requirements for tolling policies (table E1), assumed that the segmented behavioural values of time will also be applied directly in the economic appraisal stage.
B.2	Value of time adjustments for congested/unreliable conditions	• Need for quick review of how ART modelling values of time should reflect congested conditions and/or unreliable travel times. • Would be helpful to agree standard procedures to relate any uplift in standard model values to V/C ratio or similar measure (if not already available).
B.3	Suitability of current ART speed/flow functions (links and intersections) for assessing road user benefits from road pricing schemes.	• Not clear (warrants further investigation) as to how well the current ART modelling can reflect travel time savings in hyper-congested conditions (refer section 2.1). • Depending on this investigation, enhancement of ART speed/flow functions may be high priority (but may be particularly challenging).
B.4	Modelling of road user behavioural responses to changes in generalised costs of travel.	• This is an important factor in determining impacts of road pricing policies on road traffic volumes, changes in time of travel, trip frequency, time shifting, mode-shifting, etc. • Suggest a short review of ART model assumptions on these aspects, including a review of international evidence/best practice as required.
B.5	Extent to which ART model tends to under-estimate benefits for major projects (relative to project- specific models) and implications for road pricing evaluations.	• We understand that previous Auckland studies for major infrastructure projects have indicated use of ART typically results in much lower economic benefit estimates than obtained with project-specific models (refer section 2.1). • Task would review evidence on this issue (in discussion with those involved in previous evaluations), attempt to identify scale of issue and underlying reasons, and whether/to what extent it is likely to arise for road pricing evaluations. • Further work (involving ART refinements?) may subsequently be needed to overcome the problem.
Item		**Comments**
(C)	**Economic evaluation aspects**	
C.1	Application of travel time values for evaluation purposes	• Refer item B1 above. • We note that the use of behavioural values also for evaluation purposes (as required in EEM for tolling policies) appears inconsistent with the EEM requirement to use ‘Equity’ values for other (non-tolling) projects. This will give rise to issues of comparability between the different project types (to be addressed by NZTA?).

C.2	Application of 'resource cost corrections'	• In deriving user benefits for evaluation purposes from ART model outputs, 'resource cost corrections' should generally be applied for any differences between unit parameter values in the ART model (behavioural values) and for evaluation purposes (economic values, excluding any financial transfers and any taxes). • Our impression, from the information available, is that RCCs have not been applied correctly and consistently in at least some of the previous road pricing evaluations. We suggest that clear guidance for evaluators on this aspect would be helpful.
C.3	Length of analysis period	• While the 'standard' project analysis period in EEM is specified as 40 years, EEM states that *"The period of analysis may be less than the standard 40 years if it can be demonstrated that this is appropriate*" (refer section 2.2). • Our (provisional) view is that, for road pricing schemes, the analysis period should be significantly less than 40 years (maybe in the order of 10 years), as such a period would better reflect the life of the main assets involved. • We suggest this issue be further explored with NZTA with a view to determining the most appropriate policy for such schemes.
C.4	Agglomeration benefits	• Further explore the application of agglomeration benefits to road pricing schemes, with a view to establishing a generally-accepted but short-cut methodology that could be applied to all such schemes.

SUB-APPENDIX A: ARPES –APPRAISAL OF ECONOMIC EVALUATION METHODOLOGY AND RESULTS

A1. Introduction

ARPES includes the economic evaluation of five road pricing schemes, known as: single cordon, double cordon, area, strategic network, and parking. Details are provided in the ARPES reports – in particular the Final Report Appendix 19 (doc. D19), which has been used as the basis for much of the following material, and the Peer Review – Final Report (doc. G2).

The focus of this appendix is on examining the economic evaluation methodology used in ARPES, highlighting key issues and presenting and commenting on the CBA results.

