Bringing service to life

serco

Serco Integrated Transport

Title : Anders Betalen voor Mobiliteit – Phase 2

Topic 5 – Compliance and Enforcement

September 2006

Advise | Design | Integrate | Deliver

Document Control : Transport Consulting Group	
Document Reference	060728 PD 22439 MVW R01 5A
Issue Number	3.0
Status	Final
Prepared By	Joanne Dodds
Issue Date	01 Sept 2006
Checked By	Pete Dodds
Approved By	Pete Dodds

Document History	
Issue 1.0	Draft for Comment
Issue 2.0	Changes to Dimensioning, Cost Estimates and Risk Table
Issue 3.0	Amended Customer Pricing Tables (Appendix B)

Executive Summary

Serco has been commissioned by the Government of the Netherlands to provide advice on the compliance and enforcement issues associated with implementing a kilometre road pricing (KMP) scheme that would charge drivers according to road use rather than vehicle ownership. This Report identifies a strategy, concepts and cost estimates to assist with the policy and decision making processes in relation to implementation of an effective enforcement regime that will contribute to achieving a high level of compliance.

The acceptability of the KMP scheme by users, government, environmentalists and all other stakeholders will be a key focus during the policy development process. By analysing outline proposals it has been determined that an effective compliance and enforcement strategy will be obtained by achieving a balance between the various influencing factors, including:

- User Compliance
- Pricing Policy
- Occasional User Policies
- On-board Unit Complexity
- Offence Definitions
- Performance Indicators

The diversity of these factors demonstrates that measures to achieve compliance will not be limited to the 'harder' enforcement type solutions, but must include 'softer' measures such as education and public relations. It is also important to recognise that compliance measures need to be embedded and integrated within the scheme registration and payment mechanism. In addition, it is essential that the scheme utilises proven technology and is kept simple in terms of its operation and understanding by the public.

Examination of the influencing factors has enabled identification of specific enforcement cost drivers, which include:

- User Compliance – various policy issues may make the KMP more acceptable to the public as a whole, thus minimising the resistance to the scheme and marginally reducing enforcement effort required.
- Pricing Policy – different tariffs for toll routes, congested zones, urban/inter-urban, etc will lead to additional enforcement stations.
- Occasional User Policies – will influence the configuration, procedures and offences associated with the Occasional User System (OUS) and will impact on the complexity and cost of the Enforcement System (ES).
- On Board Unit (OBU) complexity – thin and thick client functionality influences the type of enforcement and thus the complexity and cost of the ES. However, this relationship only holds true up to a point and beyond this functionality threshold increasing complexity and features of the OBU does not affect the enforcement solution.
- Offences – the definition and range of offences that need to be enforced will influence ES Back Office (BO) costs. Another related factor is when an offence is deemed to occur, which may be determined by the policy regarding pre and post registration or

payment, and effects the amount and period that potential enforcement data needs to be stored.

- Performance Indicators – the specification of KPIs of the ES should focus on delivery of outputs rather than individual systems elements, which may have hidden cost implications.

A compliance and enforcement strategy was developed by analysing the interrelationship and dependencies between these cost drivers. The recommended strategy included:

- DSRC, GNSS and GPRS functionality within the OBU
- An enforceable period based (e.g. daily) lump sum payment system for the occasional users, since it was considered that a kilometre pricing system for occasional users was impractical to enforce.
- Balanced set of policies (i.e. fair, equitable, affordable) delivering a high degree of societal acceptability
- Effective, simple and cost efficient enforcement system

It is considered that an effective and efficient enforcement system will be made up from a range of targeted solutions, dependent upon the road type, vehicle class and residual opportunities to evade, whether these are real or perceived. For example, focussing enforcement on catching and penalising persistent offenders is likely to have a significant influence on the public perception of the risk of being caught and therefore the economic benefit (or rather the disadvantage) of evasion.

On the basis of the recommended enforcement strategy, various concept options were evaluated in order to determine the most appropriate configurations and processes. The degree of detection was considered to determine the processing requirements at the roadside and in the back office, which was subsequently used to quantify the communication requirements.

It was concluded that the minimum recommended form of roadside detection should include vehicle registration mark recognition, together with a corresponding context image and DSRC tag interrogation. This will facilitate enforcement for all vehicles with a registration mark by checking that they are valid users of the KMP scheme. It will also allow secondary checks to be conducted in order to ensure that the OBU has not been tampered with or is faulty. It was noted that vehicle classification would also be beneficial as part of a phased implementation of the KMP.

The resolution of the vehicle classification will dictate the complexity of the vehicle detection and significantly impact upon the cost of classification. A simple system of three to six classifications based on vehicle size would be relatively cheap compared to a system that would deduce the make and model of a vehicle.

It was recommended that the value of implementing automatic vehicle classification (and the complexity of the classification) is carefully considered, especially in the early stages of deployment, since it is envisaged that road users will initially try to evade payment for entire journeys rather than simply reducing the tariff. Selective and targeted deployment may be preferable (i.e. only equip certain sites with classification technology, not all sites).

Processing at the roadside would primarily focus on matching vehicles to a list of valid users of the KMP. Any anomalies would be considered for further processing, potentially leading to fines being issued or more serious charges being levied for deliberate evasion.

It is envisaged that most mis-matches to the list of valid users will be caused by anyone intending to post pay for their trip, evaders of the KMP and inaccuracies in the captured vehicle information. The back office would process these anomalies to ensure that as many vehicle trips as possible are paid for whilst minimising the number of appeals. A useful additional processing feature at the roadside is the ability of the system to use a 'Vehicle of Interest' list to help target persistent potential offenders and vehicles that need to be detected for other purposes (such as a stolen vehicle). It is recommended that this list is used to alert the KMP Enforcement team (e.g. a mobile patrol or back office staff) in real time and allow them to pursue and stop these vehicles.

Dimensioning of the concept options was based upon the enforcement premise that any vehicle traveling on the road network on any particular day stands a reasonable chance of being checked to ensure that it is complying with the KMP system. The definition of "reasonable" is the driving factor for identifying how many enforcement sites are required. The dimensioning strategy only considered the use of fixed and transportable equipment (mobile units were considered to be supplementary, targeting specific evaders rather than providing coverage). Two dimensioning strategy options have been used for comparison:

- Placing enforcement stations at fuel stations, KMP system boundaries
- Placing enforcement stations at set distances on the HWN and for a set number of kilometers for the OWN

For the 'fuel station' strategy option, and assuming one hundred percent coverage, it is concluded that every vehicle would be checked on average every eleven days or when entering or leaving the country. It is considered that alternative methods of obtaining fuel (e.g. by siphoning it from another tank) would be undesirable and people would instead choose to pay the KMP. Also, the number of repeated checks on the same vehicle would be considerably reduced, thereby significantly reducing the back office costs but having the negative impact of increasing implementation, operational and depreciation costs at the roadside.

The distance based strategy option has the disadvantage that certain types of road user (i.e. those in remote areas who do not use the HWN) may not be enforced for a considerable period of time whilst other (particularly those using the HWN for most journeys) would be subject to multiple enforcement checks. However, it does provide a very good way of imposing enforcement checks on the majority of users and it is considerably cheaper to implement because it requires less sites than the fuel station strategy option.

Implementation costs derived range from €97M to achieve five percent coverage of fuel stations, borders and ferry terminals to €1486M to achieve one hundred percent coverage. (The distance based coverage implementation values range from €337M to €494M).

Operational costs are lower for the fuel station strategy options (€30M/year to €137M/year), compared to the distance based strategy options (€106M to €158M/year). This is primarily due to the significant reduction in the quantity of resource required for back office processing of multiple checks on potential violators. Significantly, the cost of accommodating the back office processing requirements is excluded from these figures; it is anticipated that if these costs are included, the difference between the operational costs of the two strategy options would widen even further, since additional resource and processing would need to be accommodated within the back office.

Depreciation costs are much lower than the implementation or operational costs but they follow a similar pattern to the implementation costs, ranging from €8M to €46M for the fuel station strategy and €12M to €16M for the distance based strategy.

The Report concludes with an assessment of all the major enforcement related risks and uncertainties. The two most significant risks that have been identified are:

- That significant quantities of violations are left undetected due to having insufficient deployment of enforcement stations and not being able to measure the absolute level of violations
- Suppliers costs are higher than the estimated implementation and operational costs

These relate directly to the two different strategies that have been presented and the extent of coverage.

Assuming a system operation of at least ten years, it is recommended that one hundred percent coverage of fuel stations strategy is opted for instead of the reference architecture (35km distance spacing on the HWN and one for every 750km of OWN). This recommendation is made on the basis that after ten years, the combined implementation, operational and depreciation costs are similar but that the fuel station option will achieve much better coverage in terms of enforcement checks.

However, both of these options may be too expensive to implement and operate. If this is the case, it is highlighted that significant cost savings could be achieved by using the distance based strategy with an increased separation of enforcement stations on the HWN without compromising significantly on the number of checks a vehicle will receive.

Contents

1 INTRODUCTION 1

1.1 Background 1

1.2 Purpose of Report 1

1.3 Contents of Report 2

1.4 Key Assumptions 2

1.5 Glossary of Terms 3

2 STRATEGIES 5

2.1 Users 5

2.2 User Perception 7

2.3 Defaulters - Why People Don't Pay 9

2.4 Pricing Policy 10

2.5 Promoting Scheme Compliance (Enforcement & Encouragement) 13

2.6 Enforcement & Legislative policy 14

2.7 Enforcement Targeting 16

2.8 System Security 19

2.9 Thick and Thin Client 21

2.10 Residual Opportunities to Evade Payment 23

2.11 Performance Indicators 23

2.12 Summary 23

3 ENFORCEMENT CONCEPTS 28

3.1 Introduction 28

3.2 Roadside Enforcement Station Options – Detection Technology 29

3.3 Roadside Enforcement Station Options – RES Processing 31

3.4 ES BO Processing Options 34

3.5 Process Flow Charts – for processing RES Gathered Information 36

3.6 Recommended RES Detector, RES and ES BO Processing Package Options 38

3.7 Other ES BO Enforcement Processing Techniques (Data Mining) 38

3.8 Other ES BO Activities 41

3.9 Communications Options 43

3.10 RES Types 45

4 DIMENSIONING 47

4.1 Introduction 47

4.2 Dimensioning strategy overview 47
4.3 Assumptions 47
4.4 Overview of strategy for targeting 100% of vehicles 48
4.5 100% strategy 48
4.6 Strategy if targeting less than 100% of vehicles 49
4.7 HWN strategy 51
4.8 HWN Scenarios tested 51
4.9 HWN Impact 53
4.10 OWN strategy 53
4.11 Strategy summary 53

5 COST DRIVERS AND ESTIMATES 55
5.1 Introduction 55
5.2 RES Cost Drivers 55
5.3 Enforcement System Back Office Cost Drivers 59
5.4 Communications Cost Drivers 61
5.5 General Cost Drivers 61
5.6 Cost Estimates - Conclusion 62

6 RISKS AND UNCERTAINTY 64
6.1 Introduction 64
6.2 Risk Sources 64
6.3 Risk Consequence 64
6.4 Project Phases 64

APPENDIX A A-1
Dimensioning A-1

APPENDIX B B-18
Cost Estimates B-18

APPENDIX C C-24
Risk Assessment C-24

Table 1 – Glossary of Terms 4
Figure 1 – Enforcement & Risk Relationship 8
Table 2 – Pricing Scenarios 12
Figure 2 – Enforcement Effort Relationships 25
Figure 3 –Overview of Road User Charging System 28

Figure 4 –RES Process 36

Figure 5 –ES BO Process (for Roadside Detection) 37

Table 3: Valid Combinations of Detector, RES Processing and ES BO Processing Options 39

Figure 6 –ES BO Information Flows 44

Table 4– Effects of varying the distance between stations 46

Figure 7 – Distance Between Sites vs Checks per Day 47

Table 5 – Investment and Operational Cost Consequences 63

1 INTRODUCTION

1.1 BACKGROUND

1.1.1 In an area of 34.000 sq. kilometres, with 134.000 km of roads, the Netherlands currently accommodates approximately 9.5 million vehicles. Future forecasts indicate that this will inevitably continue to increase. Research carried out by the Dutch government suggests that the best way to solve daily recurring traffic congestion and share the cost of road maintenance is via a variable road pricing system. This system would charge drivers according to road use rather than vehicle ownership. A central component of the plan in the Netherlands is the 'mobimeter' - a GNSS based device to record road usage.

1.1.2 The key to any successful scheme will be the balance of the right charging and enforcement policies, using proven technology and keeping the scheme simple in terms of its initial operation. The focus for the scheme will be the acceptability of users, government, environmentalists and all other stakeholders.

1.1.3 Serco have been commissioned by the Government of the Netherlands to provide advice on the compliance and enforcement issues associated with implementing such a scheme. Serco were chosen due to their expertise in technology based traffic enforcement in the UK and work undertaken on the UK Government's Heavy Goods Vehicle (HGV) road user charging tender prior to the project being cancelled in 2005.

1.2 PURPOSE OF REPORT

1.2.1 This Report is intended to assist the Government of the Netherlands in determining an effective and affordable version of a Kilometre Pricing (KMP) system. Specifically, identify a strategy, concepts and cost estimates to assist their policy and decision making processes in relation to implementation of an effective enforcement regime that will contribute to achieving a high level of compliance. An optimum enforcement strategy for the KMP scheme should:

a) Maximise user compliance

b) Minimise capital and operating costs

c) Be relatively simple to understand and operate by users

d) Avoid infringement of cultural values or government policies (i.e. equality, transparency, privacy, etc.)

1.2.2 In order to determine a strategy that encourages compliance and enforces non-compliance, it is important to understand:

e) Who the KMP users will be

f) Issues that will determine user perception

g) Reasons for potential non-payment, avoidance and non-compliance

h) Pricing policy options being considered for implementation

i) Approaches available for promotion of scheme compliance, including methods of enforcement

1.2.3 An effective enforcement strategy will therefore be established by examining the issues that are expected to affect enforcement costs, including:

j) Enforcement Policies and Legislative Issues

k) Targeting Strategies

l) Thick and Thin client issues

1.2.4 Analysis of the above issues will therefore lead to the identification of key cost drivers and a robust strategy for determining Enforcement System (ES) concepts appropriate to the KMP scheme. This will allow outline unit cost estimates to be derived and, when applied to the envisaged dimensioning scenarios of the ES, will produce the required capital and operating expenditure estimates.

1.3 Contents of Report

1.3.1 This document is divided into individual chapters, which, with the exception of Chapter 1 (Introduction), correlate with the specified deliverable requirements of the commission. The commission programme (deliverable D1) was previously provided and accepted by the Client and is included in Appendix 1 for completeness. The remaining deliverables are included in the following:

- Chapter 2: Strategies (D2) – includes the identification and examination of approaches to achieve high user compliance of the KMP, primarily through various enforcement methods
- Chapter 3: Enforcement Concepts and Dimensioning (D3 part of) – utilising the previously derived strategies, the most appropriate concepts are analysed and evaluated in order to determine recommended process and system options.
- Chapter 4: Dimensioning (D3 part of) – deployment and dimensioning aspects of these concept options are also described in this chapter.
- Chapter 5: Cost Estimates (D4) – cost estimates of the recommended enforcement system concepts are produced and sensitivities examined.
- Chapter 6: Risk and Uncertainty (D5) – the risk assessment undertaken for the enforcement aspects of the KMP scheme are detailed and discussed.

1.3.2 The executive summary to this Report includes the main findings and recommendations.

1.4 Key Assumptions

1.4.1 It is considered important to identify the following key assumptions made during production of this report:

a) The scope and requirements of this commission and the Report are in accordance with the Client's Statement of Work Subject 5, dated 23 May 2006.

b) Scope does not include detailed analysis of the functionality or configuration of the KMP reporting and billing systems, the vehicle registration databases (i.e. RDW) or the fine collection process, although assumptions on their operations will be stated where they impact on or interface with the enforcement system.

c) It is understood that no decisions have been made regarding the final functionality or design of the KMP system. The high-level requirements and reference architecture documents have been used as indications of the Clients thinking only and variances from these guidelines have been considered in order to fully explore the feasibility and effectiveness of the associated enforcement system.

1.4.2 Further detailed assumptions have been made and are stated as necessary in the relevant chapters within the Report.

1.5 Glossary of Terms

1.5.1 Table 1 includes a description or meaning of the acronyms and terms used within the Report.

Table 1 – Glossary of Terms

Acronym/Term	Description/Meaning
3G	Third Generation (Mobile Telephone Standard)
ANPR	Automatic Number Plate Recognition
AES	Advanced Encryption Standard
BO	Back Office
BPM	Vehicle Purchase Tax
CCTV	Closed Circuit Television
CDS	Charging Data System
CJIB	Centraal Justitieel Incasso Bureau
CS	Central System
DES	Data Encryption Standard
DSRC	Dedicated Short Range Communications
ES	Enforcement System
Eurovignette	HGV Motorway Tax
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
HGV	Heavy Goods Vehicle
HWN	Hoofd Wegen Net (Motorway/Trunk Roads)
KMP	Kilometre Pricing
KPI	Key Performance Indicator
MRB	Vehicle Circulation Tax
OBU	On Board Unit
OR	Observation Records
OUS	Occasional User System
OWN	Onderliggend Wegen Net (Regional/Local Roads)
PSV	Public Service Vehicle
RAC	Royal Automobile Club
RDW	Rijksdienst voor het Wegverkeer (Vehicle Licensing Authority)
RES	Roadside Enforcement Station
RFID	Radio Frequency IDentification
SMS	Short Message Service
TES	Transportable Enforcement Station
UK	United Kingdom
VOI	Vehicle Of Interest
VRM	Vehicle Registration Mark

2 Strategies

2.1 Users

2.1.1 It is appropriate to consider the diversity of users and vehicle classes and some of the challenges these present to the implementation of the KMP scheme and the associated ES.

Privately Owned Vehicles

2.1.2 Of the 9.5 million vehicles on the Netherlands road network, the vast majority (approximately 7 million) are personal passenger cars, the remainder being commercial freight or public transport vehicles (e.g. buses, taxis). The acceptance and compliance by this group is therefore a key element in the success of the KMP scheme.

2.1.3 Within the personal passenger car user class the pattern of use will differ vastly for regular long distance commuters compared to those travelling only occasionally for short trips. The ES strategy and concepts must cater for and encourage compliance across the whole range of user journey profiles.

2.1.4 Ideally, all road users in the Netherlands will have a registered OBU installed in their vehicles. A key policy decision concerns whether an OBU is made compulsory or optional for those that reside in country, since this will make enforcement for the majority of vehicles relatively straightforward compared with any non-OBU variant of the KMP scheme. Irregular users, whether these are low kilometre users choosing not to install an OBU (i.e. if legal) or foreign vehicles visiting the country, will need to be catered for within the Occasional User System (OUS). The level of take-up for privately owned vehicles (e.g. optional or foreign vehicles) will be influenced by the comparative cost of purchase, installation and per kilometre charge associated with an OBU relative to the aggregate level of OUS charges.

Commercial Freight Carriers

2.1.5 The second largest generalised group of users within the Netherlands are commercial or freight carriers which currently number approximately 1 million vehicles. These differ from private vehicle owners in that the vehicle kilometres travelled by commercial users tend to be consistently higher and would almost see the fitting of an OBU as a necessity. The costs associated with OBU purchase and installation may be viewed as a ‘necessary evil’ (similar to the MRB tax that the KMP scheme will replace) and vehicle owners will need to make a business decision whether to simply pass the cost overhead onto their customers or alternatively absorb it as a one-off business costs.

Leased/Hired Vehicles

2.1.6 The case of company vehicles or hire cars raises the issue of responsibility for payment of KMP charge. In some other countries it is the driver and not vehicle owner who is responsible for any traffic offences (e.g. speeding, passing a red light), resulting in automatic enforcement and collection of fines being problematic. For example, third parties have been known to falsely claim responsibility for an offence in order to preclude a more severe punishment being handed to the real culprit who was a repeat offender. In these cases, enforcement evidence (e.g. context images) has been insufficient to prove otherwise. However, it is understood that the KMP scheme would be based on current practice in the Netherlands for speeding offences, whereby the vehicle owner is held responsible for violations. In this case therefore the owners of the leased or hired vehicles would be liable for the KMP charge and will more than likely to choose to pass it onto their customers.

Public Service Vehicles (PSV)

2.1.7 It is assumed that within the PSV regulated environment (e.g. buses, taxis, trams) that the fitting of an OBU in these vehicles will be compulsory and possibly subject to discount tariffs. This group would therefore not present any unusual problems associated with enforcement. Alternatively, if it were to be decided that this group or a sub-set is to be exempt from charges, then they could be included on an ES ‘white list’ of vehicles not subject to enforcement.

Foreign Vehicles

2.1.8 The enforcement issues associated with possible evasion of payment from foreign vehicles are complex. They range from technical issues surrounding the identification and origin of a foreign Vehicle Registration Mark (VRM) registration to political/legislative issues associated with collection. However, we are aware that the Centraal Justitieel Incasso Bureau (CJIB), who is currently responsible for issuing and collecting fines in relation to traffic offences, already has links with the registered vehicle keepers in Germany, Belgium and France. In addition, the CJIB are also preparing for the introduction of a European Framework in March 2007 which will allow cooperation in cross border collection of such fines.

2.1.9 Foreign vehicles entering or passing through the Netherlands will be subject to the KMP. Foreign personal passenger vehicles may include tourists visiting for a short period (e.g. two weeks or less) or commuters who live in adjacent countries and work in the Netherlands. The KMP and OUS pricing structure should clearly differentiate between these two groups in order not to dissuade tourists from visiting and to motivate more regular users (i.e. those who live near the Dutch border) to register with the KMP scheme and install an OBU. Since the Dutch KMP scheme appears to be leading the way in Europe, it unlikely in the early stages that foreign vehicles will be able to pay the KMP using a compatible OBU which is in use in the vehicle’s country of origin.

2.1.10 Whether foreign freight operators choose to install an OBU will be influenced by a combination of the amount of kilometres travelled within the Netherlands and any comparative long term savings that can be accrued relative to the cost of using the OUS. It is therefore important that the OUS pricing scheme be structured in such a way as to financially benefit regular foreign commercial users (e.g. in excess of 5 daily visits or 500km per year) who opt for OBU installation and registration.

Motorcycles

2.1.11 The mounting of an OBU on a motorcycle is outside the scope of this Report. However, the general physical constraints (i.e. narrow), manoeuvrability (i.e. driving between queues of vehicles), location of the VRM and sometimes the availability of adequate electrical power on a motorcycle pose significant problems in enforcing this class of vehicle.

Trailers & Caravans

2.1.12 It is understood that in the Netherlands trailers and caravans have their own unique registration and corresponding VRM. Although, there is currently a caravan tax, it is not envisaged that the trailer or caravan will be subject to the KMP similar to a powered motor vehicle. There is a tax class of vehicle which is defined as having the capability to pull a trailer, but it is unclear if and how this will relate to a KMP tariff. However, the way these issues are treated within the KMP scheme will influence the cost and possibly the effectiveness of the ES. For example, the enforcement equipment configuration needed to detect the train compared to the trailer will differ, e.g. downstream or upstream facing Automatic Number Plate Recognition (ANPR) equipment, since downstream configuration would only capture the VRM of the trailer and not the train vehicle. Also, sophisticated traffic classification equipment will be needed to detect and enforce whether a vehicle is in fact puling a trailer or not.

Other vehicles

2.1.13 It is unknown at this stage whether other valid road users who do not possess registration plates (e.g., tractors, horse drawn vehicles, pedal cyclists) will be subject to the KMP and therefore require any enforcement measures. Similarly, classic cars do have a VRM, but they do not at present pay road tax. Decisions on the inclusion of these classes of vehicle within the KMP scheme should take into account whether, if included, they can be enforced. For example, the installation of an OBU may well enable a tractor to pay the KMP charge. However, without a valid VRM by which the vehicle can be uniquely identified, automatic enforcement would impractical and manual methods would need to be employed.

Classification

2.1.14 Automatic classification of vehicles is fraught with problems due to technology limitations and the diversity and anomalies inherent in class definitions. For example, Roadside Enforcement Stations (RES) may incorrectly identify the vehicle class and then be unable to reconcile this against that declared at registration and/or included in OBU information. These may only be resolved by manual operators in the ES Back Office (BO) viewing ANPR and contextual images sent back from the roadside. Potentially, a large number of false violations may be generated due to the limits of current technology if the ES is required to differentiate between significant quantities of vehicle classes defined as part of the KMP scheme. This could lead to an increase in operating costs due to the number of uncertain or incorrect violation reports being sent back that require manual processing.

2.2 User Perception

Enforcement and Compliance

2.2.2 Effective enforcement is important to achieving a high level of compliance. This is demonstrated by examining the economic choice faced by a potential evader. A personal preference will be determined by calculating and comparing the potential benefits of the choices available (i.e. evade or comply). On one side of the calculation is the monetary value that the potential evader will save if the evasion is successful. On the other is the incurred cost of the evasion plus the penalty combined with the risk of being caught. The economic test can be presented as follows:

*monetary value saved by evading **>** cost of evasion **+** (penalty **x** risk of being caught)*

If the above test is true then there is a positive economic benefit to the individual to attempt to evade the KMP.

