EFKON Group

Anders betalen voor mobiliteit

“Cost Reduction Via Considering System Alternatives Which do Not Meet All of the 24 Requirements”

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1. Executive Summary and Introduction

After a creative phase for generating ideas and alternatives, as well as scrutinizing the NL situation with regard to requirements that cannot be ignored, there were 9 scenarios selected and described. In a subsequent conference call with the ministry, the following scenarios were identified as attractive for more detailed analysis (Other scenarios are described at the end of this report):

Scenario 1: People make declarations based on the odometer reading only. Leaving/entering the NL is put in a logbook, which is verified by a low end GPS/DSRC OBU.

Scenario 3: cars are equipped with an ultra low cost infrared transmitter. 20,000 solar powered receive-only beacons are spread around the country. The back office collects all locations and performs a least cost route calculation.

Scenario 1+3: the logbook (1) is checked by the infrared beacons (3)

Scenario 6: GSM phones receive tower IDs also if no call is made. This can be utilized to build a reasonably dense system

Scenario 8: A GPS based OBU records all movements and has the charging algorithms and border/road network data inside. Time based charging is also possible.

The risk analysis shows that it is essential to

(a) work with the *EU Commission* to accept *alternative systems, which save billions*
(b) strive for the most *user-friendly* design possible.

The payment system is identical for all scenarios where an OBU is specified; there is no optimization potential between any scenarios on this side. The same is true for the enforcement system, which may use slightly different equipment but has the same cost.

Scenario	Invest	Operation	Deprec.	Total 10Y
1-Logbook with GPS Checker	1.066	247	155	5.086
3-Infrared Continual Broadcast, Solar Powered Receivers	570	137	87	2.811
1+3-Logbook with Infrared Continual Broadcast	514	160	79	2.904
6-GSM Phone Reports Cell ID	661	478	99	6.427
8-GPS/GSM plus Infrared Data Download Infrastructure	1.309	250	189	5.693

As can be seen from the table, the *price wise* most attractive solution is *scenario 3*. Scenario 1+3 is slightly more expensive but offers loophole free charging and works with fewer beacons than 3 alone.

Scenario 8 is the one, which to the furthest extent fulfils the *24 requirements* of the original request.

The following chapters and attachments deal with the detailed description and analysis of all scenarios.

2. Scenario “1”, A Logbook with a GPS Based Validator

2.1. System overview

The basis of the system is the odometer reading, which will be declared periodically. In order to record borders crossing, this event has to be entered into a logbook by mileage, date and border crossing point name. For the first log start mileage (odometer reading), date, Points of Sale (POS) location, number plate and owner/driver, have to be entered.

In certain time intervals (e.g. once a month or in a quarter) every customer has to report the border crossings and driven mileage (current odometer reading or last logbook entry) to the toll service provider.

Additionally, every car will be equipped with an OBU to be able to verify the logbook entries. The OBU can be installed on the windscreen and connected to power within 20 minutes. Such fixed installation is recommended for NL residents and frequent foreign users.

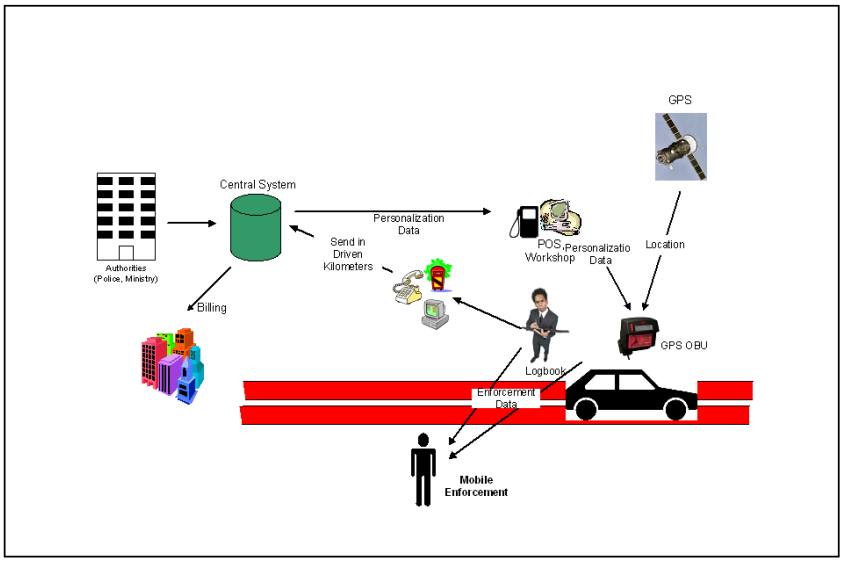
Alternatively, particularly for occasional foreign users, the OBU can be issued at the border POS, installed on the windscreen and power can be connected via a cigarette lighter within 30 seconds.

Enforcement is realized manually by logbook checking and/or OBU reading. For free flow enforcement it is necessary to equip the OBU additionally with IR or µW DSRC.

The Central System, responsible to manage the whole system, receives customer reports and enforcement data to charge users and violators. The CS defines charging models and tariffs and administrates OBUs and SW.

Domestic users obtain the OBU pre-initialized. The OBU can be plugged into the 12V cigarette lighter, or later on, connected to the mains by an authorized mechanic.

Points of Sale, located at border posts, e.g. petrol stations and workshops, offer foreign drivers to become a customer by means of a personalized logbook and OBU.



2.2. Key Elements and Relationships

2.2.1. Customer

The system is levying charges from all vehicles with a number plate. The customer is the owner of the vehicle who can be represented by the vehicle driver. The customer is described by a data set consisting of the number plate and an account with granted debit or pre-paid credit. Vehicles can be charged depending on their class (e.g. weight, environmental characteristics, etc.).

2.2.2. OBU

The OBU is equipped with a GPS receiver, display, a simple keyboard and a DSRC communication interface (IR or microwave DSRC), optionally also a smart card reader can be provided. The GPS is used to track the vehicle's route and to count the kilometers. The OBU contains the geographic outline of the NL area to automatically detect NL border crossings.

Several dedicated counters, event and violation logs store diagnostic and manipulation attempt data.

A power management detects vehicle activities according to power levels (starting, battery and generator level) and manages sleep and stand-by modes.

2.2.3. Charging models

Only a travel distance (km) based charging model is applicable. The charge can depend on the vehicle class, but not on place on time.

2.2.4. Enforcement

Enforcement is performed by reading the OBU information via an Infrared or Microwave DSRC link. The OBU information is sent to the back office for analysis and consistency checks with declaration data. The database may also reside at the roadside to produce faster decisions, but it is considered impractical. Vehicles with problems will be blacklisted.

Mobile patrols will be equipped with readers that allow verifying the proper function of the OBU. If there is a problem, or no OBU, or a blacklisted vehicle shows up, the vehicle will be stopped and enforcement staff manually reads the logbook. For verification, the OBU stored data is read out at the OBU display or by means of a notebook computer to compare OBU border crossing logs with manual kilometers declaration in the logbook.

2.2.5. Central system

Beyond the typical functions of a central system (like billing, enforcement, call center, OBU inventorizing, interfaces to police, borders, banks, maintenance operations management tools etc.) there are some particular functions required:

- Analysis tools for credibility of declarations
- Tools for fast entry of declarations from postcards

- IVR allowing to make a declaration via pin pad

2.2.6. POS

The POS is the same for all scenarios and has been independently optimized in 8 and 9. The POS sells logbooks and personalizes and hands out OBUs. Some places additionally offer fixed OBU installation. All POS' can handle cash and credit cards to open customer accounts. POS systems are permanently connected to CS.