A2. Inputs and Assumptions - Summary

The economic evaluation work undertaken involved assessing the economic costs and benefits for each of the five RP options against the base case. For all five options, charges were assumed to apply over a weekday 4-hour AM peak period (0600-1000). For each option two sets of CBA results are presented:

- Without mitigation works
- With mitigation works. The specific works mainly involved improvements to and extra capacity on the PT services: it is noted that the assumed works *"are likely to be at the upper end of the likely cost stream".*

Table A1 provides a summary of key inputs and assumptions.

A3. Basis of benefit : cost calculations

Table A2 sets out the benefit and cost components used in the ARPES economic evaluation, and shows how these have been brought together in two economic/financial performance measures:

• BCR(N)	This is the economic benefit: cost ratio, from the national economic perspective (as specified in EEM section 2.8). Note that this excludes toll revenues (which are a transfer payment rather than an economic cost) from both the numerator and denominator.
• Rev/Cost	This is a measure of financial performance, being the ratio between the total toll revenues (RT) and the financial costs for the scheme (CT). This is a purely financial ratio, so does not include the traveller benefit items (B1 to B5).

We note that the BCR(N) derivation is consistent in form with the basis for calculating BCR(N) in EEM.

Table A1: ARPES economic valuation of pricing options – key inputs and assumptions

Item	Inputs, assumptions	Specific comments
Scheme pricing		
Pricing period	• Weekdays, 0600 – 1000	
Price levels	• No clear basis defined	
Travel demand basis		
Traffic modelling basis	• Based on RART strategic model	• RART said to be "a suitable tool for the modelling of the road pricing schemes at the broad analytical level used in the study" – but model not validated to meet EEM modelling and evaluation requirements.
Model runs	• Focus on AM peak, years 2026/ 36/46	• Noted that scheme would have only minor impacts in interpeak period, so these have been ignored. Factor 1.5 assumed to convert AM peak benefits to daily benefits (PM peak modelling gave unsatisfactory results).
Road user responses to pricing schemes	• Model uses variable demand matrices to estimate changes in travel behaviour and benefits – stated that the pricing scheme will shift some travellers from car to PT and active modes, but no details (eg on cross-elasticities) are given in ARPES documents.	• Lack of detail in ARPES documentation. Unclear how peak spreading and switching of travel time from peak to off-peak periods has been modelled/ evaluated.
User benefit estimates		
Road traffic unit time savings	• Taken from RART model outputs.	• No information on values used.
PT traveller unit benefits	• Taken from RART model outputs.	• Method appears sound. No information on values used - assume account for components of GC change.
Vehicle road traffic unit operating costs	• Behavioural unit costs from RART model. • Adjustments made (RCC) for evaluation to cover additional variable cost components.	• Method appears sound in principle, but need to get further information to review detail (? adjustment for fuel tax?)
Mode switcher unit benefits	• Rule of-half applied: unit benefits = 0.5* (GC change for prior mode + GC change for new mode).	• Method appears sound.
Road traffic congestion and reliability benefits	• Calculated as 20% additional to vehicle time benefits.	• Based on experience in evaluating other NZ urban transport projects – seems plausible.
Accident benefits	• Taken as zero (App 19, p.6).	• Noted that unclear whether accident costs will increase or decrease (higher speeds, but lower traffic volumes). • App 19, s.7 suggests accident benefits included, but shown at zero in evaluation tables.
Carbon emissions	• Valued at $30/tonne, as per EEM.	• Basis of tonnes CO_2 change not reviewed.
Agglomeration benefits	• No mention	• Consider in context of further work.
Capex/opex costs		
Scheme capital costs	• Taken from Final Scheme Design Report, stated as accurate to ±25%.	• Included allowance for equipment replacement costs over economic analysis period.