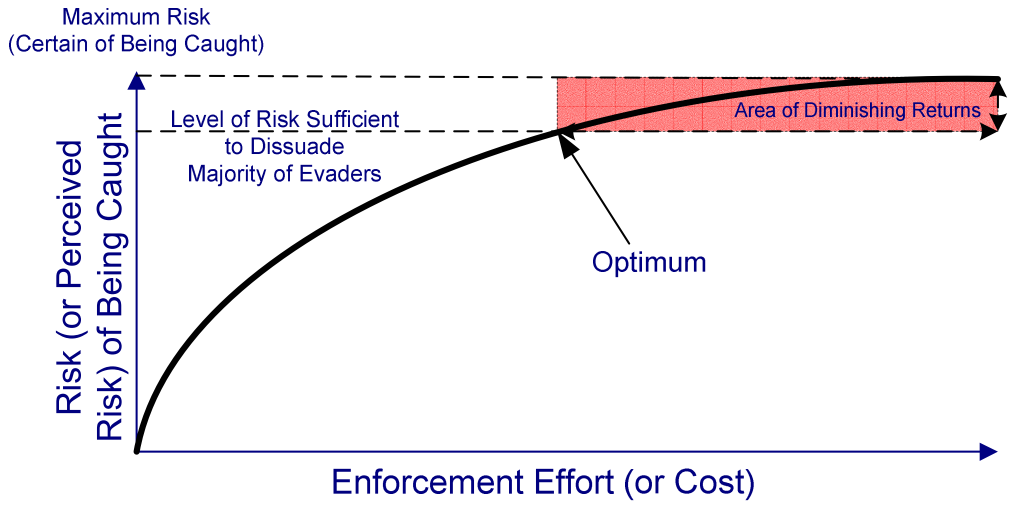
2.2.3 The amount to be saved by evading will be a function of the overall KMP pricing policy. The objective of enforcing compliance is therefore to implement an ES that will maximise the risk of being caught, or more importantly maximise the perceived risk, which is directly related to the ES effort and deployment. However, the value of managing the perceived risk through education, advertisement and public relations should not be underestimated. A phased strategy could be implemented which enhances the early enforcement effort in order to have a shock impact at the start of the scheme and periodically repeated (e.g. purges). This approach may have value in establishing the public's perception of the scheme as 'zero tolerant' to evaders.

2.2.4 In order to estimate the cost of evasion it will be important to identify the specific elements of the scheme where opportunities to evade the KMP remain (e.g. OBU security). Ideally the number of opportunities will be reduced to a minimum through the scheme design process. A cost benefit analysis, possibly using a form of the economic calculation above, should be undertaken to determine whether the cost to eliminate or reduce the outstanding opportunities to evade payment warrant the potential benefits.

2.2.5 Finally, the level of penalty can be set, dependent upon the values of the other variables, to ensure there is a sufficient level of deterrent to dissuade potential evaders.

2.2.6 It is worth noting that the relationship between enforcement effort and risk (or perceived risk) is not linear (see Figure 1). It is desirable to identify the area where an increase in effort delivers little or no increase in the risk, or perceived risk, of being caught (i.e. point of diminishing returns). The configuration and deployment of the ES aims to deliver this sufficient level of deterrent whilst not exceeding the optimum level of effort and cost.

Figure 1 – Enforcement & Risk Relationship



Other Political and Economic Issues

2.2.7 User compliance of the KMP is not simply determined by the level of enforcement and risk of being caught. A significant proportion of the population may not consider evasion if a large degree of societal acceptance is achieved. Achievement of this acceptance is likely to be influenced by many political and economic issues, including:

a) Tax or charge, e.g. benefit to the community/society or profitable venture

b) Equity, fairness, e.g. all elements of society paying proportionally to the benefit gained

c) Hypothecation, e.g. funds collected 'ring fenced' for transport investment

d) Level of Pricing, e.g. comparative replacement of existing tax

e) Individual benefits, e.g. more reliable journey times, reduced delays

f) Privacy & Data Protection, e.g. 'Big Brother' syndrome

2.2.8 The latter issue (item 2.2.7 f) can be addressed in part within the ES (e.g. data encryption, discarding compliant VRM records, etc.). The other issues cannot and are outside the scope of this Report. However, it is envisaged that a balanced set of policies associated with the KMP will be implemented, possibly including the issues listed above, and a general acceptance within society will be achieved.

2.2.9 In summary, compliance is a complex issue and is influenced by many economic and political determinants as well as enforcement. An increase in enforcement effort and cost will increase the risk of catching evaders and thus discourage potential evaders. The number of potential evaders may be reduced by gaining a high degree of societal acceptance. It is important therefore to implement a balanced set of policies together with an optimum deployment and configuration of an ES in order to achieve a high level of compliance.

2.3 DEFAULTERS - WHY PEOPLE DON'T PAY

2.3.1 As previously discussed, those who consider, rightly or wrongly, that there is a perceived economic benefit for them to evade payment of the KMP will attempt to do so. This group will remain manageable as long as there is limited opportunity to evade and no benefit for potential evaders. The ES system must minimise this group by increasing the risk of being caught and penalising those who attempt it.

2.3.2 There may be other reasons for non-payment, which are considered trivial or transitory. However, it is important to be aware of these motives in order that measures can be implemented to eliminate, minimise or mitigate their occurrence. Reasons may include:

a) Awareness, e.g. unaware of the need or how to pay. Mitigation should include the provision of adequate level of public information, both on the run-up to the KMP scheme launch (i.e. Netherlands community) and ongoing for new users (i.e. visitors or immigrants), informing them of their responsibilities and methods of payment. Consideration of a helpdesk to assist users in overcoming any difficulties and providing clarification where misunderstanding occurs.

b) Accessibility, e.g. access to appropriate paying facility. It is envisaged that a range of methods and locations for payment will be provided to ensure all members of the community (e.g. disabled, disadvantaged) have an adequate opportunity to comply.

c) Lapses, e.g. forget to pay. This may or may not be considered acceptable as part of the scheme. If so, the facility for post-payment will need to be linked to a time limit before a penalty notice is issued (e.g. one week grace period). This will however increase the amount of data communicated and stored in the ES BO before the time limit elapses.

2.3.3 User perception and compliance have been examined previously in general terms. However, not all members of society respond to either societal influences or the calculation of personal economic benefit. The reasons for evasion within this group may include:

a) Ability, e.g. disadvantaged groups, limited income and do not have the means or will to pay. This refers to the group in society that have little to lose and view the evasion of all taxes and charges as a legitimate way of life.

b) Anonymity, e.g. those who have a vested interest in remaining anonymous or untraceable (e.g. Organised Crime). This may be linked to the perception that movements can be tracked. In the main this group do not comply with other societal rules e.g. the use of false VRM.

c) Challenge, i.e. those who see the KMP as a system that is there to be beaten. This group is not particularly motivated by personal economic benefit and will see it as a challenge to find a way to dodge or evade payment (e.g. hacker syndrome).

2.4 Pricing Policy

Background

2.4.2 The current Dutch transport taxation policy is to levy charges from the following sources: vehicle purchase tax (BPM); annual vehicle tax (MRB); excise duty/ consumption tax (on fuel) and motorway tax for HGVs (sometimes referred to as Eurovignette). With the exception of fuel tax, these taxes are all fixed relative to each class of vehicle, irrespective of vehicle usage.

2.4.3 The Client-issued memorandum dated 20 June 2006 (with the subject title Tariff Scenarios) indicates that the new KMP policy will be to replace some or all of these fixed vehicle taxes with one that is related to tariffs charged for road usage. The vehicle owner will then be charged the tariff for each kilometre that is driven. All tariffs will depend on fixed vehicle characteristics and possibly additional supplementary tariffs that will relate to the particular journey that is being made (e.g. time of day, travel on a particular segment of the road network).

Enforcing a Distance Based Pricing Policy

2.4.4 The complexity (and hence cost and reliability) of the ES is heavily dependent upon the policy that is developed to charge the motorists for their motoring activities and the extent to which it is to be enforced.

2.4.5 For the purposes of enforcement, some pricing or road transport taxation policies are only practical when all vehicles are equipped with an on-board unit (OBU), whereas other policies (including the existing taxation) can be implemented purely by the use of technology deployed at the roadside, BO data processing and enforcement personnel.

2.4.6 Assuming that the KMP scheme will operate with a mix of OBU and non-OBU users on the network, a possible function of the enforcement system will be to confirm whether or not each vehicle is equipped with an operational OBU and that it is functioning as anticipated (e.g. security flag, time, location, etc.). A positive response will provide verification that the OBU is operating as it should (e.g. not tampered with). Due to the OBU internal security checks implemented, it is assumed that the ES verification will provide a high degree of confidence that that the customer (OBU) account is being automatically updated with the correct charge.

2.4.7 If confirmation of an operational OBU cannot be obtained then it is assumed that the vehicle is either registered onto the OUS or is in violation of the scheme (i.e. attempting to evade payment). Assuming the vehicle is registered, or will register (i.e. post-payment), onto the OUS and the distance based charging still applies, the enforcement system will need to use roadside technology to track the passage of the vehicle and calculate the distance driven with sufficient accuracy in order to verify any journeys that are declared. In order to apply this tracking to all OUS vehicles, RES would need to be located relatively near to the start and finish of all vehicle journeys, with sufficient intermediate enforcement stations to be able to plot each vehicle route.

2.4.8 In addition, the BO system would need to filter and process the ES tracking in order to determine the journey and then compare it to any pre-registered trip declarations. For any journeys that are not pre-registered, the records would then need to be stored and compared with any post registered journeys within the accepted notification period. Evidence packs and residual trip information (i.e. those which are not registered before the expiry of the notification period), would then be sent on to the authority responsible for calculating and imposing the fine. It should be noted that if post-payment declarations are allowed this will require the ES to store significant amount of data associated with potential evidence packages until the notification period expires. Only then can it be determined whether a vehicle is a valid OUS user or a payment evader.

2.4.9 In this scenario, where the OUS vehicles are subject to the KMP, determining the location where trips start and finish on the Onderliggend Wagen Net (OWN - regional/local road network) is not practical because there are potentially an infinite number of start and finish locations. RES would need to be provided at every local junction in order to record journeys. However, even such a large deployment may not provide the degree of accuracy (i.e. within a few kilometres) sufficient to be used for enforcement purposes.

2.4.10 It may however be considered practicable to apply this method for non-OBU trips made on the Hoofd Wagen Net (HWN - motorway/trunk road network). The linear nature of the HWN and the ease of placement of RES at the junction entry and exits points on this network may make this a practical option. Therefore it may be considered more practical and acceptable to apply a KMP for OUS users on the HWN and a non-distance based charge for use on the OWN.

2.4.11 In summary, the increase in BO filtering, processing and storage of data associated with enforcing a KMP charge for OUS users will result in significant increased costs. The practicality of enforcing an OUS distance based charge is severely problematic due to the likely accuracy required for enforcement. In addition, the infrastructure costs associated with the potential number of RES required across the road network would be prohibitive. It is concluded that a distance based charge for OUS users is not practical.

2.4.12 It is therefore suggested that RES are used to simply confirm if detected OUS users (i.e. non-OBU equipped vehicles) are registered on the KMP scheme, either pre-trip or post-trip (i.e. within the notification period). Additionally, if time and/or location dependent tariffs apply (e.g. peak/off-peak, zones), these could be verified by the ES, either at the RES (pre-trip declaration) or the BO (post-trip declarations). However, the actual distance travelled compared to that declared could not be verified. It is concluded that a tariff per time-period based payment system may be more applicable and enforceable for the OUS scheme.

2.4.13 A similar BO check of time and/or location can be undertaken for OBU users, possibly on a percentage sample basis, to verify the correct working of the OBU. However, implementation would be dependent upon individual vehicle time and location data being sent back to the billing BO via the GPRS link, which is contrary to that stated within the current reference architecture and may introduce privacy issues that are publicly unacceptable.

Comparison of Pricing Scenarios

2.4.14 Table 2 lists the potential pricing scenarios that have been provided by the Client for assessment. From the perspective of the ES, it is considered to be unrealistic to charge on a per-kilometre basis for vehicles that are not equipped with an OBU for the reasons cited in 2.4.9 to 2.4.11. However, all other options associated with the pricing scenarios incur similar additional costs to that incurred for additional charges made to OBU users.

Table 2 – Pricing Scenarios

ID	Scenario Description	OBU Equipped Vehicle	Non-OBU Equipped Vehicles
1	Flat Rate	Baseline	Can only be used to validate registration to the KMP.
1A	Flat Rate plus tolls	Same as Scenario 1 but it will require additional infrastructure at tolls (fixed sites are preferable). It will also increase BO costs in order to process the additional fees associated with the toll.	Same as Scenario 1 for distance based charge. It will require additional infrastructure at tolls (fixed sites are preferable) and will also increase BO costs to process the additional toll fee.
2	Uniform peak/ off peak	Same as Scenario 1, but an additional OBU time check is recommended. It will increase BO costs to record and validate the time of day for the journey.	Same as Scenario 1. It will increase BO costs to record and validate the time of day for the journey.
3	Peak tariff on congested segments	Same as Scenario 1A, but an additional time check is recommended and it will increase BO costs to record and validate the time of day for the journey (as for Scenario 2). Fixed or transportable enforcement systems can be used.	Same as Scenario 1A, but an additional time check is recommended and it will increase BO costs to record and validate the time of day for the journey (as for Scenario 2). Fixed or transportable enforcement systems can be used.
3A	Peak tariff on congested segments plus apportionment	Same as Scenario 3.	Same as Scenario 3

ID	Scenario Description	OBU Equipped Vehicle	Non-OBU Equipped Vehicles
3B	Peak tariff on congested segments with different peak increases plus tolls	Same as Scenario 3 but fixed enforcement systems are recommended for all tolls.	Same as Scenario 3 but fixed enforcement systems are recommended for all tolls.
4	Urban/ interurban	Same as Scenario 1A, with additional infrastructure at the city designated limits (transportable enforcement sites are preferable). It will also increase BO costs in order to process the additional fees associated with the urban/ interurban charge.	Same as Scenario 1A, with additional infrastructure at the city designated limits (transportable enforcement sites are preferable). It will also increase BO costs in order to process the additional fees associated with the urban/ interurban charge.

2.5 Promoting Scheme Compliance (Enforcement & Encouragement)

2.5.1 Compliance of any rule may be promoted in both a positive and negative manner (i.e. 'carrot' and 'stick' approach). The 'carrot' refers to offering incentives and encouragement to those that comply, whereas the 'stick' approaches acts as a deterrent to users considering non-compliance and delivers a penalty to those who evade.

'Stick' Approach

2.5.2 The ES is exclusively concerned with the 'stick' approach and we have previously concluded that a large proportion of the community will comply if an acceptable balance of factors related to user perception is achieved. In addition, potential defaulters should have the expectation of being caught and penalised accordingly. The promulgation and education regarding both the enforcement measures in place and penalties that can be expected if caught will also influence and promote compliance.

2.5.3 The frequency of issuing penalties for non-compliance with the KMP needs to be determined, since this will have an impact on the number of offences that need to be communicated and processed by the ES. For example, if an offender is detected on more than one occasion within a certain period (e.g. one day or one hour) should these be classed as separate and discrete offences requiring multiple penalty notices (e.g. potentially several fines)? The multiple penalty approach would be in line with existing traffic enforcement policies.

2.5.4 Consideration should be given to whether separate classes of offence are appropriate. For example, a single offence within a given period (e.g. 3 months) may be treated as a civil offence or misdemeanour, similar to a parking fine and subject to administrative law. Whereas it may be considered a more serious offence (i.e. criminal law) for an habitual offender or where serious acts of fraud are committed (e.g. OBU tampering, systematic evasion). This policy will affect the amount of processing in the ES BO and possibly influence whether a 'black list' of habitual offenders needs to be stored at the RES.

2.5.5 It is unclear whether a penalty point scheme is envisaged for the KMP that would operate in parallel with the penalty fine system. In such a system, points would be issued for misdemeanour and/or serious level infringements as well as a penalty fine. Points could then be reduced or cancelled after a particular period (e.g. one year) of continued compliance. Once an offender accrued a certain level of penalty points this could result in an enhanced penalty, for example, an increased fine or a permanently/temporarily increased tariff per kilometre. Ultimately this escalation could lead to further measures such as to clamp or impound a persistent evader's vehicle.

'Carrot' Approach

2.5.6 There are numerous opportunities for positive incentive schemes that may be incorporated on a temporary or permanent basis to promote and encourage compliance. These may or may not align with the overall KMP philosophy or policy. It is not intended to examine these in detail since they are beyond the scope of the brief for this commission, but include the following list for information and completeness:

a) Discounting, e.g. providing discounting or 'cash-back' for continuous compliance.

b) Discounting for early or pre-payment, e.g. season ticket

c) Discount where other modes or alternatives are not available

2.5.7 In addition value added services provided through the OBU may also encourage compliance. Although these should be chosen carefully since they may work contrary to other policies, e.g. route guidance versus congestion reduction. Value added services may include:

a) Travel Information, e.g. incident alerts, journey time advice

b) 'Bonus points' type retailer incentive schemes offering bonus/discount through the KMP scheme by visiting their location

2.5.8 As previously mentioned, promotion of compliance will also be achieved through the provision of public information through education, advertising and programmes will advise the Dutch community and foreign visitors of how the scheme operates and their personal responsibilities with respect to payment.

2.6 Enforcement & Legislative Policy

2.6.1 The ES may detect and record a vehicle that passes an enforcement point in contravention of the KMP scheme. However, it is important to define what is considered an offence under the scheme. It is suggested that driving on any road in the Netherlands whilst in contravention of the scheme is the simplest way to define an offence. More complex definitions of an offence related to the distance travelled, categories of road or time travelled on the network whilst in contravention will require a much more complicated ES to detect and provide supporting evidence.

2.6.2 When drafting legislation due consideration should be given to defining what point in time (i.e. when) a user is required to register on the scheme before they are deemed to be non-compliant and a valid offence may be detected. If pre-payment or registration is required, what is the opportunity time frame from first arrival on the road network until behaviour is considered non-compliant? If post payment is acceptable then when does non-payment become an offence?

User responsibilities

2.6.3 The ES will use the VRM to identify a vehicle that is in contravention of the scheme. The database of registered vehicle owners held by the Rijksdienst voor het Wegverkeer (RDW – vehicle licensing authority) will then be used to link the offending vehicle to a responsible vehicle owner. Thus the ES legislation should be defined ensuring that the registered vehicle owner has the responsibility for payment. In addition, attempts to tamper with VRM or vandalise/deface signs or camera equipment should be deemed to be criminal offences that will be dealt with outside the ES.

Tax or Charge

2.6.4 It is also important to ensure within the legislative framework for the KMP scheme that there is due consideration given to the enforcement penalties for evasion of payment. Does prosecution of tax avoidance have similar or different enforcement requirements to prosecution of avoidance of the KMP charge? This may be a complex issue due to the KMP scheme potentially including both elements of taxation (i.e. replacing existing road/vehicle taxes) and road charging (i.e. tolls, foreign vehicles).

Penalty vs Risk

2.6.5 As previously explained, in order to create a credible enforcement system due consideration must be given to a number of factors that relate to the size of the penalty. A potential evader will assess the economic benefit of compliance (see 2.2.2) with a key factor being the probability of getting caught, prosecuted and fined (i.e. risk). If there is a substantial probability of being caught the road user will then also balance the expected penalty against the cost to comply.

2.6.6 A relatively simple enforcement system would be capable of detecting non-compliance at a point on the road network. However, the penalty enforced must then relate to the 'possible' charge that would have been due under compliant behaviour. If compliant behaviour is based upon time of day, location on the road network and distance travelled, then there is potential for a scenario to exist where a penalty charge will in effect be less expensive than the compliant charge. This would then indicate that multiple 'offences' should be considered within a time period and that a more complicated enforcement system should be developed to effectively track non-compliant vehicles.

2.6.7 Key to the ability to provide robust enforcement will be the legislative measures developed to support the scheme. If the scheme is administered simply as a charge with financial penalties, the imposition of fines and the resulting recovery of unpaid fees may be the only solution for repeat offenders. If the scheme is seen as a tax, then there may be more severe penalties available that can be imposed.

Notification Period,

2.6.8 Due consideration must also be given to what length of time or what distance an occasional user may be on the network prior to notification before being considered an offender. The notification period will have an effect on the data storage requirements in the BO. It will also have an effect on the number of repeat offences in the early stages of the scheme. It is sensible to notify offenders very quickly at the beginning of operation of the scheme and then allow this requirement to lengthen.

Level of Enforcement

2.6.9 An effective policy should be defined to allow the ES to effectively identify offenders. It is relatively simple to state that any deviation from 'zero tolerance' enforcement adds complexity and cost to the enforcement system. However, there may be reasons associated with social acceptability that mean that some tolerances are needed.

2.6.10 The difficulty of introducing tolerances within the KMP scheme arise when they concern distance, time or person based allowances. The ES will be required to form decision making relationships with other elements of the overall scheme. This will substantially restrict the amount of data that can be analysed and securely discarded at the roadside. Thus data transfer, processing and storage in the BO increases.

Appeals and Independent Adjudication

2.6.11 There is also a need to provide an independent appeals process within the KMP scheme. The enforcement system should be constructed to fully support the anticipated information required within an appeals process. For example, how long will the evidential information need to be stored and what supporting information regarding the movement of the particular vehicle will be required? It is possible that the requirements to support potential appeals will actually set the baseline for the storage requirements of the enforcement system.

Monitoring Compliance

2.6.12 Provision should be made for continuous monitoring of the relationship between enforcement effort and compliance. In order to operate the enforcement system at the optimum level (i.e. least cost for maximum compliance) the mix between mobile and fixed enforcement needs careful consideration. This is likely to be dependent on road category, geography and time of year. An element of this monitoring must also include route analysis which is able to capture change in behaviour due to enforcement.

Data Protection Compliance

2.6.13 It is envisaged that CCTV monitoring needs to be fully compliant with the data protection legislation. Only in circumstances where VRM does not match the database records, will images be retained for enforcement purposes. In these circumstances context images of vehicles should be such that the occupants are unidentifiable (e.g. blank windows), which is understood to be in line with current enforcement for traffic offences.

2.7 Enforcement Targeting

2.7.1 Section 2.2 identified that effective compliance is predicated upon:

a) The perceived risk of being caught and fined (if not compliant)

b) The cost of evading payment for the trip

c) The cost of paying for the trip

2.7.2 Enforcement targeting seeks to maximise compliance by increasing the perceived risk of being caught, combined with ensuring that the cost of evading the charge outweighs the costs of paying (for example by taking a detour to avoid a fixed enforcement station).

2.7.3 Several different tactics are suggested for use as part of the strategy to target the following:

a) Routes with high daily traffic flow rates in order to conduct spot checks on all vehicles passing the enforcement station (i.e. fixed or transportable)

b) Areas or zones of interest (e.g. periodic purge) by conducting spot checks on all vehicles passing the enforcement station

c) Registered owners with operational OBUs who frequently do not accrue charged kilometres, e.g. registered vehicles with no monthly invoices

d) Registered owners with operational OBUs where there is a significant discrepancy between recorded (annual) odometer readings and charged kilometres

e) Registered owners with no OBUs in order to seek a declaration as to why they don't have an OBU (applies only to vehicles who are frequently checked by enforcement stations)

f) Registered owners with no OBUs that have not registered their journey within a pre-specified time frame (applies only to occasional users)

Bulk Checks on All Vehicles passing an Enforcement Station

2.7.4 Tactic (a) and (b) are recommended for distinguishing between vehicles that are pre-registered on KMP and potential violators whose information will require further processing in the BO.

2.7.5 For OBU equipped vehicles, a simple check is suggested to ensure that the details registered against the OBU account (i.e. VRM and vehicle classification) match the vehicle that is passing and that the OBU has not been tampered with (i.e. the OBU security flag is set at the correct state). Additionally, if the OBU requires time information, for the purposes of time-dependent tariffs, the OBU clock could be verified against the enforcement system clock.

2.7.6 For all other vehicles, a similar check is suggested using the VRM and vehicle classification to verify whether the vehicle is registered and has a valid declaration (i.e. pre-registration on the OUS scheme for specific location and time).

2.7.7 All vehicle information that could not be verified using these simple checks would then be sent to the BO for further investigation. Possible legitimate reasons could include that the OBU has a fault (in which case notification can be sent to the owner) or that an OUS does not register a trip sufficiently in advance of the journey being made.

2.7.8 It is suggested that both tactics could be implemented using fixed or transportable RES. However, transportable RES are most appropriate for Tactic (b) since this will allow the location of the enforcement site to be randomly varied. Tactic (a) enforcement stations are likely to only be deployed on the HWN, whereas Tactic (b) stations could be deployed on the HWN and OWN network.

