Road User Charges Review Group

Hyder

Road User Charges Review:

Expert Technological Advice

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1 EXECUTIVE SUMMARY

The New Zealand road user charges (RUC) system has been operating pursuant to the Road User Charges Act 1977 since March 1st 1978. In 2008 the Minister of Transport announced a review of the system. This report focuses on the possible application of technology to NZ RUC comparing current and future international technology based systems.

The NZ roading network consists of over 90 000kms of roads with a population of 4.5 million people, around 100 000 heavy vehicles paying RUC operated by around 30 000 transport operators who are policed by a dedicated enforcement group of 100. There is a single legal jurisdiction and no international road traffic passing through New Zealand borders. Around 30 000 NZ vehicles are currently fitted with some form of GNSS (global navigation satellite system) fleet tracking systems, this number is increasing by around 500 monthly. These facts set New Zealand apart from direct application of the European charging and enforcement models.

The current RUC system collects $876.5 million per annum and is prone to evasion generally estimated at between $40 million and $100 million, possibly as high as $200 million per annum. The net present value cost to society of ongoing RUC evasion in the order of $40–$100 million annually, could conceivably be in the range of $450 million to $4.5 billion, dependent on the value of the future cut-off benefit-cost ratio (BCR) in the transport sector.

Based on international experience of technology based RUC systems, a reduction in evasion by as much as $80 million per annum (below 2% evasion) might be achievable. Dependent on the future value of cut-off BCRs in the transport sector, this might correspond to a willingness to pay of over $600 million in present value terms, to fund a technology based initiative over 30 years. These figures are justified in section 4 of the report, “economic cost of non compliance”.

Technology is simply an enabler of business requirements. When considering technology based solutions, wider business drivers and other Government drivers (apart from RUC) will add significant value to any proposed technology solution.

This report outlines how the cooperative and integrated use of “best of breed” technology might also be applied to simplify the RUC user experience, lower the cost of compliance and minimise evasion benefiting the transport industry, Government agencies and ultimately New Zealand.

If GNSS (global navigation satellite systems) based solution is considered, this should include augmentation with electronic wheel revolution and movement sensor information, along with strong physical and electronic security and strategically placed fixed automated audit sites to mitigate the risk of evasion.

Consideration should also be given to ensuring that any potential technological solution provides a simple, continuously available, yet effective end user experience (drivers and transport operators). Consideration of business drivers, minimising the administrative and compliance costs, integrating other current and potential uses for the same technology, and the various purposes that the data output may be applied to, would maximise system efficiency and minimise overall costs.

It is noted that a partially implemented technology solution is unlikely to satisfactorily achieve all these objectives. However voluntary uptake of a complete, well architected secure technology based system that is largely automated, simple and effective to use, may be a suitable way forward in providing long term benefits to all stakeholders.

2 BACKGROUND TO RUC REVIEW

Following an increase in Road User Charges in 2008, the Road Transport Forum protested and organised a national "convoy" on July 4^{th} 2008. The Motor Industry Association publicly supported the Road Transport Forum's request for a review of the RUC system noting that light diesel vehicles support the Government's objective to reduce CO_2 emissions. Perry Kerr, CEO of The Motor Industry Association, commented that "Road User Charges are a legitimate and sensible way of recovering the costs imposed on the roading system by heavy transport, but the concept has not been modified to reflect the times".

The Minister of Transport subsequently announced a review of the RUC system. This review is being undertaken by the RUC Review Group appointed on 19 August 2008.

2.1.1 RUC Review Group

The RUC Review Group is tasked with examining the way in which the Ministry of Transport's cost allocation model apportions costs; and considering the merits of collecting revenue from diesel vehicles by way of RUC as compared to potential alternative methods.

One specific focus of the review is to examine the nature and extent of the costs associated with the current systems for setting and administering RUC (including matters relating to the impacts of the RUC scale on the efficiency of vehicles, enforcement, avoidance and evasion, administrative and compliance costs) together with any improvements that might be made to reduce those costs.

2.1.2 Expert Advice

Hyder Consulting was commissioned to provide expert technological advice, this report addresses:

1. Identification of technologies currently available and those that will be available in the near future that could replace the mechanical hubodometer for distance verification in heavy motor vehicles and heavy trailers.
2. Identification of technologies currently available and those that will be available in the near future that will provide enhanced information such as on/off road and local/State Highway road usage.
3. Recent developments in vehicle and load weighing technologies mounted in vehicles, roads and roadside enforcement (weigh stations and portable).
4. The reliability, accuracy of these technologies
5. The key issues in transitioning from the current RUC system to an enhanced system using the identified technologies.

2.1.3 Basis of advice

This report outlines how the cooperative and integrated use technology might be applied to simplify the RUC user experience, maximise the business drivers, lower the cost of compliance, and minimise evasion, for the benefit of the transport industry, the NZTA, the Ministry of Transport and ultimately for the good of New Zealand. The approach taken is to outline the current RUC system and level of evasion, consider international technology based examples and describe how a technology based solution might be used to improve the current system.

3 THE CURRENT ROAD USER CHARGES (RUC) SYSTEM

The New Zealand road user charges (RUC) system has been operating pursuant to the Road User Charges Act 1977 (as amended) since March 1st 1978. This system replaced heavy vehicle licences.

The RUC system is currently administered by NZTA (NZ Transport Agency) Economic Compliance Unit (ECU) and is enforced by the New Zealand Police and the ECU.

The current RUC system collects $876.5 million per annum in revenue. This is dedicated to the National Land Transport Fund and used for funding land transport activities.

Evasion is currently estimated at between $40 and $100 million annually using a standard definition. In excess of $8 million of evasion is recovered annually by ECU.

Excise duty is charged on petrol, compressed natural gas (CNG) and liquefied petroleum gas (LPG) (Fuels taxed at source). All other powered vehicles are taxed via the RUC system and required to display current RUC licences while operating on public roads.

Due to the damage to roads that heavy vehicles cause (comparative to light vehicles) any vehicle with a manufacturer's gross laden weight of more than 3.5 tonnes (3,500 kg) is also required to pay RUC. RUC rates are calculated on the assumption that a vehicle travels at least 50 percent of the time unladen[1].

3.1 Fleet

An October 2008 estimate[2] is that in New Zealand there are around 100 000 heavy vehicles (including trailers) operated by around 30 000 licensed transport operators.

3.2 Licences

RUC licences are purchased as both the payment mechanism and proof of payment. Originally these were handwritten by the Ministry of Transport agent (The Post Office) in a fully manual system. Over time the system has evolved to an automated system with electronic printing of licences with enforcement officers able to access the same electronic information.

All RUC licences are based on a vehicle's **motive power**, **registration number** and **weight** nominated in advance by the vehicle operator (at the time of licence application). Each vehicle must be continuously licensed so that when a distance or time is complete a new licence is required.

Distance licences also relate to the **axle configuration** and **distance travelled.** For light vehicles distance travelled is measured by the **odometer.** For heavy vehicles distance travelled is measured by the **hubodometer** which is identified by the **hubodometer serial number**.

[1] Source: 2008 RUC booklet

[2] Derived from certificate of fitness testing data.

Time licences are used instead of distance licences for a limited range of vehicle types (outlined in figure 3.3) that are taxed by **time**.

The bolded items highlight the main technical attributes of the current road user charges system because these are the critical features to be considered when assessing alternate processes.

3.2.1 Distance Licences

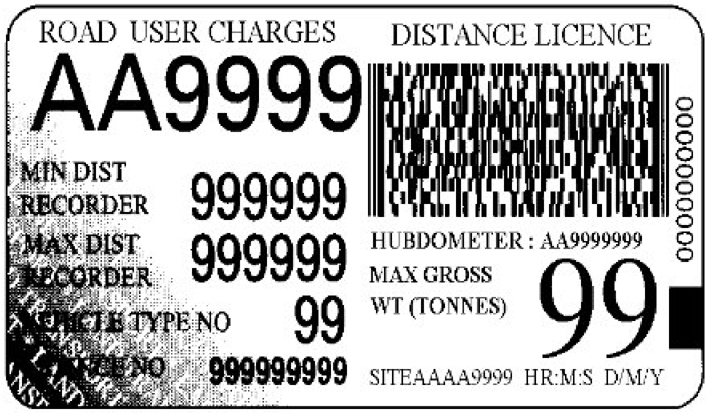

Figure 3.1: Specimen Distance licence

The majority of vehicles which are required to pay road user charges must display distance licences. Distance licences are purchased in units of 1000 km or multiples of 1000 km.

In addition to weight and distance, license fees are calculated according to:

- whether the vehicle is powered or unpowered (i.e. heavy trailers).
- the number of axles on the vehicle and axle spacing.
- the number of tyres per axle: single tyred, twin tyred or “any other configuration”.

3.2.2 Time Licences

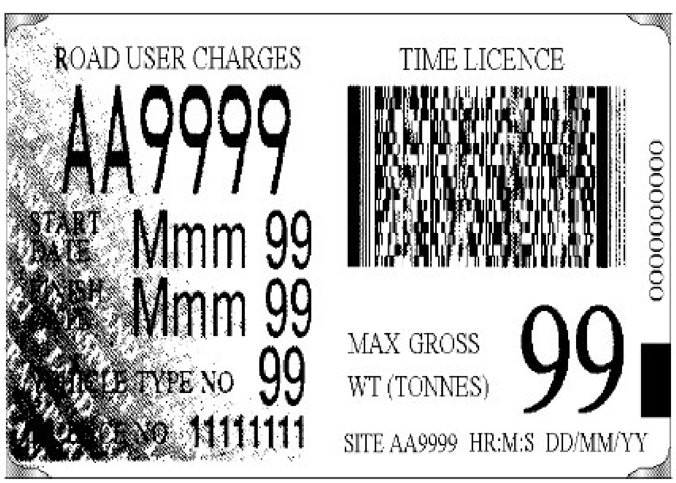

Figure 3.2: Specimen Time licence

Only those types of vehicles specified in schedule 2 of the Road User Charges Act 1977 (listed in the following table) are entitled to display time licences instead of distance licences.

	Class of Motor Vehicle
1.	Trailer scrapers
2.	Plant for servicing oil filled cables
3.	Road rollers
4.	Tractors other than those owned and operated by farmers on their own farms
5.	Post debunkers
6.	Saw bench apparatus
7.	Forestry chippers
8.	Sawing or shearing apparatus for tree cutting
9.	Stone and gravel crushing and screening plant
10.	Asphalt mixing and paving plant
11.	Bulldozers and angle dozers
12.	Tractor mounted mobile cranes and log skidders.
13.	Front end loaders
14.	Mobile pile drivers
15.	Motor scrapers
16.	Self-propelled water carts that are always unladen on the road
17.	Self-propelled trench diggers and excavators
18.	Self-propelled vehicles that are always unladen on the road and that are designed exclusively for carrying earth or other bulk materials
19.	Mobile cranes (excluding mobile vehicle recovery units, truck mounted cranes, and cranes to which a distance recording device is or could readily be fitted)
20.	Motor graders
21.	Unregistered motor vehicles operated under trade plates
22.	Cable jinkers

Figure 3.3: Vehicles entitled to display time licences

Time licences are purchased in periods of one month, with a minimum of one month and a maximum of 12 months. Purchases made part way through a month are calculated for the full month.

3.2.3 Supplementary Licences

Vehicle operators may increase the nominated maximum weight of a current distance licence either by buying a new distance licence (at an increased total weight) to replace the existing licence; or a supplementary licence at an increased total weight which will supersede a portion of the current distance licence.

In both cases the operator receives an automatic credit at the time of purchase for the unused portion of the original distance licence (provided all information is correct).

Supplementary licences provide for an increase in the weight limit of a licence to allow for the occasional cartage of heavier loads. They are more expensive than ordinary distance licences, but may be purchased in 50 km blocks.

The supplementary licence replaces the original licence for this distance, but once it has expired the provisions of the original licence will again be in force. Both the distance and supplementary licences must be displayed at all times.

3.2.4 Display of RUC Licences

Licences must be carried on the vehicle and displayed behind the inside of the windscreen on the passenger side of the vehicle. In the case of a trailer or a vehicle not having a windscreen, it must be displayed either at the front of the left side of the vehicle or behind the windscreen of the towing vehicle. The face of the licence which shows the registration plate number must be visible from outside the vehicle. Supplementary licences and the current distance licence must both be displayed.

3.3 Purchasing RUC Licences

RUC licences are available from NZTA agencies (includes RUC card for distance licences at authorised service stations and truck stops) and can be purchased by telephone, fax or computer (direct connection to the Motor Vehicle Register). In each case manual entry of relevant details is required by a customer service agent, data entry operator, or staff member.

A transaction fee applies to each licence sale, irrespective of the type of licence purchased.

The current transaction fees for these services (GST inclusive) are as follows:

Agency counter sales	$9.56 per licence	
By phone	$6.98 per licence	
By fax	$6.98 per licence	
Automatic teller sales	$5.06 per licence	RUC card at BP shops and truckstops
Direct connect	$3.38 per licence	
By internet	$9.56 per licence, maximum purchase $400, the licence takes up to 5 days to arrive via post. This is essentially a manual process disguised by an internet screen taking orders from the customers.	

Around 2 million RUC licences are purchased and printed each year.

3.3.1 Refunds

Refunds may be made (on application) for the following reasons:

- For any distance travelled off road and supported by documents.
- Time licences may become payable for any unexpired portion purchased. For example, a licence is purchased for six months but is used for less than the period purchased.
- Unused distance due to hubodometer change. Time licensed vehicles are not eligible for refunds for off-road travel.

- When a vehicle is permanently destroyed, exported or its registration cancelled
- Unused time/distance licence.

Incorrect licence details normally relate to data errors created when the licence is purchased and in most cases can be corrected by the issuing agent.

3.4 Distance Recorders

All vehicles that operate with distance licences must be fitted with a distance recorder that is of a type and accuracy sufficient to provide a reliable record of distance travelled. For light vehicles this is the odometer.

3.4.1 Hubodometers

Every motor vehicle requiring a road user charges distance licence where the manufacturer's gross laden weight is more than 3.5 tonnes must be fitted with an approved hubodometer. Only three approved brands of hubodometer are currently available in NZ, other approved brands are no longer available as shown below:

Approved Make	Currently Available in NZ	Approx Retail	NZ Distributor	Manufacturer's picture
Veeder Root	Yes	$120	TWL Ph 04 589-0089	
Accu-Trak	Yes	$150	Capital Instruments NZ (2006)Ltd Ph 09 634 7722	
Jost	Yes	$170	TRT Tidd Ross Todd Limited Ph 07 849 4839	
Macro	No			Note: this was an electronic hubodometer.
Engler	No			
Mechanex	No			
Argo	No			
Trailmark	No			
Stemco	No			
Chicago Rawhide	No			

3.5 Percentages Of Hubodometers In Use

The majority of hubodometers in NZ are Veeder Root (70%), followed by Accu Track (28%) and Jost (2%).

The other brands have been available in NZ in the past, however business drivers have resulted in them no longer being available.

Given that there were up to ten brands of hubodometer authorised for use on NZ roads one must question how long the manufacturers of the current brands will continue to produce them.

Form of Hubodometers

The hubodometer is a sealed unit that is tamper resistant and tamper evident. Due to the mounting position in the hub of a moving vehicle, hubodometers are prone to damage particularly when used in off road environments.

Function of Hubodometers

The mechanical function of a hubodometer is to measure vehicle kilometres travelled by counting wheel revolutions for an individual axle to which that hubodometer is fitted. The mechanism converts the number of revolutions to a distance reading in kilometres.

3.6 Issues With Hubodometers

It is noted that there are operational issues with fonts, readability and durability of some currently produced hubodometers. These issues may be competitively driven by increasing costs of materials and a desire to minimise the retail price.

3.7 Legal Definition Of Hubodometer

The Road User Charges Regulations 1978 defines the term hubodometer as follows:

Hubodometer *means a hubodometer manufactured under the brand name "Accu-Trak type AT", "Argo", "Chicago Rawhide", "Engler", "Jost", "Macro", "Mechanex", "Stemco", "Trailmark", or "Veeder-Root" that records in kilometres and has on its face—*

(a) A unique manufacturer's serial number that cannot be altered without dismantling the hubodometer; and
(b) The tyre size or number of revolutions per kilometre for which the device is calibrated; and
(c) A display showing the actual distance travelled.

Other requirements include:

- a hubodometer must be fitted at all times, to a non-lifting axle on the left hand side of the vehicle.
- when a hubodometer is lost or damaged and/ or found to be faulty, a replacement hubodometer must be purchased, fitted to the vehicle and a new road user licence purchased in conjunction with the replacement hubodometer.
- fitting a used hubodometer to any motor vehicle is prohibited, with a few exceptions when authorised by NZTA.

4 ECONOMIC COST OF NON-COMPLIANCE

The current RUC system is prone to avoidance and evasion. Non compliance exploits a variety of different weaknesses in the current system. The precise amount of unpaid RUC (tax) is difficult to accurately assess. The taxation leakage has a high long term cost to those who pay full RUC, and to NZ society as a whole.

The NZTA ECU is tasked with countering RUC leakage and recovers in excess of $8 million of evaded RUC every year. Although there is no degree of certainty, common estimates are that RUC evasion could be in the order of $40 – $100 million annually. The December 2008 briefing to the incoming Minister estimated evasion at $40m while a December 2008 High Court judgment stated RUC evasion was $100 million annually[3].

Another evidence based estimate[4] suggests that if evasion is defined as any fees that are unpaid at the time the distance is travelled, there may be at least $200 million evasion per annum, (but the $200 million figure might also be regarded as 'late payment', of which only a portion would fit the more widely accepted definition of evasion).

This section of the report describes how we might conceptualise the economic costs of RUC evasion. By considering plausible values of key economic parameters (particularly the transport sector's cut-off benefit-cost ratio, or BCR) we estimate that the long-term[5] economic cost to NZ of $40–100 million of RUC avoided annually could conceivably be between $450 million to $4.5 billion in present value terms.