2.3. Key functions/processes

2.3.1. Buying/Hiring a Paper Logbook and OBU

The logbook is conventional paper ware. The first logbook is handed out together with the OBU, when the customer first time registers for the service.

OBUs should be installed by a workshop. The OBUs remains in the vehicle for the complete life cycle.

Occasional foreign users can temporarily lease reusable OBUs. No procedural differences are made between buying and hiring.

2.3.2. Personalization & Installation

During sale of logbooks, staff at POS fills out start mileage (odometer reading), date, POS-ID, number plate and customer related data and stores it in parallel in the POS system for transmission to the CS.

When the logbook is obtained for the first time, the OBU has to be handed out and personalized. In this case the customer data is transmitted into the OBU via an interface. Domestic users receive the OBU pre-initialized.

Foreign users pay the minimum (initial) charge and a rental fee and attach the OBU to the windscreen with Velcro or vacuum cups and plugs the power cable into the cigarette lighter. If the customer wishes a fixed OBU installation he can visit a workshop.

2.3.3. Driving & Recording

While driving without any border crossings the driver has not to execute any special activities. Just once a month or a quarter driven kilometers have to be declared.

The OBU reads GPS location data, calculates the driven distance and periodically generates enforcement reports. Some additional data is recorded and logged:

- Time & position of border crossing,
- Time & position of lost and recovering GPS signal
- Time & position of power off/on and fraud activities.

2.3.4. Leaving and Entering NL

Every time the customer crosses the border he shall enter location, i.e. border crossing point, date and mileage (odometer reading) of this event in the logbook.

The OBU knows the geographic outline of the NL area including the position of all 350 border crossings. The OBU uses GPS data to automatically recognize border-crossing situations. These events are stored for verification with manually made customer declarations.

2.3.5. Data transfer

The customer periodically declares his driven distances by date of declaration, actual mileage, and distances driven within NL and abroad since last declaration and number of border crossings by different possibilities.

1. Electronically via CS Internet portal
2. Orally declaration via a CS call center
3. By filling out paper logbook coupons, which are then sent in by postal service to the CS.

2.3.6. Enforcement

Four levels of enforcement are possible:

Level 1: Time by time, triggered by CS or OBU, the user is asked to read out a signed code from the OBU, which represents the traveled distances, and to transfer it to the CS in his preferred way.

Level 2: If an IR (or Microwave if gantry based is OK) communication interface is implemented, a standard combined IR/video/laser enforcement with number plate recognition is able to

- Read out the prepared enforcement data set,
- Detect non-responders/non-payers.

Level 3: With an IR communication interface being implemented, mobile enforcement is additionally able to immediately react to fraud indications and non-responders/non-payers.

Level 4: In case of suspicion the regarding OBU/vehicle will be checked manually as soon as possible by enforcement personnel or a reading device (smart card reader option) will be sent to the customer to read out the data and send it back to CS.

2.3.7. Payment

Customers can pre-pay (credit) and post-pay (debit).

In pre-pay mode, at POS a customer can buy a number of kilometers together with the logbook. In post-pay mode frequent customer can pay cyclically via a bank account for a

fixed amount with a monthly/quarterly/yearly balance, similar to the rent and operating costs of a fleet.

2.3.8. Re-Use for Future System Extensions

If the OBU is equipped with IR or microwave interface a migration to scenario 8 (charging model 1) is possible by simply changing the OBU SW and setting up the necessary infrastructure.

If the OBU is additionally equipped with sufficient memory (about 300kB) to store 10.000 border crossing events, then the OBU is re-usable for a road selective tolling system, similar to the German Toll-Collect system, able to handle up to 3.000 virtual tolling points. In this case only an OBU SW upgrade would be necessary as well.

In all cases limitations in the security level because of absence of a trusted element will remain. Here, to use application embedded signature functionality would be the recommend solution.

2.3.9. Exceptions

2.3.9.1. Fraudulent Manipulation

The OBU is manipulation proof. Case unclosing is detected and registered. Invasion attempts are transmitted to CS via enforcement level 1-3 activities.

2.3.9.2. No GPS coverage

In case of restricted GPS coverage, the shortest distance between the last and newest valid location info is used for charging. This way, the user can never be overcharged. Alternatively, if location information is transmitted to the CS (event data log), a digital map can be used, to calculate the shortest possible road distance between these two locations. Additional the general availability of GPS signals in this area and time will be checked. In case of abnormal distortions enforcement levels 1 or 4 will be activated.

2.3.9.3. Passive Vehicle Transportation

Passive transportation is declared by paper logbook.

2.3.9.4. Satellite mismatch

In case of satellite mismatch without indication a systematic mismatch in position sensing of up to 100km is possible. In this case the customer declaration must be accepted without verification.

3. Scenario 3, an Infrared Sender with Solar Powered Beacons

3.1. System overview

Domestic cars get a thumbnail-size infrared button, which is connected to ignition and is continually sending a digitally signed fraud proof identification.

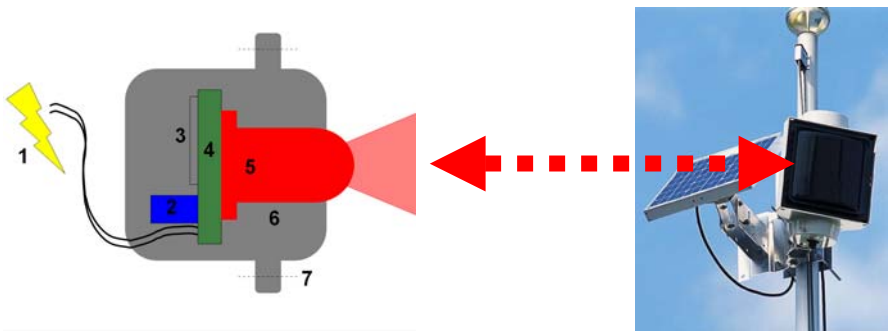
Receive-only beacons are deployed along the road and pick up the IDs and send them to the back office, which performs a cheapest route calculation. The receivers are solar powered and can be side-mounted on house-walls, traffic lights, lampposts, electricity masts etc.

The OBU has a crypto controller, an infrared transmitter, infrared transparent encapsulation with easy mounting facilities, and 1.5 m wire to connect anywhere under the bonnet. For the initial rollout, every device will be supplied with suction cup mounting and a 12V plug, both of which will be discarded when permanently mounted in the vehicle. The OBU will be like a small black button behind the grill inside the motor compartment, mounted such that it has line of sight to the roadside and enforcement facilities."

The roadside receivers are equipped with a GPRS link, which is sufficient to transmit the (encrypted) ID's to the central system. The receivers only record the serial numbers, which are continually broadcasted by the OBU. The receivers are very low in energy and solar powered and can easily be deployed on any house wall, existing pole or traffic sign. They are mass produced and very cheap.

Domestic users obtain the OBU pre-initialized. The OBU can be plugged into the 12V cigarette lighter, or later on, connected to the mains by an authorized mechanic.