Other KMP Checks

2.7.9 Tactics (c) to (e) are designed to target the owners of vehicles whose trips do not fall into the standard categories which the bulk checks are designed for and who may be acting fraudulently. The combined use of roadside technology, ES BO checks and information received from other sources will facilitate the identification of potential evaders. A means of increasing the perception of being caught and fined can then be undertaken by issuing notices for owners to declare why they are being charged at a low (potentially zero) rate per month.

2.7.10 The information to apply Tactic (c) would emanate from the charging system, by identifying registered OBU vehicles that frequently do not accrue significant distance based charges, especially if they are regularly identified by several enforcement stations. There are many genuine reasons for the low charge, for example, it is out of service or it is a classic car which is only used at weekends in summer. Alternatively, the charging system may not be detecting the vehicle for some other (possibly fraudulent) reason. Justification for this apparently abnormal use could then be sought (e.g. by seeking a declaration about vehicle use). In parallel, the ES could put the vehicle information onto a potential 'black list' to alert mobile enforcement officers or other agencies (e.g. Police) to stop and check to ensure a the OBU is operating and a charge is being accrued. The vehicle in question could be summoned for a mandatory check of the OBU installation if a system fault or potential fraudulent use is detected.

2.7.11 Tactic (d) is aimed at detecting people who, if possible, regularly cover up or block the use of the OBU by the charging system but make it available to be read by enforcement stations. A periodic check of the odometer reading (i.e. as part of a vehicle service, annual inspection or spot inspection by mobile patrols) compared to the charged kilometres will identify any significant discrepancies and a declaration can then be sought from the vehicle owner. Valid reasons would include evidence of having travelled a significant distance outside the country or 'trips' made on routes other than roads (for example, the distance travelled by a tractor when ploughing a field).

2.7.12 Tactic (e) is really designed to encourage the use of an OBU (i.e. if it is optional under the KMP scheme), increasing the perception of risk to the vehicle owner that they will not evade payment by using the OUS. This tactic could be combined with educational information that demonstrates to the vehicle owner any financial benefits of being a registered OBU user.

2.7.13 Tactic (f) is designed to identify and pursue vehicle owners where one or more trips have been made with no intention to pay (either due to lack of awareness or fraud). The BO system will request that fines are issued to the owners of these vehicles. For persistent users of the road network who do not pay, it may be desirable to put the vehicle details onto a 'black list' which will alert mobile patrols with the authority to physically stop a vehicle.

Other Non-KMP Checks

2.7.14 It may be possible to use the ES to identify other non-KMP traffic related violations (e.g. stolen vehicles or duplicate VRMs) and track the offending vehicles on the network. It is almost certain that these vehicles will be KMP evaders. However, the practicality of implementing such a scheme would primarily depend on Dutch cultural and legislative policies governing privacy, data protection and evidence gathering.

2.8 System Security

OBU installation, self or approved installer

2.8.2 Technology used to measure and collect the charge must be tamper-proof such that, if it shows no sign of tampering and is working at all, it can be assumed to be working correctly. Essentially this is achieved by an integral link between the charging system and the enforcement system.

2.8.3 The KMP OBU shall therefore be tamper-proof. The requirement should not be for the OBU to be impossible to tamper with, as such a requirement would itself be difficult or impossible to meet. Neither should it be for the equipment automatically to detect all forms of tampering, which is equally difficult or impossible to achieve. Rather, any tampering with the device that could result in it operating differently shall leave some form of permanent evidence such that the tampering can be detected by inspection.

2.8.4 This inevitably forms a relationship to the costs of the enforcement operations.

2.8.5 Whatever solutions are proposed for tamper-proofing, the KMP compliance regime should include the following tamper detection measures:

a) Authorised OBU Technicians shall look for signs of tampering (e.g. when carrying out repairs) and shall report evidence of tampering by submitting Observation Records (ORs), similar to those that could be used by compliance officers in mobile units. The system should support the ability to interface the OR's into the charging system and onward to the central system. Tampered OBU should be removed from the vehicle and held securely as potential evidence, and a replacement unit fitted immediately.

b) As vehicles pass by enforcement sites, the ES should be capable of identifying signs that the VRM has been tampered with. Due consideration within the ANPR technical solution should be given to this matter.

Evidence Pack Back Office Storage

2.8.6 In the BO, evidence packs should be stored in a secure environment with facilities to create an off site copy. Full disaster recovery should be taken into account to provide protection for the primary evidence contained within the evidence packs.

2.8.7 The primary evidence pack should be stored as it has been received and if access is required for confirmation, validation or as evidence for presentation, a copy should be created, decrypted and verified using the electronic mark as a true copy of the primary evidence.

2.8.8 Restrictions should apply to members of staff who have access to any evidence pack whether encrypted or decrypted.

2.8.9 The primary evidence packs should only be deleted from the system and any back up system when dismissed as compliant or any fines have been paid and payment has cleared, and when all avenues of appeal have been exhausted. A safeguard must be implemented to ensure that evidence packs can only be deleted when all the relevant conditions have been complied with.

Roadside Data Storage

2.8.10 Any data store in the roadside units should be protected against any attempt to tamper with it or access it. The various types of data that can be held within the roadside units can include but not be limited too:

a) White List

b) Black List

c) Temporary Evidential Storage

2.8.11 Any roadside unit should regularly be checked by the BO to ensure correct operation. There should be a tamper alarm that will cause any data held in volatile storage to be destroyed on detection.

White List

2.8.12 This is a list of vehicles that are compliant with the road charging scheme. The list can be downloaded on initialisation and updated on a frequent basis. To protect the list, it should be encrypted and held in volatile memory. When comparing any vehicle licence plates captured by the ANPR system, the derived Licence Plate will be encrypted and compared with the encrypted White List to see if a match can be found.

Black List

2.8.13 This is a list of vehicles that are non-compliant with the road charging scheme or of special interest to the authorities. The list can be downloaded on initialisation and updated on a frequent basis. To protect the list, it should be encrypted and held in volatile memory. When comparing any vehicle licence plates captured by the ANPR system, the derived VRM will be encrypted and compared with the encrypted White List to see if a match can be found.

Temporary Evidential Storage

2.8.14 Data and images that are received from the enforcement equipment will need to be temporarily stored whilst being checked against the White & Black lists and then for possible transmission to the BO.

2.8.15 To protect the integrity of the images and data, the images should be electronically marked and encrypted using an encryption method such as Triple Data Encryption Standard (DES) or Advanced Encryption Standard (AES) as soon as possible after capture. Any keys used in the encryption should be held in volatile memory. The data and images should then be assembled into a single evidence package.

2.8.16 If onward transmission to the BO is required then the evidence can be stored temporarily by the road side unit until transmission. Transmission should take place within a maximum of 24 hours of capture. A system of verifying successful receipt of the evidence pack by the BO to the road side unit should be employed. The roadside unite should delete evidence packs from the temporary storage as soon as possible after receipt verification by the BO.

2.8.17 Evidence packs that do not require transmission to the BO should be deleted by the roadside unit as soon as possible after capture. This will protect the non offender from any data protection issues by not storing any of the images or data.

Mobile Data Storage

2.8.18 Any mobile units must provide a secure environment for the storage of any evidential data that is stored within the mobile unit such as the White and Black lists and evidential data that has been captured.

Dedicated Mobile Units

2.8.19 The method of storage of any ORs should be the same as that of the roadside units in order to show that the integrity of the observation record has not been compromised. ORs may be transmitted to the BO over a live radio link i.e. GPRS or could possibly be stored and downloaded when the mobile unit returns to base.

Other Agencies

2.8.20 Other agencies may be involved in providing evidence e.g. in routine vehicle stop by the Police. Legislation would need to require that any captured evidence by these agencies would be compliant with the rules of the KMP scheme and capable of being shown to be robust and legally admissible for the purposes of enforcing the scheme.

Communications

2.8.21 The communication systems employed must provide a robust method of transmission in both directions. Sensitive data, including list information and evidence packs should be encrypted prior to transmission across any communication link. This will allow the freedom in the selection of the communication medium. It is recommended that a method of verifying transmission of data is employed to ensure successful receipt.

2.9 Thick and Thin Client

2.9.1 The term ‘thin client’ generally refers to user devices whose functionality is minimized, either to reduce the cost of ownership (e.g. per desktop) or to provide more user flexibility and mobility. Conversely the term ‘thick client’ refers to an architecture in which application-specific code runs on and processes data on the client (i.e. desktop), rather than merely rendering data which has been processed by a server.

2.9.2 Our understanding of the choice of thick or thin client architecture for KMP relates to the processing and functionality within the OBU rather than the BO. For thin client architecture the information stored and processed within the OBU is limited. For example, for ‘thin client’ architecture an OBU would store and transfer data regarding the vehicles location/time on the network to the BO where the map and tariff processing would be undertaken by the billing/payment server. For thick client architecture the OBU would contain and process map and tariff data and send back kilometres travelled or units as appropriate to a particular tariff. The BO billing/payment system will then process and collate the data in order to collect user payments. These different approaches have impacts on privacy and security and most importantly on the cost and complexity of the OBU. The functionality or the OBU (i.e. thick or thin client) does influence the scope of the ES, however this mainly concerns what, if any, verification checks concerning the OBU security can be undertaken (i.e. ‘belt and braces’ checks).

RFID/DSRC Tag

2.9.3 For a standard fixed point tolling system the OBU could simply be an RFID (Radio Frequency IDentification) tag which can be interrogated remotely via a DSRC beacon installed either over the running lane or adjacent to the roadside. In this case enforcement consists of checking that the tag is valid and/or registered on the system (e.g. the user has pre-paid or can be billed). If not the toll barrier may remain closed, or in a free flow situation, the VRM and vehicle can be photographed in order that payment can be pursued and/or a penalty issued. A simple but suitable RFID tag has the advantages of being cheap (i.e. of the order of €25) and relatively simple to install (e.g. stuck to the windscreen).

2.9.4 Use of such a RFID tag system for the general KMP scheme would not be appropriate since it would not meet the requirement of measuring and reporting the kilometres travelled. However, this simple method may provide advantages for the OUS. In enforcement terms a tag-less OUS would need to update the ES in real-time of all occasional users registered on the scheme (i.e. VRM and class) and possibly information regarding their declared journey (i.e. route, area or time vehicle is valid). The ES BO would need to communicate this in real-time, or reasonably so, to all RES in order that if detected a false violation record would not be generated.

2.9.5 An OUS tag could operate in two ways, either as an electronic ticket (e.g. pre-pay) or account identification (e.g. post-pay). Both options would reduce the amount if information stored at the roadside and dependent upon final architecture preclude the need for real-time communications. The verification of classification may be undertaken manually at time of purchase and/or automatically at the RES, although the latter may provide limited differentiation.

GNSS/GPRS

2.9.6 The current requirements for the KMP includes the incorporation into the OBU of a GNSS receiver to determine location and distance travelled and GPRS, or similar (e.g. 3G), communications for reporting relevant information to the BO in order that billing transactions can be processed. For enforcement purposes the DSRC communication facility may also be included.

2.9.7 Any OBU additional functionality provides the opportunity for the ES to interrogate and verify additional information. Although this should be minimised to those checks that will provide significant additional security without adding substantial complexity. The OBU internal security and anti-tamper systems will need to ensure the calculated distance, times and zones travelled are valid, since this cannot be done effectively from fixed or transportable enforcement points. Additional checks for inappropriate travel patterns can be undertaken using data mining techniques after transmission to the BO via GPRS.

2.9.8 In this case, it is envisaged that the OBU time (i.e. possibly GNSS derived internal clock) and a security or validity flag/code will be available for DSRC interrogation by the ES. The validity of this information combined with the KMP registration details (e.g. user/OBU registration number) can be checked by the RES and, if valid, any ANPR data or context images can be securely discarded. Detection of invalid data will result in a violation record returned to the ES BO.

Vehicle Management System

2.9.9 Connection of the OBU to a vehicle management system will provide further information for confirmation of kilometres travelled, class of vehicle, etc. Any mismatch or detection of invalid information would be flagged within the OBU security system and would not impact upon the complexity or configuration of the ES.

Onboard Mapping/Tariff Display

2.9.10 It is envisaged that any thick client functionality required to calculate and/or display tariff information will need to store and process mapping and tariff information. Again it is envisaged that the security aspects surrounding the validity of the information stored and processed will be undertaken within the OBU. The verification of the correct tariff information will be undertaken in the KMP BO after transmission via GPRS. The RES complexity and infrastructure is likely to be no different than that described for incorporation of the GNSS and GPRS functionality.

2.10 Residual Opportunities to Evade Payment

2.10.1 At this strategy and concept stage of development it has not been possible to identify specific residual opportunities to evade. The strategies and concepts identified in this Report have focussed upon either ‘plugging’ any of the potential ‘holes’ in the KMP scheme or detecting and enforcing non-compliant vehicles and potential evaders. It is recommended therefore that once policy details of the KMP scheme become more firm that an evasion risk assessment is undertaken which identifies all possible scenarios where users could avoid payment of the chosen scheme concept. This will provide an indication of the likelihood of occurrence of each evasion event, which will allow the most cost-effective and efficient methods to be identified that will target those high risk opportunities.

2.11 Performance Indicators

2.11.1 It is considered important to highlight the importance of ES performance specification, since this can have a significant impact on the configuration and dimensioning, and thus cost, of the final enforcement solution. For example if the ES key performance indicators (KPIs) focus on the technical performance of individual system elements, such as VRM capture, this can result in a significant manual resource being required to support the shortcomings of the underlying technology. It is recommended therefore that the specified KPIs focus on measurement of output delivery, for example, percentage number of payment evaders detected. This is a very complex and potentially contractual (i.e. impacts upon procurement) subject and not specifically required by scope of work for this Report. We therefore recommend that further in depth study in undertaken regarding this matter at subsequent stages in the development of this scheme.

2.12 Summary

Cost Drivers

2.12.2 It is clear from the preceding sections that there are several factors that will influence the complexity and ultimate cost of the ES associated with the proposed KMP scheme. There is no simple solution that will provide effective enforcement and therefore a balance will need to be struck between all of the contributory factors. The cost drivers identified include:

a) User Compliance – various policy issues may make the KMP more acceptable to the public as a whole, thus minimising the resistance to the scheme and marginally reducing enforcement effort required.

b) Pricing Policy – different tariffs for toll routes, congested zones, urban/inter-urban, etc will lead to additional enforcement stations

c) OUS – occasional user policies influence the configuration, procedures and offences associated with the occasional user system and will impact on the complexity and cost of the ES

d) OBU complexity – thin and thick client influences the type of enforcement and thus the complexity and cost of the ES

e) Offences – the definition and range of offences that need to be enforced will influence ES BO costs

f) Performance Indicators – the specification of KPIs should focus on delivery of outputs rather than individual systems elements, which may have hidden cost implications.

2.12.3 The interdependencies of the key cost drivers are illustrated in Figure 2. The diagram does not have an overall scale, but simply indicates the relative relationship of different influencing factors on the enforcement effort and cost.

User Compliance

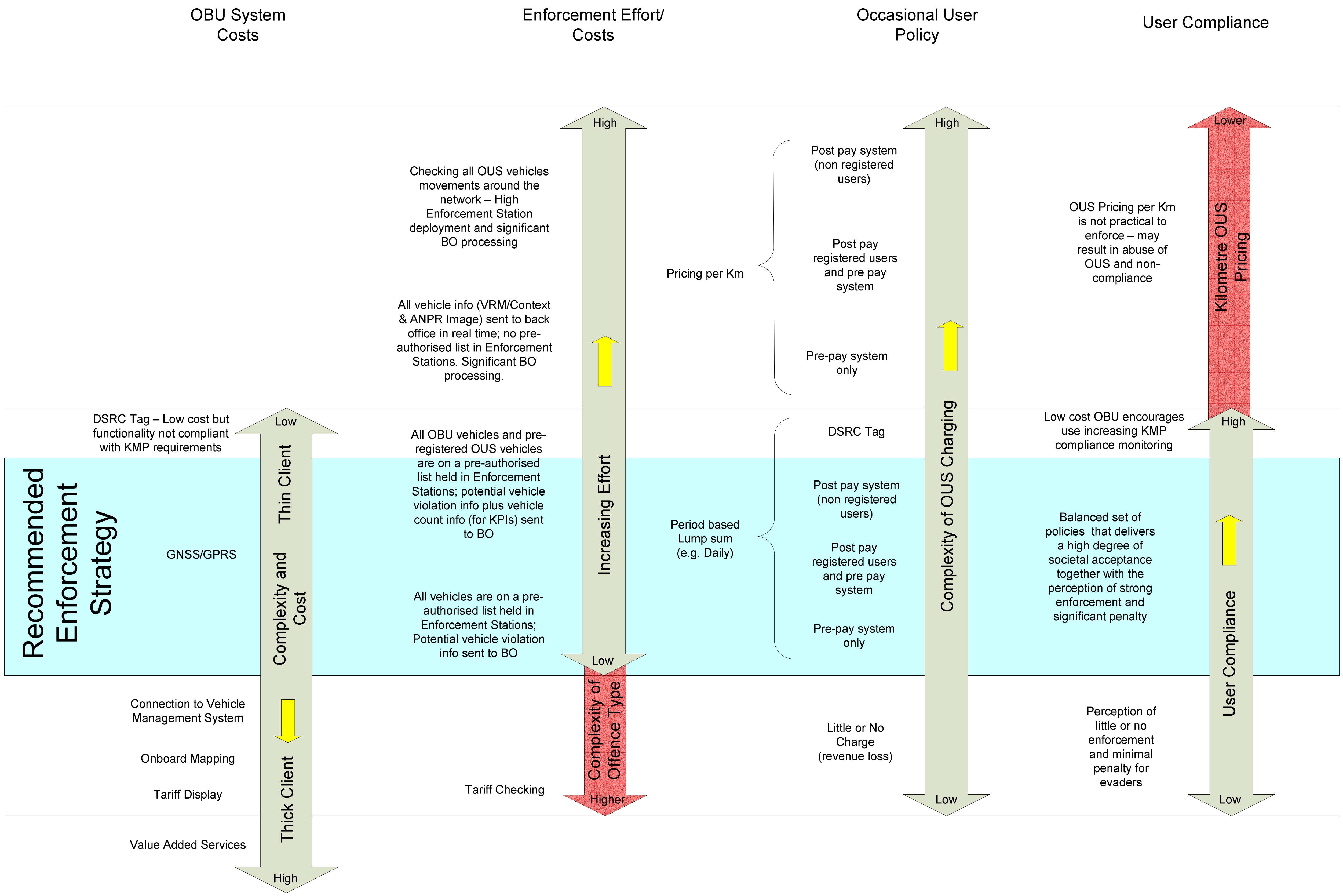
2.12.4 As previously discussed, user compliance is proportional to enforcement. In addition, the cost and complexity of the OBU may also have an influence. Assuming the user pays for the OBU, a low cost simple variant will assist user take-up and thus support compliance of the scheme.

2.12.5 The OUS policy will also influence compliance. If a kilometre price OUS is implemented which cannot be practically or effectively enforced then there is a risk that a significant proportion of the community may misuse the OUS and will be non-compliant. This led us to conclude that a period based lump sum should be adopted for occasional users. At the opposite end of the scale, if little or no charge is made for occasional use then similar widespread non-compliance may ensue.

Occasional User Policy

2.12.6 The effort and cost of the ES is proportional to the complexity of the occasional user charging policy. As stated, enforcement of a kilometre pricing OUS will require a significant (i.e. infinite) deployment of RES to track and check the movement of occasional user vehicles. Enforcement deployment for a period based lump sum OUS scheme will approximately align with the dimensioning require for OBU user enforcement. Post-payment will marginally increase enforcement effort/costs due to the capture and storage of those occasional users who have not yet registered or paid, but intend do so before the accepted post-payment time period elapses.

Figure 2 – Enforcement Effort Relationships



Left Intentionally Blank

OBU Complexity and Cost

2.12.7 The use of a simple and low cost RFID/DSRC tag for regular users of the KMP scheme would likely promote high user compliance. However, this would not have the functionality required to implement or enforce the kilometre charge philosophy of the proposed scheme. The ES is able to validate the registered tag against the VRM and registered users, which may be an appropriate option for a period based lump sum OUS scheme.

2.12.8 The addition of GNSS and GPRS functionality will increase the cost of the OBU and allow the ES to undertake ‘belt and braces’ checks to verify the correct functioning of the OBU. We consider that this is the optimum OBU functionality level that provides opportunities to enhance enforcement of the KMP scheme. The addition, of further functionality (e.g. map processing, tariff displays, etc.) does not provide enforcement benefits. If, however, the Client requires an increasingly complex tariff checking function to be undertaken by the ES, it is considered that this will result in an increase in enforcement effort and cost for little or no benefit.

2.12.9 The shaded area therefore shows the recommended ES strategy for the KMP scheme, which includes:

a) DSRC, GNSS and GPRS functionality within the OBU

b) An enforceable period based (e.g. daily) lump sum payment system for the occasional users

c) Balanced set of policies (i.e. fair, equitable, affordable) delivering a high degree of societal acceptance

d) Effective, simple and minimal cost enforcement system

3 Enforcement Concepts

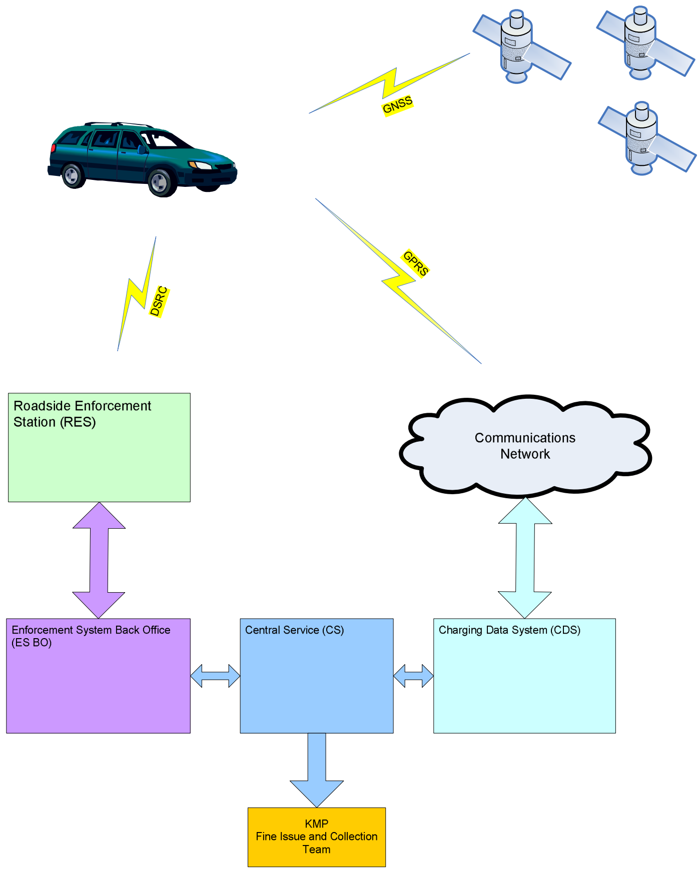
3.1 Introduction

3.1.1 Chapter 2 identified that enforcement is required to ensure that that quantity of any fraud or evasion is kept below an acceptable level. How the 'acceptable level' is defined is dependent primarily on the amount of compliance that can be achieved using the 'carrot' and 'stick' approaches described in Chapter 2. This chapter now focuses on the 'stick' approach, i.e. that of the ES

3.1.2 In particular it provides commentary on different options that can be deployed for components within the ES and highlights the dependency and interrelationship of the ES with the other components of the KMP system.

3.1.3 Figure 3 provides a simple overview of the anticipated principle components of the KMP, including the communication between components. The two key components of the ES include the Roadside Enforcement Station (RES) and the Enforcement System Back Office (ES BO).

Figure 3 –Overview of Road User Charging System



3.1.4 A summary description of the process is provided below.

3.1.5 If the vehicle shown in Figure 3 contains an on-board unit (OBU). It will use GNSS to determine its location with a significant degree of accuracy and then pass trip information back to the Charging Data System (CDS). Note that for non-OBU users, trip information will need to be entered via a different system such as roadside payment booths, the internet or SMS text messaging.

3.1.6 For each OBU equipped vehicle, the CDS will accrue all the trip information and calculate the amount due (applying different tariffs or tolls where required) and then periodically send the information to the Central System (CS).

3.1.7 The CS is the main repository of personal information that links the VRM and any OBU registration details to the vehicle owner details (name, address). It will accept trip charges from the CDS and evidence packs from ES to generate information for the organisation responsible for maintaining accounts (including issuing invoice statements and fines).

3.1.8 The purpose of the ES is to ensure that violators of the KMP system are identified and charged and that those complying with the system are not fined in error. In order to achieve this purpose, the ES will obtain from the CS a list (database) of valid VRMs, associated OBU registration and any other vehicle information that needs to be checked (for example vehicle classification). The RES will capture information from each passing vehicle in order that it can be compared with the database information.

3.1.9 Any passing vehicle that cannot be matched to the database of valid VRMs within the notification period will normally cause the ES to send evidential information for the violation to be sent to the CS for processing. Exceptions to the rule would need to be considered and defined. Exceptions are recommended where the RES cannot detect a VRM or OBU, as it would make enforcement extremely difficult. It is highly probable that the majority of vehicles without VRMs would be exempt, for example: pedal cycles, horse drawn vehicles, farm vehicles (tractors) armed forces vehicles (tanks).