The section then considers society's maximum willingness to pay to mitigate RUC evasion, and our model suggests that for instance, if the transport sector's cut-off BCR is 5, then the maximum cost to undertake an initiative to improve compliance by $30 million per year could be in the order of $24 million annually, or $270 million in present value terms over a 30-year period. It is conceivable that an initiative exists to improve RUC compliance by as much as $80 million per annum[6], corresponding to a willingness to pay of over $600 million in present value terms to fund that initiative over 30 years. Factoring in wider benefits and dis-benefits from such an initiative will have a further impact on this figure.

4.1 Conceptual Economic Cost Of RUC Evasion

There is a cost associated with current RUC evasion. Suppose for arguments sake that $50 million of RUC payments annually is evaded by heavy motor vehicle (HMV) operators. To estimate the economic cost of this non-compliance we must have regard to how constrained the funds are in the transport sector[7]. Given transport investment funds are so constrained one must not regard foregone revenues on a dollar for dollar basis and treat them as neutral transfer payments. The foregone revenue should be factored up by a factor that is based strongly on the marginal cost of funds (represented by the BCR cut-off) but perhaps moderated to take account of foregone investment in the private sector.

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[3] Land Transport NZ (NZTA) vs TD Haulage

[4] Source: Ron Veltman, NZTA statistician.

[5] Long-term is defined here as 30 years, consistent with the guidance in the NZTA's Economic Evaluation Manual.

[6] The German technology based system has reduced road user charges evasion to significantly below 2%

[7] While there is anecdotal evidence that there is a correlation between RUC avoidance and safety performance, we focus on the impacts on the transport sector's budget constraint in this discussion.

If transport sector investments were broadly made on the basis of benefit-cost ratios (BCRs) then the general rule would be to invest in a project if its BCR exceeds the BCR cut-off (the historical rule of thumb was a value of 4 when the discount rate was 10%)[8].

The $50 million that is evaded could in that case be used to fund projects with BCRs of about 4 that otherwise would not have occurred[9], implying a present value of benefits of $200 million less $50 million of investment costs resulting in a present value loss to society of $150 million *from that one year's RUC avoidance alone*. That is, the value of the RUC evasion needs to be factored up by a factor of the BCR cut-off less one (referred to below as the mark-up factor). If the BCRs of the otherwise unfunded projects at the margin were only 2 then society is $50 million worse off overall.

This logic needs to be taken further by considering the social payoff of operators using some portion of that $50 million for reinvestment into their businesses or passing on the savings downstream to consumers etc who could also reinvest some of those savings. We regard this as the social opportunity cost of the road user charge. This would reduce the extent that evasion revenues are marked up, which would reduce the social cost of avoidance.

However, one could argue that this social opportunity cost does not actually reduce the mark up factor at all because New Zealand's public sector discount rate is already a social opportunity cost rate based on forgone investment in the share market. By virtue of the public sector discount rate used, the forgone pre tax private sector returns of reinvesting the avoided RUC is already assumed to equal 8% per annum real and over 11% nominal (*Treasury (2008) Public Sector Discount Rates for Cost Benefit Analysis*). (In fact, the parameter used by The Treasury to estimate this return is based on a transport operator company 'Freightways'.) To reduce the mark-up factor to account for the social opportunity cost of RUC would be tantamount to claiming that the road transport industry earns excess profits (well in excess of 11% per annum), which would be a profound claim. As such we advise to not adjust the mark-up factor downwards to adjust for the social opportunity cost of RUC.

If we were to consider the cumulative effect of there being a loss to society of $C million of RUC avoided per annum for 30 years the stream of discounted cash flows (with a discount rate of r) would look like:

$$(cut.off-1)*\frac{\$C}{(1+r)}+\frac{\$C}{(1+r)^2}+\ldots+\frac{\$C}{(1+r)^T}=\frac{(cut.off-1)*\$C}{r}\left(1-\frac{1}{(1+r)^T}\right)$$

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[8] Cut-off BCRs have in recent times become much less well defined than it used to be as economic performance has increasingly been traded-off against non-economic considerations.

[9] Hypothecation now makes it plausible that preventing RUC avoidance would fund transport projects that otherwise would not occur. However, increased RUC revenues could reduce any level of government investment over and above funds collected from road transport users, conceivably as much as one-for-one at the limit. Yet if that were true, we could only presume the funds would be allocated to another area of government with a similar cut-off BCR, making this reallocation negligible.

The table below shows what the economic costs (in present value terms) to society over a 30-year period might be for a range of different values of annual evasion and of the cut-off BCR used in the transport sector over the 30-year period.

Annual RUC evasion	BCR cut-off 2	BCR cut-off 3	BCR cut-off 4	BCR cut-off 5
$40	$450	$901	$1,351	$1,801
$50	$563	$1,126	$1,689	$2,252
$60	$675	$1,351	$2,026	$2,702
$70	$788	$1,576	$2,364	$3,152
$80	$901	$1,801	$2,702	$3,602
$90	$1,013	$2,026	$3,040	$4,053
$100	$1,126	$2,252	$3,377	$4,503

Table 4.1: Possible present value economic costs of 30 years of RUC avoidance (millions) at a discount rate of 8%

At the transport sector's discount rate of 8% and $50 million evaded annually this sums to an overall present value of $1.126 billion if the cut-off BCR of 3 and to $563 million if the cut-off BCR was 2. If it was judged that the cut-off BCR was 4 and RUC evasion is as high as $100m per annum, then preventing this would benefit society by $3.377 billion over 30 years, and $4.503 billion present value if the cut-off BCR was as high as 5 over 30 years (which admittedly is a stretch at what might be conceivable).

A lower discount rate would lift these values via its impact on the above discounting equation as well as the higher cut-off BCR that would result, but may increase the social opportunity of funds also. (If the public sector discount rate were lowered below the social opportunity cost rate, then there would be justification in moderating the mark-up factor downward.)

In summary the annual base figure for NZ RUC evasion could be in the order of $40–100 million, and could conceivably have an economic cost impact over 30 years to the nation of between $450 million and $4.5 billion (under the current RUC system).

Based on the German experience (refer to section 7.2), properly applied technology is highly likely to significantly reduce the level of RUC evasion through automated enforcement systems by increasing the probability of detection and the operator perception that evasion detection systems are more effective.

4.2 Investment In Evasion Mitigation - Economic Justification

An economic case can be made to invest in an initiative to reduce RUC avoidance as follows:

Say an initiative saves $10 million annually in RUC avoidance, and the cut-off BCR in the transport sector is 4. This corresponds to an annual benefit of $30 million, implying that the cost of the initiative is economically viable provided its cost is not more than $7.5 million, which is $30 million divided by the cut-off BCR. The maximum cost needs to be calculated as a function of the cut-off BCR because the return of the initiative must also be at least as economically efficient as other transport investments at the margin.

More generally the economic justification to undertake an initiative to increase RUC compliance by $x is:

$$cost \leq \frac{\$x*(cut.off-1)}{cut.off}.$$

The table below plots different values of the increase in revenues from greater RUC compliance and of the cut-off BCR to determine a range of maximum annual costs for initiatives to improve RUC compliance. Given that the German experience is that evasion is significantly below 2%, and that RUC revenues are in the order of $870 million per annum, evasion could conceivably be reduced to below $17 million, which would correspond to an improvement of $80 million in RUC compliance, which is our upper limit of our conceivable range (based on the $100 million evasion figure).

Annual improvement to RUC compliance	BCR cut-off 2	BCR cut-off 3	BCR cut-off 4	BCR cut-off 5
$10	$5.0	$6.7	$7.5	$8.0
$20	$10.0	$13.3	$15.0	$16.0
$30	$15.0	$20.0	$22.5	$24.0
$40	$20.0	$26.7	$30.0	$32.0
$50	$25.0	$33.3	$37.5	$40.0
$60	$30.0	$40.0	$45.0	$48.0
$70	$35.0	$46.7	$52.5	$56.0
$80	$40.0	$53.3	$60.0	$64.0

Table 4.2: Range of maximum annual costs for implementing initiatives to improve RUC compliance ($m)

So an initiative expected to save $20 million a year in RUC avoidance supposing the transport sector's cut-off BCR is 5 could justify a spend of less than or equal to $16 million a year to implement that initiative. The following clarifies, in that case, the impact of cost deviations around this:

- If costs did equal $16 million then that would leave a surplus of $4 million per year to undertake projects returning $20 million in benefit — a net return of $16 million: society is indifferent between undertaking the initiative and not.
- If the initiative were to cost a little more than $16 million annually, say $16.5 million, there would be a surplus of $3.5 million times 4 (cut-off BCR of 5 less one) equalling $14 million in benefits — a net economic loss of $2.5 million.
- If the initiative were to cost a little less than $16 million annually, say $15.5 million, there would be a surplus of $4.5 million times 4 (cut-off BCR of 5 less one) equalling $18 million in benefits — a net economic gain of $2.5 million.

We must stress that these maximum cost values could be higher or lower once the benefits and disbenefits to road users, transport operators and administration and enforcement agencies have been taken account of. We also note these are annual costs for initiatives; technology related initiatives will have a greater upfront capital cost and lower ongoing operational costs, so these annual equivalent figures could justify much larger up-front investment in such initiatives. The table below represents these annual equivalents as 30-year annuities (the equivalent lump-sum of 30 years of payments).

Annual improvement to RUC compliance	BCR cut-off 2	BCR cut-off 3	BCR cut-off 4	BCR cut-off 5
$10	$56	$75	$84	$90
$20	$113	$150	$169	$180
$30	$169	$225	$253	$270
$40	$225	$300	$338	$360
$50	$281	$375	$422	$450
$60	$338	$450	$507	$540
$70	$394	$525	$591	$630
$80	$450	$600	$675	$720

Table 4.3: Range of maximum costs (over 30 years) for implementing initiatives to improve RUC compliance ($ million)

So the above initiative expected to save $20 million a year in RUC avoidance when the transport sector's cut-off BCR is 5 could justify a spend of less than or equal to $16 million a year to implement that initiative, which equates to $180 million as a single lump-sum. Factoring in wider benefits and dis-benefits will have a further impact on this figure. If BCR cut-offs are about 4, evasion is about $100 million annually, and a RUC system exists that can reduce evasion to only $20 million annually, then society may be willing to pay in the order of $600 million in present value terms over the 30 years to achieve that outcome.

Finally, we note that the fact an initiative is more economically efficient than the status quo is not sufficient for it to be undertaken, as other mutually exclusive initiatives may be even more economic. A proper cost-benefit analysis of all compliance initiatives would identify the most economically efficient of all initiatives.

5 CURRENT NZ RUC ENVIRONMENT

The NZ Police enforce road user charges offences for breaches of any of the RUC requirements and are empowered to issue traffic and infringement offence notices.

NZTA ECU also investigate RUC evasion through the civil process and recover unpaid road user charges (tax) either by way of obtaining voluntary agreement from an operator to repay detected evasion or by placing evidence before a district court judge under section 18A of the Act for a formal assessment of debt.

The process of applying and proving an assessment through the court process is costly and lengthy regularly taking several years to reach a conclusion. The practical effect is that such proceedings are relatively rare.

5.1 Enforcement Groups

5.1.1 NZ Police Commercial Vehicle Investigations Unit (CVIU)

The CVIU are a specialist NZ Police group comprising around 100 enforcement staff nationally. CVIU are tasked with specialist policing of the NZ commercial vehicle fleet on a full time basis.

Road User Charges enforcement forms a part of that enforcement activity and is generally conducted by way of random roadside enforcement, or at fixed weighing facilities. The RUC enforcement process is currently a manual inspection transcribed onto a paper form which is later manually entered into a database and scanned as an image file.

CVIU enforcement primarily consists of a thorough safety based check, generally taking 15 – 60 minutes for a truck and trailer combination. This check may incorporate a check of the hubodometer and distance licence, if a weight related offence is suspected, the vehicle may also be weighed. It is currently planned to electronically enter this information directly onto the RID system (refer section 5.7.3) while some portions of Police work will still require manual forms. Full development of an electronic system would assist all parties.

Many vehicles stopped by enforcement officers at the roadside are quickly and informally assessed as likely to be compliant; no formal record is kept of the details of the majority of these stops.

Current Distance tolerance

Police may check the accuracy of the distance recorder operationally by checking it over a distance of between 10 and 20 kilometres using a patrol vehicle with a certified odometer. A tolerance of plus or minus 7.5% of the patrol vehicle odometer reading is applied.

An offence notice may be issued where the distance recorded by the hubodometer is less than the certified distance by more than 7.5%.

Where the distance recorded is greater than the certified distance by more than 7.5% the owner is normally notified that the recorder is over recording.

Current Weight Tolerance

Police operationally apply a 5 percent tolerance to measured weights for road user charges purposes before any penalties may be incurred. This tolerance recognises the inherent differences in measured weights between different weighing systems and is legislatively required by the infringement fees table contained in the Transport Act 1962 schedule 2 (infringement fees).

NZTA considers any excess of the nominated RUC weight to be evasion. The High Court confirmed this view in a December 2008 declaratory ruling that there is no tolerance for Road User Charges weights.

5.1.2 NZTA Economic Compliance Unit (ECU)

The ECU is currently a national unit within NZTA with regional staff.

The ECU targets investigations and audits using intelligence based assessments of particular operators to identify possible evasion. ECU also operates operationally in conjunction with NZ Police as required.

In order to conduct an investigation the ECU has the power to require production of all relevant information which includes books or records in a persons control or possession including, logbooks, time and wage records, fuel accounts, invoices, maintenance records and depreciation records.

The main record that the investigators rely on however is the computer printout of the operator's road user charges purchases. This theoretically records the details of every road user licence purchased either for a particular vehicle or vehicles or under a particular road user charges customer number. It is dependent on correct identification of those vehicles at the time of each purchase.

The ECU also has staff who audit off road claims and fuel excise duty claims and programmes staff who process off road claims and light diesel vehicle matters.

5.2 Current NZ Vehicle And Load Weighing Technologies

Weighing of vehicles and their load for enforcement purposes is solely carried out by NZ Police Commercial Vehicle Investigations Unit (CVIU). There are currently three basic weighing methods used by Police:

1 Weigh Bridges	owned by NZTA Highways and Network Operations (formerly Transit NZ)
2 Weigh Pits	site owned by NZTA Highways & Network Operations
3 Ramp and dummy	roadside weighing at any reasonably level location.

All these methods require calibrated and certified scales. Portable scales owned by NZ Police are used in weigh pits and ramp and dummy weighing, while weigh bridges owned by NZTA use permanent scales.

Each method relies on the vehicle combination being near level with the weigh platform of the scales to minimise weight transfer between axles. In the first two methods this is achieved using level concrete pads on approach and departure from the scales. Each method is addressed in more detail below followed by maps of the weigh sites:

5.2.1 Weigh Stations

Weigh stations are permanently fitted sites generally with associated administration buildings, safety features such as barriers between the main highway and the weighing area and entry and exit lanes.

In terms of efficiency permanent weigh sites are easily the best method of weighing vehicles. All are capable of slow speed dynamic weighing, this means the vehicle or combination being weighed travels slowly across a weigh strip and the results for each axle are printed out almost simultaneously on the associated electronic system.

Photo 5.1 Plimmerton Weigh station (dynamic weigh strip beside the traffic cone)

Current weigh stations are located at Stanley Street, Neilson Street and Drury (all in Auckland); SH30 Rotokawa (Eastern side of Lake Rotorua); SH1Turangi, SH1 Ohakea, SH1 Plimmerton (north and south bound) and SH1 Glasnevin (North of Rangiora). All of these sites have alternative routes that bypass the weigh station and there is currently no system in place to detect vehicles bypassing weigh stations using other routes.

The majority of weigh stations are well set up with “all trucks stop” signs, entry and exit ramps, ample area to park and manoeuvre multiple truck combinations at one time, and (although not applicable to RUC) also have sufficient room to park and offload excessively heavy loads.

Photo 5.2 Plimmerton Weigh station (showing the dynamic weigh strip and operational requirement for a large parking area).

Privately owned weigh bridges and platforms may also be used in some areas where there is agreement with the weigh bridge owner.

There are many strategic sites with high volumes of truck traffic where no land exists to construct a full weigh station.

5.2.2 Weigh Pits

Weigh pits are purpose built, level concrete platforms, with a pit or recess into which portable scales may be placed. The pit is the correct depth so that when portable scales are placed in the (clean) pit the weighing platform on the scales is level with the concrete platform.

Weighing involves lining up the scales with the vehicle tyres for each axle, driving the vehicle onto the scales and stopping the centre of each axle in line with the centre of the scales.

A cable may be used to sum the weights for each wheel weight onto one display or alternately each scale may be checked. The weight is manually recorded onto a paper based weigh form and the process is repeated for each axle. The sum of axle weights for each vehicle is then applied to determine whether the current road user licence has sufficient nominated weight.

The pits are owned and maintained by NZTA Highways. Although there are over 100 weigh pits nationally as indicated on the map, for various reasons many of these pits are not currently available for operational use.

Photo 5.3 Weigh Pits State Highway 2, Haywards, Wellington.

5.2.3 Ramp and Dummy

This method of weighing is truly portable and may be conducted on any “reasonably level” surface. The method is time consuming and physically taxing for the enforcement officer, the driver and the vehicle(s) with every change in scales requiring the equivalent of a hill start and sudden stop on top of the scales. The method is generally used to weigh vehicles that are stopped in locations remote from weighing sites; it may also be used for vehicles that are too large for the standard weighing sites.

The same scales that are used in weigh pits are placed on a reasonably flat roadway, however, to ensure that the vehicle being weighed is level all axles need to be elevated to the same height as the weighing platform on the scales.

This is achieved by moving (generally) one or two pairs of scales along every axle of a vehicle combination, placing “dummy” blocks under every other axle in the combination and driving the vehicle up onto the scales and dummies until the weights of all axles are recorded.

Photo 5.4 Ramp and dummy weighing, Port Rd, Seaview, Wellington.

5.2.4 Current Weighing Facilities

The following 2008 maps produced from the NZTA GIS viewer are the most recently available indication of the distribution of weigh facilities throughout NZ. (Note that the count of sites shown on the legend is inaccurate).

As previously stated there are 9 weigh stations and just over 100 weigh pits nationally (in various states of repair).