Scheme operational costs	• Taken from Final Scheme Design Report.	•
PT infrastructure costs	• Allowance included (eg additional bus lanes).	•
PT operating costs	• Output from APT model. • Taken net operating costs (after deduction of farebox revenue).	• Need to review use of net v gross costs here (revenue is transfer payment).
Mitigation costs	• For the 'mitigation' options, an allowance included with scheme capital costs to provide for the increased PT services to accommodate the anticipated mode shift.	• Mitigation cost allowance probably on the high side (including components that give very low benefits) – need to review this aspect in subsequent work.
Pricing revenue		
Toll revenues	• Unit toll charges input to RART; total revenues generated in 4-hour charge period output from model.	• GST included/excluded??
Violation revenues	• Allowance made for violation revenues collected through enforcement.	• Small amount – basis not clear?
Economic evaluation parameters		
Project timing and evaluation life	• Project construction 2010/11, commence operation 2011.	•
	• Analysis period 25 years from start date.	• Consistent with (then) PEM. • Need to review in future work, given the effective li than review fe of many road pricing assets is much shorter than 25 years.
Price basis	• All financial items in $2006/07. • 2006/07 taken as base year for discounting.	•
Discount rate	• Rate 10%pa (real).	• As recommended in (then) PEM.
Other items		
Annualisation factors	• Benefit factor weekday AM peak (4-hr) to weekday total = 1.5.	• Plausible, but worth further exploration in any additional work.
	• Benefit factor weekday to annual.	• Assume factor 250 used (but not identified?)
Sensitivity tests	• In assessing potential BCR savings, have used: - Capex ± 25% - Benefits +40%, -15%.	• Probably plausible at this stage in the studies. However, benefit range should probably be wider, particularly given the RART modelling uncertainties.

As Table A2: ARPES BCR components and calculations

Cost and benefit items		Notes
C1	Capital costs	
C2	Operational costs	
CT	Total costs	C1 + C2
B1	Travel time benefit	Includes congestion and reliability benefits.
B2	Vehicle op benefit	
B3	Resource cost corrections	
B4	PT user benefits	

B5	CO_2 benefit	
BT	Total benefits	B1 + B2 + B3 + B4 + B5
RT	Total revenues	From toll charges etc
BCR(N)	Benefit: cost ratio	BT/CT. Economic basis (excludes revenues). Consistent with EEM BCR(N).
Rev/Cost	Financial revenue: cost ratio	RT/CT

A4. CBA results and interpretation

The ARPES CBA results are presented in Table A3 (excluding mitigation measures) and Table A4 (showing the impacts of mitigation measures on the economic and financial results).

As noted in the previous section, the BCR estimates appear to be consistent with the BCR(N) definition in EEM.

We provide comments on some of the key features of these results as follows:

'Base' pricing options (Table A3).

- On the cost side, the dominant component is the scheme operational (recurrent) costs, which (except in the parking option) are in the order of five times the scheme capital costs.
- On the benefits side, the dominant components are the road user travel time benefits (which account for around 75% of total economic benefits (ie before considering toll payments), followed by PT user and operator benefits, principally relating to faster travel times (accounting for c. 25% of total economic benefits).
- The total toll payments (revenue) are of similar order-of-magnitude to the road user travel time etc benefits, except for the Strategic Network option, where they are much larger than the travel time benefits. Except in this option, this indicates that the travel time savings to road users are more-or-less offset by the toll payments. Thus, on average, net benefits to individual road users will be small (positive or negative) – which is not inconsistent with the rather luke-warm public support quite commonly received for road pricing schemes.
- From a national economic viewpoint, excluding the revenue component (a transfer between transport users and the public sector), the options perform quite well in BCR(N) terms, with best estimate BCR values for four of the five options in the range 2.3 – 4.0 (the exception being the Strategic Network option). It should be noted here that, of the total economic benefits of the schemes (eg $1,256M PV for the single cordon option), the majority ($709M PV in this case) goes to the public sector in the form of revenue, with only a minority going to transport system users: in this case, the schemes could be regarded as a targeted and reasonably effective way of increasing taxes on motorised road users (in such a way as to enhance transport system efficiency from the economic viewpoint).
- The BCR(N) ranges in Table A3 include a relatively wide range of uncertainty about the economic performance of the options (these ranges are based on the sensitivity ranges specified in the last item in Table A1). As noted in Table A1, in our view there would be a case at this stage of project development for perhaps widening these ranges somewhat.