3.1.10 The complexity of the RES options is dependent on:

a) What the RES needs to check (in terms of information to be obtained and gathered from passing vehicles)

b) Where the information gathered from passing vehicles will be checked against any pre-recorded information about the vehicle

c) What information needs to be transferred between the ES BO and the RES

3.1.11 The complexity of the ES BO and communications to the ES BO from the RES depends on:

a) What the ES BO needs to check (in terms of information received from the RES)

b) Who the ES BO needs to inform

3.2 Roadside Enforcement Station Options – Detection Technology

Option 1: Automatic Number Plate Recognition – ANPR

3.2.2 This detection option is mandatory for enforcement, as it is the only common, current unique way of identifying vehicles with no OBUs fitted. It is therefore required for all RES.

3.2.3 By default it is assumed that the front VRM will be read as this offers increased reliability in successfully obtaining an ANPR read, mainly because it is less likely to be obscured by dirt. It will also enable the VRM of the train vehicle if anything is being towed but this method will fail to capture motorcycle VRMs (since they do not have front facing VRMs).

3.2.4 It is assumed that the ANPR reader will be gantry-mounted where multiple lanes are present (which is assumed to be most of the HWN) and pole-mounted by the side of single lane carriageways, as this will significantly reduce infrastructure costs.

Option 2: DSRC Reader Technology

3.2.5 This option is required in order to communicate with OBUs or any DSRC tag that the KMP system may require OUS users to display.

3.2.6 DSRC readers are commonly available and can be provided in a single unit with ANPR if required. The cost differential of providing ANPR only or ANPR and DSRC is negligible in proportion to each RES site, therefore it is surmised that the KMP scheme will always use ANPR and DSRC technology at each enforcement site. (Refer to Chapter: 5 Cost Drivers for further information).

3.2.7 Market knowledge is aware that consideration is being made in respect of embedding a DSRC into VRMs, to provide confirmation of VRM readings and help to combat the crime of using stolen or duplicated VRMs. If such a scheme is implemented in the Netherlands, this may reduce the quantity of inaccurate VRM readings but it should be noted that this DSRC tag will not be able to replace the OBU or the ANPR check cited in Option 1. The DSRC tag will not contain sufficient information to replace the OBU and the ES will always need to be able to read VRMs in order to identify vehicles without VRM tags.

Option 3: Vehicle Classifier

3.2.8 This option is required if the ES needs to verify which class of vehicle is being detected. The main purpose of vehicle classification would be to verify that road users are not trying to minimize the tariff rate that they need to pay for their journeys (e.g. by an OUS user falsely declaring their vehicle type or by not setting up the OBU to match the vehicle type).

3.2.9 It should be noted that standard vehicle classification in a free flow situation is crude and is based only on the apparent vehicle size (for example, the system will be able to distinguish between motorcycles, cars/ small vans, medium sized vans and HGVs and towed vehicles only). Detection using inductive loops, image processing and laser profiling techniques can be used in isolation or in conjunction with each other to improve vehicle classification.

3.2.10 The resolution of the vehicle classification will dictate the complexity of the vehicle detection and significantly impact upon the cost of classification. A simple system of three to six classifications based on vehicle size would be relatively cheap compared to a system that would deduce the make and model of a vehicle.

3.2.11 For the purpose of compiling a cost estimate, Chapter 5 includes a price for loop based classification only, which will provide an indication of vehicle length and hence size.

3.2.12 It is recommended that the value of implementing automatic vehicle classification (and the complexity of the classification) is carefully considered, especially in the early stages of deployment, since it is envisaged that road users will initially try to evade payment for journeys rather than simply reducing the tariff. Selective deployment may be preferable (i.e. only equip certain sites with classification technology, not all sites).

3.2.13 However, vehicle classification may be of assistance as part of a phased implementation scheme. For example, if it is decided to implement the KMP initially for HGVs, the vehicle classifier will enable the RES to immediately discard all captured vehicle data for non-HGV traffic.

Option 4: Second ANPR reader (to obtain rear facing VRM reads)

3.2.14 This option is required if it is necessary to capture the VRMs of motorcycles.

3.2.15 It has the secondary, useful benefit of improving the confidence levels of obtaining an accurate VRM reading. This will improve the possibility of matching VRMs to the list of valid users at the RES, thereby reducing the need for secondary checks to be made at the RES and the possibility that vehicles will escape from paying the KMP due to unreadable VRMs.

3.2.16 The provision of a second ANPR at RES is marginal compared to the overall cost of the RES, however, it will be more complex to configure the site. It may therefore be preferable to limit the number of sites at which a second ANPR reader is deployed.

3.3 Roadside Enforcement Station Options – RES Processing

Option 1: VRM Check Only

3.3.2 This option requires Roadside Detector Option 1 only

3.3.3 This processing is considered to be essential for enforcement purposes as it is the only mandatory unique way of identifying vehicles with no OBUs fitted. It is therefore required for all RES.

3.3.4 Following the detection of a passing vehicle, the ES would rely on a number plate reader to confirm the VRM and compare it to a list (database) of vehicles who have registered to use the road network. The VRM list will comprise of:

a) Vehicles whose owners have an account with the KMP (for example, OBU-equipped vehicles)

b) Vehicles that have been pre-registered with the KMP as an OUS

c) Exempt vehicles (for example, emergency services, armed forces)

3.3.5 Any vehicle which is not on the list would have its information passed to the ES BO for processing as a potential violator of the KMP. Note: It makes no difference to this enforcement option if a vehicle is equipped with an OBU and there is no communication between the vehicle and either the RES or CS.

3.3.6 It is acknowledged that where duplicate VRMs are in circulation (e.g. stolen VRMs), the law abiding registered owner would be charged for the journey. If this is the only check made by the RES, reliance would be placed on the registered owner to appeal against any charges or fines that have been accrued by the users of vehicle(s) with the duplicate VRMs.

3.3.7 It should also be noted that the reading of the VRM and its validation against the list of eligible vehicles could be undertaken either within the RES or at the ES BO. The choice of location for this activity is dictated by:

a) Whether the VRM is read manually or automatically (manual reading would need to take place at the ES BO, automatic reading could take place at either location)

b) Any desire to minimize communication requirements between the RES and ES BO (this leads to a preference for roadside processing, on the assumption that the information gathered from passing vehicles is greater than update information for the valid vehicle database).

c) Any issues relating to the download and secure storage at the roadside of a database containing VRMs (this leads to a preference for ES BO processing)

3.3.8 It is assumed that automatic VRM reading will be achieved using ANPR. It is further assumed that the initial validation will take place at the roadside since the amount of communication from RES to ES BO (and hence cost) is likely to be significantly greater than the cost of downloading valid vehicle information to the RES and resolving any issues related to roadside storage.

3.3.9 Once confirmed as being a valid user, it is recommended that a vehicle counter is incremented for key performance indicator (KPI) statistics and the record of the passing vehicle is deleted to minimise storage requirements and any data protection issues.

3.3.10 If the vehicle cannot be validated, it is suggested that the information is sent to the ES BO for further processing.

Option 2: VOI Check

3.3.11 This option requires Detector Option 1 only.

3.3.12 This option will raise an alert to the appropriate authority (the Police or KMP Enforcement Officers) every time a VOI is detected by a RES. Local alert notification may be desirable (to allow the Police or KMP Officer to pursue and stop a vehicle). Alternatively, it may be used to gather information about the use of a vehicle with an unusual journey log.

3.3.13 VRMs will be placed on the VOI list as part of an ES BO process. They will only be added to the VOI list if the Police or KMP Enforcement Officers have a particular reason for tracking a vehicle, perhaps because it is a stolen vehicle (Police interest) or if the registered trip information collated by the CDS or other source is showing significant anomalies that could amount to KMP evasion (KMP enforcement interest).This type of use for the ES is possible for both OBU and OUS road users.

3.3.14 It is acknowledged that the ability to undertake VOI checks may be unacceptable in terms of privacy requirements, although a recent survey undertaken by the Royal Automobile Club (RAC) in the United Kingdom (UK) has indicated improved societal acceptance if any road user charging scheme helps to track stolen vehicles. The use of VOI checks by KMP Enforcement Officers may be less acceptable, especially as it will need specific journey records to be captured by the ES to compare it with registered trip information held in another part of the KMP, for example, OUS registered trip information will probably emanate from the CS and the OBU registered trip information will emanate from the CDS.

Option 3: OBU Check

3.3.15 This RES processing option requires Detector Option 1 and 2.

3.3.16 Its purpose is to check that:

a) The OBU matches the VRM

b) The OBU is recognized (i.e. that it is not shielded, switched off or disconnected in order to attempt to evade payment)

c) The OBU security flag status is correctly set (i.e. it is not indicating that it has been tampered with),

d) Any other parameters within the OBU that the KMP requires to be checked (e.g. clock accuracy, location accuracy, vehicle classification, tariff) match information that is held by the CS regarding the OBU and/ or CDS.

3.3.17 The RES will attempt to match the captured VRM with the OBU registered users and a decision will need to be made when a match is not achieved. Non-matches could arise for a variety of reasons, including:

a) Errors in the accuracy of the ANPR reader (likely, especially if the VRM is obscured by poor weather or dirt)

b) Errors in the accuracy of the DSRC reader (less likely, except if the OBU has been shielded, in which case the it will be processed in the same way as an OUS)

c) Duplicate VRMs in circulation (registered owner has an OBU, other users of the VRM do not).

3.3.18 If desired, items (a) and (b) above can be improved by specifying higher performance standards for the ES. (It is acknowledged that the occurrence of duplicate VRMs in circulation cannot be controlled using the ES).

3.3.19 It should be noted that the received OBU information may reduce the dependency on the interpretation of the VRM reading undertaken as part of RES Processing Option 1. For example, if three or more digits/ figures in the VRM are matched to the VRM related to the OBU, there may be sufficient confidence to assume that the vehicle is a registered and valid user.

3.3.20 Further checks are then recommended to determine whether or not the OBU shows any signs of a potential security breach or failure. These checks are described as part of the ES BO Option 3 process (refer to section 3.4.12).

3.3.21 To cater for the possibility of duplicate VRMs, it is strongly recommended that the CS implements a procedure such that it is not possible to register an OBU against a VRM unless conclusive proof can be obtained to link the registered owner to both the OBU and VRM. If a VRM is fraudulently duplicated, the user of the duplicate VRM will not be able to obtain an OBU and this check will be able to raise an alert to the appropriate authorities.

Option 4: Collate Random Sample Vehicle Information for ES BO Checking

3.3.22 This RES option requires Detector Option 1 only.

3.3.23 The purpose of this option is to verify vehicle sightings by RES against journey logs that will be held in the CDS (OBU users) or entered onto the CS by OUS users).

3.3.24 It assumes that journey logs held by the CDS or CS contains information that will enable the tracking of vehicles to the RES points on the road network.

3.3.25 It is suspected that the availability of this information within the CDS will depend very much upon the thick or thin architecture of the OBU. For a thin client architecture, in a situation where the OBU does not contain a record of the tariff, it is more likely that journey logs will be available. However, if a thicker client micro declaration only includes a log of distance traveled at each applicable tariff, journey log information is unlikely to be available.

3.4 ES BO Processing Options

Option 1: Process only when VRM is not on the list held at the RES (essential)

3.4.2 This option requires RES Option 1 only and is considered to be a mandatory function of the ES.

3.4.3 Its purpose is to identify all vehicles that have not registered to use the road network. Once the notification period has expired (for post pay users) and the VRM has been positively identified, evidence packs (a VRM and evidential context image of the violation) will be issued to the KMP department that is responsible for issuing fines for non payment on expiry of notification.

3.4.4 It is recommended that the record identifies whether or not the VRM should have an associated OBU, as this type of check will identify vehicles that have their OBU shielded (in an attempt to evade payment) and illegal users of duplicate VRMs.

Option 2: Process VOI information received from the RES

3.4.5 This option requires RES Option 1.

3.4.6 The process will be to determine to whom any evidence pack should be sent.

3.4.7 Its implementation is strongly recommended since it can be used to target persistent or suspected evaders of the KMP and it can also be optionally used by the Police Authority to track vehicles that have been associated with criminal activity.

3.4.8 An overhead for maintaining the VOI database will be incurred and its size will very much depend on how requests for adding or deleting VOIs from the VOI list will be managed. However, this overhead is considered to be very small in comparison to processing random checks (option 4) and it is considered likely to generate significant returns in terms of issuing fines or prosecuting fraudulent users.

Option 3: Process Potential OBU Security Breach

3.4.9 This option requires RES option 3.

3.4.10 Its purpose is to determine whether an OBU is faulty and also whether the fault on the OBU may have been due to tampering (for fraudulent purposes).

3.4.11 The most likely initial outcome of this ES BO process will be to inform users that their OBU is suspected as being faulty and that they should take it to an approved garage for investigation. Positively identified OBU fraud (either by the ES or through subsequent investigation by the approved garage) will be notified to the KMP Enforcement Team so that they can determine what subsequent action should be taken.

3.4.12 This ES BO process assumes that the OBU will be able to communicate the following information to the RES:

a) An anti-tamper status flag

b) Any time and date facility within the OBU (which may be used for peak/ off peak tariffs)

c) The location where the OBU thinks it is situated (which may be used to determine different zone, segment or toll tariffs)

d) The vehicle classification (which may be used to determine the schedule of tariffs applicable to that vehicle)

3.4.13 Checks will be performed to validate this data. It is considered likely that most OBU security breaches will be attributable to users switching off or disconnecting parts of the OBU.

3.4.14 More potential evaders are expected to fail make the OBU recognizable to the ES whilst leaving the status of the anti tamper flag unchanged. It should be noted however that this is a dependency on the OBU and will require OBU manufacturer consultation to confirm this OBU security capability. It is further assumed that the potential evaders who do manage to tamper with the OBU without raising the security status flag will probably not be able to alter the other parameters in an inconspicuous manner.

3.4.15 The decision on reliance on OBU self-checking compared to undertaking more checks within the RES or ES BO is highly dependent on the security that the OBU can provide and the information that can be transmitted between the OBU and the RES. The 'window' for transmitting information between the RES and OBU over the DSRC link is currently only 40mS, therefore, there may be a restriction on the amount of information that can be sent, dependent on the bandwidth allowance for this communication.

3.4.16 It is also acknowledged that it is not currently usual for the OBU to transmit its location to the RES; it is more common for the OBU to perform a self check against location information sent over the DSRC and then raise an alert if there is a significant discrepancy. However, this puts an extra reliance on the security of the OBU.

Option 4: Process Random Sample Checks

3.4.17 This option requires RES Option 4.

3.4.18 The sampled vehicles will be subjected to an identical set of checks as for ES BO Option 3.

3.4.19 The principal value of this option is to provide confirmation that the CDS is operating as anticipated, by providing supplementary checks on vehicles, irrespective of whether or not they pass the same tests at the RES. For the ES, this option does not add any value and it will dramatically increase the amount of data that needs to be processed at the ES BO and therefore the cost.

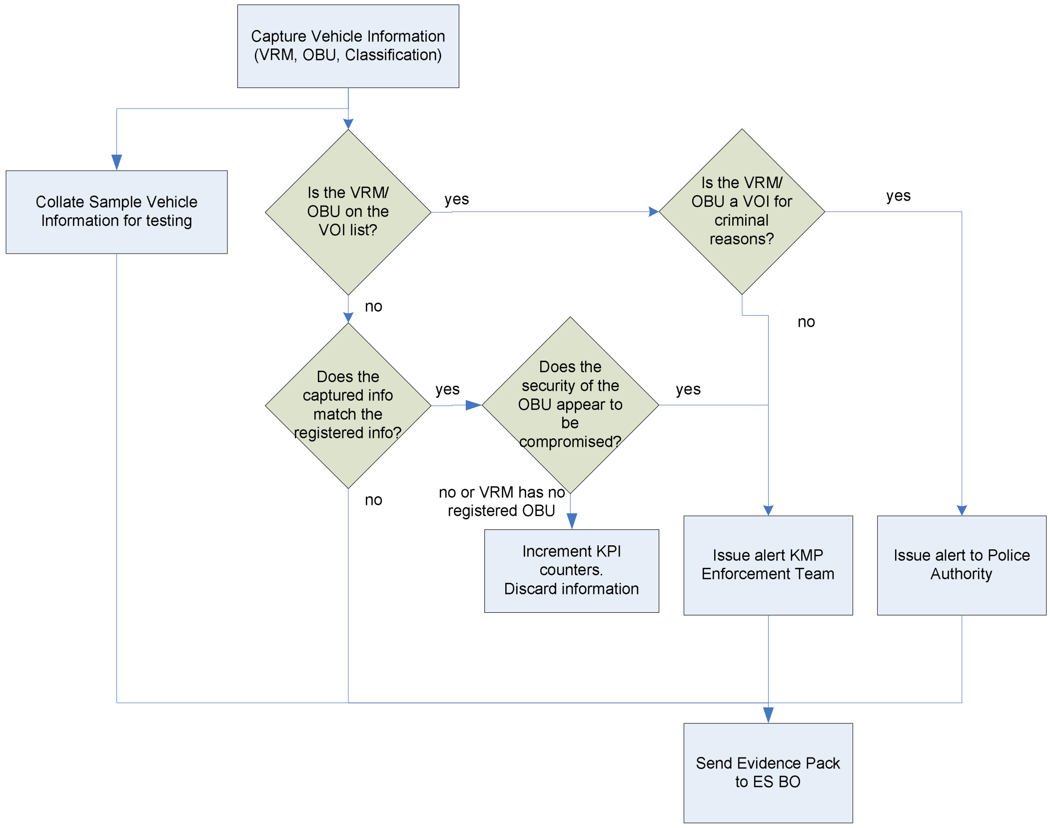
3.4.20 It is strongly recommended that the value to the CDS of obtaining random sample information is carefully considered before adding this overhead onto the ES.

3.5 Process Flow Charts – for processing RES Gathered Information

RES Processing

3.5.2 Figure 4 demonstrates the process that occurs in each RES prior to sending any vehicle information to the ES BO

Figure 4 –RES Process



3.5.3 This is a generic process covering all options. To interpret this diagram for only selected options, ignore any process boxes that do not apply (and assume the 'no' route is followed from decision boxes that do not apply).

3.5.4 All information sent from the RES to the ES would include:

a) The VRM

b) The time and date to identify when the VRM was read

It would also optionally contain:

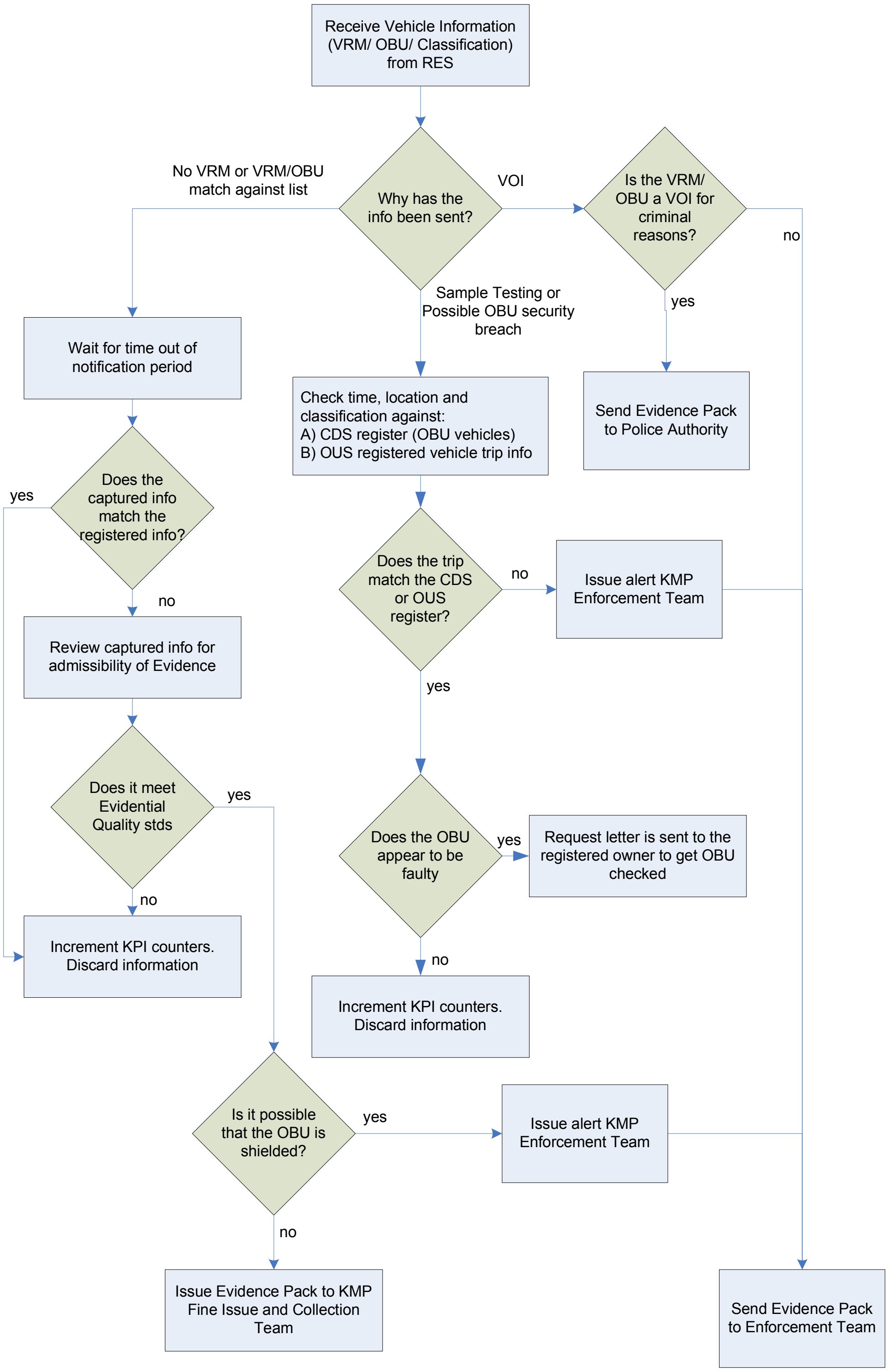
a) The RES ID (this is required but it could be identified by the ES rather than being transmitted)

b) The context image (depending on whether evidence is required for a potential violation or a criminal investigation)

ES BO Processing

3.5.5 Figure 5 demonstrates the process that occurs in the ES BO when information is received from the RES.

Figure 5 –ES BO Process (for Roadside Detection)



3.5.6 This is a generic process covering all options. To interpret this diagram for only selected options, please ignore any process boxes that do not apply and assume the 'no' route is followed from decision boxes that do not apply.

3.6 Recommended RES Detector, RES and ES BO Processing Package Options

3.6.1 Table 3 provides a list of valid (and efficient) combinations of options for the deployed detector technology, RES processing and ES BO processing. It ignores combinations where the benefit is no greater than can be obtained by a simpler combination of options

3.6.2 The options presented assume that the ES will always want to issue evidence packs to generate fines if payment has not been made for road usage.

3.7 Other ES BO Enforcement Processing Techniques (Data Mining)

Ensuring Annual OBU Checks

3.7.2 It is assumed that there will be an annual requirement to confirm that the OBU is functioning within an acceptable tolerance, it has not been tampered with and that it remains valid on the road network. It is expected that this will be incorporated into the annual APK test but that special arrangements will need to be made for vehicles which are not subject to this test (for example, vehicles less than three years old).

3.7.3 It is assumed that this information can be provided automatically by testing stations. The impact on the ES BO from this standard functionality will be the volume of data that needs to be recorded, which will be directly related to the number of OBUs installed. Therefore there are no strategic consequences that affect the ES BO and will not be considered further within this document.

3.7.4 If legislation is such that all OBUs must be tested annually, i.e. it is an offence to have an untested OBU fitted, there must be a check for vehicles not tested. It is suggested that it is a function of the CS to notify vehicle owners of their responsibility and to ensure records are updated. Any OBU that has not been subjected to the test would then be flagged for further investigation by the KMP Enforcement Team, which may result in the valid vehicle database being updated.