The weigh motion sites indicated on the maps are operated by NZTA (formerly Transit) for purely statistical purposes and the data obtained from these sites is not attributable to identifiable vehicles, is not produced in a readily understood format, or in sufficient time for enforcement purposes.

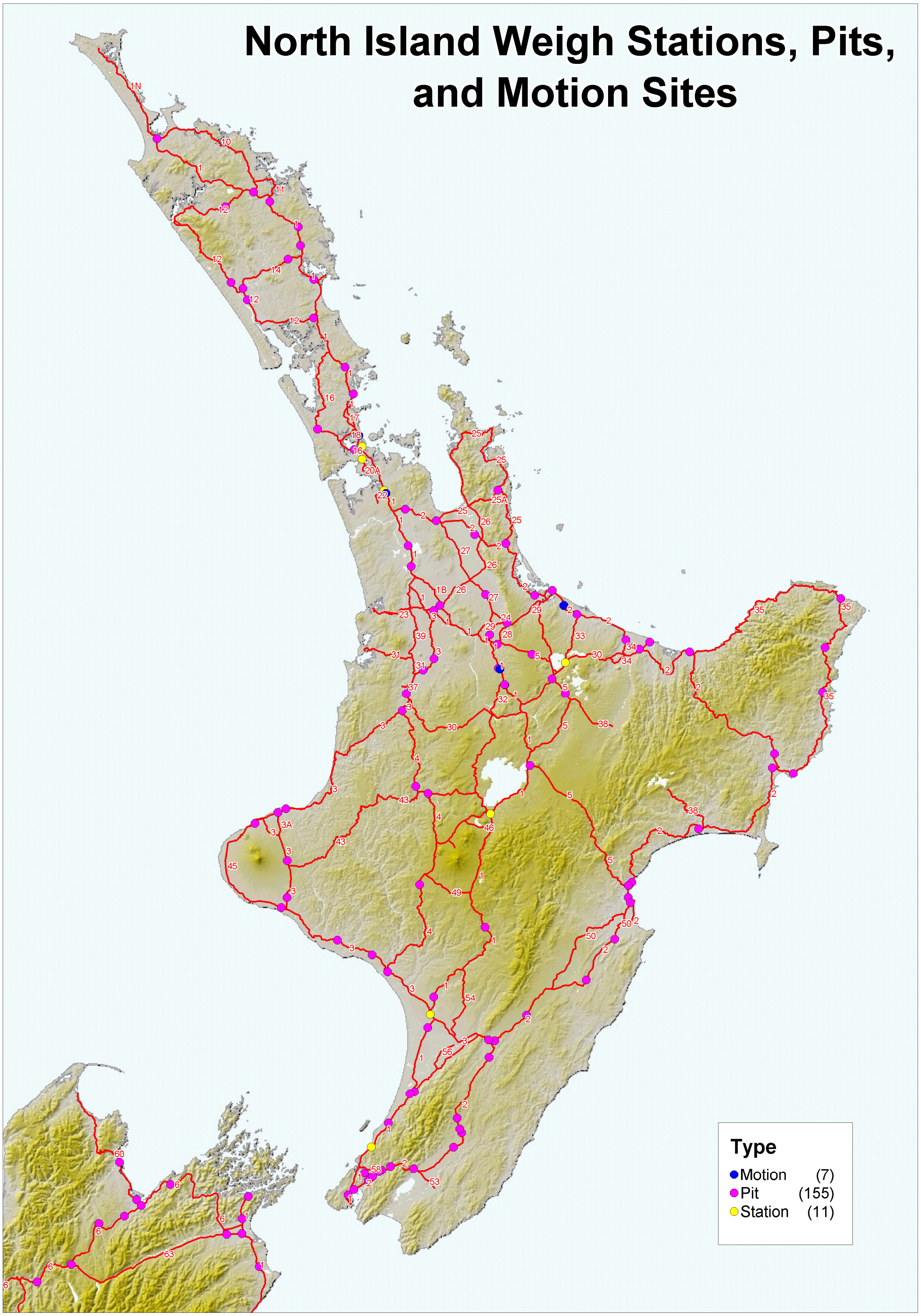

Figure 5.5 Map of North Island weighing facilities (produced by the NZTA GIS viewer)

Figure 5.6 Map of South Island weighing facilities (produced by the NZTA GIS viewer)

5.3 Reliability And Accuracy Of Devices

5.3.1 Odometers

We are unable to locate any existing NZ or international quantitative research on the accuracy of odometers. Anecdotally it is apparent (from many years experience calibrating speedometers in enforcement vehicles) that the speedometer (integrating the odometer) may be almost perfect in some vehicles and is inaccurate on a wide range of vehicles. The degree of inaccuracy varies, and in extreme cases may be up to 10kmh too fast at 80kmh on a standard production vehicle. This level of inaccuracy on a light diesel vehicle would likely cause overcharging of distance. Speedometers / Odometers generally operate from the vehicle gearbox, as such, changes in gearbox ratios (for legitimate reasons) may cause inaccuracies in the distance recorded.

5.3.2 Hubodometers

We are unable to locate any recent NZ or international quantitative research on the accuracy of hubodometers. The manufacturers of hubodometers also do not make any claims as to their accuracy or otherwise.

The DSIR conducted tests[10] on the accuracy of hubodometers for the NZ Road Transport Association at the time of their introduction to NZ in 1978. These tests consisted of mounting hubodometers on a lathe and rotating them and later road testing on a Bedford truck. The results verified the hubodometers were relatively accurate when properly mounted. Inaccuracies of 2% to 4% were noted due to tyre wear, it was also noted that other issues could add up to 8% -10% error. The hubodometers tested (Veeder Root, Engler, Mechanex, Argo) were significantly sturdier in construction than most of those currently available.

Essentially it can be stated that hubodometer devices themselves are relatively accurate because they are simply revolution counters for the nominated number of revolutions per km. Any inaccuracy that arises is likely to be the result of incorrect mounting, damage or deliberate evasion techniques.

The current approval process for new hubodometers essentially involves gaining ECU and Police approval followed by the required regulatory change to the definition of hubodometer.

5.3.3 Weighing Systems

As with most mechanical devices, scales may be subject to minor variance and require re calibration from time to time. Police are instructed not to use uncalibrated scales. All portable scales carried by Police CVIU are calibrated at regular intervals by qualified Police calibration staff. Permanent scales fitted at weigh stations are owned by NZTA (Highways) and operated by Police CVIU. NZTA is responsible for calibration of these units and this role is contracted out to the private sector (IRL).

At times delays are experienced between the expiry of a calibration and re calibration. Any weights measured during the interim period are legally unenforceable. The net result is that the weigh station is normally closed during those periods.

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[10] Sources: DSIR report (supplied courtesy of Road Transport Forum NZ), discussed with Terry Porritt (involved with 1978 testing at DSIR Engineering Metrology labs).

5.4 Current Enforcement Information Flows

The information from any (reported) vehicle weighing is manually recorded on a triplicate form in a process that (at best) takes around fifteen minutes for a thorough check, and may take up to an hour or longer for a large vehicle combination that is weighed using ramps and dummies.

This time taken to thoroughly inspect a vehicle or combination means that the CVIU enforcement officer is occupied so cannot perform other duties. It also means delays to the operator with logistics consequences such as vehicle schedules, ferry schedules, freight transfer schedules and delivery deadlines. This may flow on to financial impact even when no offence is detected.

As a result there is a general tendency for enforcement officers only to report vehicle inspections when an issue is detected on a preliminary scan.

The completed form is forwarded to NZTA by post, a copy retained by the Police for prosecutions purposes and a copy for the driver/owner.

Many completed forms are received by NZTA in a timely manner although some are sent to the incorrect office, some are received with delays and some are never received.

NZTA manually enters information from the completed form onto a portion of the database that contains the Motor Vehicle register.

This methodology is time consuming, inefficient, prone to data loss and data error at each manual step. The result is that the quantity and quality of data available for RUC enforcement purposes is significantly diminished.

5.5 Current NZ Vehicle Tracking Providers

Currently there are over ten commercial providers of vehicle tracking systems operating in New Zealand. These tracking systems already serve an estimated 30 000 or more vehicles nationally (not all are heavy vehicles) increasing at approximately 450 to 500 per month. Each NZ system has been independently designed and implemented for a variety of purposes. A handful of companies with large fleets of trucks also operate their own tracking systems.

The current NZ systems are all based on GNSS devices; some are augmented for various purposes. The indicative cost to an operator (per vehicle) for an all inclusive package is generally in the vicinity of $100 per month, with some variation between providers, dependent on the services and equipment provided.

Currently these systems are purely commercial and voluntary, generally for fleet management and logistics purposes. At least one provider also uses the same information to generate accurate near real time traffic information. Security is not a focus for the majority of these systems.

5.6 GNSS

All GNSS based systems coupled with GIS (including accurately defined parameters) offer positioning that relatively accurately describes on/off road usage, whether a vehicle is operating on a highway or local road and any other type of location and time based information. The only real question is the required degree of accuracy and security for RUC purposes.

5.7 NZTA

5.7.1 Current NZTA Back Office

The database for the RUC system resides alongside the motor vehicle register in a legacy system. The operation and maintenance of the NZTA database is outsourced to Unisys. Any changes to the database are at additional expense, are relatively costly and are prioritised with legal requirements taking top priority and many other requirements being deferred. The database management system (DBMS) is nearing the end of its life cycle (legacy) and has a number of issues in relation to providing the level of service required for RUC.

5.7.2 Digital Regulatory Management Strategy

The business development unit of NZTA recognised the potential of using technology to integrate a wider approach to unified data capture for various (currently disparate) purposes.

The NZTA drafted a technical concept document in 2007 as a cooperative, wide ranging strategic integrated approach to government and industry requirements using available technologies. Further development of the digital regulatory strategy is anticipated in the future to form a policy oriented document. The strategy considers electronic overdimension and overweight permits, digital driving hours logbooks, mass and network monitoring, a Police intelligent transport systems (ITS) strategy, automated RUC and linkages to external services.

5.7.3 RID

The NZTA Roadside Inspections Database (RID) is a partly developed concept to electronically collect all the information required by Police and NZTA once from each vehicle inspection, near real time in a single and simple check simultaneously querying key information fields (registration number, Driver's Licence number and Transport Service Licence number) to return known information already stored on NZTA databases directly to the enforcement officer.

The benefits arising from the RID concept will be rapid, accurate, consistent and timely data collection for all parties, enforcement officers, operators, NZTA and Police.

The RID application was trialled in 2008 and is capable of receiving safety information. In early 2009 the application will be enhanced to enable collection of RUC data.

For legal and practical reasons Police CVIU require handheld devices to electronically collect key data at the physical point of inspection. No handheld devices have been issued as yet therefore no information is currently being entered into the RID system.

5.7.4 Toll Roads

While the toll road does not directly relate to the current RUC system, tolling is an internationally recognised form of Road user charging and may share technologies.

NZTA is soon to open the State Highway 1A (Alpurt B2) toll road. Tolling is essentially a local road user charge using many of the vehicle recognition technologies that may be readily applied for a national audit system for road user charging.

The notable differences between the NZ tolling system and many other automated road user charging sites is that the NZ system relies solely on automated numberplate recognition (ANPR) without any use of DSRC "tags" or dynamic weighing of vehicles. Technically weigh in motion systems are relatively simple to add to tolling technologies if required. Sharing gantries and high resolution cameras would enable operational data to be obtained once (for many purposes) and processed slightly differently for each. A very useful video describing operation of the toll system is available from the NZTA website at the following link: http://www.landtransport.govt.nz/tollroad/index.html.

5.8 Proposed New Zealand Standards

The ECU recognised that a variety of commercial fleet tracking services were providing GNSS based information supporting claims for off-road refunds. These providers lacked any performance or outcome standards.

In 2007 the Land Transport NZ (now NZTA) business development unit assessed alternative options and relative costs of digital based monitoring in New Zealand. This included consideration of TCA (Transport Certification Australia). Factors considered included the existing providers, political and legal requirements, the cost of compliance and the beneficial outcomes that a cooperative and integrated approach offers.

As a result the NZTA leadership team endorsed the consideration of Standards New Zealand's consensus-based process and the external (commercial) collection of a common data set relating to all the vehicles using each service provider.

In July 2008 Standards New Zealand held a scoping workshop to assess the requirements of potential vehicle data Standards to support a Digital Regulatory Management Strategy. NZTA has recently approved development of the New Zealand Standards relating to the collection of data from moving vehicles. These standards will differ from the TCA regime because they will focus on accuracy of device and system outputs and outcomes rather than defining prescriptive technical standards for each device and each system.

It is proposed that device and system, testing and audit, will be performed in a similar manner to other NZ automotive applications. A certified engineer (accredited by NZTA) will inspect or audit the devices and systems against the yet to be developed New Zealand Standard output and outcome requirements.

The digital data suite of standards is also innovative for Standards NZ, because rather than the traditional Standards New Zealand model where each user purchases a standard; alternative options are being considered that will significantly improve the accessibility of the standards to users and the public.

In November 2008 NZTA agreed to sponsor the development of the digital data suite of standards and this work is likely to progress in 2009. The proposed standard will enable multiple commercial tracking providers to provide RUC services, provided their systems meet the NZ standard (and any additional RUC requirements).

5.9 Enabling Legislation For Electronic Hubodometers

The Road User Charges Regulations 1978 regulation 6 (5) currently states that*: every electronic hubodometer fitted to a motor vehicle for the purposes of this regulation shall be affixed to the motor vehicle in such a manner that—*

(a) It accurately records the distance travelled by a vehicle; and

(b) Its wheel revolution detector is affixed by a rigid bracket in such a manner that it accurately records the revolutions of a non-lifting wheel of the vehicle; and

(c) The face of the distance recording unit thereof, its unique serial number, and the distance travelled are readable from outside the left-hand side of the vehicle; and

(d) All cables and fittings of the hubodometer are easily visible without dismantling any part of the vehicle; and

(e) It cannot be switched off or temporarily disconnected from within the vehicle; and

(f) Where its functioning is dependent upon internal re-chargeable batteries, it is connected to a power supply that continuously re-charges the batteries whenever the vehicle is moving.

Where an adjustable bracket is used to affix a wheel revolution detector to a vehicle, the bracket shall be welded, riveted, or otherwise modified to ensure that, once so affixed, the detector's position cannot be altered.

This section was written specifically for the Macro hubodometer and amendments may be required for any new systems.

Dependent on formal legal opinion of the interpretation of a **hubodometer** (regulation 2), amendments may be required to add each brand of electronic hubodometer to the current regulation.

If a GNSS systems including digital tachygraph are recommended by the review team these would need changes in law and should include consideration of the issue of a smart card driver’s licence for drivers of commercial vehicles.

6 A CONTEXTUAL GLIMPSE OF STANDARD VEHICLE TECHNOLOGY IN THE NEXT 10 YEARS

Many commercial fleet operators in NZ currently use GNSS positioning systems with mobile data communications for fleet management and logistics purposes. These systems are currently fitted to around 30 000 NZ vehicles and increasing at around 500 per month.

Electronic vehicle systems are prevalent as standard equipment in current vehicle manufacture. ABS antilock brake systems, ESC electronic stability control systems, electronic engine management systems, pre deployment of airbag systems, early collision alert and avoidance systems, cruise control, GPS positioning systems for route guidance, bluetooth and vehicle internet connections are increasingly common. All major vehicle manufacturers are actively researching the use of technology to make vehicles safer, smarter and more fuel efficient.

In 2001 the US Department of Defense mandated that by 2015 one third of the operational ground combat vehicles will be unmanned. In response DARPA (Defense Advanced Research Projects Agency) set up a competition for development of autonomous vehicles. (Driverless and without remote control). The first DARPA grand challenge was conducted in 2004 and the third challenge in 2007 was the DARPA urban challenge. In late 2007 six out of 11 robotic vehicles completed the 60 mile (96km) simulated urban environment within a six hour time limit. The autonomous vehicles had to safely negotiate manned and unmanned vehicles, obey traffic laws and negotiate all types of stationary and moving obstacles. They also had to deal with parallel parking and other traffic at intersections. The vehicle positioning units used in DARPA are GPS augmented by gyroscopes and a range of other sensors. Obviously these vehicles also have extensive robotics and artificial intelligence.

In early 2008 General Motors announced that it intends to release autonomous vehicles for public use within 10 years, using the technology developed by DARPA. There are a range of potential safety and other benefits in the use of autonomous vehicles.

It is a reasonable inference that over the next ten years, increased onboard technology, including GNSS devices will be fitted to every new vehicle at manufacture. GNSS receivers are already standard equipment in a large percentage of NZ new trucks and many new cars.

One OBU with two way external communications is capable of delivering a range of services to the vehicle. In the future this is likely to include real time traffic management and congestion information, traffic directions, estimated journey time, automated charging for various services such as fuel, parking, road use and quite possibly when vehicles are autonomous, on board entertainment. Many of these services are already offered in New Zealand along with other services such as pay as you drive insurance and remotely powering down and disabling stolen vehicles.

The concept of autonomous vehicles might seem strange, however in 2008 most of the vehicle technologies mentioned above are already fitted as standard equipment in many new cars sold in NZ.

The RUC review presents a relatively early opportunity for NZ Government to adopt and manage the way vehicle technology is harnessed in NZ.