Mitigation pricing options (Table A4)

- Compared with the 'base' options (Table A3), these options involve additional costs of around $300-400M PV (except for the Parking option, with much lower costs), and incremental benefits of around $300M PV (apart from the Strategic Network option, with much lower incremental benefits).

Table A3: ARPES economic evaluation results for 'base' pricing options

NPV ($M)	Single	Double	Area	Strategic	Parking
Capital Costs	60.	69.	71.	67.	8.
Operation Costs	298.	349.	307.	415.	182.
Total Costs	**358.6**	**418.9**	**378.8**	**483.4**	**191.3**

Travel Time Benefits (incl. congestion & reliability)	929.1	870.7	635.7	195.5	549.7
Vehicle Operating Benefits	-9.9	-40.4	-43.1	0.6	5.8
Resource Cost Correction VOC	-6.6	-26.9	-28.8	0.4	3.9
Accident Benefits	0.0	0.0	0.0	0.0	0.0
PT Benefits	331.3	422.7	303.0	140.1	198.4
CO2 Benefits	11.8	18.2	15.2	9.9	5.1
Total Benefits	**1255.7**	**1226.1**	**866.8**	**336.7**	**757.9**
Total Revenues	**708.5**	**910.5**	**902.1**	**638.3**	**501.8**
BCR	**3.5 (2.4 - 6.5)**	**2.9 (2 - 5.5)**	**2.3 (1.6 - 4.3)**	**0.7 (0.5 - 1.3)**	**4.0 (2.7 - 7.4)**
Revenues/Costs	2.0 (1.2 -	2.2 (1.3 -	2.4 (1.4 -	1.3 (0.8 -	2.6 (1.6 -

Source: ARPES Final Report, Appendix 19.

Table A4: ARPES economic evaluation results for pricing options including mitigation measures

NPV ($M)	Single	Double	Area	Strategic	Parking
Capital Mitigation	67.	103.	93.	154.	44.
Operation Mitigation	357.	318.	228.	222.7	31.
Total Cost incl Mitigation	**784.1**	**840.7**	**701.5**	**860.3**	**267.3**
Resource Cost Correction PT Fares	190.6	328.2	251.4	58.7	189.5
Total Benefits including RCC PTFares	**1446.4**	**1554.4**	**1118.2**	**395.4**	**947.4**
BCR including Mitigation	**1.8 (1.3 - 3.4)**	**1.8 (1.3 - 3.5)**	**1.6 (1.1 - 3)**	**0.5 (0.3 - 0.9)**	**3.5 (2.4 - 6.6)**
Revenues/Costs including Mitigation	0.9 (0.5 -	1.1 (0.6 -	1.3 (0.8 -	0.7 (0.4 -	1.9 (1.1 -

Source: ARPES Final Report, Appendix 19.

- Consequently, the BCR(N) ratios for these 'mitigation' options are quite considerably lower than those for the base options, but still above 1.5 in all cases except for the Strategic Network option.
- However, only very limited work has so far been undertaken on the mitigation options and therefore the Table A4 results should be treated with considerable caution. As noted in the ARPES papers (Final Report, Appendix D19):

"It is recognised that the mitigation works assumed are likely to be at the upper end of the likely cost stream. It is expected that there will be some rationalisation of the mitigation works in the refinement of the schemes with elements that produce the maximum benefits included and those that produce little benefit at large implementation or operating costs possible being excluded.

These BCR estimates are therefore expected to be conservative compared to an assessment that re-evaluated the mitigation works to reduce the scale and increase the effectiveness of the mitigation works."

The mitigation results (Table A4) are likely to "under-estimate the BCR as the costs of mitigation works include other components (such as integrated ticketing) that are not necessary for the projects and provide little benefit, but substantial cost. It is expected that the further refinement of the mitigation scope through an iterative process that determines the optimal package of mitigation works will produce BCR results that fall somewhere between the two tabulations set out above."