Table 3: Valid Combinations of Detector, RES Processing and ES BO Processing Options

Detection Technology Option	RES Processing Options	ES BO Processing Option	Fines	VOI Targeting	OBU Checking	Random Checking	Comment	Carried forward for Comparison
1 and 2 (ANPR and DSRC)	1 and 3 (VRM and OBU)	1 and 3 (VRM and OBU)	✓	✗	✓	✗	Simplest System to detect non payment and conduct simple fraud checks OBU / DSRC OUS	
1 and 2	1, 2 and 3 (VRM, OBU and VOI)	1, 2 and 3 (VRM, OBU and VOI)	✓	✓	✓	✗		✓ - Package Option 1
1 and 2	1, 2, 3 and 4 (VRM, OBU, VOI and sample)	1, 2, 3 and 4 (VRM, OBU, VOI and sample)	✓	✓	✓	✓		✓ - Package Option 2
1, 2 and 3 (ANPR, DSRC and classification)	1 and 3	1 and 3	✓	✗	✓	✗	Allows a more complex OBU check to ensure payment is being made for the correct vehicle classification	
1, 2 and 3	1, 2 and 3	1, 2 and 3	✓	✓	✓	✗		✓ - Package Option 3
1, 2 and 3	1, 2, 3 and 4	1, 2, 3 and 4	✓	✓	✓	✓		
1, 2 and 4	1 and 3	1 and 3	✓	✗	✓	✗	Double check of most VRMs Ensures motorcycles and train vehicles (in a towing situation) have their VRMs read	
1, 2 and 4	1, 2 and 3	1, 2 and 3	✓	✓	✓	✗		✓ - Package Option 4
1, 2 and 4	1, 2, 3 and 4	1, 2, 3 and 4	✓	✓	✓	✓		
1, 2, 3 and 4	1 and 3	1 and 3	✓	✗	✓	✗	Check of vehicle classifications and double check of most VRMs. Ensures motorcycles and train vehicles (in a towing situation) have their VRMs read	
1, 2, 3 and 4	1, 2 and 3	1, 2 and 3	✓	✓	✓	✗		
1, 2 , 3and 4	1, 2, 3 and 4	1, 2, 3 and 4	✓	✓	✓	✓		

Left Intentionally Blank

Validation of Odometer Reading

3.7.5 Another annual check that could be used to detect possible KMP violations is to take a record of the odometer reading for the vehicle and compare the distance traveled to the distance paid for as part of the KMP scheme.

3.7.6 To prevent anomalies from occurring, it is suggested that a zero rate tariff may be possible for application in some circumstances i.e. for OBU-equipped vehicles that are out of the country but can still communicate with the CDS (via GPRS). When there is a significant discrepancy, between odometer readings and distance paid for, it is suggested that the KMP Enforcement Team are alerted to the possible evasion.

3.7.7 It should be noted that some OBU users will regularly accrue differences in odometer readings and distance paid for if their journey patterns are such that they frequently cross the borders, for example, people who work in the Netherlands but live in Belgium or Germany (or vice versa), therefore sensitive processing and discretion is advised rather than automatically suspecting OBU users of potential security breaches.

Detecting Unusual Journey Logs gathered by the CDS

3.7.8 It is probable that the most likely form of deliberate persistent evasion will be caused by the drivers of vehicles shielding their OBUs from the CDS system, only to uncover them at RES sites to prevent being processed as an invalid vehicle. This type of evasion will only be spotted if:

a) The driver failing to spot a RES and uncovering the OBU within a sufficient time (detection is more likely with mobile of transportable RES). However, it should be noted that only owners of vehicles who are persistently detected can be fined, not owners who may have a genuine fault with their OBU that they are not aware of)

b) The CDS noting significant gaps in data transmission from the OBU

c) Significant differences in the odometer reading compared to the distance paid for in the KMP (and no valid reason such as ‘out of country’ driving)

d) Data mining of CDS journey logs to identify a series of disjointed journeys logged with the CDS (for OBU users)

3.7.9 It is suggested that the KMP Enforcement Team would need to work closely with any CDS Team that would be noting significant gaps in OBU data transmission or data mining activities.

3.8 Other ES BO Activities

Maintaining Accurate Database Information in the RES (for registered users)

3.8.2 The ES BO will need to regularly download the list of valid users (or its updates) to each RES, otherwise the number of potential violations reported by the RES will rise and the ES BO will incur a significant increase in the number of validations that it needs to perform.

3.8.3 The infrastructure and operational costs associated with the valid users will be dependent on:

a) The number of RES

b) The number of changes to the valid users list and the frequency of the updates

c) The level of automation that can be applied to automatically update the list of registered vehicles.

Maintaining the Register of VOIs

3.8.4 It is anticipated that registration of vehicles onto the VOI will be a process that is manually implemented, with automated assistance.

3.8.5 Database infrastructure initial costs and operational costs will be largely dependent on the policy for using the VOI. For example:

- Will the Police be able to use the VOI to detect vehicles that are wanted in connection with crimes?
- What is the likely (and maximum) monitoring period for vehicles suspected of KMP evasion?
- Is there an expiry period? (i.e. stolen vehicles that are not detected within a year of being registered as a VOI)

Measuring Key Performance Indicators

3.8.6 It is assumed that the ES will take measurements of its own efficiency and the related efficiency of the KMP. For example, it is anticipated that statistics will be required to identify various quantities for specified time periods.

3.8.7 For RES KPI monitoring, the measured quantities may include:

a) Vehicles passing a RES

b) OBU-equipped vehicles passing a RES (matched to registered list)

c) Pre-registered OUS vehicles passing a VRM (matched to registered list)

d) Vehicles who have faulty or tampered with OBUs

e) Vehicles that cannot be matched to the registered list

f) VOIs (interest for criminal reasons)

g) VOIs (interest for KMP enforcement reasons)

h) Random sample size recorded

i) Availability of the RES

3.8.8 For ES BO KPI monitoring, the measured quantities may include:

j) Evidence packs received from each RES

k) Post Pay OUS users (i.e. payment made within notification period)

l) Evidence packs that meet evidential quality standards

m) False/ unobtainable ANPR reads

n) False/ unobtainable DSRC reads

o) False/ unobtainable vehicle classification

p) False RES notification of potential OBU security breach

q) Quantity of random sample checks of time, location and vehicle classification

3.8.9 The level of effort associated with the KPI will be affected by the amount data being returned from each RES, which is dependent on KPI requirements.

3.8.10 The requirement for additional effort for KPIs for the ES may require additional processing and personnel effort but this cannot be quantified until the preferred set KPI requirements have been identified.

3.9 Communications Options

3.9.1 Figure 6 shows the anticipated data flows between the ES BO, the RES, the CS and the CDS.

3.9.2 The technical communications solution to adequately service these data flows will depend primarily on:

a) The volume of information to be transmitted (which is dependent on the previously described options)

b) The direction of the information flow

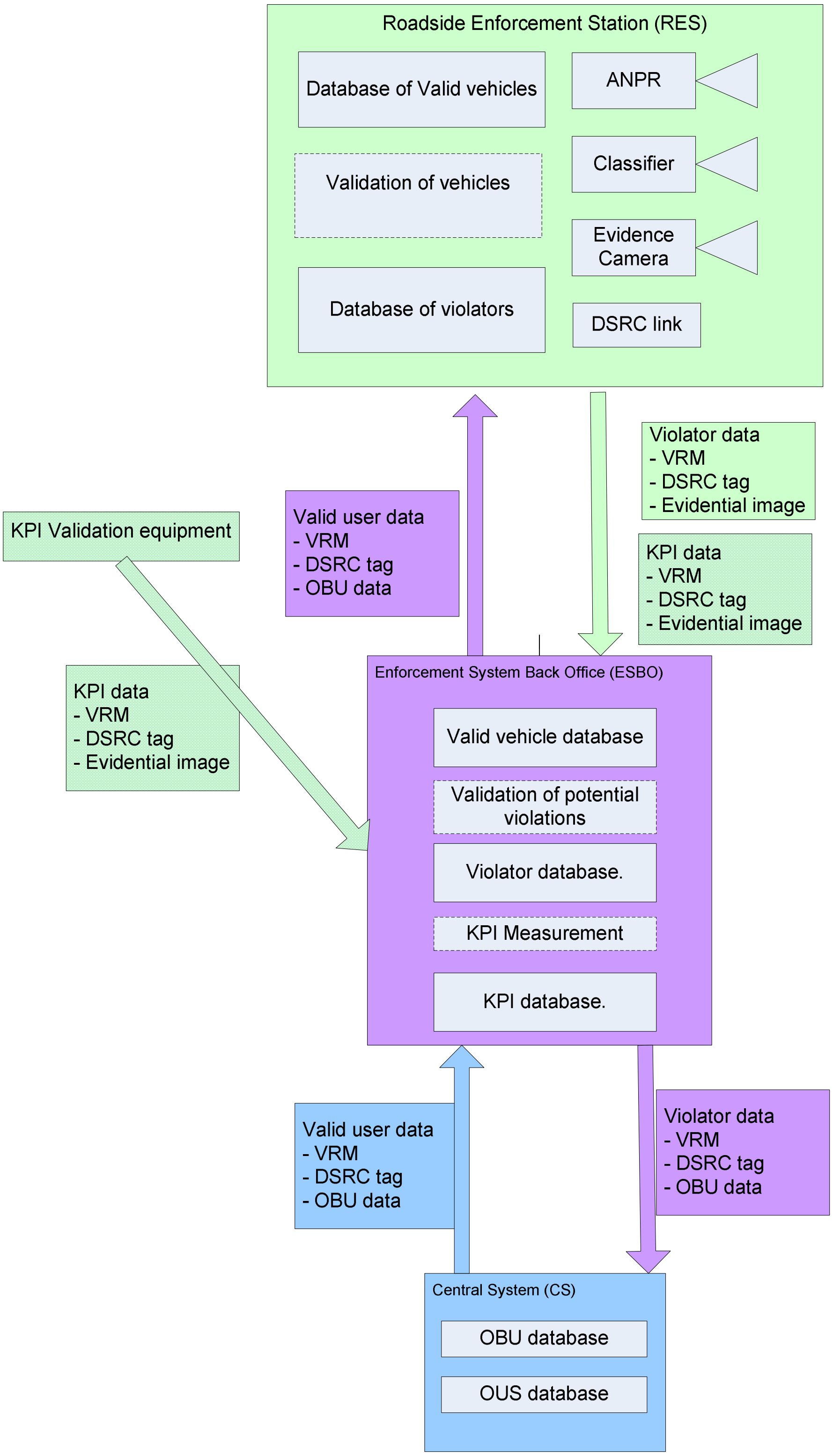
c) The required timeliness of that information

d) The proximity of components relative to each other (i.e. the ES BO and CS may physically reside in the same building and therefore a dedicated network can be provided but the communication between the ES BO and each RES is likely to be better serviced by using a virtual private network (VPN).

3.9.3 For example, communication from the RES to the ES BO is likely to be significant in terms of volume, primarily due to the assumed requirement to send evidence (in the form of a context image). It is also likely that the direction of data flow from the RES to the ES BO will be significantly greater that data which flows from the ES BO to the RES.

3.9.4 Package Options 1, 3 and 4 are broadly similar in terms of communication requirements. The communications requirements for Option 2 will be influenced by the sample size; this option will incur significantly higher costs if the number of sampled vehicles is high.

Figure 6 –ES BO Information Flows



3.10 RES Types

3.10.1 Three types of RES have been proposed by the reference architecture: Fixed, Transportable and Mobile. Each of these are described below, as design factors may significantly increase the price.

Fixed RES

3.10.2 As the name implies, these REA are permanent installations by the roadside, comprising of:

e) a mast or gantry (portal or cantilever)

f) enforcement equipment (as described previously in this Chapter)

g) associated infrastructure (foundations, safety fence, equipment cabinet, etc.)

h) a fixed power supply

i) a permanent communications service (to transmit potential violations to the ES BO in real time and to receive updated lists of valid users and VOIs).

Transportable RES

3.10.3 Transportable RES are considered to be RES units that only operate whilst stationary but are provided as part of a vehicle or trailer that can be easily be moved between sites.

3.10.4 Two options are provided for the Transportable RES:

a) Whether they are attended (manned) or unattended when in operation

b) Whether or not the Transportable RES have prepared sites of operation (i.e. a power supply and communications service to which it can connect, hard standing areas, etc.) or if it needs to operate in a stand alone mode (power supply from a generator, communications only when the Transportable RES is garaged)

3.10.5 Unattended enforcement equipment and any associated mobile power supply is often a target for malicious damage and/ or theft. To limit the possibility of this occurring, it is recommended that a pre-prepared RES site is provided which includes a mechanism for securing the RES to the site and, ideally, has a permanent power supply and communications system that sends alerts to the ES BO if any anti-tamper alarm (fitted on the Transportable RES) is activated. This may include the provision of a dedicated hard standing area and will undoubtedly increase the infrastructure costs for every Transportable RES site. Also, drivers will be able to detect where Transportable RES sites are and take a detour to avoid them if they wish to evade the system (the element of ‘surprise’ is removed when fixed sites for this type of RES are used).

3.10.6 Advantages, include the Transportable RES’ ability to monitor a site on a permanent (24/7 basis) and, assuming it is supplied with a fixed power supply and communications, it could operate in the same manner as a Fixed RES if desired.

3.10.7 In contrast, an attended Transportable RES significantly reduces the likelihood of malicious damage or theft. There is no need to provide any permanent infrastructure, power or communications at the Transportable RES site and hence the site is much more flexible. However, the cost of the personnel to accompany the RES has a very significant impact upon the operational costs per unit.

3.10.8 For estimating purposes, the attended Transportable RES options has been chosen, with no dedicated RES site infrastructure.

Mobile RES

3.10.9 The Mobile RES is a vehicle that is equipped with enforcement equipment which allows it to operate whilst in motion or stationary.

3.10.10 The Mobile RES is considered to be supplementary to the Fixed and Transportable RES quantities that will determine the amount of enforcement coverage; they will be used to target persistent evaders and remote areas where the use of a Fixed or Transportable RES is not viable due to the low amount of traffic volume.

3.10.11 For the Mobile RES, it is proposed that an enforcement vehicle is fitted with a DSRC reader and processor. The processor would be used to read the OBU information and compare it to the list of valid vehicles and those on a VOI list. The processor would respond to each detected vehicle by returning the associated VRM and vehicle classification for the Enforcement Officer to conduct a manual match. Note: whilst it is possible to utilize ANPR readers to automate the process, there is likely to be a significant number of mismatches due to movement of both the ANPR reader in the enforcement vehicle and the vehicle that is being checked.

4 Dimensioning

4.1 Introduction

4.1.1 The enforcement strategy must balance user compliance, capital and operating costs, as stated in Chapter 2. To achieve this the RES must be deployed so that:

a) Any vehicle not complying with the system is caught within an acceptable period of first offending

b) The user has a high perception of the chance of being caught

c) The number of enforcement stations is optimised to ensure reasonable capital costs whilst reducing the possibility of a violator evading capture

d) The number of potential violations being returned to the ESBO is cost effective, with respect to the amount of infrastructure and personnel required to satisfy the enforcement policy.

4.1.2 To catch a system violator the vehicle must be identified either by the annual APK test or by an RES. The annual APK testing will not be discussed in this chapter as it does not influence testing (refer to Chapter 3).

4.1.3 The options that are available for roadside enforcement stations were discussed in Chapter 3. The number of RESs required are independent of which RES solution is used.

4.1.4 The aim is this chapter is to identify potential enforcement strategies and the number of RESs required to support those strategies, so that the cost impact be identified within Chapter 5.

4.1.5 All the options discussed in Chapter 3 can be installed as fixed, transportable or mobile. This chapter will also discuss which type of installations should be made to satisfy the strategies discussed.

4.2 Dimensioning strategy overview

4.2.1 Two different strategies will be discussed: one to check 100% of vehicles and the other to examine the optimum dimension with less than 100% of vehicles checked.

4.2.2 To target 100% of vehicles then RESs should be deployed at either all junctions on both HWN and OWN or all fuel stations and KMP system boundaries. The number of junctions on the network, particularly on the OWN, would make 100% deployment prohibitive. Therefore deployment at fuel stations and KMP system boundaries will be examined.

4.2.3 The original concept was to deploy RESs dispersed throughout the road network, giving less than 100% coverage this is discussed in detail below.

4.3 Assumptions

4.3.1 Every vehicle whatever its type, average journey length or annual usage must purchase fuel from a fuel station in the Netherlands or must cross the KMP system boundaries to a station outside the boundaries.

4.3.2 The boundaries of the KMP system are the same as the national borders of the Netherlands.

4.3.3 If an enforcement strategy provides an easy way for a system violator to evade being caught then more users will choose not to comply with the system.

4.3.4 There will always be determined individuals who will take extreme measures to avoid complying with the KMP system. Therefore whichever strategy is chosen an additional enforcement method is required that will target violators in an unpredictable manner. To this end all strategies, and variants within those strategies, include 25 mobile enforcement stations.

4.3.5 Data about the road network and the number of kilometres driven by each type of vehicle has been provided, along with an assumption that half the distance traveled over a year is on the OWN and half on the HWN.

4.3.6 Commercial vehicles (rigid, articulated and special vehicles) travel much greater distances each day than passenger vehicles.

4.3.7 Given the number of vehicles, the number of days driven and the predicted fraud levels there will be 834,084 system violators on the network each day.

4.4 Overview of strategy for targeting 100% of vehicles

4.4.1 There are benefits to choosing a strategy that aims to target all vehicles on the network:

a) Most violators will be identified, note: with any strategy there will be individuals who will take extreme measures to avoid compliance.

b) There will be a widespread perception that it is difficult to avoid detection if an individual chooses to violate the system and therefore more people will comply with the KMP system.

4.4.2 There are two possible strategies to target 100% of vehicles:

a) To deploy enforcement stations at every junction on the network.

b) Target all fuel stations and borders.

4.4.3 The first option would require very high numbers of RESs to cover the whole network. The OWN, particularly, would require a prohibitively large number of RESs, which would significantly increase the implementation and operational costs. Therefore the second option of targeting all fuels stations and borders will be discussed in more detail.

4.5 100% strategy

4.5.1 All vehicles need fuel, whether they make many short journeys on the OWN, average length journeys on both HWN and OWN or few long journeys on the HWN. They will therefore need to refuel regularly; the frequency of refueling will be dependent on the journey pattern, fuel efficiency of the vehicle and the size of the fuel tank. Therefore if all the fuel stations are targeted then all of the users of the road network will be checked.

4.5.2 It is assumed that many fuel stations will also provide KMP payment stations. If enforcement stations are placed at these fuel stations then it will provide a simple incentive for drivers, especially occasional users, to easily comply with the system.

4.5.3 Foreign users may travel through the Netherlands with a full tank of fuel and therefore not visit a fuel station. Also those users living close to the KMP system boundaries may chose to use fuel stations outside the boundaries to avoid being checked by an enforcement station. To target both these types of user all the boundaries of the system should be targeted. The system boundaries are assumed to be the borders of the Netherlands.

4.5.4 It is assumed that the entrance to each fuel station on the HWN has multiple lanes and that on the OWN it is a single lane. The ferry terminals and half the borders will require a gantry monitoring multiple lanes.

4.5.5 The number of RES required will be:

Location	Number of Roadside Enforcement Stations	Number of gantries	Number of masts
HWN Fuel station	250	250	0
OWN Fuel station	4,069	0	4,069
Borders	350	175	175
Ferry terminal	4	4	0
Total	4,673	429	4,244

4.5.6 There will be very few multiple checks on a vehicle each day as only vehicles making journeys significantly longer than average will require to refuel twice in one day. This will have the following benefits:

a) Efficient communication levels. Data about potential violators will be sent to the ESBO only once.

b) Reduced enforcement effort. The enforcement personnel at the ESBO will receive only one enforcement data pack for each violating vehicle.

c) Reduced data processing and storage at the ESBO.

4.5.7 Vehicles will be checked less frequently than using the strategy described below, however it is will be more difficult to avoid being checked. This will also provide the benefits described above and there will be fewer vehicles identified as violators due to ANPR inaccuracies.

4.6 Strategy if targeting less than 100% of vehicles

Fuel Stations, Borders and Ferry Terminals

4.6.1 The strategy of targeting fuel stations and borders can be used to target less than 100% of vehicles, and figures are provided for targeting 50% or 5% of fuel stations and borders.

4.6.2 If less than all the fuel stations and borders are targeted then fixed RESs alone cannot be used, as vehicles would avoid being checked by using a fuel station that did not have a RES. Therefore a combination of fixed stations and transportable RESs would be used.

Distance Based Coverage

4.6.3 The premise for this enforcement strategy is that: any vehicle traveling on the road network on any particular day stands a reasonable chance of being checked to ensure that it is complying with the KMP system. The definition of “reasonable” is the driving factor for identifying how many enforcement sites are required.

4.6.4 This strategy will discuss deploying RESs throughout the road network

4.6.5 The number of RESs will need to be at a sufficient level so that it is difficult to avoid being checked.

4.6.6 The following assumptions have been made:

a) On average commercial vehicles travel a greater distance each day and therefore they will be checked more frequently than a passenger vehicle.

b) There are considerable more passenger vehicles travelling on the road network than commercial vehicles.

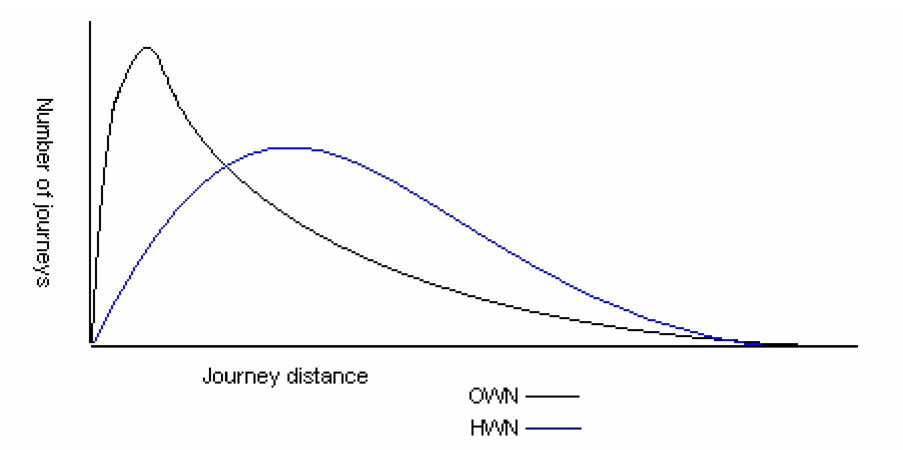
c) The number of checks a passenger vehicle can expect will be used when assessing the number of enforcement sites because of the two assumptions above

d) The optimum value for the number of checks per day will be based on different and competing requirements such as the cost of enforcement stations, the perception of the chance being caught, plus other requirements. A vehicle should expect to be checked by at least one enforcement station per day. Various scenarios are used below to achieve this value.

e) Each of the RESs discussed in Chapter 3 will monitor one lane of traffic. Therefore multiple RESs will be required at each enforcement site. On the OWN a site will monitor both directions of flow, on the HWN a site will monitor all the lanes, i.e. 6 lanes.

f) In addition to the three lanes on the HWN there is also a hard shoulder. It is assumed that any vehicle travelling on the hard shoulder will be doing so illegally and separate enforcement equipment may be deployed to target this. This is outside the scope of the KMP system enforcement. Therefore no RES will be required to monitor the hard shoulder.

g) It is assumed that journeys on the OWN are shorter than those on the HWN, but that more journeys are made on the OWN so that annually 50% is travelled on the OWN and 50% on the HWN. The journey profile is shown below:



4.6.7 The size and complexity of the OWN means that a different enforcement strategy must be used to that employed on the HWN.

4.7 HWN STRATEGY

4.7.1 RESs will be placed on gantries monitoring all lanes of the HWN. These can be placed at junctions or mid-link depending on choice and detailed design.

4.7.2 The HWN is shorter and has significantly fewer junctions when compared to the OWN, and therefore it may be possible to target every junction. The number of junctions is not known. Therefore for this dimensioning exercise the baseline value of 35km is assumed to equate to the average distance between junctions.

4.7.3 If every junction was targeted then 100% of vehicles, traveling on the HWN, would be checked. Violators would have enforcement data returned to the ESBO every time they passed a junction leading to duplicate violations being generated and communicated to the ESBO.

4.7.4 Various scenarios are investigated below to assess the number of checks a vehicle can expect and consequentially the number of RESs required.

4.7.5 The number of checks per day can be calculated in two different ways, both are valid, and give the same number of checks per year, but they give different daily results. To understand this difference: assume the average distance traveled each day is 55km, and that the average number of days driven per year is 300, 50% is traveled on the HWN, 50% on OWN. Examining two different ways of splitting a day's travel gives rise to the different results. Method a) states that a day's travel takes place either on the OWN OR the HWN. (i.e. 150 days on the HWN and 150 days on the OWN) So the number of checks per day for a HWN is 55km * the number of checks per km on HWN. The appropriate values are then used for the OWN. Method b) states that one day's travel is split equally between the OWN AND the HWN. So a vehicle would travel 300 days where each day consists of 27.5km on the HWN and 27.5km on the OWN. In this case the number of checks per day is the SUM of the number of checks on the HWN and the number of checks on the OWN. The number of checks per km on the OWN is significantly lower than that for the HWN which will give an obvious difference in the daily values depending on calculation method. The results from both methods are shown in the table below.

4.8 HWN SCENARIOS TESTED

4.8.1 Baseline: Distances between enforcement sites as suggested in the document Cost Format Phase 2 v 1.0 22Jun06. These are considered as the baseline and the following scenarios vary these values.

4.8.2 The distance between sites on HWN has been increased from the baseline so that the distance is equal to the average km travelled by a passenger vehicle per day. This will ensure that if a passenger vehicle completes all of a days travel on the HWN then it should be checked once.