Points of Sale, located at border posts, e.g. petrol stations and workshops, offer the OBU to foreign drivers in the suction cup version with a 12/24V power plug.



1. Connect to Ignition 2. Quartz for Timing 3. Secure Smart Card Type Crypto Chip 4. PCB Carrier 5. Infrared Diode to Send out Pulses 6. Enclosure 7. Mounting (Bolts, Suction Cups)

3.2. Key Elements and Relationships

3.2.1. Customer

The system is levying charges from all vehicles with a number plate. The customer is the owner of the vehicle who can be represented by the vehicle driver. The customer is described by a data set consisting of the number plate and an account with granted debit or pre-paid credit. Vehicles can be charged depending on their class (e.g. weight, environmental characteristics, etc.).

3.2.2. OBU

The OBU is mounted in the vehicle windscreen or grille and continually broadcasts its information. To prevent any replay attacks, a counter is included which will be included in the digital signature. There will probably be 5-10 universal mounting hinges for attaching the device in the motor compartment of many different vehicles.

3.2.3. Charging models

Vehicles can be charged by time and place. A typical model would be to use a least cost route calculation, plus a surcharge for hitting particular strategic points. Alternatively (performed by the central system) only a travel distance (km) based charging model is applicable between pay points.

The charge can depend on the vehicle class, and to a lesser extent on place and time depending on where the beacons are placed. The place and time dependency would be included in the least cost calculation of the central system.

3.2.4. Central system

Beyond the typical functions of a central system (like billing, enforcement, call center, OBU inventorizing, interfaces to police, borders, banks, maintenance operations management tools etc.) there are some particular functions required:

- Least cost route calculation algorithms
- Enforcement data generation from analysis of strange patterns
- Loophole identifier, where calculations can be made where how many people could be charged in addition if another beacon was placed.

3.2.5. POS

The POS is the same for all scenarios and has been independently optimized in 8 and 9. The POS sells the suction cup type OBU, personalizes and hands them out. Some places additionally offer fixed OBU installation right away. All POS' can handle cash and credit cards to open customer accounts. POS systems are permanently connected to CS.

3.3. Key functions/processes

3.3.1. Buying/Hiring an Infrared Button OBU

To the domestic user, the OBU is pre-initialized and sent to the customer by mail. The user may attach the OBU using the included suction cups, or the OBU could be installed by a workshop. Once installed, the OBUs remain in the vehicle for the complete life cycle.

3.3.2. Driving & Recording

No activities are required by the customer who may obtain information on his reading via several channels, but not by mailed statement unless he pays for it.

3.3.3. Leaving and Entering NL

There are no beacons outside NL, and if there were they would properly report into a different service. The distance between exit and re-entry will not be recorded as driven on Dutch territory, even if the vehicle theoretically might have driven from A to B right inside the border. If this is a frequent problem, additional beacons will be added to prevent “tunneling” the system.

3.3.4. Data transfer

Data are transferred from the receiving beacons to the back office via GPRS.

3.3.5. Enforcement

Stationary gantries will detect close to 100% of all vehicles, verify the IDs with the calculated number plate and measured class, and compare the ID to the list of insufficiently funded accounts. If there is no signal, there is also a violation taking place.

Mobile patrols will be able to "listen" to the devices and check the integrity, the vehicle type/class, and the presence of the sending device. If there is no signal, or if the integrity of the signal is violated, the car is stopped.

The mobile patrol will also have the possibility to wait behind the charging point and verify if the charging point receiver has received the OBU ID. Otherwise, someone may intercept communication of the OBU by e.g. deactivating the device at the charge point, then turning it on again.

Vehicles with problems will be blacklisted and can easily be spotted and caught by the mobile enforcement personnel.

Vehicles with illogical patterns will be investigated. Example: Someone travels from A to C but was not seen in B. Yet, the only way to be in C at that speed is via B. The offender might have avoided registration in by B to escape the local / time surcharge. Or someone always gets recorded in one direction but never on his way back.

3.3.6. Payment

Domestic users will be charged automatically. They will be able to view their account, and, if having given permission, also their track, on the Internet, via SMS, or the call center. They may also actively ask for a mailed statement, but no automatic repeat mailings (too expensive or has to pay for it). The track will normally not be stored, just the last location and the money consumed so far.

For foreign users, the ID can also be linked to a credit card which will perform automatic refill to € 50 if the balance falls below € 5. This is done via an 0800-number and the call center.

The OBU can also be mailed to users long before the journey if they register in any of the channels and make a down payment."

3.3.7. Re-Use for Future System Extensions

The enforcement system, a large extent of the back office system and the field payment service infrastructure can be re-used. It will not be possible to re-use the OBUs and beacons in case of a wish to upgrade to the full GPS/GSM system.

3.3.8. Exceptions

3.3.8.1. Fraudulent Manipulation

The OBU is built in a tamperproof enclosure. Furthermore, the security of the crypto controller chip is de-facto unbreakable. A manipulation of the device can be excluded.

Removal of the OBU will be detected by the enforcement system. If there is no OBU, there is no signal.

OBUs are only given out against an ID, not anonymous. Therefore everybody would just hurt himself.

The attempt to use an OBU from someone else's car would require the same type of vehicle, the same number plate, and it would be detected immediately as soon as the person reports the missing device. The incentive to do so is high since someone else is consuming his km and money!

3.3.8.2. Passive Vehicle Transportation

If the ignition is turned off, there will be no recording. It is a matter of definition to say "You are liable to tolls as soon as your ignition is turned on", instead of saying, "as soon as you are driving" to prevent occasions where an ignition is turned on while the car is towed.

4. Scenario "1+3", a Logbook Plus Infrared Sender

This scenario is a combination of scenarios 1 (Logbook) and scenario 3 (Infrared send only button in grille, which is installed instead of the GPS+HMI+DSRC unit of Scenario 1).

The advantage is that it is loophole free with regard to km (which are via the odometer and the logbook as of scenario 1), and requires less beacons than scenario 3 – a more realistic rollout scenario than 1 and 3 alone.