6.1 Relevant Technology Types

Common electronic technology types used or relevant to electronic road charging systems are:

ANPR	(automated numberplate recognition) records images using high resolution digital cameras assisted by IR (infra red) or other technologies for night time detection, then automatically processes the images, accurately and automatically reading the numberplates of around 95% of vehicles, at highway speeds and forwarding images that cannot be recognised to operators for manual inspection.
AVL	(automated vehicle location): describes GNSS positioning systems (see below) applied to fleet management. Also known as telelocation.
Bluetooth	Bluetooth is a short range (around 10 metres) communication method that is increasingly fitted as standard equipment in new vehicles, mobile phones and laptop computers. Bluetooth may be considered for future use by enforcement officers to facilitate data uploads from stationary vehicles. There are some security implications in terms of a possible avenue for malicious attacks on enforcement systems.
CANbus	(Controller Area Network communications bus) is an electronic unit that interfaces with and integrates a vehicle's electronic engine management systems, braking systems, transmission, airbags, cruise control and other electronic vehicle systems. The CANbus also integrates electronic systems from any properly electrically connected trailers with electronic systems. Some information collected by CANbus may be collected through an FMS or firewalled gateway (protected output). This information may provide augmentation for GNSS receivers. CANbus is a European standard adopted by many USA manufacturers. Similar technologies exist in Japanese and other truck management systems.
Digital Tachygraph	a digital tachygraph (also known as tachograph, or tachyograph) is an electronic device that records driver and vehicle activities. It also holds data relating to faults, speeding, calibration details and any attempts to tamper with the system. All the data is stored in its own memory and on driver smart cards. Tachygraphs generally operate with four types of smart cards, driver card, company (operator) card, workshop card and control. They may also provide output to OBUs.
DSRC	(digital short range communication) generally between "RFID tags" or OBUs carried in vehicles and corresponding roadside infrastructure (similar to wireless networks) to collect vehicle specific identification data at highway speed. DSRC is widely used in tolling and vehicle safety systems. The 5.9Ghz radio frequency band is widely used and the range of DSRC is around 100 metres.
GIS	(Geographic information systems) capture, store, display and allow humans to make sense of the electronic data collected by GNSS receivers. GIS generally include "base maps" of the area in question accompanied by "layers" of information types overlaid on the base

	map. The most publicly accessible GIS is “Google Earth” and this provides a sound understanding of the types of layers available. NZTA (highways) has an excellent in house GIS. This is technically available to external parties via internet however current policy only permits NZTA users to have access.
GNSS	(global navigation satellite systems) including (and often referred to as) the well known US NAVSTAR GPS system, the Russian Glonass system, the European Galileo system, the Chinese Beidou system and India’s IRNSS system. Of these, the only fully operational system is GPS. Positioning chipsets for general commercial use are currently accurate (at device level) to around 5-7 metres with older and less expensive devices having reduced accuracy. GNSS is prone to a number of weaknesses such as canyoning (bouncing signals) and loss of signal at certain locations (due to canopy cover) and times (poor satellite constellation reception). GNSS receivers form a part of the system with communications and back office systems supporting the receivers. The retail cost of commercial receivers with mobile data communications is currently around $500 per unit and may reduce to around $100 per unit over the next 5-7 years.
GNSS Augmentation	Uses GNSS and other reference sources such as fixed reference sites, inertial systems, gyroscopic systems, accelerometers and revolution counters to improve the reliability of positioning and/or accuracy of measurement.
GSM	(Global System for Mobile Communications) is the most widely used mobile communications standard. The GSM standard is digital permitting data transfer as well as voice.
IR	Infra red communication is purely line of sight similar as used in many television remotes. This has significant disadvantages when applied to moving vehicles.
OBU	(on board units) these operate in a vehicle performing a positioning, measuring and/or counting function specific to the system, most have some method of mobile data communication polled to a remote database at regular intervals. Each OBU is designed and configured according to business requirements or objectives.
Post processing	Raw GNSS positioning data requires interpretation to present information that can be understood by humans. This may be achieved by a thick client processing the data at the receiving device and displaying it on for example a small map screen (the same as many domestic GPS devices currently sold for location and direction purposes or thin client where the raw data is sent to a central “back office” for interpretation (does not process the data within the device). There are arguments for each type of set up. There is also no reason why a thick client cannot be configured to transmit raw data for RUC and other law enforcement purposes while retaining the onboard capability.
RFID	(radio frequency identification) involves electronic tags that respond to a nearby reader. The reader effectively activates the tag to send a

	coded signal back. There are two types of RFID; passive and active. Active RFIDs require a battery and can perform additional functions for example monitoring temperature or movement. They are widely used in logistics, manufacture and tracking of high value goods and in many libraries. The weakness of RFIDs for RUC purposes is they can relatively easily be read and altered, each providing scope for fraud.
Wimax	a wireless high speed internet protocol. A variant is currently being developed to make this suitable for transmission to vehicles.

All current and planned technology based road user charging systems require various components to operate. These generally include devices on the vehicles, communications systems; vehicle and/or back office based geographic information systems (GIS), performance parameters and back office systems to conduct the vehicle and distance recognition and charging. The components included in any system are defined by the business requirements and applicable constraints.

Gantry based road user charging systems require dedicated roadside infrastructure on every road that is to be subjected to charges along with new communications networks to operate the primary data link. If Motorway only charging was considered gantry based systems may be considered however careful consideration would be required as to the cost benefit in comparison with other technology approaches.

GNSS based systems use existing (multi purpose) mobile data infrastructure for the primary data stream although they assume availability of the satellite constellations (already in orbit). They cover the majority of the NZ roading system with ease and rely on augmentation to confirm approximate position or precise distance travelled. A limited number of strategically placed audit/enforcement sites would electronically confirm the accuracy of the GNSS based electronic data stream at that point as a security measure.

6.2 Systems Tampering

Currently in NZ, there is little, if any, commercial advantage to tampering with existing GNSS devices or their associated back office systems. Ideally, if every operator was happy to pay road user charges there would be no reason why the majority of these systems could not already be used to collect road user charges.

Almost thirty years of New Zealand RUC history has shown that there is a good proportion of transport operators who are prepared to evade RUC. The decrease in expenses permits increased profit and undercutting the rates of operators who elect to pay full RUC. Evaders have used a variety of simple and some more innovative evasion methods. With every increase in RUC rates the commercial incentive to evade the RUC regime is increased. Every case of evasion contributes to further increases in costs for those who pay RUC.

If currently available NZ GNSS monitoring systems were to be adapted for RUC revenue collection, physical security, tamper resistance, tamper evidence and tamper reporting become real issues along with electronic system security at every level.

For enforcement action to ultimately be successful, either all reasonable doubt of system error must be eliminated, or a law change would be required to shift the degree of proof to absolute liability.

In any event commercially significant penalties would be required to deal with commercial tracking service providers who operate systems that are shown to be inaccurate.

7 INTERNATIONAL RUC EXAMPLES

New Zealand and Iceland were the first countries in the world to introduce national road user charging for trucks using manual paper based systems in the late 1970s. Other countries have followed in more recent years, generally using technology based solutions for national solutions. New Zealand has modified the original manual system by introducing electronically generated paper licences to replace the previous handwritten licences.

Road User Charges are applied in New Zealand as a weight based charge approximately proportionate to wear caused to the flexible pavement surfaces in NZ.

Internationally many road surfaces are rigid (concrete or similar), priorities are different and RUC seeks to address other issues including emission levels, congestion charging, tolling to recover construction costs, heavy vehicle charging for the amount of road space used (sometimes time sensitive) or motorways used in international transit, equity charging for hybrid and fuel efficient vehicles and even collection of parking charges.

These purposes have a number of commonalities and some differences. Many of the technologies and systems used for one purpose may readily be used for another. The degree to which technologies can be used for a range of purposes is largely dependent on sound strategic planning, political will, commercial support and funding.

Fuel taxes are often considered in place of a distance-based fee, however they are directly related to consumption of energy rather than consumption of road space (congestion), actual road use, or road damage.

7.1 European Union

The heavy vehicle issues identified generically in Europe are:

- congestion management and promotion of efficient road freight services, allowing for transnational trucking routes that travel through many European nations
- creating fair conditions for competition
- harmonisation of standards between nations
- developing interoperable charging and enforcement systems
- digital tachygraph linked to a standardised electronic driver licence
- tracking and managing hazardous goods vehicles

European law known as the Eurovignette Directive lays down common principles for tolls and user charges for heavy goods vehicles. The tolls charged must be based on actual costs of construction, operation and upgrading of the motorway network.

National electronic road user charging has been introduced as follows: Switzerland (2001), Austria (2004), Germany (2005), Czech Republic (2007). National road user charging is planned for Hungary and Slovakia (2009); Holland and Poland (2011); The Netherlands (2012).

7.2 Germany

Germany has a population of 82 million, a land area of 349 223 square kilometres and a roading network of 644 480 kms including 12 400kms of motorways. The network is entirely paved.[11]

The German LKW-MAUT system has a strong focus on infrastructure financing but there is also a focus on applying the “user pays” principle, more efficient use of transport capacities and emission related tolls as well as providing fairer conditions for rail transport.

The German system differs from the NZ system in that it does not vary charges by weight and also has to deal with foreign vehicles. The system was developed and is privately operated by the “Toll Collect” consortium. The funds collected are used by the German Government for road construction and improvements. German charges are based on **distance** driven, **number of axles** and **emission category**.

The system uses three payment channels: at the time of travel using personalised OBUs with vehicle recognition and automated billing, payment in advance by internet with automated invoicing, and manual payment in advance (cash, fuel card, credit card or virtual card) at around 3500 dedicated terminals in Germany and neighbouring countries.

The German system is amongst the most advanced in the world. It was implemented in 2005 and automatically collects charges for vehicles with a maximum weight of over 12 tonnes that are travelling on the 12 400 km of autobahns. The system includes over 2200 junctions and 250 interchanges. The system processes around a million trucks per annum.

Freeflow charging

German OBUs contain GPS based location devices manufactured by Navman (designed and formerly owned in New Zealand) augmented by odometer or tachygraph information along with 200 solar powered GPS-backup beacons at locations where there is poor GPS coverage. The OBUs come in a dash-mounted or an in-dash version designed to fit in a radio slot.

Distance is measured and tolls charged with reference to a base map and charging parameters or “virtual toll stations” stored in the OBU. The unit contains communications capability via the mobile data network to authorise payment and upload new maps and charging parameters. The charging system is effectively near real time.

Photo 7.1 German dash mounted OBU

[11] All facts about population, land area and roading networks for the nations in this section are sourced from the CIA factbook.

Manual charging

For vehicles not fitted with OBUs, tickets may be purchased in advance via internet or at network of automated terminals. The terminals issue a receipt on payment.

Automated enforcement

Automated enforcement is carried out by a network of over 300 gantries which are fitted with high resolution digital cameras and IR (infra red) detection connected to ANPR systems in order to recognise each vehicle. The gantries are on the autobahns. They communicate with the OBUs using DSRC to validate the GPS position and also alert BAG (Federal Office of Freight) enforcement officers if there are violations. Vehicles using avoidance routes are monitored by GPS and charged accordingly.

Effectively, for the honest operator who elects to fit an OBU, the enforcement gantries are quality assurance points confirming the OBUs including GPS units are functioning properly and permitting travel without enforcement stops.

Manual enforcement

Traditional stationary and mobile enforcement is carried out by 540 BAG enforcement officers who are able to scan moving trucks with a handheld enforcement device that communicates with the truck's OBU using DSRC. The BAG vehicles are equipped with payment terminals, mobile office facilities, copiers and scanners to enable capture of toll violation evidence. This system acts as an incentive to operate an OBU, because a truck that is not fitted with an OBU is likely to be stopped and checked, whereas those with OBUs fitted are unlikely to be stopped. Further checks are carried out at the operator's premises.

The enforcement operation continues 24 hours per day, 7 days per week, and 365 days per year. Checks are carried out on a random basis but they cover the whole network. Every tenth journey is checked. The level of detected violations is significantly below 2 per cent. This applies both to domestic vehicles and to vehicles from abroad. The low violation rate demonstrates the effectiveness of the combined automated and manual enforcement system.

Around a million trucks are registered and around 90% use the OBU Freeflow system. It is compatible with the Austrian microwave tolling system.

7.3 Austria

Austria has a population of 8 million, a land area of 82 444 square kilometres and a roading network of 107 262 kms including 1677kms of motorways. The network is entirely paved.

The Austrian system is mainly focused on road infrastructure financing operating a solely **distance** based **motorway** tolling system for all vehicles above 3.5 tonnes.

The objective is to charge tolls without disturbing traffic flows and this is achieved with an OBU – DSRC/gantry system similar to the German system.

The system is managed by a public limited company which invests revenue back into the development and maintenance of the road network.

7.4 Czech Republic

The Czech Republic has a population of 10 million, a land area of 77 276 square kilometres and a roading network of 128 512 kms including 657kms of motorways. The network is entirely paved.

The Czech Republic road charging system generates revenue to offset maintenance costs, future investment, and tax foreign trucks on the road network.

The existing paper based system was replaced with a Freeflow distance based toll on all vehicles and combinations with a maximum permitted weight of 12 tonnes or more from 1st January 2007.

The system is based on the **number of axles** in the combination; **emission class** (defaults to Euro II emission class unless proof is provided of a greater standard).

Before entering a tolled road the vehicle must be fitted with an OBU which is detected and registered by a DSRC/ toll gantry. In order to obtain these it is a legal requirement to provide proof of operator, vehicle identification and information about whether the vehicle has a metal-coated windshield (this may disrupt radio signals).

Photo 7.2: Czech "premid" OBU

Payment is either pre pay at contact points using cash, bank cards and prepay cards or post pay "on account" involving an agreement with the provider.

Automated enforcement systems identify offending vehicles and pass their details to Czech Customs administration staff.

7.5 Switzerland

Switzerland has a population of 7.5 million, a land area of 39 770 square kilometres and a roading network of 71 298 kms including 1758 km of motorways. The network is entirely paved.

The Swiss HVF (performance related Heavy Vehicle fee) system has a clear focus on applying the "user pays" principle, protecting the environment and increasing the rail share through investment of revenue in the rail system.

The HVF is a federal tax levied on the basis of **total permitted weight**, **emission class** and **distance** driven in Switzerland and the principality of Liechtenstein.

HVF must be paid for all the vehicles and trailers which have a total weight of more than 3.5 tonnes, are used for the carriage of goods driving on Switzerland's public roads network. There are exemptions for military, Police, Fire and other special types of vehicles.

The Swiss operate a principle of obligatory cooperation for persons who are subject to the fee in ensuring that the tax is paid correctly and the units are working properly.

OBUs consist of GPS augmented with a motion sensor linked to a digital tachygraph and this combination of systems makes tampering evident. The system switches the distance recorder on and off at border crossings using DSRC with infrastructure at the borders.

Photo 7.3: Swiss Tripon OBU

53,000 Swiss vehicles fall into the HVF category and are required to be fitted with OBUs. Foreign vehicles are issued with an identification card and may voluntarily fit an OBU.

Trailers are charged in conjunction with the tractor unit rather than separately up to the maximum weight limit of 40 tonnes permitted on Swiss roads. The driver is required to enter a trailer on the OBU using a smart card, choosing the appropriate make and model from a list or keying in the data. Trailer data can only be entered when stationary and a trailer recognition system prompts the driver to enter trailer data.

The system is interoperable with surrounding countries using DSRC although other systems are not fully interoperable with the Swiss system due to the fact that they do not use a digital tachygraph.

The Swiss example is also a good example of multiple systems providing independent information streams that verify each other, making it very difficult to successfully tamper with the OBU (or data streams).

The Swiss system cost around $500 million NZ to set up including the Government funding the initial investment in tripon units (fitting at operator's expense).

7.6 Sweden

Sweden has a population of 9 million, a land area of 410 934 square kilometres and a roading network of 425 300 kms including 1740 kms of motorways. 286 000 kms of this network is unpaved.

In late 2008 Sweden announced a 3 year trial of electronic GNSS based charging for all public Swedish roads and some privately owned roads. The overall objective for the transport policy in Sweden is that taxes and charges in road traffic should reflect the socio-economic marginal costs and contribute to achieving the transport policy objectives. For a distance based tax for HGVs this calls for internalisation of external effects like wear, maintenance costs, pollution and accidents.

The proposed charging basis is the **distance** travelled, **weight** (above 3.5 tonnes) and **environmental class.** Also considered were **road class** and **time of day.**

The Swedish road network is similar to NZ in some respects (differing from many other European nations) in that the network is large, has low traffic volumes (estimated 250 000 trucks), is not based on motorways and there is a large network of privately owned forest roads.

The Swedish approach was strategic in considering the relationship between distance taxation, road tolls and congestion charging and the requirements for technical interoperability to serve a variety of "value add" purposes apart from road charging. In order to create a system that takes the needs of all parties into consideration, the charging system is being developed in cooperation with authorities, researchers, road users and private enterprises. The goal is to enable authorities, operators, users and suppliers to cooperate in developing a solid and acceptable system.

The proposed model is to have multiple competing toll service providers (and integrated services) charging the same per-kilometre rate on behalf of the toll charger. The trial concept has four key elements, a thin client, a secure module, selectable position indicators and toll chargers key open interface. The system is enforceable with an anchor of trust embedded in the OBU hardware according to a secure module, trusted equipment concept.

Figure 7.4: Proposed Swedish system

7.7 The Netherlands

The Netherlands has a population of 16 million, a land area of 33 883 square kilometres and a roading network of 134 981 kms including 2604kms of motorways.

Previous road user charge initiatives (1988, 1992, 1994, 1999 and 2001) have failed due to a lack of political support. It is widely recognised that public and political acceptance is a key factor.

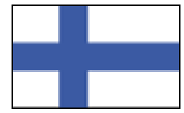
The Government of The Netherlands intends to implement a road user charging scheme whereby all road users are charged a fee. The first phase will be for heavy good vehicles (2012) and from 2016 onwards will be for all vehicles.

The fee will depend on **where** and **when** users make use of the road network, along with the **level of congestion**.

The objective of the scheme is to mitigate congestion by making the user more aware of the cost of using the road network and to give incentives either to use public transport, or not to use the road network during rush hours. On average the cost impact to the user is intended to be neutral through the abolition of taxes on car ownership and the taxes on the purchase of a car.

The proposed system will be GNSS based and will allow both thin and fat client OBUs.

7.8 Finland

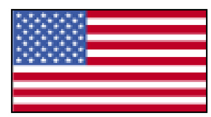


Finland has a population of 5 million, a land area of 304 473 square kilometres and a roading network of 78 821 kms including 700 kms of motorways. 27 967 kms of this network is unpaved.

The 2008 Government long term policy report on road user charging and congestion charging states that the government shall be ready to use congestion charging, as well as electronic fee collection based on satellite positioning within the next decade. The Ministry of Transport and Communications in Finland is currently investigating congestion charging in the Helsinki Metropolitan Area.