4.8.3 The impact of varying the average distance between sites on the OWN should also be considered. A vehicle has a much lower chance of being checked on the OWN compared to the HWN, so the impact of reducing the distance between sites on the OWN was considered. The distance was chosen so that a passenger vehicle could reasonable expect to be checked twice for every 1000 km travelled on the OWN. This value was chosen to balance the significant increase in number of sites with the chance of being checked.

4.8.4 Using the values obtained for the OWN in scenario 4.8.3, the distance between sites on HWN so that a passenger vehicle could expect to be checked once per day if a day's travel was done on both the HWN and the OWN, i.e. using calculation method b) described in 4.7.1.

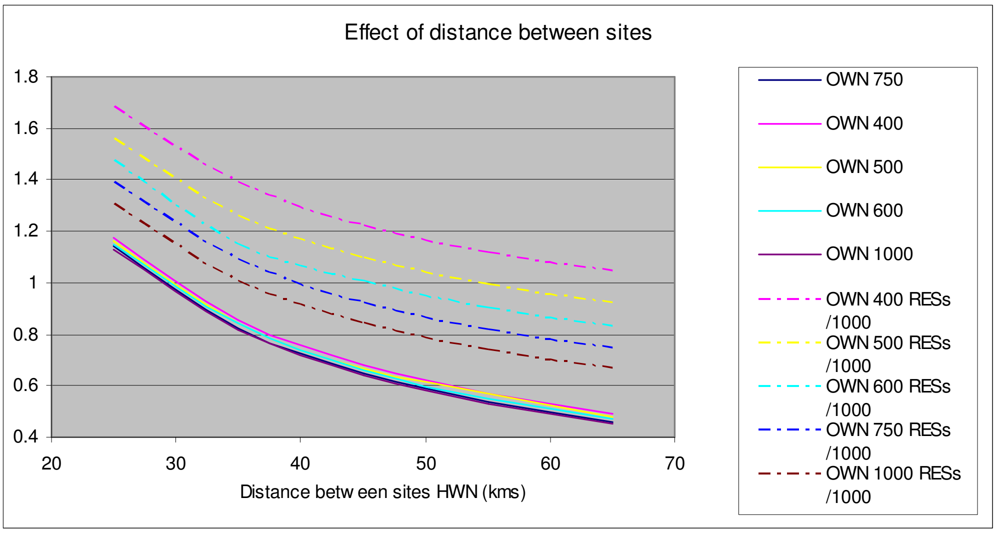
Table 4– Effects of varying the distance between stations

Scenario		Distance between sites (km)	Number of sites required	No. checks per day. [Method a) 4.7.1]	No. checks per day [Method b) 4.7.1]
4.8.1 Baseline	HWN	35	94	1.576	0.825
	OWN	750	170	0.393	
4.8.2	**HWN**	**55**	**60**	**1.003**	**0.538**
	OWN	750	170	0.393	
4.8.3	HWN	55	60	1.003	**0.557**
	OWN	**500**	**255**	**0.110**	
4.8.4	**HWN**	**29**	**113**	**1.902**	**1.006**
	OWN	500	255	0.110	

4.8.5 The impact on the number of checks per day, using method b) and the number of RESs required was further investigated for varying distances between sites on the HWN and the OWN. This is shown in the graph in Figure 7.

4.8.6 In the graph two sets of trends are shown. The first, solid lines, shows the number of checks per day using method b) for varying distances between sites. Each line represents a constant distance between sites on the OWN. The second, dotted lines, shows the number of RESs required (/1000) for varying distances between sites on the HWN. Each line represents a constant distance between sites on the OWN.

Figure 7 – Distance Between Sites vs. Checks per Day



4.8.7 Appendix A details the calculations used to provide the above results.

4.9 HWN Impact

4.9.1 The cluster of lines in the lower part of the graph shows that there is little variation in the number of checks a passenger vehicle can expect when the distance on the OWN is changed.

4.9.2 Changing the distance between sites on the HWN has a significant impact on the number of checks that a vehicle can expect.

4.9.3 Due to the length of the OWN network it is not realistic to expect the same density of enforcement sites as on the HWN.

4.9.4 Changing the number of sites on the HWN has a 6 fold impact on the RES requirement, as three lanes in each direction must be monitored.

4.9.5 Changing the distance between sites on the OWN has a significant impact on the number of RESs required for very little increase in the number of checks a passenger vehicle can expect.

4.10 OWN strategy

4.10.1 The data used in the above calculations is very useful for assessing the requirement for sites on the HWN, however it is less useful when assessing the OWN requirement.

4.10.2 The length and complexity of the OWN means that using a value of distance between sites results in consistently low values for the number of checks a vehicle can expect when traveling on the OWN.

4.10.3 It is assumed that a targeting strategy will be chosen so that the number of times a vehicle is checked is increased from the values calculated in this document without increasing the number of RESs.

4.10.4 On the OWN there will be a mixture of fixed sites and transportable RESs.

4.10.5 Fixed sites will monitor where high traffic flow is predictable and unavoidable, such as the arterial routes of major cities.

4.10.6 Transportable RESs will be deployed using a targeting strategy that will combine identifying roads of high flow, roads used to avoid fixed placed RESs, fuel stations and random placement so that vehicles find it difficult to avoid being detected.

4.11 Strategy summary

4.11.1 Mobile units will be used to carry out random checks of vehicles in a way that minimises the opportunity to avoid detection. Traffic congregation points should be targeted, such as car parks, shopping centres, schools, churches and lorry parks.

4.11.2 A summary of the impact of the two strategies discussed above is shown in the table below

Table 5– Impact of enforcement strategies

	100% Fuel stations and borders	50% Fuel stations and borders	5% Fuel stations and borders	35km HWN 750km OWN	55km HWN 750km OWN	55km HWN 500km OWN
Number of fixed gantries	429	107	0	188	120	120
Number of fixed masts	4,244	1,061	0	85	85	127
Number of Transportabl e	0	1,168	243	85	85	128
Number of Mobile	25	25	25	25	25	25
Total number of RESs	4,698	2,361	268	383	315	400
Amount of violators data returned to ESBO	59,127	29,563	2,956	803,526	524,363	542,276
Amount of violator data returned to ESBO due to ANPR inaccuracies	11,772	5,886	589	142,297	92,860	96,032
Duplications	negligible	negligible	negligible	138,847	72,862	50,097

4.11.3 Data from the table above is used to provide cost estimates for each strategy, and the cost impact of each strategy is discussed in the following chapter.

4.11.4 When using the second strategy of deploying enforcement stations throughout the network much fewer RESs are required than using the strategy of targeting fuel stations and borders.

4.11.5 The second strategy significantly increases the communications, ESBO processing and ESBO personnel requirement.

4.11.6 The strategy of targeting all vehicles on the network will increase the visibility of the enforcement system and give a realistic perception that it is difficult to evade complying with the system. Therefore it is expected that compliance levels will increase so reducing the number violations. If this were to happen the ESBO effort would reduce and the operational costs would also reduce proportionally.

5 Cost Drivers and Estimates

5.1 Introduction

5.1.1 This Chapter focuses on the costs of implementing an ES for the KMP.

5.1.2 In particular, the cost drivers for the three key elements of the ES are described as the cost of one key element may increase, reduce or have a neutral financial impact on the other key elements. These three key elements are:

a) Roadside Enforcement Stations (RES)

b) Enforcement System Back Office Costs

c) Communications Costs

5.1.3 Finally, it is important to recognise that there will be a significant cost associated with the initial roll-out of this scheme, in terms of design, development, project/ contract management, supervision and administration.

5.2 RES Cost Drivers

5.2.1 The RES cost drivers in terms of implementation and maintenance are governed by the quantity and type of RES as there are significant costs attributed to the infrastructure (for fixed sites) and the vehicle (for mobile sites). The amount and type of enforcement equipment provided at each RES does have some influence but this is not as significant.

Dimensioning

5.2.2 The quantity of deployed RES is the largest cost driver and this is dependent very much on the policy adopted, in terms of the percentage of the network covered to ensure sufficient enforcement checks are made.

5.2.3 The key criteria affecting the dimensioning are:

a) The percentage of the network covered by sites (albeit that there are different criteria for obtaining that coverage, dependent on whether the road is HWN or OWN)

b) The percentage of coverage at each RES site. For example, will enforcement be carried out on all lanes or selected lanes, both directions or a single direction)

c) The extent of the enforcement check at each site, in terms of the ‘Package’ Options presented (refer to Table 3: Valid Combinations of Detector, RES Processing and ES BO Processing Options).

5.2.4 The dimensioning issues have already been discussed in Chapters 3 and 4 and hence are not repeated here but are included in the final estimates presented.

Types of RES

5.2.5 Three types of RES were identified within the reference architecture:

a) Fixed RES: These sites are permanent installations at the roadside which are always equipped with enforcement equipment. The principle support is:

- a gantry (portal or cantilever) to cater for multiple carriageways
- a mast to cater for single carriageways (one for each direction)

b) Transportable (Stationary Portable) RES: This type of RES is assumed to be stationary when undertaking enforcement activities but 'transportable' by virtue of the fact that it can be moved to any number of sites. It is possible for this type of RES to operate in an attended (manned) or unattended mode, each of which have different advantages and disadvantages.

c) Mobile RES: This is vehicle mounted equipment that is capable of operating whilst in motion.

5.2.6 Further descriptions of the types of RES can be found in Section 3.10.

Implementation Costs

5.2.7 The implementation costs will be dictated by the quantities involved and the types of RES provided.

5.2.8 The Fixed RES implementation costs are primarily governed by the cost of providing the infrastructure, particularly when the erection of gantries is required. The cost of a gantry to cover a single carriageway has been estimated at €255K (there are only slight variations for the number of lanes spanned), compared to a mast installation, estimated at €32K. The enforcement equipment costs include a general cost per site (provision of communications interface, installation, commissioning, power, etc.) of approximately €22K plus a further €11K for each lane that is to be monitored. Further general costs per site (€6K) and for each lane (€19K) are incurred if vehicle classification is required.

5.2.9 The Transportable RES implementation costs are primarily governed by the procurement of a special vehicle that is equipped with a retractable mast; this is estimated to cost €72K. Enforcement equipment (assuming a single lane style of enforcement) is comparable to the Fixed RES provision (at €33K). Again, vehicle classification equipment is an additional cost, at approximately €29K. Assuming that vehicle classification is not required, the cost of a Transportable RES is €105K.

5.2.10 Like the Transportable RES, the Mobile RES implementation expense is most strongly influenced by the vehicle, which is estimated to cost €43K. The enforcement equipment costs are considerably less though since it is anticipated that the VRM will be read manually, by the patrol officers and therefore only the DSRC reader and processor will be required. The DSRC reader, processor and associated installation costs are estimated to be €12K, meaning that the implementation cost of a Mobile RES is €55K.

5.2.11 In addition, to support both the Transportable and Mobile RES, vehicle management and garaging facilities will be required to keep these RES types securely when they are not in service and to allow the captured vehicle data to be downloaded to the ES BO (note: it is assumed that the Transportable RES will not download data in near real time in the same manner as the Fixed RES). It is assumed that the garaging facilities can be provided within existing accommodation provided for the road network maintenance teams but it is estimated that the vehicle management system required to download the information will cost approximately €2K per vehicle.

5.2.12 A summary of the implementation costs for each type of RES is shown in Table 6.

Table 6– Implementation Costs for each type of RES

Type of RES	Infrastructure	Vehicle	Enforcement equipment	Total
Fixed: 3L gantry	255	0	55	310
Fixed: Mast	32	0	33	65
Transportable	0	72	35	107
Mobile	0	43	14	57

Note: values shown are in €K.

Operational Costs

5.2.13 The operational costs of the Fixed RES are attributable primarily to the maintenance team and the associated resources that will be required to periodically visit site to service, repair and replace equipment. It is anticipated that a two-person team would be able to service 60 RES per year and that each maintenance person would cost €85K per year (inclusive of a maintenance vehicle, vehicle fuel and support equipment). In addition, it is anticipated that a specialist maintenance platform vehicle would be required or twice per year, at an approximate hire cost of €145 per day. This approximates to €3K per year per RES before repairs or replacement equipment procurement, (a further €1K per year per site should be added to cover this expense).

5.2.14 Each site will incur an ongoing cost for power and communications. It is suggested that an allowance of €500 per year is made for power and a further €2K per year for a standard communications link (assuming a 516Kb/s uplink).

5.2.15 The operational costs of the Transportable RES and Mobile RES are considered to be very similar in the type of costs they attract. Costs are primarily associated with the cost of the personnel who permanently man the equipment, which is estimated to cost approximately €87K per year (two people per vehicle). A further €15K per year is estimated to cover vehicle costs (servicing, fuel and repairs) and enforcement equipment costs. In addition, a further €2K per year is added to provide a standard communications link (assuming a 516Kb/s uplink) to download the captured images from the vehicle management system (at the garaging facility) into the ES.

5.2.16 A summary of the anticipated maintenance costs for each RES is shown in Table 7.

Table 7– Operational Costs for each type of RES

Type of RES	Maintenance Team and vehicle	Equipment Repair	Power and Communications	Total
Fixed: (gantry or mast)	3	1	2.5	6 to 7
Transportable	87	15	2	104
Mobile	87	15	2	104

Note: values shown are in €K per RES per year.

Depreciation Costs

5.2.17 It is recommended that equipment refresh and renewal is based on the following timescales:

- Vehicles: 3 years
- Enforcement Equipment: 5 to 7 years
- Infrastructure: 40 years

5.2.18 Without taking into account any increases or decreases in the cost to supply the equipment, vehicles or infrastructure, based on the estimated implementation costs, annual depreciation costs are shown in Table 8.

Table 8– Depreciation Costs for each type of RES

Type of RES	Infrastructure	Vehicle	Enforcement equipment	Total
Fixed: 3L gantry	6.4	0	9.2	16
Fixed: Mast	0.8	0	5.5	6.3
Transportable	0	24	5.5	30
Mobile	0	14.3	2.0	16

Note: values shown are in €K per RES per year.

5.3 Enforcement System Back Office Cost Drivers

5.3.1 The ES BO cost drivers are primarily lead by the volume of potential violations that need to be processed. Other activities will, to a lesser extent, affect the price of the ES BO. These include:

a) Managing and processing any post-trip payment system

b) Managing the update and distribution of registered vehicles and exempt vehicles

c) Managing the update of any VOI list

d) Any further involvement in the processing of violations (after making the decision that a violation has occurred)

Dimensioning

5.3.2 For the ES BO, dimensioning is measured in terms of:

a) The personnel required to administer enforcement (and the facilities needed to support them)

b) The volume of automated processing requirements

Implementation Costs

5.3.3 The implementation costs are attributable partly to the provision of accommodation for the ES BO function (office space, welfare facilities, utilities, etc). These have been excluded from the cost estimates supplied, although it should be noted that they will need to be taken into account for the purpose of the final estimate.

5.3.4 The remaining ES BO implementation costs relate to the cost of the hardware and software required to administer enforcement and, to a lesser extent, the cost of recruiting and training personnel to use the ES.

5.3.5 In addition, there will be significant development costs, software licences, installation and the provision of standby equipment, all dependent on the system processing and availability requirements.

5.3.6 Assuming that up to twenty staff are employed on a full time basis to process potential violations, it would be reasonable to assume that one SAN, twenty servers and forty operator workstations would be required (the excess twenty being used to provide facilities for management and support staff in addition to 'hot standby' spares).

Cost estimates and quantities which comprise the implementation costs are summarized in Table 9.

Table 9– ES BO Implementation Costs

Type of Supply	Items	Unit Cost	Quantity	Total Cost
Hardware	SAN	360	1	360
	Servers	30	20	600
	Workstations	4	40	160
Communications Networking	External Comms	300	1	300
	LAN and DMZ	300	1	300
Other Costs	Dev SAN & Serv	1500	1	1500
	Install & Set Up	300	1	300
	Software Licence	700	1	700
	Recruitment	2	20	40
	Training	2	20	40
Total	**ES BO Implementation**			**4300**

Note: cost values shown are in €K.

Operational Costs

5.3.7 The operational costs primarily relate to the cost of employing sufficient personnel to administer the ES. A much smaller (but additional cost) will be incurred as a result of any requirements to save captured violation data and store it in a secure manner to use as evidence.

5.3.8 There will also be a cost associated with servicing the accommodation and facilities provided for the personnel but this has not been taken into account when developing the cost estimates.

5.3.9 The type of personnel that are anticipated to ensure the ES BO is effective is documented in Table 10.

Table 10– ES BO Operational Costs

Type of Supply	Role	Cost to Employ	Quantity	Total Costs
Personnel	Enforcement Director	150	1	150
	Systems/ IT Manager	120	1	120
	Maintenance Manager	120	1	120
	Liaison Coordinator	120	1	120
	Administration Support	70	1	70
	Administration	60	4	240
	IT Support	90	4	360
	Enforcement Officer	60	20	1200
	Enforcement Supervisor	90	4	360
Total	**Personnel Costs**			**2738**

Note: cost values shown are in €K per year.

Depreciation Costs

5.3.10 It is recommended that a planned replacement and renewal cycle of between five and seven years is used to refresh all the enforcement technology equipment within the ES BO. Using a six year duration period, depreciation costs (per year) have been calculated and they are presented in Table 11.

Table 11– ES BO Depreciation Costs

Enforcement Equipment	Implementation Costs (qty x unit cost)	Depreciation (per year)
SAN	1 x 360	60
Servers	20 x 30	100
Operator Workstations	40 x 4	27
Total	**Depreciation Costs**	**187**

Note: cost values shown are in €K per year.

5.4 COMMUNICATIONS COST DRIVERS

5.4.1 For Package options 1 to 3 (refer to Table 3), the implementation and operational costs of the communications equipment are included in the costs for the ES BO and RES. However, for package option 4 (sending back a sample of all received information), it is considered that increased communications (i.e. greater than 512Kbps uplink) will be required. This will significantly increase implementation and operational costs a both the RES and instation. It is therefore not recommended as Chapter 3 concluded that there were not any operational benefits to be achieved.

5.5 GENERAL COST DRIVERS

5.5.1 The estimates indicated above ignore the significant effort that will be required to design, develop and then manage the delivery of such a scheme and the associated implementation costs.

5.5.2 The general costs fall into the following broad categories:

a) Project/contract management costs (from the perspective of client, contractor and any appointed consultant)

b) Liaison and coordination costs

c) RES site designs

d) System design and development

e) Risk and contingency costs

f) Profit and overheads

Project/Contract Management Costs and Liaison

5.5.3 It is recommended that an allowance of ten percent of the implementation costs is set aside for the project/ contract management costs and liaison/ coordination for both the contractor and consultant.

RES Site Designs

5.5.4 This cost is attributable to the design of the infrastructure for a RES. It will only apply to fixed RES and is estimated to cost eight percent of the cost of implementation at that site, as this will take account of the significant additional effort that will be required to design a gantry site in comparison to a mast site. This equates to €25K for the design of a gantry RES and €5K for a mast-based site.

RES System Design and Development

5.5.5 The design of the system for each RES is considered to be comparable to the subsequent cost of procurement of that type of RES. For example, the cost of designing and developing a Transportable RES is €107K.

ES BO System Design and Development

5.5.6 The design and development of the ES BO is very dependent upon the amount of bespoke activities that need to be undertaken (in comparison to using commercial –ff-the-shelf designs). These costs will vary between 50 and 150 percent of the ES BO implementation costs (of €4.3M).

Risk and Contingency Costs

5.5.7 The amount of risk and contingency will vary considerably depending on the commercial conditions, performance requirements, programme and other factors which are important to the tenderers for this work. As a guide, it is recommended that a twenty percent allowance of the contract value is made for risk and a further twenty percent for contingency.

Profit and Overheads

5.5.8 These values are impossible to gauge as they will depend very much on any contractor's desire to win the commission. These values are therefore excluded from the estimate.

5.6 Cost Estimates - Conclusion

5.6.1 Using the cost drivers presented in this Chapter, cost estimates have been derived based on three levels of RES coverage of fuel stations, borders and ferry terminals (as described in Chapter 4). Coverage levels used are: 100%, 50% and 5%.

5.6.2 The quantities of Fixed and Transportable RES have been varied according to the percentage of RES cover, in accordance with Table 12. A token value of 25 mobile RES has also been included in the cost estimate, irrespective of the coverage by the other RES.

Table 12– Link between Percentage Coverage and Types of RES

Percentage Coverage	Fixed RES	Transportable RES
Full coverage (100%)	100%	0%
Half coverage (50%)	50%	50%
Minimal coverage (5%)	0	100%

5.6.3 To minimize the quantity of variables, two types of Fixed RES were considered: a three lane, single carriageway gantry version and a one lane mast version. In all RES cases, it was assumed that ANPR and DSRC provision was made for all lanes being monitored by the RES (vehicle classification was omitted).

5.6.4 The costs for these three choices of coverage are presented in Appendix B.

5.6.5 From the prices presented, it can be seen that although there is a considerable saving in implementation costs by providing Transportable RES, the associated operational and maintenance costs are considerably higher. From the figures extrapolated, if the equipment is to be used for more than two years, it becomes more cost effective to implement one hundred percent coverage using Fixed RES, compared to 50% coverage using a combination of Fixed and Transportable RES. However, if a much lower coverage (i.e. five percent) is required, it then becomes considerably cheaper (as well as being more effective) to use Transportable RES only.

5.6.6 From the results presented in Tables B1, B2 and B3, it can be seen that although the anticipated implementation costs are greater for the fuel station strategy (primarily due to the larger volumes of infrastructure required), the quantity of repeated checks and hence the number of violations is considerably lower, resulting in less ES BO costs.

5.6.7 Overall, assuming a ten year lifecycle, it is predicted that a fifty percent coverage of all fuel stations is significantly higher in cost than all other methods. In contrast, a five percent coverage of all fuel stations is the cheapest option. This can be seen in the results presented in Table B4.

5.6.8 More practical considerations are to be the cost of deploying RES as proposed in the reference architecture (35km on the HWN and for every 750km on the OWN) is comparable to 100% coverage of fuel stations. Assuming a ten year lifecycle and it will be cheaper to provide 100% coverage of fuel stations if a lifecycle in excess of ten years is used (the price for implementation and ten years operation and depreciation for both these options is €2,200M).

5.6.9 However, the cost comparisons show that the more effective options are to deploy RES at 55km intervals on the HWN (irrespective of whether or not RES are deployed for every 500km or 750km on the OWN). In these cases the price for implementation and ten years operation and depreciation for both these options is €1,512M or 1,632M (dependent on OWN deployment).

6 Risks and Uncertainty

6.1 Introduction

6.1.1 This Chapter focuses on the risks and uncertainties related to the successful implementation of an ES. It introduces and describes the ranges used to identify and distinguish the risk.

6.1.2 The risk assessment tables are presented in the Appendix C.

6.2 Risk Sources

6.2.1 The key sources of risk for the ES are considered to be:

a) Technical requirements

b) Procurement costs

c) Societal acceptance

d) Policy

6.2.2 It is recognised that a balance will need to be achieved between all of these risk sources. For example, the accuracy of each component of the ES will require additional investment but may save significant subsequent procurement costs associated with the additional processing requirements required at the BO due to the high volume of potential violations.

6.3 Risk Consequence

6.3.1 The choice of consequences provided for use is not entirely suitable for the ES. Consideration of consequences in terms of time does not seem appropriate for any of the risks considered to the ES. Similarly, the ES system does not require kilometres to be captured, or time/ place differentiation, therefore the consideration of functionality loss using the ranges specified is not appropriate.

6.3.2 It is noted that spot values are provided for investment and operational costs. For clarity, this consequence classification has been developed and as highlighted in Table 13.

Table 13 – Investment and Operational Cost Consequences

C	Investment Cost Range	Operational Cost Range
1	Up to €10M	Up to €7.5M /year
2	€10M up to €30M	€7.5M /year to €12.5M /year
3	€30M up to €70M	€12.5M /year to €27.5M /year
4	€70M up to €150M	€27.5M /year to €75M /year
5	Over €150M	Over €75M /year

6.4 Project Phases

6.4.1 The project phases have been identified to show when the risk will manifest itself if it is not prevented or minimised due to mitigation.