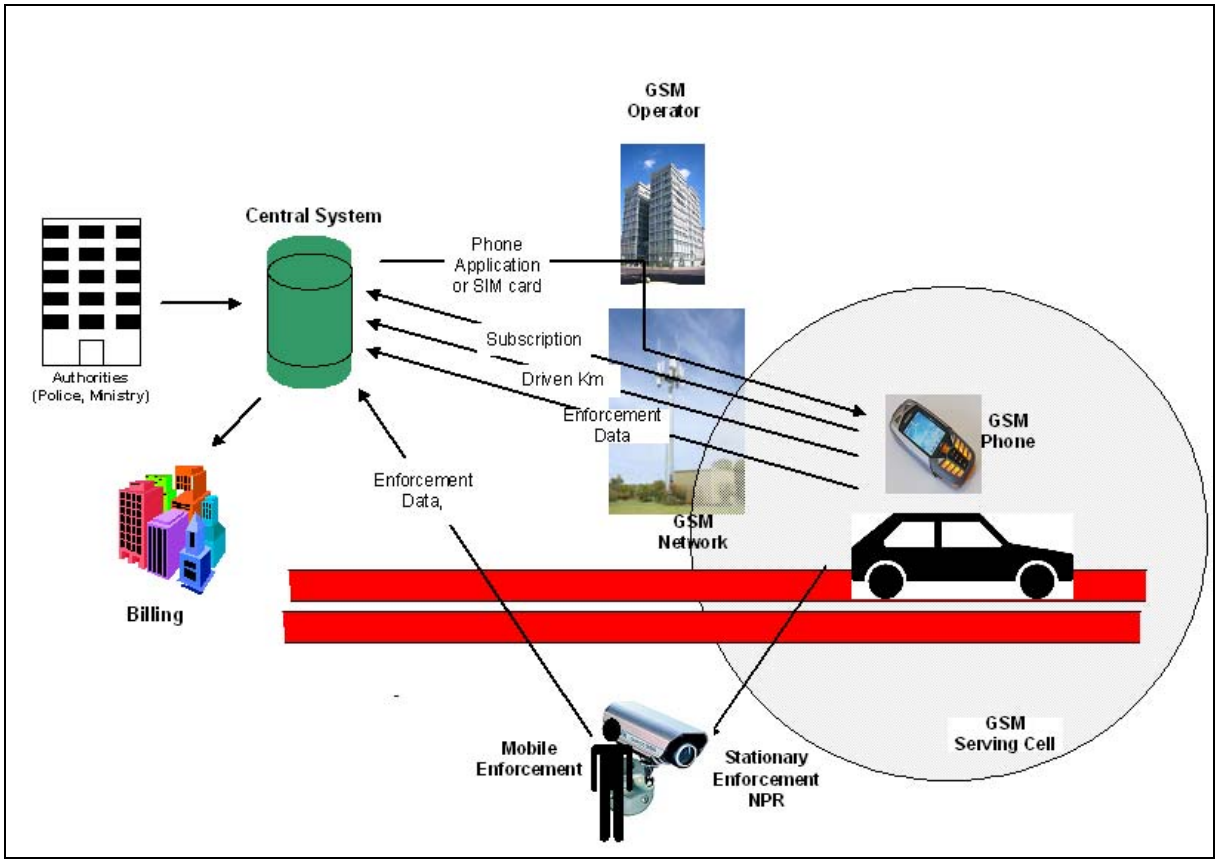
There is also the possibility to produce time and place dependency, since the beacons can be used for both generation of enforcement input data and a point based or least cost calculation based surcharge.

In addition, there will be close to 100% recognition of vehicles in enforcement operations as the send-only information produces a very good dummy declaration and can easily be compared with the actual paper declarations made in the logbook.

When leaving the country, the logbook entry can only be consistent with the automatically recorded point and time of exit and re-entry.

5. Scenario “6” - GSM Cell ID Recording by Mobile Phone

5.1. System overview - Key Infrastructure



The idea is to use a mobile phone application, which identifies the location of the mobile phone by the current serving cell. The serving GSM cell is the cell with the best current reception conditions. It is pre-selected in idle mode; i.e., when the phone does not execute any communication service. The mobile phone uses this cell, if it sets up an active communication. If the phone moves - together with the vehicle – the phone permanently updates the appropriate serving cell (cell reselection and hand-over process), whether it is executing a call or not. This consecutive set of serving cells, described by their Cell ID (CID) is transmitted to the Central System (CS) together with some other information time by time. In the CS, knowing the geographic position of the cells and the road network layout, a travel distance is calculated.

The phone application can be developed using the SIM Application Toolkit (mobile communication standard GSM 11.14). This toolkit allows downloading a specific application, e.g. a tolling application, into a mobile phone SIM via the GSM Air Interface. Alternatively, a phone with SIM card containing a preinstalled tolling application can be handed out to the user. SIM Toolkit applications allow the adding of specific dialogs, i.e. menu items and

keyboard input reactions, to a normal phone. Alternatively, Java based mobile applications can be used as a technology platform.
From the technical point of view, such solutions are well established and can be rated feasible. Existing mobile banking and payment solutions or quick Internet access keys use the same technology.
The advantage of such system is, that no special Road Side or In-Vehicle Equipment has to be installed. A common GSM network feature – the serving cell selection - is used to locate the vehicle and calculate the distance traveled. Furthermore, the tolling of any kind of vehicles, including motorcycles, where the installation of special In-Vehicle Equipment can be a problem, can easily be solved by a mobile phone.

5.2. Key components

5.2.1. The Customer

The system is levying charges from all vehicles with a number plate. The customer is the owner of the vehicle who can be represented by the vehicle driver. The customer is described by a data set consisting of the number plate, and an account with granted debit or pre-paid credit. Vehicles can be charged depending on their class (e.g. weight, environmental characteristics, etc.). More details about payment are described in the paragraph “Example Payment Systems”.

5.3. Generic Characteristics of In-Vehicle Equipment - Distance Recording

5.3.1. In-Vehicle Equipment - The Phone

The In-vehicle Equipment is a GSM phone that supports the SIM Toolkit or the Java 2 Micro Edition (J2ME) execution environment. Only the tolling application is executed on the phone.
An especially branded phone with functionality reduced to tolling can be used. The phone can be fix installed in the vehicle and connected to the car’s power supply, e.g. by lighter socket or special cabling. Due to the fact, that the phone is using the car power supply, it does not need a battery pack. This will further reduce the phone cost. The latter is the version that has been used to cost the system in the detailed costing spreadsheets.

The use of service user owned phones is also imaginable, but no discussed here in detail.

5.3.1.1. Value Added Services

A value added service, e.g. “Emergency Call” with location provision in the accuracy of GSM cells can be provided by such phones.

Normal phone use, e.g. with reduced tariffs, could be an additional service provided by the network and tolling operator to the user on request to co-finance the equipment.

5.3.1.2. Starting and Stopping the Tolling Process

It is assumed, that the road user is registered in the CS (see paragraph “Installation and Registration of In-Vehicle Equipment”) and a tolling application runs on his phone. In the moment the road user enters the vehicle, he has to declare this to the CS by executing a special activity with his mobile phone or a specific phone key. This can be done by e.g.

selecting a “Start Tolling” item in a special phone menu. From this time on, the movement of the phone is bound to a moving vehicle. When the journey ends, and the user wants to leave the vehicle, he selects and quits a “Stop Tolling” dialogue on the phone.

5.3.1.3. Passive Vehicle Transportation

If the vehicle is moved by other means, e.g. carried on a train, ferry etc., the user has to declare “Passive Transportation” on his mobile phone. The phone can be switched off afterwards. If the passive journey ends, the user has to declare “Start Tolling”. Explicit declaration of passive movement helps to support plausibility checking of odometer reading against kilometers charged. When the phone application is switched to „Passive Transportation”, all currently stored cell data is transferred to the CS.

5.3.1.4. Driving Abroad - Leaving and Entering NL

If the vehicle is leaving NL the user has to declare “Driving Abroad” on his mobile phone. The mobile will not send location information to the CS until driving abroad. The mobile detects this situation by being roamed to a foreign network. If the user re-enters NL, the user has to declare “Start Tolling”. Explicit declaration of traveling abroad helps to support plausibility checking of odometer reading against kilometers charged.