One of the approaches being considered is a common shared platform for road user charging, safety and security, environmental impact estimation, statistics, floating car data (traffic monitoring and management), crash detection, crash management and emergency response.

7.9 USA



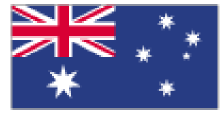
USA has a population of 303 million, a land area of 9 161 923 square kilometres and a roading network of 4 209 835 kms including 75 040 kms of motorways. 2 255 964 kms of this network is unpaved.

In the USA road user charging targeting heavy motor vehicles is not a significant issue. The key uses of similar technology are tolling, homeland security, traffic management, effective enforcement of weights, and intelligent transport systems interoperability.

There are numerous toll roads however there is no national system or national standard in place. Some cities, notably Manhattan, electronically monitor the movement of every vehicle, as a counter terrorism measure.

Due to the fact that USA was an early adopter of technology, there is a proliferation of disparate technology systems. A multi million dollar national intelligent transport systems (ITS) architecture is being developed (largely in hindsight) in an attempt to structure new and existing electronic services to maximise the strategic benefits that technology offers.

7.10 Australia



Australia has a population of 21 million, a land area of 7 617 930 square kilometres and a roading network of 812 972 kms. 471 524 kms of this network is unpaved.

Australia has a range of privately operated DSRC and ANPR based free flow tolling systems charging all users on toll roads and bridges. The majority of these toll roads and bridges are located in Brisbane, Sydney and Melbourne. There is no national road user charge.

Australia also has the New South Wales based RTA safe-t-cam system operating in partnership with Transport South Australia. This system automatically monitors heavy vehicle average speed and driver fatigue as a safety initiative to decrease the incidence of truck crashes. There are 11 strategically placed sites in SA and 23 more in NSW (shown in the following map).

Figure 7.5 New South Wales automated "safe t cam" enforcement sites

A GNSS based fleet tracking and monitoring initiative in Australia is the IAP or Intelligent Access Programme. This voluntary, cooperative programme permits qualifying operators to have higher mass and dimension limits in exchange for a range of safety requirements and real time GNSS monitoring of vehicles to ensure strict compliance. The automated systems generate exceptions (non compliance reports) for the jurisdiction's enforcement agency whenever an operator is outside set parameters. The system is monitored and tested by Transport Certification Australia (TCA) which is based in Melbourne.

The identified monitoring parameters are **vehicle and trailer identification**, **vehicle position** for spatial and route compliance, **vehicle time** for temporal compliance, **vehicle speed** for speed compliance and **tampering**. **Weight** is currently an operator nominated field. TCA has been researching the feasibility of monitoring onboard scales in conjunction with Queensland Government Department of Main Roads.

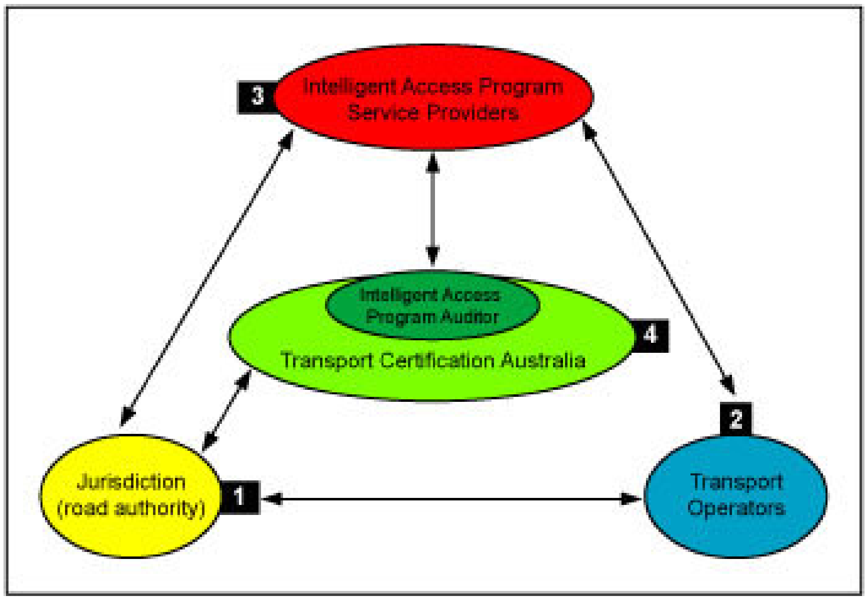


Figure 7.6 IAP relationship to TCA, operators and jurisdictions

The IAP system is being set up cooperatively by the 8 Australian state jurisdictions: Queensland, New South Wales, Victoria, South Australia, West Australia, Australian Capital Territory, Northern Territory and Tasmania. Each jurisdiction operates (or is developing) its own IAP schemes.

The transport operators pay fees directly to the IAP service providers for provision of the monitoring service. The same service may also incorporate logistics and fleet management services. In return for monitored compliance, the operator is permitted incentives such as higher mass limits, additional trailers, specific hours, electronic exception permits, and exceptions to dimensions etc.. All these incentives enable productivity gains, generation of additional revenue, demonstrate to customers the commitment to meeting chain of responsibility obligations and therefore create competitive advantage. A vehicle can operate under a number of IAP Applications granted by more than one road authority in different states.

Photo 7.7 Australian Road train

The intelligent access program service providers are required to undertake rigorous system testing at their expense. The testing is conducted by a central monitoring and management agency, Transport Certification Authority (TCA), which is based in Melbourne.

The TCA is funded by the participating states and the testing fees for devices and systems. Audits are conducted by TCA approved auditors at the expense of the IAP service providers.

The TCA regime is focused on strict compliance with comprehensive technical specifications and testing of all devices and systems against those specifications. The TCA has shown interest in including New Zealand as the 9^{th} jurisdiction in the scheme.

Example IAP Jurisdiction: Queensland

The Queensland IAP is currently under development; key issues to be addressed include driver fatigue, and speed related safety concerns, congestion and flexible charging systems. Queensland has taken a strategic view in integrating technology systems to address these issues.

Like many other integrated solutions Queensland has recognised the business drivers of offering voluntary uptake of smart compliance solutions in order to gain access to greater concessions.

Queensland will offer an integrated and streamlined road access management and vehicle monitoring solution delivering an improved balance between industry efficiency and sustainable road asset use.

The information available from this type of system enables greater efficiency, targeted demand and revenue management, and readily provides the evidential basis for a viable incremental pricing platform.

7.11 Lessons from International Experience

Key points highlighted by the review of current international technology based systems include:

Public and political acceptance of any system.

The main driver for most existing European systems has been to capture transnational heavy through traffic (Switzerland and Germany, for example, have a high percentage of foreign heavy through traffic that does not otherwise contribute to the cost of developing and maintaining the road infrastructure in those countries). The proposed Netherlands system is targeted at congestion and encouraging use of public transport.

Some systems are focused primarily on the motorway toll collection task; (Austria, Czech Republic), with systems designed accordingly; others include wider policy objectives (such as environmental, congestion and demand management, modal shift and rail-freight objectives) using solutions to combine current requirements with provision for future options.

The existing European systems all address heavy vehicles (above 3.5 or 12 tonnes) while some future systems account for congestion and plan long term to include all vehicles.

The extent of the monitoring networks (national vs. motorway) covered have had a major influence on the key technology decisions (e.g. GNSS vs. DSRC/Gantry).

Gantry/DSRC Charging systems which only apply to highways result in increased usage of nearby routes by heavy vehicles; whereas GNSS based systems (such as the Swiss system) monitor and charge for all road use do not suffer from this issue.

All future (currently planned) European systems are being designed as GNSS based, covering all roads. None of the European jurisdictions provide refunds for “off road” use because a technology based solution does not charge for off road use in the first instance.

A variety of technologies are used to meet the requirements of each jurisdiction. In each case the technology is configured to meet the legal and outcome requirements rather than vice versa. There are examples of systems that have successfully integrated existing distance measuring devices (e.g. Swiss system includes the Tachograph).

In all cases a range of effective enforcement systems are considered essential and beneficial to compliant operators. By using a variety of automated techniques, backed by targeted enforcement, compliance is encouraged, offending is deterred and lost revenue recovered more effectively. Time delays caused by enforcement stops and consequential commercial costs are minimised for compliant operators. Non compliant operators are automatically reported to enforcement agencies, enabling thorough time consuming enforcement checks on those who are identified as evaders. In many cases the automated system is capable of generating infringement notices for a range of offences.

One of the primary issues in considering a GNSS system is the ongoing cost of mobile data communications with OBUs, the associated value of benefits in relation to the objectives of the RUC system and potential wider benefits of a shared information system.

8 RECENT DEVELOPMENTS IN VEHICLE AND LOAD WEIGHING TECHNOLOGIES

International developments in weighing technologies cater for roadside enforcement (improved portable and weigh station capability) along with fully automated free flow sites that enforcement officers are able to electronically access for exception reports. The associated technologies are readily integrated and often share the same components as charging technologies.

8.1 Weigh In Motion (WIM)

New Zealand enforcement weigh stations currently use low speed weigh in motion (also known as dynamic weighing) systems to accurately record vehicle weights axle by axle. NZTA (formerly Transit NZ) has operated a number of stand alone highway speed weigh in motion sites around NZ developed for statistical purposes however the data output is not easily understood. All other NZ enforcement weighing currently uses portable static scales and privately owned weigh platforms.

8.2 Automated & Integrated Weigh in Motion

8.2.1 Australia

Some heavy vehicle checking stations in New South Wales use automated enforcement systems with integrated ANPR for vehicle recognition, automated vehicle status checking, weigh in motion and Safe-t-cam as screening devices.

Compliant operators are seldom required to stop for enforcement purposes. The result for compliant operators is greater predictability in journey times, fewer delays and consequential cost advantages in fleet and freight logistics.

Correspondingly, enforcement staff are able to focus detailed checks on all aspects of those operators that the automated systems select for a manual check.

Other automated systems generate infringement notices for any commercial vehicles that do not comply with the signal to stop at the weigh station or use avoidance routes.

Photo 8.1 Automated enforcement gantry approaching Marulan weigh station, NSW.

8.2.2 United States

The United States has various isolated automated weigh in motion sites for various purposes ranging from reduction of overloading on damaged bridges to overloading enforcement.

In New York, the State Department of Transportation has collaborated with the New York State Police Commercial Vehicle Enforcement Unit to screen vehicles using Weigh-in-Motion (WIM) devices combined with variable message signs to direct vehicles to continue or stop in designated areas. Many other automated systems are offered and are used at a variety of weighing facilities across the USA.

8.2.3 The Netherlands

The Netherlands identified that around 15% of the trucks on Dutch roads were overloaded with consequential road damage, unfair competition and safety issues. In response, the Rijkswaterstaat (Dutch Ministry of Transportation and Water Management) piloted automated, integrated weigh in motion sites and in 2001 developed an operational system of permanent sites that identify heavy vehicles (ANPR), weigh them axle by axle while the vehicle is in motion at highway speeds and records all data for a variety of purposes. The system operates using a number of integrated components including:

- Two rows of piezo quartz load sensors to perform the weigh function
- induction loops to identify the vehicle type, number of axles, speed and length
- enforcement cameras, ANPR reading and image storing

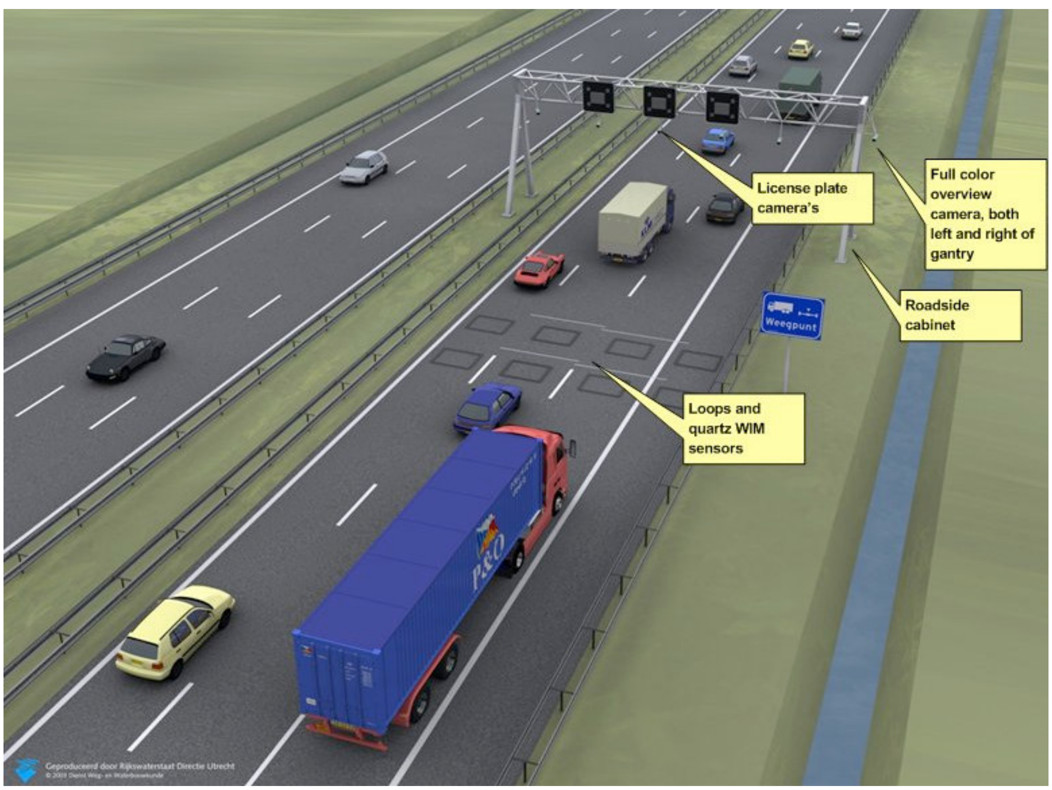


Figure 8.2 Rijkswaterstaat Integrated WIM and data collection system

The back office system works real time to collect all images, process and store the data, then distribute information to several groups as shown in figure 8.3.

Figure 8.3 System architecture.

All data is stored and analysed by the Traffic Inspectorate (IVW). The information is used for company profiling and repeat offenders are visited and assisted with measures to improve compliance.

The Rijkswaterstaat and their consultants use the data for road management, traffic statistics and research.

The Police are able to access the system real time via laptop in order to identify images and weights of approaching vehicles. The laptop screen shows a colour image of the target vehicle, the date and time, the numberplate, axle weights and highlights overloaded axles in orange. Police must perform a second evidential weighing before a prosecution is permitted under local law.

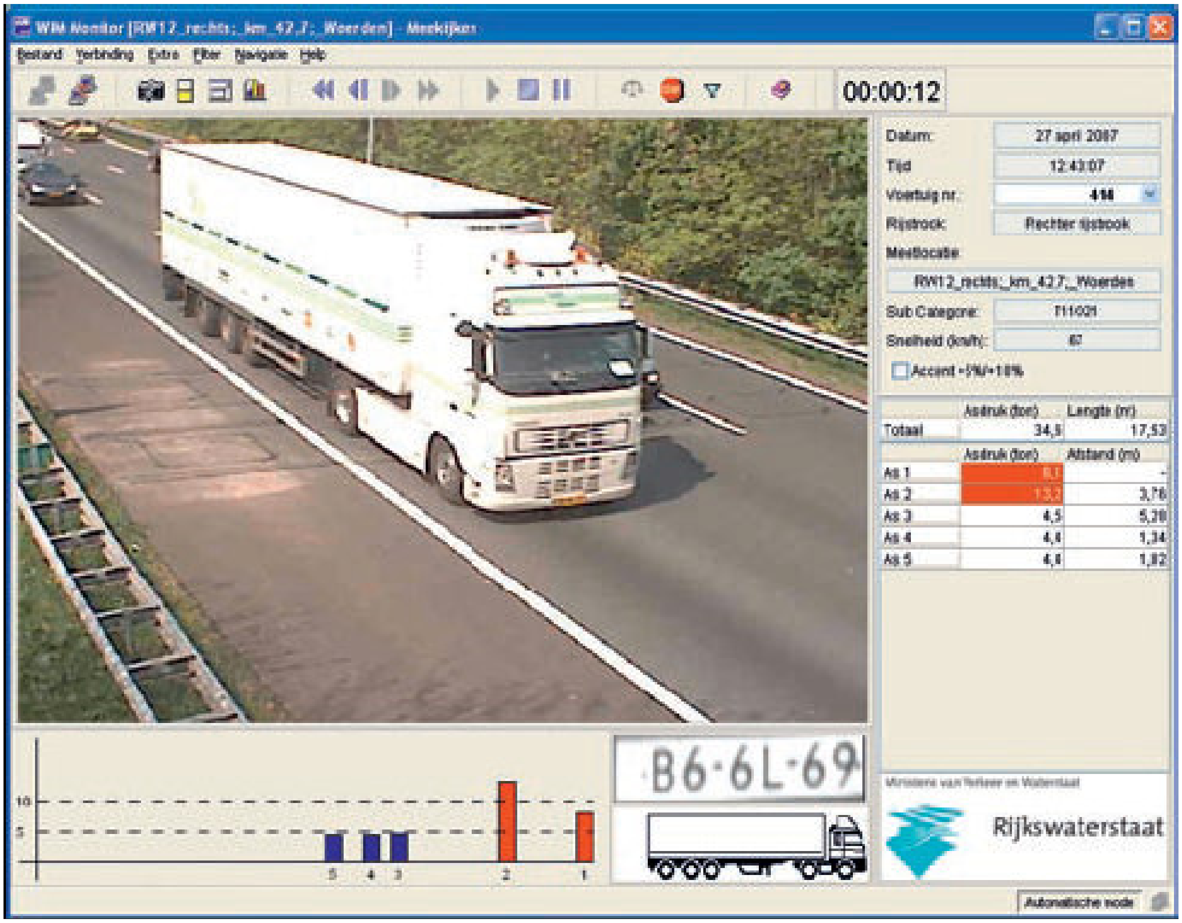


Photo 8.4 Screen shot from the Netherlands WIM system.

8.3 Portable Dynamic Scales

Portable dynamic weighing systems have recently become available, however there is a legal constraint in NZ requiring all axles to be raised to be "reasonably level".