SUB-APPENDIX B: ATAP – APPRAISAL OF ECONOMIC EVALUATION METHODOLOGY AND RESULTS

B1. Introduction

The ATAP study included the economic evaluation of three representative road pricing options, focused on demand management:

- A CBD cordon scheme, similar to the option modelled in the ARPES Evaluation Study (2006).
- A motorway network charge, similar to the option modelled by Auckland Council during the ATFP work.[53]
- A comprehensive network charge applying to all journeys across the network.

The focus of this appendix is in summarising the economic evaluation methodology used in ATAP, highlighting the key issues and presenting a commentary on the CBA results. The material in this appendix is largely drawn from the following documents:

- ATAP Pricing Workstream Report – First Round Assessment. Paper by John Williamson, June 2006.
- ATAP Demand Management Pricing Report – Evaluation of Three Representative Options (nd) [Q4].
- ATAP Economic Evaluation – Approach and Assumptions. Paper by Richard Paling, Sept 2016.
- Review of ATAP Methodology and Evidence: Advice from the Independent Advisor. AECOM, Sept 2016 [Q9].

We note that ATAP is the most recent of the various studies undertaken into road pricing for Auckland: it would thus be expected that the assessment methodologies used in ATAP would build on and would generally be superior to/more robust than those applied in the previous Auckland road pricing studies.

B2. Inputs and Assumptions - Summary

B2.1 Options examined

The road pricing economic evaluation work reviewed here is that involving the estimation of the economic costs and benefits of the three options on a ‘stand-alone’ basis (ie with no other transport system changes) against the APTN base case. No examination of ‘mitigation’ add-ons to the pricing options appears to have been undertaken (unlike the ARPES work).

The papers available refer to these evaluations as ‘first round’ ATAP assessments, but it appears that no further evaluations of the pricing options on a stand-alone basis were undertaken.

B2.2 Summary of inputs and assumptions

The key inputs and assumptions to the demand modelling and economic evaluation of the three ATAP pricing options were generally similar (or identical) to those used in the ARPES work (refer table A1), so are not covered in detail here. Again, as in ARPES, the economic inputs (unit parameter values, etc) adopted were consistent with the EEM specifications and values (as far as we have been able to check).

B3. Basis of Benefit: Cost Calculations

Table B1 sets out the benefit and cost components included in the ATAP economic evaluation and shows how these have been brought together in two economic/financial performance measures:

- BCR(N).
- Rev/Cost.

This basis is consistent with that used in the ARPES evaluation, except that the benefit items have been grouped rather differently (refer Appendix A, Table A2) for definitions of the performance measures and further comments.

[53] Subsequent to this assessment an alternative distance-based motorway charge was also assessed: that assessment tended to confirm the conclusions reached in the assessment of the motorway network charge option.

Table B1: ATAP ALL BCR components and calculations

Cost and benefit items		Notes
C1	Capital costs	Not included
C2	Operational costs	
CT	Total costs	C1 + C2
B1	Travel time benefit	Includes congestion and reliability benefits(?)
B2	Vehicle op benefit	
B3	Disbenefits to 'tolled off' motorists	
B5	CO_2 benefits	
BT	Total benefits	B1 + B2 + B3 + B5
RT	Total revenues	From toll charges etc
BCR(N)	Benefit: cost ratio	BT/CT. Economic basis (excludes revenues). Consistent with EEM BCR(N).
Rev/Cost	Financial revenue: cost ratio	RT/CT

B4. CBA Results and interpretation

The ATAP CBR results for the three road pricing options are presented in Table B2.

The two performance ratios outlined earlier (BCR(N) and Rev/Cost ratio) are provided as the last entries in the table. We understand that the economic parameter values applied in this evaluation are generally consistent with EEM values, and that the evaluation methodology, including the BCR(N) formulation, is consistent with that specified in EEM.