5.3.1.5. Distance Calculation and Data Transfer

The traveled distance is calculated at the CS side. The phone just sends the vehicle position to the CS. To determine its position, the application reads and stores the Serving Cell ID (CID) and Location Area ID (LAI), which define a network unique number. These parameters are permanently available in the phone, if it is registered in the GSM network. No active communication has to be executed by the phone (idle mode), i.e. no communication cost is generated to collect the CID and LAI. Of course, when the phone is making a call etc., the CID and LAI information is available as well. After a certain time or if a predefined number of CIDs was stored, the phone sets up a GSM communication (e.g. SMS, data call or GPRS service) and transmits a set of CIDs and LAIs to the CS. When the phone application is switched to “Stop Tolling”, all currently available cell data is transferred to the CS.
The traveled distance is calculated in the CS (see paragraph “Central System”).

For plausibility check and enforcement reasons, a time stamp for the first contained CID can be included. Time by time, the CS can interrogate the tolling service user to transmit the current odometer reading.

The GSM security standard GSM 3.48 „Security Mechanisms for the SIM application toolkit“ solves security issues for SIM toolkit applications.

5.3.1.6. Odometer Reading Interrogation

The odometer reading difference of the vehicle from the point of registration of the vehicle to the service and the charged travel distances shall show a certain correlation. To use this fact for enforcement reasons, the CS can interrogate the tolling phone. In this case, the user has to type in the current odometer reading into the phone for transmission to the CS. In

particular, status changes like passive transportation and driving abroad can be verified that way.

5.3.1.7. Credit Expiration Information and Interrogation

If credit of a pre-pay user is near to expiration, i.e. it reaches a certain “low water mark”; the CS sends a corresponding information to the mobile phone. The phone displays an appropriate text to warn the tolling service user. The user has to make sure, that his credit is not fully expiring.
Vice versa, the user can interrogate the tolling centre about credit/debit status or current tariffs at any time. A corresponding interrogation/information message pair will be exchanged between the phone and the tolling centre.

5.3.1.8. Some Accuracy Estimations

The GSM networks in NL operate about 7000 cells with an average cell range of about 950 meters. These cells are not equally distributed over the country and density is higher in some areas than in others. The cell distribution reflects mainly the distribution of the population and takes into account the road network system.

See http://client338.lab.telin.nl:8080/wasp/jsp/CellStats.jsp for more information.

Not knowing the real distribution of GSM cells the location accuracy at least in higher populated areas and along the road network can be estimated to be in the range of 1-2 km. Special cases, e.g. system behavior in part of the road network with less cell density has to be studied in more detail

5.3.1.9. Issues for Further Investigation

- Charging of service users, usually moving within the boundaries of a cell/
- Charging of service users, usually moving small distances at the boundary of two cells
- Reduced GSM coverage in tunnels etc.

Odometer interrogation can be a solution for these problems. If the CS detects that the vehicle does nearly no change its position, it asks more frequently for odometer reading transmission.

5.4. Installation and Registration of In-Vehicle Equipment

5.4.1. Registration

The user has to see a Point of Sale (POS) to be registered as service user. Staff at POS registers the phone number and IMSI, number plate, current odometer reading, vehicle related data, owner identification data and bank account (for post-pay clients) in the CS.

If the service user’s own phones are used, more than one phone can be registered per service user, to allow the car to be operated by several persons, which all can use their own phones.

5.4.2. Obtaining the In-Vehicle Equipment

At the POS, the phone is handed out to the user and the number plate is stored in the phone.

The user itself can install the phone in his car by just connecting it to cigarette lighter. For fix installation, any car service station can easily connect the phone to the car power supply.

5.4.3. Occasional and Foreign Users

Occasional users can temporarily lease a phone without fix installation, i.e. the phone is connected to the lighter socket. Frequent foreign users, e.g. the about 15.000 German commuters per day can be equipped with temporarily leased or fix mounted phones. All registration procedures will remain unchanged.

5.5. Central System

The CS receives CID and LAI information data sets, including the number plate, from the tolling enabled mobile phones via the GSM Air Interface. At CS side, a GIS system is used to calculate a journey that fits to the GSM cells passed. As a first approach, the shortest possible road network distance between two cells (i.e. position of the BTS) can be used for distance and charge calculation. More sophisticated algorithms are imaginable.

5.6. Payment and Invoicing

Payment models by bank account or pre-pay models mainly identical to what is described in paragraph “Example Payment Systems”.

5.7. Enforcement

A simple enforcement solution can be implemented by checking the status of the tolling application phone via interrogation in the CS. Enforcement personnel can sent the number plate of a passing vehicle to the CS to check, if the phone bound to vehicle is in active state.
Furthermore, in the case of incorrect charging, or manipulation or fraud is assumed, the user can be informed to see a POS for investigation.
A connection can be established to the phone to read out diagnostic data without user intervention.

Automatic Number Plate Recognition (ANPR) solutions work as described for all other scenarios, described as general enforcement solutions in paragraph “Enforcement”.

5.8. Time and Location Dependent Tolling

Time and location dependent tolling is possible in the limits of the corresponding data resolution. The time interval for a set of cells depends on the cruising speed and can vary considerably. Location can be detected only with the accuracy of the serving cell dimensions, i.e. differentiation within a cell is impossible. Anyway, appearance in greater central areas, e.g. the inner city of a town, can be detected, because cells range is much smaller there. With the proposed scenario, corresponding charging schemes, e.g. a congestion charge, can be implemented.

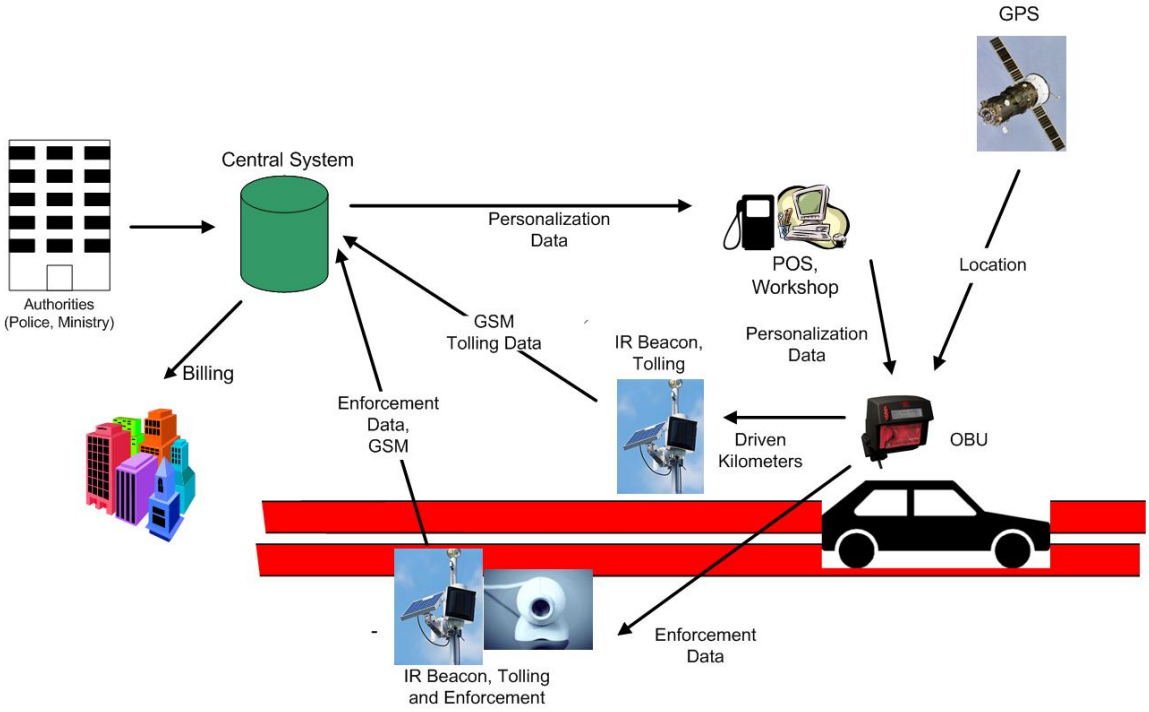
5.9. Migration to Complete System

5.9.1. Reuse at In-Vehicle Equipment Side

Migration to a complete system including a GSM mobile communication device is easily possible. Communication infrastructure at the CS side can be preserved. If distance calculation is executed in the Central System, the main task distribution between In-Vehicle Equipment and CS can be re-used. If vehicle localization is based on other principles, e.g. GPRS or DSRC beacons, the distance calculation SW module has to be modified.