6.4.2 The project phases identified for the purposes of the ES are:

a) Planning/ Preparation
b) Business Case Evaluation
c) Development
d) Installation
e) Operation

Appendix A

Dimensioning

A.1 Assumptions

a) Half annual distance is travelled on HWN and half on OWN

b) Commercial vehicle describes articulated, rigid and special vehicles.

c) Vans are distinct from commercial vehicles.

d) Data for average kms per year is from 1997 and has NOT been extrapolated to 2006

e) Where data is not given in the provided documentation then values are obtained from http://statline.cbs.nl/statweb. This is the source of the data given in the documentation provided and is therefore valid.

f) The average kms per year for commercial vehicles and vans is obtained from the source referenced in e). In this two values are given: one for the total average distance and one for the average distance traveled in The Netherlands. To be consistent with the value provided for passenger vehicles the “total” value is used.

g) The average usage days for a van is not given therefore it is assumed to be between commercial and passenger vehicles.

h) All lanes on the HWN are monitored.

i) On average the HWN are 3 lanes in each direction.

j) There is 1 lane in each direction on the OWN, and there is no hard shoulder.

k) Monitoring the hard shoulder of the HWN will reduce the opportunity for a vehicle to avoid being checked, but will have no impact on the number of checks that a vehicle can expect, therefore enforcement of the hard shoulder has been excluded.

l) The average distance between sites will be used for estimation purposes only and will not indicate a recommended spacing for a final solution.

m) It is not possible to monitor multiple lanes with a single station.

n) A roadside enforcement site consists of multiple roadside enforcement stations (RESs).

o) A roadside enforcement station consists of all the equipment required to obtain data about a vehicle, and capture an evidential image if required. This equipment is dependent on various options detailed in Chapter 3.

p) No assumption is made about whether processing of the vehicle data takes place at the station, site or is passed back to the Enforcement System Back Office.

q) The average vehicle km/year has not changed since 1998.

r) Average distance travelled per day is either on HWN or OWN, not divided between them.

s) A vehicle will make two journeys per day, one to its destination and one returning. Therefore a journey is ½ the distance travelled in a day.

t) The number of checks per day can be calculated in two different ways, both are valid, and give the same number of checks per year, but they give different daily results. To understand this difference: assume the average distance traveled each day is 55km, and that the average number of days driven per year is 300, 50% is traveled on the HWN, 50% on OWN. Examining two different ways of splitting a day’s travel gives rise to the different results. Method a) states that a day’s travel takes place either on the OWN OR the HWN. (i.e. 150 days on the HWN and 150 days on the OWN) So the number of checks per day for a HWN is 55km * the number of checks per km on HWN. The appropriate values are then used for the OWN. Method b) states that one day's travel is split equally between the OWN AND the HWN. So a vehicle would travel 300 days where each day consists of 27.5km on the HWN and 27.5km on the OWN. In this case the number of checks per day is the SUM of the number of checks on the HWN and the number of checks on the OWN. The number of checks per km on the OWN is significantly lower than that for the HWN which will give an obvious difference in the daily values depending on calculation method.

A.2 Calculations

The calculations are based on data provided in Cost Format phase 2 v1.0 and Statistical data phaseII v1.1 30jun06.

A.3 Constant data

The documents referenced in 0 have provided the following data that is fixed and not variable:

Table 1 – Constant values

Constant data	Value
Length of HWN	3,268
Length of OWN	127,129
Total length of road network, sum of HWN and OWN	130,397
Average kms travelled per year for a passenger vehicle	16,550
Average kms travelled per year for a commercial vehicle (sum of values for rigid, articulated and special)	58,919
Average kms travelled per year for a van	24,270
Average number of usage days per year for a passenger vehicle	300
Average number of usage days per year for a commercial vehicle	200
Average number of usage days per year for a van	250
Percentage travelled on HWN	50%

A.4 Derived data

The documents referenced in 0 have provided the following data that is derived from the fixed data and is not variable within the calculations:

Table 2 – Derived values

Derived data description	Formula	Value
Average kms driven on HWN for a passenger vehicle each year	Ave kms per year for passenger vehicle / 2	8,275
Average kms driven on OWN for a passenger vehicle each year	Ave kms per year for passenger vehicle / 2	8,275
Average kms driven on HWN for a commercial vehicle each year	Ave kms per year for commercial vehicle / 2	29,460
Average kms driven on OWN for a commercial vehicle each year	Ave kms per year for commercial vehicle / 2	29,460
Average kms driven on HWN for a van each year	Ave kms per year for van / 2	12,135
Average kms driven on OWN for a van each year	Ave kms per year for van / 2	12,135

Derived data description	Formula	Value
Average number of usage days on HWN for a passenger vehicle	Ave usage days per year for passenger vehicle / 2	150
Average number of usage days on OWN for a passenger vehicle	Ave usage days per year for passenger vehicle / 2	150
Average number of usage days on HWN for a commercial vehicle	Ave usage days per year for commercial vehicle / 2	100
Average number of usage days on OWN for a commercial vehicle	Ave usage days per year for commercial vehicle / 2	100
Average number of usage days on HWN for a van	Ave usage days per year for van / 2	125
Average number of usage days on OWN for a van	Ave usage days per year for van / 2	125
Average distance travelled per day for a passenger vehicle	Ave kms per year / ave number of days driven per year for a passenger vehicle	55.2
Average distance travelled per day for a commercial vehicle	Ave kms per year / ave number of days driven per year for a commercial vehicle	294.6
Average distance travelled per day for a van	Ave kms per year / ave number of days driven per year for a van	97.1
Average journey distance for a passenger vehicle	Distance travelled per day for a passenger vehicle / 2	27.6
Average journey distance for a commercial vehicle	Distance travelled per day for a commercial vehicle / 2	147.3
Average journey distance for a passenger vehicle	Distance travelled per day for a passenger vehicle / 2	48.5

A.5 Variable data

The following values can be varied:

Table 3 – Variables

Variable	Impact
Distance between sites on HWN	Number of sites on the HWN
Distance between sites on OWN	Number of sites on the OWN
Average number of lanes monitored on the HWN	The number of RESs required at each site on the HWN
Average number of lanes monitored on the OWN	The number of RESs required at each site on the OWN

A.6 Calculated data

Using the above data and variables the following is calculated:

Table 4 – Calculated data

Result name	Formula
Number of checks per 1000km on HWN	(Length of HWN/1000)/ number of sites on HWN
Number of checks per 1000km on OWN	(Length of OWN/1000)/ number of sites on OWN

Result name	Formula
Number of checks per 1000km on the whole network	((Length of HWN + Length of OWN)/1000) / (number of HWN sites + number of OWN sites)
For each vehicle type (passenger vehicle, commercial vehicle, van)	
Number of checks per year on HWN	(Kms per year driven on HWN/1000) * (Number of checks per 1000km on HWN)
Number of checks per year on OWN	(Kms per year driven on OWN/1000) * (Number of checks per 1000km on OWN)
Number of checks per day on HWN	Number of checks per year/ number of days driven on HWN
Number of checks per day on OWN	Number of checks per year/ number of days driven on OWN
Number of checks per journey on HWN	(Average journey distance on HWN/1000) * number of checks 1000km on HWN
Number of checks per journey on OWN	(Average journey distance on OWN/1000) * number of checks 1000km on OWN
Number of checks per day with a day's travel split equally between HWN and OWN	Sum of number of checks on HWN and number of checks on OWN

A.7 Scenarios

a) To estimate the number of enforcement stations required and to investigate the impact of monitoring the hard shoulder on the HWN the following expectations were tested

b) What is the impact of the baseline values?

c) Given this value what is the impact of monitoring the hard shoulder?

d) What is the maximum distance between sites on the HWN so that a passenger vehicle can expect to be checked at least once a day?

e) Given this value what is the impact of monitoring the hard shoulder?

f) What is the maximum distance between sites on the OWN so that there are 2 checks per 1000km?

g) Given this value what is the impact of monitoring the hard shoulder?

h) What is the impact of monitoring only 1 direction on the OWN as well as the hard shoulder given the values in e?

i) What is the maximum distance between sites on the HWN so that a passenger vehicle will be checked once per day if an average day's travel is split between OWN and HWN? The distance between sites on the OWN will be that determined by f)

j) Given this value what is the impact of monitoring the hard shoulder?

k) Keeping the distance between sites on OWN constant what is the effect of changing the distance between the sites on the HWN?

l) More scenarios are shown after the table of results.

Table 5 – Results

		Dist between sites	Number of sites	No. of lanes monitored	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
b)	HWN	35	94	6	564	28.571	Passenger	236.429	1.576	0.788	Passenger	0.825	Dist between sites as suggested. 3 lane HWN, no monitoring of hard shoulder (HS)
							Commercial	841.702	8.417	4.209			
							Van	346.714	2.774	1.387	Commercial	4.405	
	OWN	750	170	2	340	1.333	Passenger	11.033	0.074	0.037			
							Commercial	39.279	0.393	0.196	Van	1.452	
							Van	16.180	0.129	0.065			
	Total		264		904	2.025							
c)	HWN	35	94	8	752	28.571	Passenger	236.429	1.576	0.788	Passenger	0.825	As in a above with hard shoulder monitored.
							Commercial	841.702	8.417	4.209			
							Van	346.714	2.774	1.387	Commercial	4.405	
	OWN	750	170	2	340	1.333	Passenger	11.033	0.074	0.037			
							Commercial	39.279	0.393	0.196	Van	1.452	
							Van	16.180	0.129	0.065			
	Total		264		1092	2.025							
d)	HWN	55	60	6	360	18.182	Passenger	150.455	1.003	0.502	Passenger	0.538	Dist between sites on HWN varied to achieve >=1 check/day for passenger vehicles. No HS monitoring.
							Commercial	535.629	5.356	2.678			
							Van	220.636	1.765	0.883	Commercial	2.875	
	OWN	750	170	2	340	1.333	Passenger	11.033	0.074	0.037			
							Commercial	39.279	0.393	0.196	Van	0.947	
							Van	16.180	0.129	0.065			
	Total		230		700	1.764							

		Dist between sites	Number of sites	No. of lanes monitor ed	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
e)	HWN	55	60	8	480	18.182	Passenger	150.455	1.003	0.502	Passenger	0.538	As in c above, with hard shoulder monitored.
							Commercial	535.629	5.356	2.678			
							Van	220.636	1.765	0.883	Commercial	2.875	
	OWN	750	170	2	340	1.333	Passenger	11.033	0.074	0.037			
							Commercial	39.279	0.393	0.196	Van	0.947	
							Van	16.180	0.129	0.065			
	Total		230		820	1.764							
f)	HWN	55	60	6	360	18.182	Passenger	150.455	1.003	0.502	Passenger	0.557	Dist between sites on HWN varied to achieve >=1 check/day for passenger vehicles. Dist between sites OWN decreased to 500 km. No HS monitoring.
							Commercial	535.629	5.356	2.678			
							Van	220.636	1.765	0.883	Commercial	2.973	
	OWN	500	255	2	510	2.000	Passenger	16.550	0.110	0.055			
							Commercial	58.919	0.589	0.295	Van	0.980	
							Van	24.270	0.194	0.097			
	Total		315		870	2.416							
g)	HWN	55	60	8	480	18.182	Passenger	150.455	1.003	0.502	Passenger	0.557	As in e above, with hard shoulder monitored.
							Commercial	535.629	5.356	2.678			
							Van	220.636	1.765	0.883	Commercial	2.973	
	OWN	500	255	2	510	2.000	Passenger	16.550	0.110	0.055			
							Commercial	58.919	0.589	0.295	Van	0.980	
							Van	24.270	0.194	0.097			
	Total		315		990	2.416							

		Dist between sites	Number of sites	No. of lanes monitored	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
h)	HWN	55	60	8	480	18.182	Passenger	150.455	1.003	0.502	Passenger	0.557	As in e above, with hard shoulder monitored only 1 lane of OWN monitored.
							Commercial	535.629	5.356	2.678			
							Van	220.636	1.765	0.883	Commercial	2.973	
	OWN	500	255	1	255	2.000	Passenger	16.550	0.110	0.055			
							Commercial	58.919	0.589	0.295	Van	0.980	
							Van	24.270	0.194	0.097			
	Total		315		735	2.416							
i)	HWN	29	113	6	678	34.483	Passenger	285.345	1.902	0.951	Passenger	1.006	Dist between sites on HWN varied to achieve >=1 check/day for passenger vehicle where travel is on both HWN and OWN. Dist between sites OWN 500 km. No HS monitoring.
							Commercial	1015.848	10.158	5.079			
							Van	418.448	3.348	1.674	Commercial	5.374	
	OWN	500	255	2	510	2.000	Passenger	16.550	0.110	0.055			
							Commercial	58.919	0.589	0.295	Van	1.771	
							Van	24.270	0.194	0.097			
	Total		315		1188	2.822							
j)	HWN	29	113	8	904	34.483	Passenger	285.345	1.902	0.951	Passenger	1.006	As in h above, with hard shoulder monitored.
							Commercial	1015.848	10.158	5.079			
							Van	418.448	3.348	1.674	Commercial	5.374	
	OWN	500	255	2	510	2.000	Passenger	16.550	0.110	0.055			
							Commercial	58.919	0.589	0.295	Van	1.771	
							Van	24.270	0.194	0.097			
	Total		315		1414	2.822							

		Dist between sites	Number of sites	No. of lanes monitored	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
j	HWN	25	131	8	1048	40.000	Passenger	331.000	2.207	1.103	Passenger	1.140	OWN 750
							Commercial	1178.383	11.784	5.892			
							Van	485.400	3.883	1.942	Commercial	6.088	
	OWN	750	170	2	340	1.333	Passenger	11.033	0.074	0.037			
							Commercial	39.279	0.393	0.196	Van	2.006	
							Van	16.180	0.129	0.065			
	Total		315		1388	2.308							
k	HWN	45	73	8	584	22.222	Passenger	183.889	1.226	0.613	Passenger	0.650	OWN 750
							Commercial	654.657	6.547	3.273			
							Van	269.667	2.157	1.079	Commercial	3.470	
	OWN	750	170	2	340	1.333	Passenger	11.033	0.074	0.037			
							Commercial	39.279	0.393	0.196	Van	1.143	
							Van	16.180	0.129	0.065			
	Total		315		924	2.822							
l	HWN	65	51	8	408	15.386	Passenger	127.308	0.849	0.424	Passenger	0.461	OWN 750
							Commercial	453.224	4.532	2.266			
							Van	186.692	4.494	0.747	Commercial	2.463	
	OWN	750	170	2	340	1.333	Passenger	11.033	0.074	0.037			
							Commercial	39.279	0.393	0.196	Van	0.811	
							Van	16.180	0.129	0.065			
	Total		315		748	1.695							

		Dist between sites	Number of sites	No. of lanes monitored	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
m	HWN	25	131	8	1048	40.000	Passenger	331.000	2.207	1.103	Passenger	1.172	OWN 400
							Commercial	1178.383	11.784	5.892			
							Van	485.400	3.883	1.942	Commercial	6.260	
	OWN	400	318	2	636	2.500	Passenger	20.688	0.138	0.069			
							Commercial	73.649	0.736	0.368	Van	2.063	
							Van	16.180	0.243	0.121			
	Total		449		1684	2.822							
n	HWN	35	94	8	752	28.571	Passenger	236.429	1.576	0.788	Passenger	0.857	OWN 400
							Commercial	841.702	8.417	4.209			
							Van	346.714	2.774	1.387	Commercial	4.577	
	OWN	400	318	2	636	2.500	Passenger	20.688	0.138	0.069			
							Commercial	73.649	0.736	0.368	Van	1.508	
							Van	16.180	0.243	0.121			
	Total		449		1388	3.160							
o	HWN	45	73	8	584	22.222	Passenger	183.889	1.226	0.613	Passenger	0.682	OWN 400
							Commercial	654.657	6.547	3.273			
							Van	269.667	2.157	1.079	Commercial	3.642	
	OWN	400	318	2	636	2.500	Passenger	20.688	0.138	0.069			
							Commercial	73.649	0.736	0.368	Van	1.200	
							Van	16.180	0.243	0.121			
	Total		449		1220	2.990							

		Dist between sites	Number of sites	No. of lanes monitored	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
p	HWN	55	60	8	480	18.182	Passenger	150.455	1.003	0.502	Passenger	0.570	OWN 400
							Commercial	535.629	5.356	2.678			
							Van	220.636	1.765	0.883	Commercial	3.046	
	OWN	400	318	2	636	2.500	Passenger	20.688	0.138	0.069			
							Commercial	73.649	0.736	0.368	Van	1.004	
							Van	16.180	0.243	0.121			
	Total		449		1116	2.899							
q	HWN	65	51	8	408	15.386	Passenger	127.308	0.849	0.424	Passenger	0.493	OWN 400
							Commercial	453.224	4.532	2.266			
							Van	186.692	4.494	0.747	Commercial	2.634	
	OWN	400	318	2	636	2.500	Passenger	20.688	0.138	0.069			
							Commercial	73.649	0.736	0.368	Van	0.868	
							Van	16.180	0.243	0.121			
	Total		449		1044	2.822							
r	HWN	25	131	8	1048	40.000	Passenger	331.000	2.207	1.103	Passenger	1.159	OWN 500
							Commercial	1178.383	11.784	5.892			
							Van	485.400	3.883	1.942	Commercial	6.187	
	OWN	500	255	2	510	2.000	Passenger	16.550	0.110	0.055			
							Commercial	58.919	0.589	0.295	Van	2.039	
							Van	24.270	0.194	0.097			
	Total		386		1558	2.960							

		Dist between sites	Number of sites	No. of lanes monitored	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
s	HWN	35	94	8	752	28.571	Passenger	236.429	1.576	0.788	Passenger	0.843	OWN 500
							Commercial	841.702	8.417	4.209			
							Van	346.714	2.774	1.387	Commercial	4.503	
	OWN	500	255	2	510	2.000	Passenger	16.550	0.110	0.055			
							Commercial	58.919	0.589	0.295	Van	1.484	
							Van	24.270	0.194	0.097			
	Total		349		1262	2.676							
t	HWN	45	73	8	584	22.222	Passenger	183.889	1.226	0.613	Passenger	0.668	OWN 500
							Commercial	654.657	6.547	3.273			
							Van	269.667	2.157	1.079	Commercial	3.568	
	OWN	500	255	2	510	2.000	Passenger	16.550	0.110	0.055			
							Commercial	58.919	0.589	0.295	Van	1.176	
							Van	24.270	0.194	0.097			
	Total		328		1094	2.515							
u	HWN	55	60	8	480	18.182	Passenger	150.455	1.003	0.502	Passenger	0.570	OWN 500
							Commercial	535.629	5.356	2.678			
							Van	220.636	1.765	0.883	Commercial	3.046	
	OWN	500	255	2	510	2.000	Passenger	16.550	0.110	0.055			
							Commercial	58.919	0.589	0.295	Van	1.004	
							Van	24.270	0.194	0.097			
	Total		449		990	2.899							

		Dist between sites	Number of sites	No. of lanes monitored	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
v	HWN	65	51	8	408	15.386	Passenger	127.308	0.849	0.424	Passenger	0.480	OWN 500
							Commercial	453.224	4.532	2.266			
							Van	186.692	4.494	0.747	Commercial	2.561	
	OWN	500	255	2	510	2.000	Passenger	16.550	0.110	0.055			
							Commercial	58.919	0.589	0.295	Van	0.844	
							Van	24.270	0.194	0.097			
	Total		306		918	2.347							
w	HWN	25	131	8	1048	40.000	Passenger	331.000	2.207	1.103	Passenger	1.149	OWN 600
							Commercial	1178.383	11.784	5.892			
							Van	485.400	3.883	1.942	Commercial	6.137	
	OWN	600	212	2	424	1.667	Passenger	13.792	0.092	0.046			
							Commercial	49.099	0.491	0.245	Van	2.023	
							Van	20.225	0.162	0.081			
	Total		343		1472	2.630							
x	HWN	35	94	8	752	28.571	Passenger	236.429	1.576	0.788	Passenger	0.843	OWN 600
							Commercial	841.702	8.417	4.209			
							Van	346.714	2.774	1.387	Commercial	4.540	
	OWN	600	212	2	424	1.667	Passenger	13.792	0.092	0.046			
							Commercial	49.099	0.491	0.245	Van	1.468	
							Van	20.225	0.162	0.081			
	Total		349		1146	2.676							

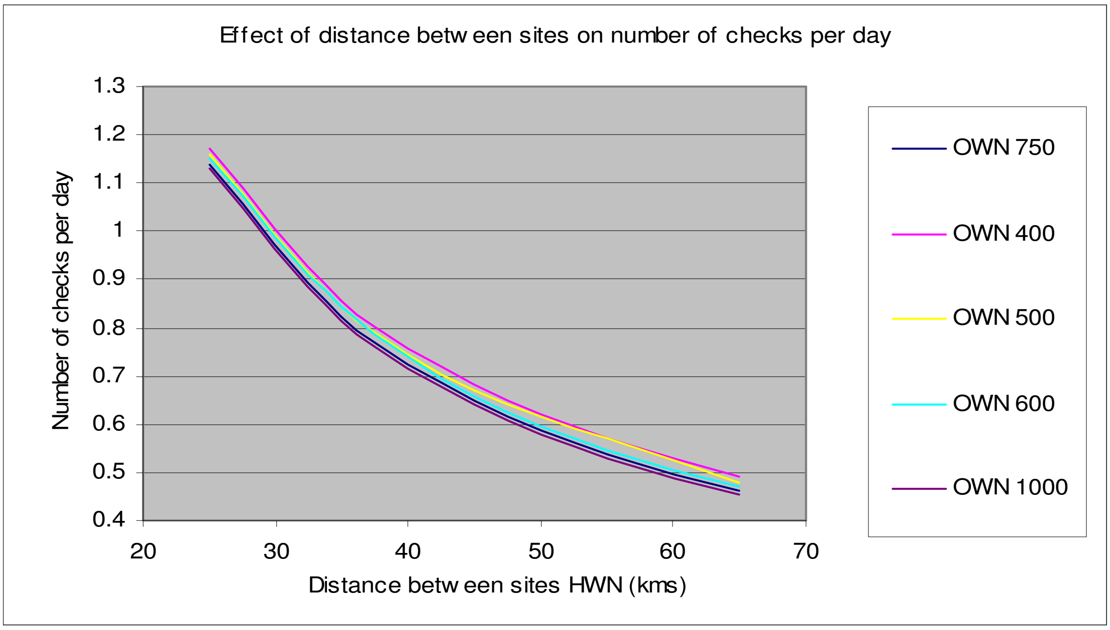
		Dist between sites	Number of sites	No. of lanes monitored	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
y	HWN	45	73	8	584	22.222	Passenger	183.889	1.226	0.613	Passenger	0.659	OWN 600
							Commercial	654.657	6.547	3.273			
							Van	269.667	2.157	1.079	Commercial	3.519	
	OWN	600	212	2	424	1.667	Passenger	13.792	0.092	0.046			
							Commercial	49.099	0.491	0.245	Van	1.160	
							Van	20.225	0.162	0.081			
	Total		285		1008	2.186							
z	HWN	55	60	8	480	18.182	Passenger	150.455	1.003	0.502	Passenger	0.547	OWN 600
							Commercial	535.629	5.356	2.678			
							Van	220.636	1.765	0.883	Commercial	2.924	
	OWN	600	212	2	424	1.667	Passenger	13.792	0.092	0.046			
							Commercial	49.099	0.491	0.245	Van	0.963	
							Van	20.225	0.162	0.081			
	Total		272		904	2.086							
aa	HWN	65	51	8	408	15.386	Passenger	127.308	0.849	0.424	Passenger	0.470	OWN 600
							Commercial	453.224	4.532	2.266			
							Van	186.692	4.494	0.747	Commercial	2.512	
	OWN	600	212	2	424	1.667	Passenger	13.792	0.092	0.046			
							Commercial	49.099	0.491	0.245	Van	0.828	
							Van	20.225	0.162	0.081			
	Total		263		832	2.017							

		Dist between sites	Number of sites	No. of lanes monitored	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
ab	HWN	25	131	8	1048	40.000	Passenger	331.000	2.207	1.103	Passenger	1.131	OWN 1000
							Commercial	1178.383	11.784	5.892			
							Van	485.400	3.883	1.942	Commercial	6.039	
	OWN	1000	128	2	256	1.000	Passenger	8.275	0.055	0.028			
							Commercial	29.460	0.295	0.147	Van	1.990	
							Van	12.135	0.097	0.049			
	Total		259		1304	1.986							
ac	HWN	35	94	8	752	28.571	Passenger	236.429	1.576	0.788	Passenger	0.816	OWN 1000
							Commercial	841.702	8.417	4.209			
							Van	346.714	2.774	1.387	Commercial	4.356	
	OWN	1000	128	2	256	1.000	Passenger	8.275	0.055	0.028			
							Commercial	29.460	0.295	0.147	Van	1.435	
							Van	12.135	0.097	0.049			
	Total		222		1008	1.702							
ad	HWN	45	73	8	584	22.222	Passenger	183.889	1.226	0.613	Passenger	0.641	OWN 1000
							Commercial	654.657	6.547	3.273			
							Van	269.667	2.157	1.079	Commercial	3.421	
	OWN	1000	128	2	256	1.000	Passenger	8.275	0.055	0.028			
							Commercial	29.460	0.295	0.147	Van	1.127	
							Van	12.135	0.097	0.049			
	Total		201		840	1.541							

		Dist between sites	Number of sites	No. of lanes monitored	No. of RES	Number of checks per 1000km		Number of checks per year	Number of checks per day. (Travel on HWN OR OWN)	Number of checks per journey. (Journey is ½ km in a day)		Number of checks per day (Travel BOTH HWN and OWN))	Comment
ae	HWN	55	60	8	480	18.182	Passenger	150.455	1.003	0.502	Passenger	0.529	OWN 1000
							Commercial	535.629	5.356	2.678			
							Van	220.636	1.765	0.883	Commercial	2.825	
	OWN	1000	128	2	256	1.000	Passenger	8.275	0.055	0.028			
							Commercial	29.460	0.295	0.147	Van	0.931	
							Van	12.135	0.097	0.049			
	Total		188		736	1.442							
af	HWN	65	51	8	408	15.386	Passenger	127.308	0.849	0.424	Passenger	0.452	OWN 1000
							Commercial	453.224	4.532	2.266			
							Van	186.692	4.494	0.747	Commercial	2.413	
	OWN	1000	128	2	256	1.000	Passenger	8.275	0.055	0.028			
							Commercial	29.460	0.295	0.147	Van	0.795	
							Van	12.135	0.097	0.049			
	Total		179		664	1.373							

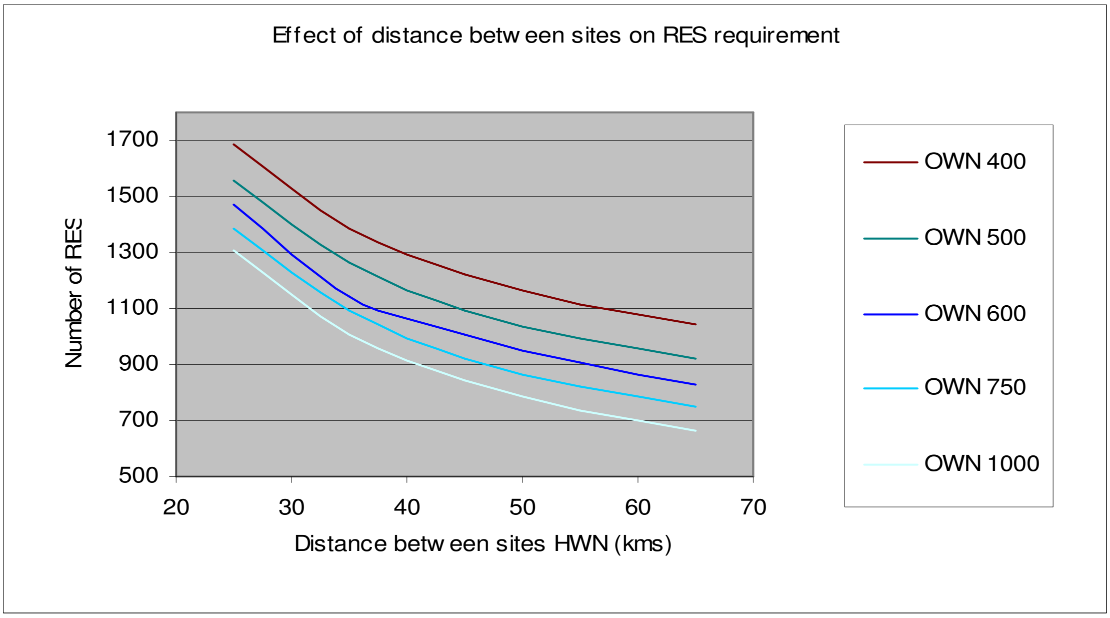
Using different constant values for the distance between sites on the OWN what trends are seen when the distance between sites on the HWN is varied?