We note the following points, which appear to detract from the comprehensiveness of the evaluation results:

- The evaluations cover a single year only (2036), rather than the evaluation period usually adopted for major transport projects (generally 40 years in EEM, although it may be argued that this is excessive for a project of this nature, for which the technology may well be obsolescent within a period of c. 10 years).
- Related to the above point, no capex is included in the evaluations. In the case of a single year evaluation such as this, we suggest it would be more appropriate to include an average annualised capital charge in addition to the opex costs.
- It is unclear whether any allowance has been included (within the user benefits – time savings category) for increases in the 'standard' value of time to allow for congestion and reliability effects (such an allowance is included in the ARPES road pricing evaluations – refer Appendix A).
- No safety benefits have been included.

Table B2: ATAP economic evaluation results for pricing options (Annual costs and benefits, 2036 in 2015$M)

	Item	CBD cordon	Motorway	Network
C1	Capital costs	Not included ⟵		⟶
C2	Operations costs	10	79	97
CT	Total costs	10	79	97
B1	User benefit – time savings	35.3	129.8	301.5
B2	User benefit – VOC savings	0	0.9	14.7
B3	Dis-benefit from 'tolled-off' trips	-14.3	-26.4	-160.3
BT	Net user benefits (excl toll payments)	21.0	104.4	156.0
RT	Total revenues	97.0	297.9	1146.2
	Total user impact (incl charges)(BT-RT)	-76.1	-193.5	-990.3

	Economic surplus after Opex (RT-CO)	11	25	59
BCR(N)	Benefit : cost ratio (2036 annual basis)	2.1	1.3	1.6
Rev:Cost	Financial revenue: Opex ratio (annual basis)	9.7	3.8	11.8

Note: Figures in this table are taken from the ATAP Pricing Workstream Report (Williamson) and the ATAP Demand Management Pricing Report. A spreadsheet provided by Paling ('Analysis of Benefits of Charging Options from First Round Appraisal') gives somewhat different and higher unit benefit figures and consequently higher BCR estimates (2.8, 2.3, 3.6): it appears to omit the disbenefits to 'tolled-off' travellers.

- It is unclear whether/where the evaluation has included resource cost corrections (for both VOC and PT fares).
- Global environmental (CO_2) costs have not been included.
- Agglomeration benefits/disbenefits have not been included.

It is unclear whether re-working of the evaluations to take account of the above comments would result in significant increases or decreases in the BCR(N) and Rev/Cost ratio performance indicators.

Based on the estimates given in Table B2, in broad terms the evaluation results are not very different from those for the ARPES work (Table A3), so reference should be made to section A4 for a discussion of these. However, it is notable that the ATAP results indicate that revenues are an order-of-magnitude greater than the net economic (ie excluding revenue) benefits, exceeding benefits by factors of between 2.8 (Motorway option) and 7.3 (Network option) – whereas for the ARPES evaluation these ratios are between 0.56 and 1.89.

These relatively large ratios for revenue payments: other (economic) benefits in ATAP suggest that public/driver reaction to the RP schemes may be very negative: road user time savings resulting from the scheme will be valued at only quite small proportions of the charges paid, ie people individually will feel significantly worse off (in generalised cost terms).

This large difference between the ATAP and ARPES evaluations is of some concern – the factors behind these differences are unclear (and would require detailed appraisal of the traffic modelling aspects if clarification were to be sought).

SUB-APPENDIX C: ARPS – APPRAISAL OF ECONOMIC EVALUATION METHODOLOGY AND RESULTS

The Auckland Road Pricing Study (ARPS – MoT, 2008) was essentially an 'add-on' to the ARPES 2006 work, in particular involving further research into some of the major issues emerging from the public submissions on the 2006 study.

ARPS did not involve any additional work on economic (welfare) evaluation of the road pricing options under further consideration in the study. It did however involve additional work on:

- Economic impact assessment -- focusing on the impacts on the business sector arising from traffic congestion and the potential effects of tw all this o hypothetical road pricing schemes (a 'revenue' scheme and a 'congestion' scheme).
- Financial modelling -- estimating the financial impacts (capex. opex and revenues) of the two hypothetical schemes (some of the financial modelling figures would also be relevant to any economic appraisal).

Given the above, nothing can be learned from the ARPS work relating to the economic appraisal of potential road pricing schemes for Auckland.