The practical effect is that where weigh pits are not suitable, plastic mats are required to be provided for twice the length of the vehicle combination (to raise the combination to the same level as the scales). The required 42 metres of plastic mats (for a 21 metre combination) currently weigh around 500Kgs and operationally require a trailer to transport them.

Adoption of any portable scales of a different thickness (to those currently used) will require rebuilding of over 100 weigh pits to suit. Likewise, any increase in permitted combination length would require additional approach and departure space to be added to each weigh pit under current laws.

9 RELIABILITY, ACCURACY, SECURITY AND COST OF TECHNOLOGIES

Before considering the reliability, accuracy, security and cost of technologies, a suitable base line is the current system.

Section 4 of this document outlines the economic cost of current RUC evasion estimated at $40 to $200 million per annum (5% to 20%) and the benefits to society of using technology to reduce evasion, most likely to levels demonstrated in the German example (significantly below 2%).

The current administrative system is largely manual, supported by a legacy database and dedicated specialist “zebra” printers. The cost of administration is significantly higher than a truly automated system would offer and service levels are sub optimal because the system is not continuously available and does not fully interface with customers via the internet. If a truly automated RUC system was to be implemented, a separate database and separate private sector provider should be considered.

Accuracy and reliability of any technologies applied to road user charges depends on GNSS devices that are augmented by one, preferably two other data streams (motion sensor and wheel revolution or speed/time counter), security systems that make tampering evident, electronically report device and system tampering and mitigate the risk of evasion through automated audit and regular enforcement verification. In the absence of adequate security measures, accuracy of data will be uncertain, the information gained cannot be relied on and the degree of evasion is likely to remain constant.

9.1 Reliability And Accuracy Of Technologies

9.1.1 GNSS Devices

GNSS devices have an inherent degree of inaccuracy, positioning chipsets for general commercial use are currently accurate (at device level) to around 5-7 metres. Older and less expensive devices have reduced accuracy with 5 year old GNSS devices accurate to within 30 metres.

GNSS is prone to a number of weaknesses such as canyoning (bouncing signals) and loss of signal at certain locations (due to canopy cover) and times (poor satellite constellation reception).

GNSS receivers form a part of the system with back office systems supporting the receivers electronically (in some cases manually) correcting or “post processing” raw device data that does not “fit” to make it more accurate.

GNSS presents a near flat view (projection) of the earth meaning that there is some theoretical reduction in distance travelled over hilly terrain due to the triangular difference between the horizontal vector seen by the positioning system and the vertical vector of travel up and down hills. In practice this difference is negligible.

9.1.2 GNSS Augmentation

Augmentation of GNSS positioning data is considered essential in any system requiring a degree of accuracy and/or security.

Modern vehicles provide opportunities for augmentation through engine management and other electronic systems that correspond with wheel rotations or distance/ time (speed). The Swiss system uses digital tachygraphs to perform this function (amongst other functions the tachygraph performs).

Motion sensors augment GNSS positioning by approximating position when the GNSS signal is unavailable. These are generally gyroscopic MEMS (micro electro mechanical sensor) devices. The Swiss system incorporates motion sensors.

Base stations can also provide augmentation by way of a DSRC signal secondary to GNSS. These require the cost of installation and maintenance and are potentially a costly option. The German system includes solar powered base stations.

9.1.3 Communications

Communications systems are generally very accurate and have levels of security that progressively make data tampering more difficult.

The minimum requirement is a digital network for data transfer. It is strongly recommended that for RUC purposes the digital signal is also encrypted.

Communications systems are reliable for the area they cover, however it is noted that NZ has large areas that lack mobile data coverage. Any system would need to have some onboard storage capacity for periods when the vehicle is not in mobile data coverage areas.

9.1.4 GIS - Geographic information systems

Raw position data (and weight data) is not readily interpreted and may not make sense on its own. An essential component of a distance-based road user fee system is its ability to reconcile GNSS and other OBU data with digital maps and associated parameters defining, for example, public roads, set routes, local authority areas, legal restrictions and times.

The GIS is the software (application) that performs this task and interprets raw data, transforming data into information visually on a map layer or by reports.

Base Maps and Parameters

The GNSS device requires a nominated degree of accuracy; the interface between GIS maps and the GPS receivers should be accurate enough to distinguish whether a vehicle is on a road or off road (for example on private roads adjacent to the highway).

Legislation may need to be amended to define “off road” as a nominal distance from the centre line, legal road boundaries or some other defined parameter. Ideally the system will recognise off road running and will not charge for it, eliminating off road refunds.

Once the “off road” parameter is formally defined the technology will readily and relatively accurately distinguish whether a vehicle is off road, on a local road, or on a highway. This is achieved by setting the same type of parameters either by a data query or a visual query in a GIS “viewer”.

9.2 Security Of Technologies

In assuring the integrity of any technology based charging system, physical and electronic security is essential.

While levels of reliability and accuracy can readily be demonstrated by a number of current technology based position monitoring systems in New Zealand, these systems are invariably designed for willing participants who have no incentive to tamper. There always is a strong financial motive to tamper with revenue (taxation) collection and law enforcement systems where tampering may offer financial advantage.

In considering the adoption of technology we believe that adoption of sound physical and electronic security accompanied by automated enforcement methodologies are essential.

The levels of security required would necessarily include physical and electronic security at device level, during communications and in the back office system(s) along with independent audit systems. The audit systems would locate vehicles at specific times and places and confirm that the primary data stream is accurate.

At every level there is a range of preventive and tamper evident methodologies that are available. Security at each level is a matter that is essential in assuring data reliability.

Likewise automated auditing sites at strategic locations are considered essential to confirm accuracy or otherwise of the onboard devices.

9.3 Cost Of Technologies

As technology progresses, the accuracy of GPS based devices increases and the price decreases. For example in 2003, GPS units suitable for commercial fleet use retailed for around $2000 with an accuracy of 30 metres and lacked mobile communications capability.

Current GNSS devices (OBUs) retail for around $500 each with a raw accuracy of 5-7 metres and are fitted with communications capability, in many cases include augmentation systems and a few include security and tamper reporting systems. Some commercial systems operators include the purchase price in their monthly charge.

In the next 5-7 years similar improvements can be anticipated in cost, accuracy, integration and security. Some emerging GNSS based OBUs being developed in New Zealand and internationally are already addressing these issues.

The cost of back office, infrastructure, maintenance and support is dependent on the technologies used, the business architecture and the requirements on the technology. Sharing technology and communications channels with the private sector will significantly reduce costs. As a high level indicative costing the Swiss system cost around NZ $500 million to set up including all infrastructure, back office and the purchase of the first OBU for every Swiss vehicle in the scheme. This system is not shared with the private sector.

It is anticipated that the NZ system cost may be significantly less due to the fact that there are already over ten NZ fleet tracking systems solely funded by commercial transport operators. These systems could be adapted for common purposes. The majority of commercial fleet tracking providers see advantage in providing RUC and other Government administration functions as part of their suite of services.

10 TECHNOLOGIES THAT MAY REPLACE HUBODOMETERS

New Zealand's interest in a technology based RUC system has different drivers to the overseas examples and the country's starting point and environment is different. It is suggested that in 2008 NZ's key drivers for technology enabled RUC are:

- ensuring an efficient inter regional, multi modal freight system, delivering cargo for rail, coastal shipping and export to the transfer points reliably, cost-effectively and with minimum emissions.
- ensuring that costs of transport accurately reflect the investment requirements, encouraging fair competition and recognising the externalities imposed on other road users, the community and the environment.
- contributing to economic transformation, partly through the intelligent use of new information and communications technology, but more importantly through the more efficient charging for, and use of, the road network.

As noted previously, New Zealand already has a relatively sophisticated manual RUC system with a semi electronic back office. Therefore from a policy perspective, NZ has an advanced starting point. Some European countries are starting from a point of having no pre-existing weight/distance charging system and need to deal with the political implications of a new tax.

New Zealand does not have the cross-border payment problems that form such an important driver for similar technology to be introduced in the European countries or the state and federal jurisdictions that cause costly issues in Australia. The New Zealand national toll road network, another common area of application, consists of only one soon to be opened road. Consequently the objectives for an technology based RUC system in New Zealand differ significantly from overseas examples.

New Zealand also has a low population density and low population to road ratio when compared with the majority of European countries.

In this context, a range of options for the introduction of technology based RUC system was assessed in 2003/04 against key decision factors for Government, focused primarily on the costs, benefits and feasibility of a voluntary system, but also extended to explore the effects of a progression through to a managed transition for the whole RUC vehicle fleet. That work looked at three possible system designs, in the following range:

'Basic' (simply replicating the current RUC system but with electronic rather than mechanical units).

The Macro electronic hubodometer that was previously available in NZ was significantly more expensive than competitor's approved products and offered no commercial advantage. As is currently the case, the cheapest approved hubodometer product serves the required purpose and takes market share. The same market forces led to the demise of the Macro electronic hubodometer remain in the current environment. There may be little (if any) advantage and many possible disadvantages to a direct replacement of the hubodometer with an electronic version unless the electronic version is cheaper and offers the same degree of reliability.

'Intermediate' (greater functionality, particularly the ability to declare the *actual* weight of the vehicle at any time, rather than using the existing RUC system's average charge).

Declaring the actual weight would result in higher RUC fees and little or no real overall long term cost benefit. It would cost more for those who travel with full loads over 50% of the time and less for those who travel with partial or empty loads. The effect may be to sustain otherwise marginal transport operators.

'Ultimate' (the most sophisticated, enabling policy options such as location, time and environmental-based charging).

The ultimate solution requires technologies that either are fixed on all toll roads (roadside infrastructure - gantries/DSRC and communications), or vehicle based GNSS and weighing technologies transmitted via the mobile data network, automatically audited by strategically placed gantries that confirm the vehicle based information is accurate and indicate where tampering, calibration or communication issues exist.

In the period since 2004, technology has advanced. 2006 was widely considered to be the year that GNSS based tracking systems became commercially cost effective. Their voluntary uptake in New Zealand and abroad has demonstrated this with a current estimate that 30 000 NZ light and heavy vehicles being tracked, increasing at a rate of around 500 per month.

Consideration of a wider intelligent transport systems (ITS) view is likely to show that a strategic and cooperative way of thinking has significant advantages for all parties. Perhaps the greatest advantage of properly applied technology is the ability to collect a dataset once at one point for many Government and business information purposes, enabling cost sharing.

A sound existing NZ example of a properly applied single point of collection information system may be found in the system operated by Foodstuffs. Every grocery item scanned at supermarket tills alters electronic shop stock levels, generates orders to the warehouse and when warehouse inventory is low electronically orders stock from manufacturers and suppliers. The same system provides relevant information for marketing, logistics, financial, taxation and other purposes.

This type of information sharing system is made feasible by SOA (service oriented architecture). Interoperable systems in a SOA perform separate functions around each business process and the systems exchange information both internally and externally via web services.

Through simplification and adaption of multiple current transport technology systems which collect similar data, for different purposes, it is feasible to enhance the quality and quantity of information available; provide more effective administration, and lower the cost of compliance. Major hurdles in achieving this are gaining the cooperation of all parties and meeting legal requirements.

Adoption of technology will rely on building understanding and delivering sufficient benefits to each of the parties to gain their cooperation. A well thought out, strategic, cooperative approach to application of technology offers significant long term cost, output and outcome benefits at a variety of levels. To achieve this will require sound strategic analysis; strategic business architecture; strong political will; appreciation of wider business drivers, Government objectives and inclusion of associated business requirements.

Automated audit / enforcement systems that are properly architected and implemented might readily reduce road user charges evasion levels from the currently estimated NZ level of 5 - 10% down to significantly below 2% as demonstrated by the German system providing at least $500 million of long term funding.

The generally accepted software life cycle is 5-7 years. Commonly, government departments follow a two to three year planning process followed by a further two to three years for development. The net result may be release of a product after 4-6 years (nearing the end of its life cycle). International experience demonstrates that outcome focused, private sector system development is likely to achieve superior results in a more cost effective and timely fashion.

10.1 Enhanced Information

If properly architected the data gathered electronically for RUC is potentially extremely beneficial and valuable for a variety of other commercial and administrative applications. There is significant potential for those operators who elect to minimise administrative and compliance costs through electronic systems sharing the same technologies for the following purposes (amongst others):

- Freight and Vehicle Logistics information for the operators.
- Driving hours reporting and monitoring for the operators and enforcement officers (requiring approval as an alternative to logbooks).
- Hazardous goods declaration and monitoring for operators and emergency services to enhance incident response management.
- Traffic information (in conjunction with floating vehicle data) in line with the NZTS to improve traffic management; reduce traffic congestion, lowering costs to the operators and the nation.
- Driver, vehicle and operator licensing, optionally ensuring that vehicles are only driven by appropriately licensed drivers who are authorised by the owner.
- Vehicle and driver safety including incident response and emergency chain management.
- Identification of and deliberate RUC evasion to enable targeted enforcement by Police and ECU.
- Anonymised statistics forming a solid evidence base for well informed policy and economic decisions from a variety of local and national agencies.

10.2 Position

It is noted that the current legal requirement for an electronic hubodometer is that the number of wheel revolutions is counted. This requirement remains sound. Augmentation of GNSS and wheel revolutions (or associated electronic pulse) would increase confidence in the measured distance, significantly increase the complexity of tampering, and is likely to make any tampering electronically evident. Addition of gyroscopic devices would further increase confidence in position, approximate position when the satellite constellation is not visible to the receiver and further reduce the chance of data tampering/ evasion.

10.3 Trailers

An issue that is grappled with internationally is that an equitable and reliable technology based charging system for heavy trailers. It stands to reason that a truck towing a heavy trailer should be charged more than a truck not towing a trailer.

The New Zealand industry also has a common practice of placing empty trailers on empty trucks to eliminate trailer road user charges for empty running. Ironically this started in the late 1970s with the logging industry realising the benefits of paying RUC for trailers only when laden. Any technology based system will need to manage this fact possibly through a fee based (actual weight) incentive to tow the trailers.

Several possible options are identified to deal with the trailer issue:

1 It is technically feasible to electronically link and electronically identify trailers when the electrical system is coupled to a towing vehicle (tractor unit). However it is recognised internationally that it is equally feasible (and somewhat less safe) to tow a trailer without connecting the electrical system in order to evade RUC.

2 Electronic declaration by the driver that a trailer is being towed relying on honesty and a combination of automated and random manual enforcement checks. This can be verified by the back office system recording where trailers are last electronically uncoupled and providing an exception report if the trailer is next electronically coupled at a different location.

3 Separate OBUs mounted to each trailer, this dictates ultra low power usage and long battery life to cater for occasions when the trailer is not being towed. This also relies on at least occasional connection of the tractor electrical system to recharge the battery. There is one system under development in NZ that offers this potential and others that rely on more frequent electrical connection.

   An enhancement on this business model would have for example a green LED for normal operation, an orange LED low battery warning with a very substantial minimum penalty (or infringement) for operating a trailer with a unit not showing a green or orange LED on a road.

4 Continued use of mechanical hubodometers on trailers as a backup to either of the above systems.

5 A combination of the above.

10.4 Weight

If weight continues to be an element of an electronic RUC system there are several potential options for this parameter. Possible options are:

1 Electronic declaration of weight by the driver or operator. This relies on honesty and operator perception of a good probability of automated and manual enforcement checks. It is similar to the RUC current system and offers some improvement in terms of service to the operator, statistical data gathering and targeted enforcement of evaders.

2 On board scales fitted to vehicles are generally electronic and capable of reporting measured weight real time to an OBU. Electronic on board scales are already fitted to many vehicles in New Zealand.

3 Pre programmed in the system at a maximum operating weight - particularly suited to light diesels.

4 Voluntary adoption providing a choice of either, possibly with charging incentives for the automated option.

The current onboard systems are largely (suspension) airbag or beam based with accuracy normally within 10 percent (if calibrated correctly).

Some manufacturers supply load cells designed to fit under the chassis, 5^{th} wheel, container twistlocks, cranes, bulk tippers, rubbish skips and rubbish forks to measure payloads.

Some of these systems also operate wirelessly.

Figure 10.1 Sample onboard electronic weight display

These systems are readily able to be calibrated by the driver and rely on electrical connection to the trailer. This offers potential for evasion when used for RUC purposes however in comparison to the existing nominal weight system offers distinct advantages with few disadvantages.

Dr Charles Karl (Manager Major Projects - TCA Australia) and two associates have conducted research on the feasibility of onboard mass monitoring OBM technologies for evidentiary purposes; however the findings are commercially sensitive and publicly unavailable.

11 VISION OF A TECHNOLOGY BASED NZ RUC SYSTEM

11.1 An Integrated Strategic Approach is the key

Technology is simply an enabler for business process requirements. In determining what technology (if any) might be adopted it is essential to follow a systems approach. Firstly clearly determine the strategic business requirements; secondly the data requirements to meet the business requirements and thirdly developing a coordinated business architecture to support the business requirements.

11.1.1 System objectives

The pivotal question in architecture of any technology solution is whether the NZ Government considers the 30 year old objective of NZ road user charging (road maintenance) should remain the sole objective, or whether a holistic approach should be adopted incorporating other commercial, government and transport sector objectives.

The system can be designed to efficiently and effectively deliver the government objectives for infrastructure funding, travel demand management, and economic development. It is preferable to set these out in a hierarchy from the outset so the most efficient solution can be determined.

We suggest consideration of the fact that a technology based road user charges solution, including an automated enforcement system is a valuable strategic opportunity to address:

- Commercial profit objectives relating to fleet and driver management, freight logistics and automated business process to reduce administrative costs and time delays for compliant operators. Automated enforcement systems would strongly promote commercial equity by detecting, reporting and potentially automatically fining those who deliberately break the law to undercut rates of compliant operators.
- E- Government strategy to make New Zealand a world leader[12] in using information and technology to realise its economic, social, environmental, and cultural goals, to the benefit of all its people.
- E- Government key messages to provide an online world, put people first, collaborate, build trust and deliver results.
- New Zealand Transport Strategy 2008 objectives relating to monitoring and managing road safety, emissions, congestion and travel demand management.
- NZTA objectives of delivering integration, safety, sustainability and value for money.
- Police objectives in increasing overall compliance, road safety and operational efficiency while reducing costs.