Graph 1 – Impact on number of checks per day for a passenger vehicle when the distance between sites on HWN is varied.



What trends are seen in the RES requirement given the same data used in **Error! Reference source not found.**? Assume the hard shoulder is monitored?

Graph 2 – Impact on RES requirement when the distance between sites on HWN is varied.



A.8 Varying the distance between sites

Reducing the distance between sites on the HWN has the most impact to the volume of equipment required. This is due to the number of lanes to be monitored when compared to the number of lanes monitored on the OWN. The number of monitoring stations is reduced from 904 to 700 by increasing the distance between sites by 15km. If the impact is compared when the hard shoulder is monitored then the difference is even greater. There is a reduction from 1092 to 820 stations.

A.9 Varying the number of lanes monitored - HWN

The volume of enforcement stations required is directly proportional to the number of lanes monitored. Therefore the decision as to whether to monitor the hard shoulder significantly affects the number of stations required on the HWN. If the hard shoulder is monitored with the sites being placed 35 km apart there is an increase of 188 stations. If the distance between sites is 55km then there is an increase of 120 stations to monitor the hard shoulder.

A.10 Varying the number of lanes monitored - OWN

Monitoring 1 direction of flow on the OWN as opposed to both directions will halve the number of stations required at each site. i.e. a reduction of 255 if the sites are space every 500 km, and 170 if the sites are spaced every 750 km. As there are more sites on the OWN than on the HWN then there is a more significant impact on the volume of equipment required. Only monitoring one direction of flow will mean that on average half the vehicles passing a site will not be checked.

A.11 Issues with the calculations

In all the calculations averages are used. Averages of averages are statistically questionable and therefore the resulting values can only be considered to be approximations for comparison of the impact of changes, rather than attainable levels or targets.

The data provided relating to the vehicle km/year is from 1998. The data for the length of road network is from 2005. These 2 values would not normally be used together, but in the absence of more recent figures then an assumption is made that although there are more vehicles on the road network the average vehicle km/year has not changed significantly.

The averages used are most useful where the enforcement equipment will be placed permanently. This will be the case on the HWN and on some sites on the OWN.

B.1 Introduction

This appendix provides the cost of enforcement in the layout requested and supporting information regarding the quantities of each type of RES used and the number of potential violations that are expected.

A number of versions of the preferred layout are provided, depending upon the amount of coverage (in terms of RES) that is provided and the type of targeting strategy deployed.

One strategy that has been recommended is to target fuel stations, since all vehicles need to be provided with fuel at intervals related to the distance that they have driven and their fuel tank size. Assuming a 50 litre fuel tank, an average distance of 55km travelled per day and a fuel consumption of 7.7 litres for every 100km driven, this means that passenger vehicles will re-fuel approximately every eleven days. Avoidance of fuel stations can be achieved either by purchasing fuel from outside the country or be acquiring fuel from a location that is not a fuel station (e.g. diesel stores on farms, siphoning fuel from other vehicles). The easier avoidance option for motorists driving through the country is to fill up with sufficient fuel in order to avoid the need to use a Dutch fuel station. To overcome this avoidance tactic, it is recommended that additional ES are located in close proximity to borders and ferry terminals (although it is recognised that the additional infrastructure may not be desirable). It is recognised that it will be more difficult to identify vehicles that have been fuelled at locations other than fuel stations, but in most cases, this will be seen by the motorist as impractical (in comparison to paying the KMP).

Nominal values of 100%, 50% and 5% coverage of fuel stations, ferry terminals and border crossings have been used to show the range of costs involved for the different deployment strategies.

- For 100% coverage, it is envisaged that all fuel stations, borders and ferry crossings are equipped with gantry or mast style Fixed RES.
- For 50% coverage, it is envisaged that half of the RES will be fixed (gantry or mast) and the remainder will be Transportable. This mix is recommended such that the significantly high usage sites are equipped with Fixed RES and the ‘surprise’ element of the Transportable RES is used to ensure that motorists retain that perception of a high probability of being checked.
- For 5% coverage, it is assumed that all RES will be Transportable, once again, to emphasise the ‘surprise’ element that will retain the perception of being checked.

The other strategy is similar to that which is recommended by the reference architecture, i.e. to check all vehicles at regular intervals on the HWN and for a set number of kilometres on the OWN.

Nominal divisions have been used to show the range of costs involved for three different distance based deployment strategies:

- Every 35km on the HWN and for every 750km of OWN
- Every 55km on the HWN and for every 750km of OWN
- Every 55km on the HWN and for every 500km of OWN

Table B1

Enforcement Strategy 1: Enforce at fuel stations, borders and ferry terminals

	100% coverage		50% coverage		5% coverage	
	qty	cost (€K)	qty	cost(€K)	qty	cost(€K)
Implementation Cost						
Fixed RES - 3L gantry	429	132,990	107	33,248	0	0
Fixed RES - mast	4,244	275,860	1,061	68,965	0	0
Transportable RES	0	0	1,168	125,003	234	25,033
Mobile RES	25	1,425	25	1,425	25	1,425
		410,275		**228,640**		**26,458**
Operational Costs						
Fixed RES - 3L gantry	429	2,789	107	697	0	0
Fixed RES - mast	4,244	27,586	1,061	6,897	0	0
Transportable RES	0	0	1,168	121,498	234	24,331
Mobile RES	25	2,600	25	2,600	25	2,600
		32,975		**131,692**		**26,931**
Depreciation Costs						
Fixed RES - 3L gantry	429	6,667	107	1,667	0	0
Fixed RES - mast	4,244	26,737	1,061	6,684	0	0
Transportable RES	0	0	1,168	34,853	234	6,980
Mobile RES	25	417	25	417	25	417
		33,821		**43,621**		**7,396**

Table B2

Enforcement Strategy 2: Enforce at points on the HWN and OWN

	HWN: 35km OWN: 750km		HWN: 55km OWN: 750km		HWN: 55km OWN: 500km	
	qty	cost (€K)	qty	cost (€K)	qty	cost (€K)
Implementation Costs						
Fixed RES - 3L gantry	188	58,280	120	37,200	120	37,200
Fixed RES - mast	85	5,525	85	5,525	127	8,255
Transportable RES	85	9,095	85	9,095	128	13,696
Mobile RES	25	1,425	25	1,425	25	1,425
		74,325		**53,245**		**60,576**
Operational Costs						
Fixed RES - 3L gantry	188	1,222	120	780	120	780
Fixed RES - mast	85	553	85	553	127	826
Transportable RES	85	8,840	85	8,840	128	13,312
Mobile RES	25	2,600	25	2,600	25	2,600
		13,215		**12,773**		**17,518**
Depreciation Costs						
Fixed RES - 3L gantry	188	2,922	120	1,865	120	1,865
Fixed RES - mast	85	536	85	536	127	800
Transportable RES	85	2,536	85	2,536	128	3,819
Mobile RES	25	417	25	417	25	417
		6,410		**5,353**		**6,900**

Table B3

ESBO Costs for the Enforcement Strategies -
Fuel Stn, borders and ferry terminals based coverage

Coverage	100%	50%	5%
Quantities of Potential Violations			
number of fraudulent users expected	59,127	29,563	2,956
number of ANPR inaccuracies predicted	10,799	5,399	540
number of potential violations	69,926	34,963	3,496
ES BO Metrics			
number of Enforcement Officers reqd	78	39	4
number of quantum ES BO units reqd (Officers/ 20)	4	2	1
Costs			
Implementation Cost (€K)	17,199	8,599	4,300
Operational Costs (€K)	10,951	5,476	2,738
Depreciation Costs (€K)	746	373	187

Table B3

ESBO Costs for the Enforcement Strategies -
Distance based coverage

Coverage	HWN: 35 OWN: 750	HWN: 55 OWN: 750	HWN: 55 OWN: 500
number of fraudulent users expected	803,526	524,363	542,276
number of ANPR inaccuracies predicted	142,297	92,860	96,032
number of potential violations	945,823	617,222	638,307
number of Enforcement Officers reqd	1051	686	709
number of quantum ES BO units reqd	53	34	35
Implementation Cost (€K)	227,885	146,190	150,490
Operational Costs (€K)	145,104	93,086	95,823
Depreciation Costs (€K)	9,891	6,345	6,532

B.2 Customer Pricing Tables (All Prices shown are in €K)

100% Coverage of Fuel Stations, borders and ferry terminals

Enforcement		*Initial costs*	*Operational costs ex depreciation*	*Depreciation*
Fixed enforcement stations & labour		408,850	30,375	33,405
Transportable enforcement stations & labour		-	-	-
Mobile enforcement equipment & labour		1,425	2,600	417
Enforcement backoffice costs		17,199	10,951	746
Other (General Costs)		242,798	-	-
Sub total		670,272	43,926	34,568
IEP		-	-	
Total ex VAT		670,272	43,926	34,568
VAT	19%	127,352	8,346	6,568
Total incl VAT		797,624	52,272	41,136

50% Coverage of Fuel Stations, borders and ferry terminals

Enforcement		*Initial costs*	*Operational costs ex depreciation*	*Depreciation*
Fixed enforcement stations & labour		102,213	7,594	8,351
Transportable enforcement stations & labour		125,003	121,498	34,853
Mobile enforcement equipment & labour		1,425	2,600	417
Enforcement backoffice costs		8,599	5,476	2,738
Other (General Costs)		124,676	-	-
Sub total		361,916	137,167	46,358
IEP		-	-	-
Total ex VAT		814,358	137,167	46,358
VAT	19%	68,764	26,062	8,808
Total incl VAT		430,680	163,229	55,167

5% Coverage of Fuel Stations, borders and ferry terminals

Enforcement		*Initial costs*	*Operational costs ex depreciation*	*Depreciation*
Fixed enforcement stations & labour				
Transportable enforcement stations & labour		25,033	24,331	6,980
Mobile enforcement equipment & labour		1,425	2,600	417
Enforcement backoffice costs		4,300	2,738	187
Other (General Costs)		18,068	-	-
Sub total		48,825	29,669	7,583
IEP		-	-	-
Total ex VAT		48,825	29,669	7,583
VAT	19%	9,277	5,637	1,441
Total incl VAT		58,102	35,306	9,024

Distance Coverage of HWN: 35km, OWN: 750km

Enforcement		*Initial costs*	*Operational costs ex depreciation*	*Depreciation*
Fixed enforcement stations & labour		63,805	1,775	3,457
Transportable enforcement stations & labour		9,095	8,840	2,536
Mobile enforcement equipment & labour		1,425	2,600	417
Enforcement backoffice costs		227,885	145,104	9,891
Other (General Costs)		47,947	-	-
Sub total		350,157	158,319	16,301
IEP		-	-	-
Total ex VAT		350,157	158,319	16,301
VAT	19%	66,530	30,081	3,097
Total incl VAT		416,687	188,399	19,398

Distance Coverage of HWN: 55km, OWN: 750km

Enforcement		*Initial costs*	*Operational costs ex depreciation*	*Depreciation*
Fixed enforcement stations & labour		42,725	1,333	2,401
Transportable enforcement stations & labour		9,095	8,840	2,536
Mobile enforcement equipment & labour		1,425	2,600	417
Enforcement backoffice costs		146,190	93,086	6,345
Other (General Costs)		35,721	-	-
Sub total		235,156	105,858	11,698
IEP		-	-	-
Total ex VAT		235,156	105,858	11,698
VAT	19%	44,680	20,113	2,223
Total incl VAT		279,836	125,971	13,921

Distance Coverage of HWN: 55km, OWN: 500km

Enforcement		*Initial costs*	*Operational costs ex depreciation*	*Depreciation*
Fixed enforcement stations & labour		45,455	1,606	2,665
Transportable enforcement stations & labour		13,696	13,312	3,819
Mobile enforcement equipment & labour		1,425	2,600	417
Enforcement backoffice costs		150,490	95,823	6,532
Other (General Costs)		39,973	-	-
Sub total		251,039	113,341	13,432
IEP		-	-	-
Total ex VAT		251,039	113,341	13,432
VAT	19%	47,697	21,535	2,552
Total incl VAT		298,736	134,876	15,984

Table B4

Cost Comparison over lifecycle

number of years operation	2	3	4	5	6	7	8	9	10
100% fuel stn, borders	1642970	1721464	1799957	1878451	1956944	2035438	2113931	2192424	2270918
50% fuel stn, borders	1181409	1364934	1548460	1731986	1915511	2099037	2282563	2466088	2649614
5% fuel stn, borders	171404	208656	245907	283159	320410	357661	394913	432164	469416
35km HWN, 750km OWN	843206.5	1017826	1192445	1367064	1541683	1716302	1890921	2065540	2240159
55km HWN, 750km OWN	571919.6	689475.7	807031.8	924587.8	1042144	1159700	1277256	1394812	1512368
55km HWN, 500km OWN	620898	747670.9	874443.9	1001217	1127990	1254763	1381536	1508309	1635082

Costs shown are in €K.

Risk ID	Risk Event	Risk Source	Risk Probability (Description)	Consequence (Description)	RP	C	Severity Index (RP*C = SI)	Project Phase	Mitigation Measure	Risk Owner (Public - Private)
1	Volume of violations is larger than predicted (i.e. larger than the dimensioning predictions) due to pricing policy issues (item 2.4). For example, implementation of a per km OUS item (2.4.11), a too high a charge rate being set (item 2.2.7) or a too low a fine rate being set (item 2.2.2). A consequence arising from of any of these causes may be an increase in BO and fine collection costs necessary to handle and process the increased volumes of violations.	policy	very low	70M€ to 150M€ investment costs OR 27.5M€ to 75M€ operational costs OR 18 months to 36 months delay OR functionality not completely met, including no time or place differentiation	1	4	4	Operation	(a) Consideration and introduce of a flat rate OUS scheme which can be enforced (b) When developing a pricing strategy undertake appropriate financial modelling of the potential economic benefit to evaders combined with their risk of being caught (c) Maximise perception of being caught by public education and awareness of enforcement measures.	public
2	Volume of violations is larger than predicted (i.e. larger than the dimensioning predictions) due to widespead lack of acceptance of the scheme by the public. Potential issues that may cause this non-acceptance include whether it is seen as a tax or additional charge, whether it is equitable and fair (i.e. all pay) and is not seen as invading individual privacy (item 2.2.7).	societal acceptance	very low	10 to 30M€ investment costs OR 7.5M€ to 12.5M€/year operational costs OR 4 to 9 months delay OR functionality but no place differentiation	1	2	2	Operation	(a) Scheme developed with equity and fairness underpinning the policy making decisions (b) Pricing policy demonstrates basis of the scheme is tax neutral and is not generating additional revenue (b) Keep secure and minimise the storage and processing of an individuals private information and data. Discard captured vehicle data safely at roadside once valid registartion is verified. Only transfer vehicle data/images for potential violators and amalgamate personal data with vehicle information at fine collection stage.	public
3	Volume of violations is larger than predicted (i.e. larger than the dimensioning predictions) due to under performing equipment in poor environmental/weather conditions. For example, heavy rain or snow may interfere with the correct performance of the DSRC communications or ANPR cameras, resulting in the instances where the RES cannot match and verify OBU data with the VRM (i.e. potential violator occurrence). After a certain performamce threshold, the number of failed matches may increase exponentially, swamping the communication paths and BO processing.	technical requirements	medium	over 150M€ investment costs OR over 75M€/year operational costs OR over 36 months delay OR over 50% of KMs not met	3	5	15	Operation	(a) The Client should be aware of current technology limitations and set realistic performance standards (b) Monitoring levels of violation detected at each RES and suspend enforcement processing from individual or groups of RES when violation levels increase beyond a reasonable factor greater (e.g. 200%) than those normally expected from the site.	public

4	Significant quantity of violations are left undetected (i.e. more than the stated tolerance standard) due to being unable to measure absolute level of violations and having insufficient deployment of enforcement equipment on the road network (i.e. HWN and OWN).	procurement costs	high	over 150M€ investment costs OR over 75M€/year operational costs OR over 36 months delay OR over 50% of KMs not met	4	5	20	Operation	(a) During design phase undertake travel pattern analysis of road netwrk and strategically deploy RES sites to maximise vehicle capture (e.g. highly trafficked/unavoidable routes, fuel stations) (b) Introduce monitoring and verification processes (e.g. regular spot manual checks in random locations unrelated to RES deployment) in order to audit and verify the actual level of background violations in order to compare with those being detected by the ES. (c) If level detection level is not does not meet enforcement performance criteria, review RES deployment and amend strategy (e.g. refocus/target areas, increase number of RES deployed).	private
5	Significant quantity of violations are left undetected (i.e. more than the stated tolerance) due to underperforming (i.e. inadequate or faulty) enforcement system	technical requirements	low	70M€ to 150M€ investment costs OR 27.5M€ to 75M€ operational costs OR 18 months to 36 months delay OR functionality not completely met, including no time or place differentiation	2	4	8	Operation	(a) Use proven technology and systems that have demonstrated capability to meet performance criteria. (b) Introduce monitoring and verification processes (e.g. regular spot manual checks upstream/downstream of RES deployment) in order to audit and verify that the actual level violations on that link are being being detected by the ES. (c) Specify remote monitoring and fault alerts processes as an integral part of the RES delivery (d) RES procurement should include monitoring and maintenance response criteria	private
6	Planning stage identifies that the enforcement operating costs are too high relative to the income of the road charging scheme (i.e. fails business case)	policy	medium	over 150M€ investment costs OR over 75M€/year operational costs OR over 36 months delay OR over 50% of KMs not met	3	5	15	Business Case	(a) Adjust output performance criteria (e.g. frequency of vehicle checking or percentage violation capture). That is minimise the number of RES and thus the BO violation processing resource. (b) Change deployment policy to reduce costs. For example, use more fixed RES (i.e. automated) rather than transportable RES (i.e. labour intensive) equipment thus reducing operating costs at the expense of implementation costs.	public
7	Planning stage identifies that the enforcement implementation costs are too high relative to the budget (i.e. fails business case)	policy	low	over 150M€ investment costs OR over 75M€/year operational costs OR over 36 months delay OR over 50% of KMs not met	2	5	10	Business Case	(a) Adjust output performance criteria (e.g. frequency of vehicle checking or percentage violation capture). That is minimise the number of RES required to be deployed on the network. (b) Change deployment policy to reduce costs. For example, use more transportable RES (i.e. labour intensive) rather than fixed RES (i.e. automated) equipment thus reducing implementation costs but increasing operating costs.	public

8	Suppliers quotations are higher than estimated investment and operation costs	procurement costs	high	over 150M€ investment costs OR over 75M€/year operational costs OR over 36 months delay OR over 50% of KMs not met	4	5	20	Business Case	(a) Implement procurment strategy that transfers some or all of budget management risk to the suppliers (e.g. request budget constrained/managed proposals from supply consortia) (b) Adjust output performance criteria to reduce scope (i.e. to reduce deployment quantities). (c) If practicable possible, adjust fixed/transportable deployment balance (see risks 6 & 7) to match implementation and opetaional budget limitations.	public
9	Specified KPIs are focussed on technology/equipment performance and do not deliver the required outputs. In addition, the specified criteria causes an increase in cost without delivering a corresponding increase in quality of performance.	technical requirements	medium	70M€ to 150M€ investment costs OR 27.5M€ to 75M€ operational costs OR 18 months to 36 months delay OR functionality not completely met, including no time or place differentiation	3	4	12	Planning / Preparation	(a) Focus performance requirements on reasonable, practicable and acceptable outputs (b) Review and develop performance requirements with supplier/consortia to optimise performance and cost-effectiveness as the scheme develops.	public
10	Fixed enforcement is not effectively deployed. That is, costs are sunk into fixed infrastructure which does not deliver the required output performance and cannot be cost effectively re-deployed.	procurement costs	very low	0 to 10M€ investment costs OR up to 7.5M€/year operational costs OR <4 months delay OR functionality but no fine mesh place differentiation	1	1	1	Planning / Preparation	(a) Agree with supplier designers, criteria that define an efficient and effective site (b) Undertake adequate analysis and modelling of the traffic and road network in order to gain certainty (i.e. reduce risk) that fixed deployment sites will be cost effective (i.e. meet pre-defined criteria). (c) Engage competent/experienced designers and focus on delivery of output.	public
11	Proportion of OUS is greater than anticipated due to the pricing policy. That is the OUS is or is perceived to be more cost-effective to the individual than investing in an OBU.	policy	low	over 150M€ investment costs OR over 75M€/year operational costs OR over 36 months delay OR over 50% of KMs not met	2	5	10	Operation	(a) When developing a pricing strategy undertake appropriate financial modelling of the potential economic benefits in using the OBU system rather than the OUS (b) Consider subsidised scheme for the provision of OBUs (c) Implement policy/legislation to make OBUs mandatory for all NL registered vehicles (d) Implement policy/legislation to make it mandatory to supply and fit all new vehicles in NL with integral OBUs (e) Implement policy/legislation to restrict the number of days that an NL registered vehicle can use the OUS.	

12	Effective enforcement of the KMP scheme, particularly the OUS for foreign visitors, necessitates the need for enforcement infrastructure at borders. It is assumed that this deployment is not desireable, since it may give the perception of monitoing entry and exit to and from the country.	policy	high	30M€ to 70M€ investment costs OR 12.5M€/year to 27.5M€ operational costs OR 9 to 18 months delay OR functionality and place differentiation but no time	4	3	12	Planning / Preparation	(a) Implement less overt monitoring and enforcement infrastructure at borders (e.g. where possible post mounted rather than gantries) (b) Implement ES as far away from border as possible on upstream/downstream link (i.e. before/after border) (c) Undertake traffic pattern analysis to strategically place ES for border traffic away from border crossings	public
13	Charging policy based on tariffs for different vehicle class increases enforcement complexity (e.g. motorcycles, trailers/ caravans)	policy	low	70M€ to 150M€ investment costs OR 27.5M€ to 75M€ operational costs OR 18 months to 36 months delay OR functionality not completely met, including no time or place differentiation	2	4	8	Planning / Preparation	(a) Decouple vehicle class enforcement from the KMP system (i.e. Police enforce correct vehicle class, as existing vehicle tax) (b) Strategically target potential class violators using manual checks, agressively during early phases of KMP introduction, to deter and reduce the need for automatic checks at RES (c) Strategically deploy vehicle classification check RES at a reduced proportion of RES sites to minimise costs.	public