SUB-APPENDIX D: ATFP – APPRAISAL OF ECONOMIC EVALUATION METHODOLOGY AND RESULTS

D1. Introduction and scope

The Alternative Transport Funding Project (ATFP) was undertaken by an Independent Advisory Body on behalf of Auckland Council/Auckland Transport in 2014.

Inputs to the project included a paper on the "Economic Impact of Funding Pathways" (Ascari Partners, Oct 2014). That paper focused on an economic welfare appraisal of two motorway charging (road pricing) options for Auckland, primarily as a means of raising funds for transport investment in the region. The two options both involved set charges for use of the motorway network, which were distinguished by the base level of charge and the time periods over which the charges would apply. These options were appraised relative to a 'baseline' option of raising additional funds through combinations of increases in fuel excise and/or targeted regional rates.

The appraisal was intended to be consistent with NZTA's EEM procedures, resulting in estimation of key performance indicators for the benefit: cost ratio (BCR) and net present value (NPV). Two BCR measures were outlined:

- BCR(N) – benefit: cost performance from the national economic perspective ('unleveraged' ratio)
- BCR(G) -- benefit: cost performance from the government funding perspective ('leveraged' ratio).

The economic benefit components in the appraisal were the changes (relative to a baseline) in:

- Travel time -- private vehicle users and PT passengers
- Travel time reliability -- private vehicle users and PT passengers
- Vehicle operating costs
- Accident costs
- Emission levels from road traffic
- Productivity improvements resulting from improved accessibility.

The report notes that results for the productivity/accessibility (agglomeration) benefits are to be treated with considerable caution, as the EEM agglomeration methodology is intended for use in the assessment of specific projects and was not designed to assess the effects of major policy changes such as direct road use charging.

Outputs from the ART3 model were used, for three modelling years – 2021, 2031, 2041[54]. A 60 year evaluation period was adopted, to allow inclusion of benefits from projects implemented towards the end of the 30 year Auckland Plan period.

Economic appraisals were carried out for two sets of options:

- Initial funding pathways -- evaluated five options for motorway charging, which also included some component of fuel excise and rate increases, relative to a 'do minimum'/baseline case.
- Revised funding pathways -- evaluated two motorway charging options (as noted above) relative to a 'do minimum' case of raising funds through 'existing tools' (a combination of fuel excise and rates increases).

The remainder of this summary relates to the results for the Revised funding pathway options only.

D2. Economic appraisal results and comments

[54] The report notes that *"ART…… Is not able to accurately represent delay at the local level, for example at intersections. For this purpose a local traffic model is generally used to derive project benefits. As a consequence, the ART model may under- estimate the benefits of localised congestion relief from projects."*

Table D1 provides a summary of results, in terms of BCR(N) and NPV, for the primary economic appraisals of the Revised Pathways options:

- The top part of the table provides appraisal results for the two motorway charging options (labelled MC1 and MC2) and a PED option, which is based on the benefits of increased expenditure through increases in fuel taxes and household rates: these options were appraised relative to the 'base' expenditure levels and associated projects included in the Auckland Plan
- The lower part of the table then compares options MC1 and MC2, in this case as increments to the PED option.

Key features of these results are as follows:

Options MC1, MC2 and PED

- Both MC options have BCR results of around 1.7 (excluding WEBs) or 1.8 to 1.9 (including WEBs), on total costs of $800M to $900M (PV)
- While the PED option shows a very high BCR (relative to the do minimum baseline), this relates to a very low cost ($18M PV): the benefits of this option are only a small proportion (c 15% - 30%) of the benefits for the two MC options.

Options MC1 vs MC2

- Both MC options have incremental BCRs (incremental to the PED option) of around 1.4 (excluding WEBs) or 1.3 (including WEBs).
- Relative to MC1, option MC2 has incremental BCRs of about 1.1 (excluding WEBs) or 0.9 (including WEBs). However the differences between the two motorway charging options in terms of their total costs and total benefits are relatively small.