11.1.2 Data requirements

Once the system objectives are defined, the datasets to be collected and measured for RUC and other purposes may be readily identified. (eg distance, weight, axle configuration, emissions).

[12] NZ Digital Strategy

11.1.3 Business architecture

Only when a clear description of what data is to be collected (based on the system objectives) should the business architecture encompassing business processes, required law, IT requirements, communications, enforcement and change management be developed.

Industry standard *voluntary* systems are designed by honest people for honest people and do not require thought about evasion. Because RUC is a *mandatory*, tax based system, prone to evasion, the business architecture requires a different mode of thinking. A practical, security conscious architect with a sound understanding of human motivation, business and business drivers, law, compulsory information systems, evasion and enforcement is considered essential to creating a system that functions properly. A sound architecture will deliver an efficient and equitable collection system that helps the government achieve it's objectives when fully implemented.

11.1.4 Risk of Failure

The success of any business system relies on all parts being included and working to specification. By way of comparison a mechanical clock missing a vital cog may appear the same externally but is highly unlikely to function properly.

Many systems have been well designed and failed due to cost cutting, or elimination of features that (for example) meet the requirements of external users. Those making the cutbacks have failed to recognise that the external users provide the data on which the systems rely.

Attempts to make one system perform all business functions result in complex designs and have ended with many notable Information System failures in NZ and internationally.

In order to maximise the contribution to economic growth that any technology based RUC system may make it will be essential to have a simple yet sound design with the political will and funding to ensure proper implementation of information systems, automated enforcement systems and related law changes to full business architecture specification.

11.2 Sample high level systems architecture

Technology is simply a tool, enabling and serving the business process. The simpler the design of the tool the more effective it will be at performing a specific business function.

A service oriented architecture (SOA) keeps the technology serving each business process simple, while making the process and information derived from that process available to other parts of the system. A federated architecture operates in a similar manner between interoperable independent lines of business (LOBs) within a large business or external systems.

The basis of these architectures is having each business requirement being processed by a different part of the system. For example a service might query registration numbers, returning the underlying vehicle identification number for each. This data can be used for another service, for example querying the currently paid road user charges weight and distance. By simplifying each process and having designated system "areas of expertise", if any one process requires modification it is relatively straightforward and does not require extensive (costly) testing of implications to other parts of the system. These architectures utilise web services enabling communication and simple addition of other business functions (internal and external).

This type of architecture may be compared to building using Lego blocks to complete an effective overall structure. There is always scope to readily add on compatible business systems utilising relevant existing services.

It has been identified that any feasible systems architecture relies on a sound definition of business requirements and corresponding consistency in law, communications and policy. Equally it is recognised that an ideal systems architecture will never be perfect because the business environment is prone to change; each change may impact the “ideal” systems architecture.

Strategic thinking and simple design of a service oriented technology solution supporting each business process enables greater systems flexibility and agility.

The Following diagram indicates a possible high level systems architecture based on the currently available NZ fleet tracking systems combined with the best features of international examples. An OBU collects data from GNSS, an inbuilt gyroscope, wheel revolutions (possibly via a digital tachygraph) and weight (via onboard scales or declared). There are three data streams and a variety of services although only the RUC service is shown.

11.2.1 Primary data stream

The primary information stream is via the mobile data network and transfers all data from the OBU at regular intervals to a commercial tracking provider chosen by the operator. The commercial tracking providers make relevant information available near real time to a private sector tracking data pool. (subject to data communications being in range).

11.2.2 Audit data stream

The audit data stream is via a fixed link from strategically placed automated audit sites. The primary purpose of these sites is to confirm that at any given time the information collected by the primary data stream is accurate and reliable. Where the information provided by the primary stream is different from (outside set parameters) the audit data stream, the system will generate an exception report. Subject to policy and law changes the exception report could be used to automate infringement notices and/or electronically advise the Operator, ECU and Police of the exceptions.

11.2.3 Enforcement data streams

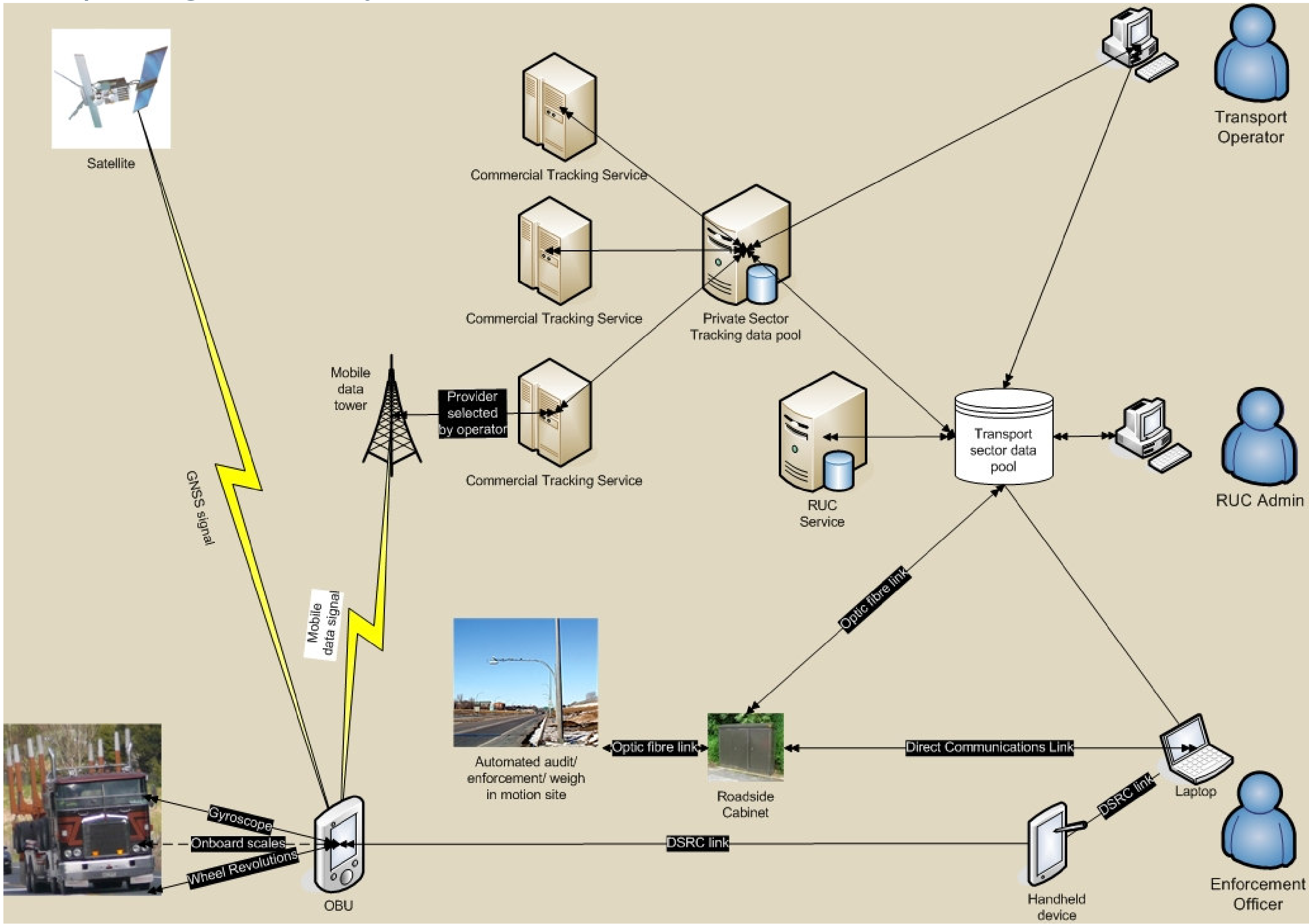
The enforcement data stream is vital to targeted enforcement. Enforcement officers are able to directly query the OBU at any given time they are within range (via DSRC), can elect to be advised real time of exceptions generated by the audit data stream and can access the transport sector data pool for legitimate enforcement purposes.

11.2.4 Transport Sector Data Pool

Information relevant to a variety of transport purposes is obtained from a variety of sources (including mobile vehicle data and historic data). This data is available to a number of services (such as the RUC service – which obtains vehicle weights and distances are at any given time and charges operators accordingly by credit arrangements such as direct debit (daily, weekly, monthly etc)). RUC information is available to operators, RUC admin staff and enforcement staff.

Other services possibly accessing information from the transport sector data pool are indicated in section 10.1 (Enhanced Information).

11.3 Sample High Level System Architecture



11.4 Best of Breed

From international examples and New Zealand requirements, the technologies that might form a best practice NZ technology based RUC system include parts of the systems used or planned in The Netherlands, Germany and Switzerland (amongst others):

11.4.1 Strategic Requirements

- Requirement to gain political and public support and financial commitment for any proposed system.
- Clear definition of all outcome requirements, data outputs and parameters.
- Consideration of data requirements and business drivers of all parties (transport operators, Government and service providers) prior to architecting any solution involving law, optimum business process, communications, audit, enforcement and technology.
- The principle of obligatory cooperation.
- Rigidly defined and enforced penalties for evasion based on economic risk analysis models.

11.4.2 Onboard systems

- Location determination by GNSS based OBU, augmented by gyroscopic and wheel revolution (or equivalent systems) possibly via tachygraph. Augmentation is considered essential to maximise accuracy and minimise the risk of tampering/evasion.
- Consideration of digital tachygraphs with smart card driver's licences enabling driver identification feeding information to the OBU. Optional feature: vehicle immobilised unless driver is currently licensed for that class and authorised by the owner to drive that vehicle. Optional feature: replaces driver logbooks.
- Optional onboard vehicle weighing systems electronically feeding weights to the OBU, alternately declaring actual weight via the OBU.
- OBU physically and electronically secure. Permanently fitted to the vehicle in such a way that the box needs to be opened to remove it from the vehicle. OBU configured to send an exception report (alarm) to the mobile provider whenever the box is opened, a new device is added or any existing devices lose connection.
- Electronic recognition and declaration of trailers with OBU providing driver reminders to confirm attachment based primarily on electrical connection and also on significant changes to engine torque requirements.
- Outcome based technical requirements to ensure minimum device security, reliability and accuracy while permitting new devices that exceed minimum specifications.
- Class certification by a NZTA authorised qualified engineer. This enables factory certification of compliant OBUs.
- Re certification required whenever OBU seals are opened. Formal electronic identification of certifying engineers may be by way of tachygraph smart card enabling electronic tracking of uncertified OBUs.

11.4.3 Communications

- Encrypted digital mobile data communications (GSM or other mobile network) as the primary secure communications channel with encrypted DSRC as a secondary communications channel enabling secure communications with gantries and other enforcement devices.
- Communications capability enclosed in the OBU.

11.4.4 Tracking Services

- A range of commercial tracking service providers driven by market forces, each meeting and maintaining minimum performance and outcome requirements.
- Post processing systems verified by independent qualified persons authorised by NZTA.
- Must supply raw data to NZTA for audit purposes.
- Must supply post processed data to the private sector tracking data pool and the transport sector data pool in conformance with data format requirements.
- High commercial penalty if any evasion is conducted during the tracking service process.

11.4.5 Data Pools

- Data sharing from a privately operated near real time vehicle tracking data pool. Strictly as authorised by the Privacy Act (in this case for RUC and RUC enforcement purposes) and anonymised data available for statistical and traffic management purposes.
- Services for RUC and other administrative functions sharing common pool of fleet data.

11.4.6 Administrative

- Fully automated charging and direct debits from bank /credit card accounts for actual distance and weight with no manual intervention.
- Remote single login access (possibly Government Shared Network) accessible by operators (for own fleet) to accounting system and fleet tracking via internet and web services for automated systems integration.
- Option of advance RUC payment or requesting credit option for monthly or quarterly invoicing, submitted via secure internet login.

11.4.7 Audit / Enforcement

- Strategically placed, automated freeflow (highway speed) ANPR /OBU vehicle checking and recognition incorporating high resolution cameras, dynamic weighing, height and width detection and DSRC confirmation of current OBU position, weight and trailer information. Option to include information not required for RUC such as driver identification and driving hours (via tachygraph and OBU).
- Real time automated checking and comparison of multiple databases for compliance whenever a vehicle passes a freeflow audit site or is stopped by enforcement officers. Automated generation of infringement notices for clear non compliance and exception reports for apparent non compliance. Storage of key identification/ time /date /position/ weight data. Automated comparison with similar data from other automated audit sites to ensure average speed and driving hours compliance and provide sound near real time data for statistical and traffic management purposes.

- Well informed enforcement staff advised within seconds of nearby non compliant operators by automated systems such as the Netherlands WIM screen, enabling targeting of non compliant operators and limiting the number of physical enforcement checks on compliant operators.
- Enforcement functions of administrative system and audit site information accessible via secure internet directly to handheld device.
- Mobile electronic checking of moving vehicles with enforcement staff using handheld devices and secure DSRC communications (eliminating the need to stop a compliant operator for a check of documentation).

11.5 Potential Application To Light Vehicle Fleet

Medium to long term, consideration might be given to applying the same systems to light diesels and other light vehicles currently paying RUC.

If GNSS based systems are operating accurately and reliably for the commercial fleet there are potential technical advantages to standardisation of the same technology system to the light vehicle fleet.

A technology based system is likely to be technically capable of automated payment of congestion charging (by time and emissions class), payment of parking, potentially for fuel purchases (enabling monitoring of actual fleet fuel consumption), as an alternate to licensing fees and fuel excise duties.

12 TRANSITION TO A TECHNOLOGY BASED SYSTEM

12.1 The New Zealand Environment

New Zealand has a population of 4.5 million, a land area 268,021 sq kilometres and a widely dispersed 93 576km road system including around 370[13] km of motorways carrying 9% of traffic, 10700kms of state highways carrying 46% of traffic and 32012 kms of unpaved roads. There are many private roads through forests and farms and traffic volumes are low in comparison with most other developed countries.

In comparison with the international examples New Zealand has a low population, a low population density and a low population to road ratio. The only exceptions to this are Sweden and Australia, each of which have large areas of inaccessible land.

Country	Population (million)	Land Area square kms	Road kms	Population density people per sq km	Population / km road
Australia	21	7617930	812972	2.76	25.83
Austria	8	82444	107262	97.04	74.58
Czech Republic	10	77276	128512	129.41	77.81
Finland	5	304 473	78821	16.42	63.43
Germany	82	349223	644480	234.81	127.23
New Zealand	4	268021	93576	14.92	42.75
Sweden	9	410934	286000	21.90	31.47
Switzerland	7	39770	71298	188.58	105.19
The Netherlands	16	33883	134981	472.21	118.54
USA	303	9161923	4209835	33.07	71.97

Table 12.1 Comparison of International examples

New Zealand also has strong rural heavy transport requirements, particularly in the agricultural, dairy, livestock and forestry sectors.

In this environment there exists a comparatively low number of trucks per kilometre of road, a relatively low funding potential to significantly increase Police staff levels and a low probability of a vehicle being stopped for an enforcement check (on most routes).

NZ administration and enforcement agencies currently lack a solid accurate evidence base describing the activities of the New Zealand transport industry and much “known” information is developed using samples and statistical inference. Correspondingly, intelligence and targeted enforcement of non compliant operators is currently largely gained by enforcement stops and word of mouth. This means that compliant operators are subjected to many more time consuming enforcement stops than would be the case with automated audit/enforcement systems used to identify and report “poor” operators.

These factors all provide strong support for an automated enforcement network.

[13] Sources MOT website, Statistics NZ and CIA factbook.

12.2 NZ Transport Strategy

The New Zealand Transport Strategy mentions consideration of "systems based on distance, time and location of travel and type and weight of the vehicle"

With high-efficiency diesels, hybrid gas-electric and petrol-electric engines, hydrogen fuel cells appearing on NZ roads and more to follow, petrol taxes may no longer be a predictable or reliable source of transport revenue for light vehicles.

A distance-based user fee system must be able to ensure a stable stream of revenue for the road network, as well as being equitable and efficient to collect, convenient, and flexible in its application and ensure user privacy. Once implemented, distance-based charges could supplement or replace existing fuel taxes for light vehicles.

12.3 Political Issues

New Zealand has a number of influential industry groups and Government agencies in the transport sector. Alignment of all these parties has been difficult to achieve. The recommended approach is to build a business model that provides a suite of integrated benefits for all parties rather than one with a narrow focus on RUC enforcement.

12.4 Cooperation With Industry And Academia

There may be significant value to NZ Government in cooperating with and involving the transport industry, information technology providers, related agencies and tertiary educational institutions to adapt and integrate existing technology and expose possible evasion methods, thus lowering the overall cost of RUC administration for all parties.

Technology coordination is a major theme of international examples and makes business sense from every perspective. Many international examples contract private sector expertise with a vested interest (system ownership or performance based payments) to develop and operate the systems.

Given the generally accepted system life cycle of 5-7 years, the agility that the independent private sector offers with a vested interest will almost certainly provide superior results in a shorter time frame. (As distinct from insourced or sole contracted outsource provider)

12.5 Anticipated Level Of Support

The existing group of tracking system users are not separately represented by any industry body. Informal conversations suggest strong support for technology based road user charging and other Government commercial vehicle administration regimes to increase transaction accuracy and timeliness, effectively manage their fleet and lower the cost of compliance both of the operator's administrative systems and the RUC administrative system which forms part of the cost to the public.

It is recognised equally that there is a large group of transport operators who do not care about how the system is administered and yet another group who may actively oppose the use of technology solutions for a variety of reasons including cost, resistance to change and increased probability of evasion detection.

Involvement of all parties, clear definition and transparent communication of the purpose of RUC and any associated changes are considered important in gaining wide acceptance of the charge and any new collection system.

12.6 Legal Issues

The current laws were designed for the 30 year old manual RUC system and amended specifically for the Macro electronic hubodometer which is no longer manufactured.

Any new system is likely to require sound technical based legislation to maximise compliance and minimise evasion. Rather than amending old legislation it may be preferable to write a new Act fully compliant with the business architecture, incorporating some features of the old Act.