6. Scenario “8”: GPS/ ISO TC 204 CALM Infrared Device

6.1. System overview



Ten million users with a pre- or post-paid account drive with OBU-equipped vehicles in NL. OBUs are simultaneously recording every km driven within the area of NL. The OBU is personalized on issuing.

The area of NL is equipped with about 5.000 IR beacons, which transfer charge data from vehicles to the Central System. Beacons are placed in strategic locations and borders. Some of these beacons are part of the enforcement system, which is additionally equipped with units for vehicle detection, classification and number plate recognition. CS communication of the beacons is realized by fixed line (at enforcement locations) or via GPRS communications on all other beacons. Additionally, similarly equipped mobile enforcement helps to identify violators.

The Central System, responsible to manage the whole system, receives vehicle charge data and enforcement data to charge users and violators. The CS defines charging models and tariffs, controls data streams for money transactions, and administers OBUs and SW.

The OBU can be installed on the windscreen and connected to power within 20 minutes. Fixed installation is recommended for NL residents and frequent foreign users, e.g. using the example process described in 8.1.2 and thereafter.

For occasional foreign users, the OBU can be installed on the windscreen and power can be connected via the cigarette lighter within 30 seconds according to 8.1.3.

6.2. Key components

6.2.1. Customer = Vehicle & Account

The system is levying charges from all vehicles with a number plate. The customer is the owner of the vehicle who can be represented by the vehicle driver. The customer is described by a data set consisting of the number plate, and an account with granted debit or pre-paid credit. Vehicles can be charged depending on their class (e.g. weight, environmental characteristics, etc.).

Please see the processes defined in chapter 9 for OBU issuing and payment.

6.2.2. OBU

There is only one type of OBU, equipped with

- CPU,
- Memory,
- Trusted element,
- Power management,
- GPS / Galileo,
- Display,
- Keyboard,
- IR communication interface,
- Database and application.

The OBU contains several dedicated counters, event and violation logs, the tolling SW application and a database.

A trusted element grants signed communication, encryption and decryption for data security.
A power management detects vehicle activities according to power levels (starting, battery and generator level) and manages sleep and stand-by modes.

The GPS service is used to track the vehicle routes and to count driven kilometers.

The database contains vehicle related data, tariff models and any charging model.
The tolling application counts kilometers, logs events, recognizes road segments and virtual toll plazas and generates charging data sets.

An optional smart card interface could be added to transfer Data to the CS for vehicles never passing any of the beacons.

6.2.2.1. Explanation of OBU Price

The cost of the OBU can be as low as EUR 50 as shown in the following list (we used 70 in the detail costing):

At this high quantity, the breakdown of the OBU price is as such:

- EUR 12 for the segregated GPS functionality
- EUR 8 for the bi-directional infrared functionality
- EUR 10 for the required processor capacity, which would ideally be achieved by talking to the maker of the GPS module to modify their code. The application would require 512k of memory, typically available on such processors.
- EUR 4 for power management and connectors
- EUR 1 for the service interface
- EUR 1 for case
- EUR 2 for HMI (buttons, LED, beep)
- EUR 3 for the circuit board and assembly/testing
- EUR 3 for mass storage and history log (50Mbyte flash memory)
- EUR 6 for contingency, other small parts, quality rejection and warranty losses, internal logistics, etc.

The OBU has the capacity to work as a thin client or a fat client – there is no difference in cost. In fat client mode, the tariff calculation would reside in the OBU, together with the information about borders, city outlines or other zones of higher charging, motorway virtual toll plazas, etc. Download beacons would also be placed such that they would identify certain road sections where GPS would not be precise enough. Where the required precision can not be guaranteed, the lowest applicable tariff would be used. The OBU also has the possibility to differentiate the time via the GPS signal.

6.2.3. Charging models

There are different charging models possible to be able to differentiate charging depending on road classes, vehicle classes, travel time and other parameters.

6.2.3.1. Model No 1:

A flat km fee is applied to the total area of NL

6.2.3.2. Model No 2:

There is a time and location dependent charge. In order to stay up to date, the beacons have the possibility to update the fare tables e.g. price vs. class vs. time. The memory is sufficient to store such data.

6.2.3.3. Other models:

Tbd.

6.2.4. Beacons

Beacons are equipped with an IR communication interface, a fixed line or GPRS interface for CS communication and, for some locations, a solar power module. They can be located at petrol stations, borders, traffic lights, masts, bridges and so on.

The communication bandwidth between the vehicle and IR beacon is nominally 1-2 Megabit, i.e. probably 500kbit net. A transaction data set volume for model 1; including event and violation indication transmission is about one kilobyte (2 milliseconds).
The worst-case dimension of an IR beacon's footprint is about 5m. Transaction time available at 250km/h vehicle speed is then about 70ms.

6.2.5. Central system

The Central System consists of a vehicle unit manager, a road-charging manager, an enforcement manager, a billing manager, a communication server, management & escalation services and a call center for customer support.
Vehicle unit manager manages unit versions, SW versions, supplying POS', update services.
The road charging manager defines charging models, tariffs, road segments, toll areas, borders, etc. to be used in the CS and OBU database.
The enforcement manager coordinates all enforcement tasks.
The communication server is responsible for communication between CS and all other system components to route and distribute data.
The management & escalation services are responsible (among others) for contacts to police and customs.

6.2.6. POS

There are two types of POS – a simple point of sale- selling and personalizing the unit, and POS' with all facilities of a workshop, providing fixed OBU installation. All POS' can handle cash and credit cards to open customer accounts and activate trusted elements. They are permanently connected to CS. See chapter 9 for more detailed description and decision.

6.3. Key functions/processes

6.3.1. Buying/Hiring an OBU

Domestic and frequent foreign users obtain an OBU, which is installed by a workshop. The OBU remains in the vehicle for the complete life cycle.

Occasional foreign users can temporarily hire (reusable) OBUs. No procedural differences are made between buying and hiring.

See the example processes described in 8.1.2, and 8.1.3. for obtaining and personalizing of OBUs, and making the deposit and initial fee payments according to any one of the options offered in 9.