D3. Conclusions

The report's 'Summary of findings' from the appraisal are set out as follows (quoted in abbreviated form):

- *"All scenarios generate positive economic benefits compared to the 'do minimum' (Auckland Plan network), by improving the operation of the transport network, reducing travel times and overall congestion.*
- *The two motorway charging pathways generate significantly higher economic benefits than the existing tools pathway, reflecting the significant effect of direct charging on people's travel choices. The charging options therefore lead to significantly greater improvements in travel times, congestion, vehicle operating costs and emissions compared to the existing tools pathway.*
- *Overall the economic analysis confirms that either of the motorway charging pathways is preferred over the existing tools pathway option. The difference between the two motorway charging pathways is too small to make a definitive judgement on from an economic perspective."*

We concur with these findings, on the assumption that the appraisal methodology and its inputs are sound.

The report methodology and the key inputs used are generally well documented. As far as we can tell from the material presented, the methodology appears to be consistent with that used in the earlier ARPES work. However, it has not been possible to trace through all steps of the analysis in detail, including in particular the ART demand modelling aspects (the model formulation, its inputs and its outputs).

Table D1: ATFP Economic Appraisal Results for Revised Pathways
60 year evaluation period, 6%pa discount rate, all figures in $M PV terms

Item	Option MC1	Option MC2	Option PED
Results relative to 'Do minimum'			
PV benefits – excl WEBs	1418	1500	265
PV benefits - WEBs	159	142	244

PV benefits -- total	1577	1642	509
PV costs	833	907	18
BCR – excl WEBs	1.70	1.65	14.7
BCR – iincl WEBs	1.89	1.81	28.3
	Option MC1	**Option MC2**	**MC2 – MC1**
Results incremental to PED option			
PV benefits – excl WEBs	1153	1235	82
PV benefits - WEBs	-85	-102	-17
PV benefits -- total	1068	1133	65
PV costs	815	889	74
BCR – excl WEBs	1.41	1.39	1.11
BCR – iincl WEBs	1.31	1.27	0.88

SUB-APPENDIX E: EEM KEY FEATURES RELEVANT TO URBAN TRANSPORT PROJECT EVALUATION

Table E1: EEM key features relevant to urban transport project evaluation

Ref	Item	Notes
Key economic parameters		
2.5	Discount rate	6% pa (real terms)
2.6	Analysis period	40 years (standard, including implementation period); may be less if appropriate
Key 'value for money' performance measures		
2.8	Key performance measures	BCR(N) = PV national economic benefits/PV national economic costs – measure of value for money (economic efficiency) from the national economic perspective. BCR(G) = PV national economic benefits/PV government (financial) costs - measure of value for money (economic efficiency) from government expenditure perspective
4.7.3	Treatment of travel time in demand modelling and economic evaluation	EEM states that: *"Evaluation of toll roads (including tolling policies) must use a distribution of values of travel time consistent with users' willingness to pay (WTP) values established through SP surveys or other means, a consistent distribution of values of travel time must be used in both the traffic modelling and economic efficiency evaluation."*
Benefit categories		
A4	Travel time ('base') benefits	Relates to in-vehicle values of time in 'standard' conditions
Road traffic 'base' time adjustments		
A4.4	Congestion	
A4.5	TT reliability	
PT travel 'base' time adjustments		
A18.2	Timetable reliability	
A18.4	Service frequency	
A18.5	Vehicle transfer	
A18.6	Seat availability & crowding	
A18.6	Mode specific values	
A18.7	Vehicle & stop/station quality	
A5	Vehicle operating costs	
A6	Crash (accident) costs	
A8	External (local envt) impacts	Includes valuations for traffic noise
A9	Vehicle emissions (local, global)	Includes valuations for particulate and CO_2 emissions
Wider economic benefits		
A10.3/4	Agglomeration economies	
A10.5	Imperfect competition	
A10.6	Increased labour supply	
A10.7	National strategic factors	
A10.8	Security of access	
A10.9	Investment option values	