It is recognised that any legislation is likely to take around two years or more from drafting to implementation.

12.6.1 Public Records Act 2005

The Public Records Act 2005 requires all records (electronic and paper) obtained or created by Government agencies to be maintained for a period to be approved by the Chief Archivist.

Discussions with Archives NZ resulted in a clear recommendation that any position data collected by a private company was unlikely to be considered a public record until agencies such as NZ Police or NZTA obtained the data. This would allow maintenance of critical data and consideration might be given to disposal of some time/ position data, for example along a straight section of road with no alternative routes.

For this reason a privately operated data pool is recommended rather than direct collection of all position data by any Government agency.

12.6.2 Privacy Issues

As with any monitoring regime there will inevitably be opposition from those who are legitimately concerned about personal privacy and those that select this emotive avenue to oppose change for other reasons.

Electronic monitoring for RUC purposes monitors vehicles, not people (unless digital tachygraphs are included). It is accepted that there is some correlation between vehicles and people in any event.

The Privacy Act 1993 exists to protect personal privacy and it is recommended that full compliance with this act is a fundamental requirement of any technology based solution. If the Government elects to make exception to the Privacy Act for RUC purposes, legislation is required to do so.

It is noted that many transport companies already monitor their fleet and that voluntary uptake of any technology based RUC scheme, with commercial incentives to do so, provides a valuable choice for those who feel strongly enough not to opt in.

Privacy concerns may also be allayed to some degree by storing all position data in a private sector data warehouse (or virtual data warehouse) and making it available on request of Government agencies strictly following the principles of the Privacy Act 1993.

For this reason a privately operated data pool is recommended rather than direct collection of all position data by any Government agency.

Privacy issues support voluntary uptake of technology based solutions and full compliance with the Privacy Act 1993.

12.6.3 Requirement For Current Legal Defences

The current legal defences for RUC were designed to be fair at a time when the manual system was only available during office hours and licences could not be purchased after hours or on weekends.

A continuously available, real time, electronic RUC system would eliminate the need for these legal defences and remove the ability of RUC evaders to exploit those defences when detected.

12.7 Existing Technology Adoption

The New Zealand commercial fleet is already relatively well served by technology with many larger and medium operators using fleet monitoring to deliver a variety of services for commercial gain. The current services provided in NZ include: real time fleet visibility and traffic management, logistics optimisation, fleet performance analysis, speed analysis, driving hours and driver fatigue analysis, messaging, planning, scheduling, automatic vehicle location, mapping and driver directions, reporting, vehicle maintenance and COF status, driver status and validation of overtime claims, in-vehicle telemetry used particularly in agricultural applications, in-vehicle navigation and off road RUC claims. Some fleet management systems offer users reduced insurance premiums. Other potential uses include electronic logbooks, pay as you go insurance and a variety of Government administrative processes including RUC.

It is reliably estimated that well in excess of 30,000 NZ vehicles (including light vehicles) are already equipped with these systems and this number is increasing by 450 – 500 every month. It is anticipated that the operators of these vehicles recognise the benefits of a technology based RUC system, including lowering their administrative costs. As such it is anticipated the majority are likely to support an electronic RUC initiative.

12.7.1 Mandatory On-Board Units (OBUS), Is This Feasible?

Mandatory requirement to install OBUs for the sole purpose of RUC in the current environment will undoubtedly lead to vocal opposition from a wide variety of infrequent or non commercial operators of heavy motor vehicles. This group will include powerful lobby groups such as Federated Farmers.

Voluntary uptake of OBUs is a fact of life with over 30 000 units already installed. The greatest short to medium term issue is replacing existing units with OBUs that meet the security requirements for any given system. It is anticipated that OBU equipment turnover might be achieved within 3 years of releasing a requirements definition.

Given the current cost of installing the technology, the ongoing monthly charges for the associated services, privacy concerns and the lack of commercial gain for this group it is suggested that mandatory requirement of OBUs for RUC is not currently a viable short term option.

Longer term when the cost of the technology and ongoing communications charges have reduced, the Government may consider mandatory application of an electronic system for purposes such as replacing fuel tax for petrol powered vehicles. At this stage it would be feasible to reconsider requiring compliant OBUs to be fitted in all (including light) vehicles.

12.7.2 Thin Client vs. Thick Client Approach To OBUs

A thick client is an OBU that processes data to make sense of it and provide information directly to the user. This has the advantage that processing is distributed (performed by a number of processors) placing little or no pressure on mobile communications and reducing the need for centralised processing. A thick client has the disadvantage for the RUC purpose that it can more readily be programmed for a variety of purposes, potentially including evasion. Additionally any software updates need to be either manually installed or transmitted via the communications network.

A thin client merely collects the data and transmits raw data via the selected communications channel to a central processing agency. It does not normally contain a computational processor to translate data into information. The primary advantage has traditionally been lower unit cost although this advantage is diminishing over time as processors become less expensive. The major disadvantage is that communications networks require the capacity to carry all data and the processing agencies require significant processing and storage capability. These disadvantages are disappearing with the capacity of optic fibre communications and significantly lower cost of processing and storage.

An international debate focuses on the relative advantages and disadvantages of each system and there is no clear answer until all purposes of a particular system for a particular user are defined.

There is no reason why a thick client cannot be configured to deliver raw data for law enforcement purposes and process the same data for commercial and private purposes. Indeed this may be an ideal solution for a cooperative technology system.

A distributed system uses multiple processors to achieve rapid results when large amounts of processing power is required. Parts of computer applications run simultaneously on multiple computers communicating over a network. There is no reason to prevent processing being performed within the OBU for commercial and navigation purposes while RUC data may be required to be transferred in a raw state. This would relieve centralised processing requirements and tend to support a hybrid thick client solution.

12.8 RUC Back Office

If significant changes to the RUC system are proposed, it may be an opportunity to consider a new separate, privately operated, web oriented database management system for the RUC component of a service oriented architecture.

12.8.1 Requirement For A Printed RUC Licence

The current purpose of a displaying RUC licence is proof of purchase.

If an electronic RUC solution was provided, including near real time vehicle monitoring and continuously available internet based access; operators could purchase and monitor RUC and enforcement staff could check RUC online. There would appear to be no further requirement to print or display physical licences in a fully electronic system. This would result in significant cost savings.

Consideration might be given to proof of purchase being sent by text message to nominated cell phones or by email.

12.8.2 Requirement For Supplementary Licences

A technology based system might readily permit increased or decreased weights at any distance interval. If the technology solution were fully or even partially implemented there would be no requirement for supplementary licences. This would result in cost savings and satisfied customers (operators).

12.8.3 Requirement For Off Road Claims

Some current NZ systems are used in support of off road claims for Road User Charges and each can be differentiated in terms of set up, purpose and capability. International road user charges examples do not have off road claims.

A technology based system could readily eliminate the need for off road claims by simply not charging for off road distance. This would eliminate the costly administrative process for off road claims, associated costs and the scope for false off road claims.

12.8.4 Channels

Currently the RUC sales channels are virtually all manual. The properly automated systems (single manual entry) are direct connect (for fleet purchases only) and automated machines in some BP stations. The RUC system is not continuously available and the “internet” transaction results in a second manual entry and a time delay of up to 7 days in receiving the distance licence.

To reduce the cost of compliance it is essential to (as far as possible) eliminate all manual intervention. Base on the mid range transaction fee of $5.06 applied to 2 million sales per annum a conservative estimate might indicate potential savings in excess of $10 million per annum from a properly automated modern system.

Consideration might be given to a range of technology options:

Charge as you drive: It is feasible to use GNSS based technology to charge as distance is travelled or to aggregate daily, weekly, fortnightly, monthly, quarterly etc charges for a fleet or vehicles where suitable credit arrangements are entered into. Payment might be direct debited from a nominated bank account (with prior email or text advice to the customer). This model would result in very limited scope for administrative RUC evasion and would be a value for money solution in terms of limiting administrative costs which are currently passed on to the end user.

In the fully automated model, charging would require very limited manual intervention perhaps only to change fleet details and arrange credit limits. Weights might be entered in the system for light vehicles and automated real time by onboard scales for heavy vehicles and possibly confirmed by the driver at the OBU, or alternatively manually keyed in at the OBU. Secure internet access would be essential for customers, administrators and enforcement staff to view details.

Internet and text message purchases: In a semi automated system, real time direct internet access to the RUC database would mean that purchases and account management could be conducted online by all RUC customers and accessed real time by enforcement staff. Subject to law changes this might dispense with the requirement to display RUC licences. As with many other electronic systems a reference number could be provided by internet, email or text message.

Consideration might be given to eliminating all current manual methods of RUC purchase (fax, phone, existing internet and agencies). This is subject to a legal opinion and policy decision deciding whether a requirement exists to provide a cash channel for payment.

12.8.5 Automated Audit Systems

Strategic placement of automated weigh in motion and ANPR sites around New Zealand would confirm that the position and weight information given by the majority of OBUs was accurate at that point in time and generate exception reports where the OBU data did not correspond with the known information gathered by the automated site.

Key sites are likely to include international shipping port gates, major routes in and out of Auckland and other cities, key inter regional routes, on approach to weigh stations and in key trucking areas such as immediately north of Taupo and south of Turangi to monitor overnight line-haul trailer “swapovers”.

Proper strategic placement would require consultation with local experts (most likely CVIU) to ensure that the sites are not readily able to be detoured around.

12.9 Audit/Enforcement Issues

Automated audit systems collecting a large data pool for analysis would enable evidence based targeting of CVIU and ECU resources to those operators who demonstrate a pattern of evasion.

Targeting of evasive operators would reduce the time spent checking compliant operators and increase the enforcement “time cost” to evasive operators.

A properly designed system would require little technical ability on the part of enforcement officers. For example a well designed “dashboard” type web screen would enable enforcement staff to readily navigate to the information they require. Exception reports could be used to generate lists of the most frequent offenders. Simple offending such as exceeding the nominated weight while passing an automated audit site (subject to tolerance) might result in an automatically generated infringement notice.

13 TECHNOLOGY ADOPTION FROM A CUSTOMER PERSPECTIVE

It is essential that the use of technology from a customer perspective must simplify the RUC administrative task, be cost effective, be accurate, preferably offer some business driven incentives such as minimising the amount of time spent for enforcement stops, charging by actual weight carried, possibly discounted off peak travel in urban areas and reducing the risk of time consuming manual enforcement checks.

The cost of using a technology based tracking system is currently around $100 per month per vehicle. Therefore it is an absolute business requirement (from the customer perspective) that the information gathered is available for a variety of business purposes rather than siloed for RUC.

This type of thinking fits neatly with a service oriented architecture; the view that is preferred is that the OBU performs the business function of collecting data from the vehicle and driver for a variety of purposes including a RUC administration system.

The traditional view is that the OBU might simply replaces the hubodometer. While the SOA view is likely to result in buy in to a technology based RUC scheme with other business and Government benefits, the more traditional view of a direct swap or electronic replacement for a hubodometer is likely to dictate duplicated technology systems and as such is likely to face significant opposition from a business perspective. Therefore, if a technology solution is considered, a cooperative approach is considered essential.

13.1 Downside Of Technology From A Customer Perspective

As with any change to taxation it is probable that there will be opposition for a variety of reasons.

GNSS technologies and associated communications currently cost around $100 per month per vehicle. Longer term this is likely to reduce substantially. Around 30 000 NZ vehicles are already fitted with these technologies on a purely commercial basis.

Any operator currently deliberately evading RUC is likely to perceive, correctly, that the scope for evasion is significantly reduced by technology based charging solutions and these operators are unlikely to support or adopt the changes unless they are mandatory.

There may be some legitimate privacy concerns about vehicles being tracked and these are best addressed with reference to the Privacy Act.

Voluntary adoption of any technology based system might address all these concerns.

14 SUMMARY

The NZ roading network consists of over 90 000kms of roads with a population of 4.5 million people, around 100 000 heavy vehicles paying RUC operated by around 30 000 transport operators policed by a dedicated CVIU enforcement group of 100. There is a single jurisdiction and no international road traffic passing through New Zealand borders. These facts set New Zealand apart from direct application of the European charging and enforcement models.

The current NZ RUC system is essentially administered through a labour intensive manual regime supplemented by legacy technology systems. The current system does not meet the business efficiency requirements of many major technology enabled transport operators and the cost of compliance is considered to be high.

The current RUC system collects $876.5 million per annum and is prone to evasion generally estimated at between $40 million and $100 million, possibly as high as $200 million. The real long term cost to society of RUC evasion is estimated at between $450 million and $4.5 billion.

Based on international experience of technology based RUC systems, a realistic reduction in evasion levels by as much as $80 million per annum might be achieved, corresponding to a willingness to pay over $600 million in present value terms, to fund a technology initiative over 30 years. Factoring in wider benefits and dis-benefits from such an initiative would have further impact on this figure.

Development of a full economic model may be considered to determine the appropriate level of RUC penalties, support an optimum number of strategic audit/ enforcement facilities and justify funding for developing integrated RUC technologies.

Technology should be considered as an enabler of business requirements. It is considered essential (if any technology solution is contemplated) to firstly define the objectives of the RUC system. This may be achieved by clearly confirming the existing sole focus on collection of revenue for land transport purposes, or redefined to include other objectives for example vehicle emissions reductions or congestion mitigation.

Once the objective is defined then the parameters for measurement need to be reconfirmed to the current **motive power**, **distance (or time)**, **weight** and **axle configuration** or including some other parameters for example **emission standard**.

A sound requirements basis for technology architecture can only be achieved when the objectives and parameters have been defined.

Any technological solution should provide a simple, yet effective end user experience, consider business drivers, minimise the cost of compliance and administration and should integrate other current and potential uses for the technology and data gained to maximise system efficiency.

The report considers a range of possible technology alternatives and the relative merits of each in the New Zealand context.

If a GNSS (global navigation satellite systems) solution is considered for RUC purposes, it should be augmented with electronic wheel revolution and movement sensor information. Strong physical and electronic security/ audit measures are required to mitigate the risk of evasion. This is likely to include independent verification by numerous strategically located automated audit/enforcement sites.

This type of system would also provide reduced long term administrative costs and burden, significantly lowered evasion, offer safety benefits and minimise enforcement stops and related down time for compliant operators.

Lack of strategic analysis, lack of consideration of the wider requirements and motivators for all users, poor or complex design, or partial implementation of any technology based solution would risk failure. The RUC system as a taxation / revenue collection system cannot afford system failure, therefore if a technology based approach was recommended it would require significant political and financial commitment to ensure success.

If such an approach was recommended it would most likely use and standardise existing vehicle tracking systems, building on them to develop a range of services meeting the needs of all parties.

International experience suggests that potentially a technology based NZ RUC system could provide the following opportunities:

- Stable revenue stream
- Low cost and ease of administration for road users and Government
- Equitable charging for road use and road damage regardless of fuel type.
- Low evasion rate through sound architecture of the system, laws and enforcement.
- Provision for congestion, location and time based charging.
- Interoperability with other fleet, logistics, TDM and traffic management systems.
- Maintenance of the degree of privacy required by NZ law.
- Promotion of efficient road freight services.
- Creating fair conditions for competition.
- 24x7x365 internet access for RUC purchasing with electronic proof of purchase.
- digital tachygraph linked to a standardised electronic driver licence (or smartcard)
- tracking and managing hazardous goods in heavy vehicles

Consideration should be given to the following:

- The weaknesses of the current RUC system and amount of current evasion compared to international experience of evasion significantly below 2% with a technology based charging solution.
- Automated vehicle based systems providing continuous position and weight information for RUC reporting.
- A network of automated continuous verification/ audit / enforcement sites (high speed weigh in motion and vehicle recognition) at carefully selected strategic locations throughout NZ to complement existing CVIU and ECU enforcement capabilities in minimising RUC evasion.
- Development of an economic principal agent model would guide the appropriate level of penalties and support determination of an optimum number of strategic automated audit/ enforcement facilities.

It is noted that many of the technologies required to build a service oriented system are already in widespread commercial use in New Zealand, particularly for fleet management and freight logistics.

It is noted that voluntary commercial use of vehicle tracking technologies does not require the same level of security that is required for taxation purposes (including RUC), enforcement and evidential use. This is because there is limited motivation and no commercial benefit tampering with an entirely voluntary commercial system. Security would be essential for RUC purposes.

15 APPENDIX A – Glossary Of Terms

ANPR	(automated numberplate recognition) digitally records images using high resolution cameras assisted by IR (infra red) or other technologies for night time detection, then automatically processes the images, accurately and automatically reading the numberplates of around 95% of vehicles, at highway speeds and forwarding images that cannot be recognised to operators.
CVIU	NZ Police Commercial Vehicle Investigations Unit: responsible for enforcement of commercial vehicle activities.
DBMS	Database management system: the software application that runs a database. Technically the data base itself consists only of the data set.
DSRC	(digital short range communication) or tags carried in vehicles with corresponding infrastructure to collect the data.
ECU	Economic Compliance Unit: NZTA unit responsible for administration of the RUC system including detection of evasion and civil debt recovery.
GNSS	(global navigation satellite systems) including (and often referred to as) the well known US NAVSTAR GPS system, the Russian Glonass system, the European Galileo system, the Chinese Beidou system and India's IRNSS system. Of these, the only fully operational system is GPS. Positioning chipsets for general commercial use are currently accurate (at device level) to around 5-7 metres with older and less expensive devices having reduced accuracy. GNSS is prone to a number of weaknesses such as canyoning (bouncing signals) and loss of signal at certain locations (due to ground cover) and times (poor satellite constellation reception).
GNSS Augmentation	Uses GNSS and other reference sources such as fixed reference sites, inertial systems, gyroscopic systems, accelerometers and revolution counters to improve the reliability of positioning and/or accuracy of measurement.
NZTA	New Zealand Transport Agency: formed in 2008 by joining Transit NZ - the NZ highways agency with Land Transport NZ - the Government funding and operational entity.
OBU	(on board units) these operate in a vehicle performing a positioning, measuring and/or counting function specific to the system, most have some method of mobile data communication polled to a remote database at regular intervals.
OBM	Onboard mass monitoring
RUC	Road User Charges
WIM	Weigh in Motion

16 APPENDIX B – REFERENCES

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