6.3.2. Driving & Recording

While driving, the OBU reads GPS location data and calculates the driven distance and the corresponding value according to any one of the charging models of 6.2.3. A useful set of additional data will be recorded and logged, e.g. time & position of border crossing, time &

position of lost and recovering GPS signal, time & position of power off/on, user declarations, fraudulent activities, etc…

6.3.3. Driving Abroad - Leaving and Entering NL

Charging model 1 as well as all others know the geographic outline of the NL area including all the positions of all 350 border crossings. The OBU uses GPS data to recognize border-crossing situations. If the vehicle leaves NL, distance calculation is interrupted automatically. When re-entering NL, distance calculation is re-activated. Border crossings are registered by the OBU.

6.3.4. Data transfer

A special task cyclically prepares charge data sets to be transferred via IR beacons. Such a data set contains OBU ID, health status, mileage counter (NL and abroad), and fraud and event indicators. Additionally, if special events are logged, an event data set will be generated.

If the vehicle passes an IR beacon, the charging data set is read out of the OBU in free traffic flow. In case of low speed or standstill, e.g. at a petrol station, also the event data set will be transferred.

If the driven distance exceeds a certain value without transmission to the CS, the user is informed via the HMI. In the case of a display being present (add €2) he shall transmit the driven distance (as a signed value) to the CE by himself. This can be done by sending a postcard, phone call or Internet portal. An upgrade with a chip card reader based transmission solution is possible (at €3; the contactless card is mailed to the central system).

6.3.5. Payment

The customer has the option to pre-pay (credit) and post-pay (debit) according to any of the processes using any of the infrastructures defined in 9.

In post-pay mode, the user account is regularly charged for the driven distance.

6.3.6. Exceptions

1. *Fraudulent Manipulation:* The OBU is manipulation proof. Case unclosing is detected and registered. Invasion attempts are reported to CS and enforcement units.

2. *No GPS coverage:* In case of restricted GPS coverage, the shortest distance between the last and newest valid location information is used for charging. This way, the user can never be overcharged. Alternatively, if location information is transmitted to the CS (e.g. via passing one of the beacons), a digital map can be used, to calculate the shortest possible road distance between these two locations. Additionally the general availability of GPS signals in this area and time will be

checked. In case of abnormal distortions enforcement levels 1 or 4 will be activated.

3. *Passive Vehicle Transportation*: Passive transportation is declared by the user before the transport and logged in the OBU. After transport, recording is re-activated.

4. *Satellite mismatch:* In case of satellite mismatch without indication a systematic mismatch in position sensing of up to 100km is possible. For such cases a special action plan has to be prepared.

6.4. Enforcement

Enforcement beacons can be combined with cameras, image processing, and an appropriate communication link to CS and mounted on the roadside (the solar powered version would not work any more with so many active devices). The roadside mounted unit is a state of the art, full service, free flow stationary enforcement unit.

Mobile enforcement, equipped with an IR beacon, charging model database and connection to CS is able to check customers also in places difficult for automatical access. Mobile enforcement is additionally able to immediately react to fraud indications and non-responders.

In addition, the mobile enforcement equipment has an up-to date blacklist of vehicles with outstanding fines, notorious violators, unsecured data integrity and other indications. The mobile patrol is equipped with an hand-held infrared reader and will stop every vehicle with is not OK or has no OBU at all (no response)

Optionally (display required, €2) it is also possible to request from the user to report the odometer reading time by time by mail or call center.

In case of suspicion the regarding OBU/vehicle may be actively visited or asked to show up to be checked manually as soon as possible by enforcement personnel.

7. Enforcement System(s)

The scenarios have been analyzed also with regard to their implication on enforcement systems. Every enforcement system has the same structure:

- *Stationary enforcement systems* collect evidence which are to generate penalty charge notices for domestic users and users or collaborating countries in cross-border enforcement; and to generate blacklists for non-resident users. These are multi-lane free flow installations placed on gantries in high volume traffic locations and at major border posts. The electronic equipment allows
  - Capturing and reading of number plates,
  - Communicating with OBUs,
  - Vehicle classification, and
  - Matching of all data into a court-proof evidential record.

- *Portable enforcement* systems are the same as stationary but can easily be moved from point to point. They also look at on single lane only, which can be either lane one or lane two.

- *Mobile enforcement* vehicles are equipped with all technology required to pre-select or randomly check vehicles for irregular status, or for verification against a blacklist. Typical operational modes are This includes

  - Mobile (tripod mounted) number plate readers,
  - Hand-held and roof mounted communication equipment to verify OBUs,
  - Synchronized operation with the back office,
  - Mobile office equipment to capture passports, and vehicle documents, receive payments in all means of payment,
  - Systems to modify OBU settings if necessary
  - Communication links to fixed enforcement in order to wait for blacklisted vehicles at border points

The many ways and attempts possible to circumvent the enforcement systems are not discussed hereunder as they are quite well known. EFKON considers the approach as fully sufficient to be in control of the situation.

We do recommend that the enforcement system use infrared communication according to the ISO TC 204 CALM worldwide standard for vehicle communication. The main purpose is to allow for active, continual sending of enforcement information – allowing performing hidden checks. A Microwave DSRC based system always requires interrogation from the

roadside and is easily detected and jammed by organized road tax evaders. In addition, infrared enables monitoring of OBUs in a very easy and efficient manner by long-range hand-held devices:

With regard to the scenarios hereunder, no changes are made in the cost as the main variation, if any, it is only some price wise negligible modifications to equipment. The slight technical and organizational differences are discussed in the individual chapters.

8. Example OBU Issuing Process

The process used for costing includes an OBU that is sent to every domestic user by mail. It is pre-initialized, but otherwise identical to the foreign user OBU and has a 12V power plug and windscreen mounting facilities.

The user can at any time go to a workshop and have the OBU permanently fitted to the power mains of the vehicle.

The described processes may be optimized further but are considered most efficient for the time being.

8.1. OBU Issuing Process

8.1.1. Personalization

OBUs must be personalized. There must be an identical connection between the number plate and the OBU for enforcement purpose.

Where required, staff at POS loads the number plate, odometer reading, vehicle related data and owner data into the OBU. Customer bank account data or pre-paid value is transmitted to the Central System. Where required, the SW application, tariff data and transmission keys are downloaded into the trusted element from the CS.

A special card will be given out with each OBU that carries the OBU number and which should be kept with the vehicle credentials.

8.1.2. Connecting to Power Where Required

For domestic and frequent users, OBUs may be connected to the mains of the vehicle. Domestic users will have the possibility to have the OBU fitted long before the scheme starts.

The process used for costing includes an OBU that is sent to every domestic user by mail. It is pre-initialized, but otherwise identical to the foreign user OBU and has a 12V power plug. The user can at any time go to a workshop and have the OBU permanently fitted to the power mains of the vehicle.

Frequent foreign users may obtain the OBU in the same way as domestic users. Users may call the toll-free number to locate and schedule a visit to a workshop.

8.1.3. Occasional Users

Occasional users obtain a device that can be mounted in the windscreen by suction cups or double sided sticky tape and a mounting hinge. Where required, OBUs are connected to the

mains of the vehicle via the cigarette lighter plug (which has another plug on the reverse side so it can still be used by other equipment).

The car owner obtains the OBU across the counter and pays a deposit and/or a pre-paid minimum amount of toll using any means of payment.

Staff at POS loads the number plate, odometer reading, vehicle related data and owner data into the OBU. Customer bank account or credit card data or pre-paid value is transmitted to the Central System. Where applicable, SW application, tariff data and transmission keys are downloaded into the trusted element from the CS.

There may be deviations to the process if the “Type 4” vending terminal is used to deal out OBUs. There is no cost implication; therefore such deviations are not discussed in this document any further.

9. Payment and OBU Issuing Infrastructure

During the study, a decision was taken to separate the cost estimations of the OBU and charge-data infrastructure from the field infrastructure. The various options are studied separately below and the cheapest options can then be re-combined with the OBU scenarios.

9.1. Which Is Better: Pre-Paid or Post-Paid?

9.1.1. No Bank Account

(a) User accounts that have no link to a bank account can be loaded pre-paid. This can be done via any of the means described below (payment terminals in the field, in offices, smart cards, scratch cards).

(b) Alternatively, it may be permitted that the payment is made within a certain time limit e.g. 3 bank working days. This can be done via any of the means described below (payment terminals in the field, in offices, smart cards, scratch cards).

9.1.2. With Bank Account / Credit Card

(a) OBUs that have a link to a bank account will be able to do fully automatic post-paid payment.
(b) If the credit worthiness is insufficient, there may be a set-up where the bank account is charged in advance, i.e. the central account is pre-paid every time the balance falls below a certain threshold.

9.1.3. Low Flexibility Pre-Payments

One of the scenarios that had initially been developed asks for everybody to buy the next set of kms (e.g. 200km) via a sticker and use them up. This involves the need of being able to offer cash payment at all locations around the country as foreigners may need to buy a ticket in the middle of the night with cash as they run out of kms. The implication is the erection of thousands of cash accepting payment terminals throughout the country with tremendous operating costs for transport of cash. Such scenarios have not been considered further.

9.1.4. Conclusion: No Difference

Since there are no cost differences in pre-paid on the spot, post-paid after certain time, with or without bank account connection, there is no need to try to find any optimization potential depending on the pre- or post-payment scenario.

A system that is not including the possibility for domestic users to connect to their bank account is considered as almost non-viable. The maximum that can be asked is to buy km in the gasoline shops, but it would create lots of hold-ups. At the same time, to set up the automatic link is an effort, which is very much smaller (mathematically: “<<”) than the cost of the total system, so there is no reason to deny this convenience.

Therefore, no further split or research has been conducted on the cost variations due to pre- or post paid scenarios.

9.2. Linking the OBU to a bank account or credit card

At any point of time, the user may assign a bank account or credit card if he wishes to do so for automatic settlement.

The user may make use of many channels like the Internet, a call center, or mail.

9.3. Scratch Cards

Scratch cards are value tokens that can be distributed all over the country similar to loading of pre-paid cell phones. The payment is made pre-paid at the counter of numerous shops (e.g. gasoline stations, at borders, at tobacconists etc.).

It is also possible to sell these via vending machines.

The user may scratch the card at any time, call a 0-800 number and, when prompted by the voice, enter the code on the scratch card, and the serial number code of the OBU. The scratch card code is stored in the back office and will be activated and immediately linked to the user account.

9.4. Pre-Paid Chip Cards

Some OBUs may provide facilities to insert a chip card (contact-less like in public transport or contacted like in banking, or offering both interfaces).

The payment is then made by buying pre-paid cards filled up with a certain amount at one of the many outlets, or reloading at ATMs and special service points.

The card is inserted into the OBU and the value is deducted as the vehicle travels.

The advantage is that the user always knows how many tokens/Euros are left on the card/account.

9.5. Cost of Manned Point of Sale

The following versions have been considered for comparing the cost:

Own 24/7 POS infrastructure, where everything is dedicated to the road tax, and where all the cost is billed to the road tax operator.

Shared 24/7 operations, where the road tax takes up a certain percentage of the time of the anyway present shop attendant, and where the terminal takes up about 1m² of space in the station

Utilizing an existing shop with normal operating hours of 6-22 (e.g. a restaurant). The road tax operator has to pay 100% of the additional personnel required to fill in the gap between 20:00 and 6:00, plus one day per week e.g. Sunday.

Please see the cost overview and conclusion table in 9.9.

9.6. Definition of Terminals for Point of Sale

During the evaluation phase, it turned out that the payment infrastructure is a major cost driver. It is therefore necessary to take a closer look at the cost components, and ways to minimize the cost of this subsystem.

It is also necessary to apply the minimum infrastructure in identical ways to the various scenarios; otherwise there would be strong fluctuation in the overall results, which would conceal the true cost differences between the scenarios.

9.6.1. Generic Processes to Be Supported

The terminal infrastructure, together with the operating personnel, the local and corresponding back office facilities, must support the following processes:

- Issuing of OBUs to occasional users or setting up of an account depending on the scenario
- Collecting any OBU deposits as the scenario may require
- Topping up the account or making a post-payment
- Accepting of OBU returns or account deletions as the scenario may offer
- Refunding of unused funds and deposits in the same way the last payment has been made

- Operation with bank accounts, bank cards, credit cards, petroleum cards, km-pricing specific cards, cash (this includes also refunding large amounts of cash if such a payment has been made before)
- Entry of number plate data and/or odometer status as a scenario may require
- Immediate access to a call center helpdesk
- Multi-lingual

9.6.2. Types of terminals overview

There are four levels of vending terminals defined:

1. Using SMS and a QWERTZ type or touch screen smart phone, for easy entry of number plate information.

2. Standalone terminals providing all data entry options and accepting all means of payment except cash. The latter can be circumvented by asking the shop to sell scratch cards or pre-loaded chip cards which can be inserted in the terminal. Versions 2a and 2b are for indoor and outdoor use but otherwise identical.

3. Standalone terminals providing all data entry options and accepting all means of payment including cash and giving change. Versions 3a and 3b are for indoor and outdoor use but otherwise identical.

4. Same as (3), but also issuing OBUs and accepting the return of OBUs. Versions 4a and 4b are for indoor and outdoor use but otherwise identical.

The types are described and their investment and operating impact is evaluated in the next chapters. Note that there may be lots of derivatives of the defined terminal levels. The ones that have been defined below are considered sufficient with regard to all boundary conditions.

The types and process are also harmonized to the extent that any combination of the below terminal versions will be interoperable, i.e. an account set up in terminal type 3 can be topped up in type 2 and deleted in type 1 if there is a cost advantage in the respective scenario.

9.6.3. Payment Terminal Type “1”: Using SMS And A QWERTZ Phone.

9.6.3.1. Description of equipment and processes

A shop may provide collection of the money and stocking/storing the OBUs. After obtaining the OBU, the data have to be provided to the back office by phone in order to activate the account.

The shopkeeper will use a QUERTZ type cellular phone, and type a structured SMS containing the account number, the name, ID document number, the number plate, country,

vehicle class and the money that has been collected. The account number contains a two digits strong checksum, providing for 99% safety against wrongly entered numbers.

For new accounts, the back office will recognize the entry of a new number and ask for confirmation that this is a new account.

For topping up existing accounts, the user will provide his account number or number plate (plus country) and the shopkeeper will send a structured SMS to the central system.

There will be a return code, which will immediately be provided by SMS to the shopkeeper. The return code can be entered into the existing cash register infrastructure (as if it was a bar code), enabling the cash register to print an invoice with the return code.

The pre-condition is the availability of a bar code reading cash register – most places would have such a system in place. It is envisaged that the shop is an over-the-counter style shop.

Other actions may include structured SMS for refunding.
The cash is processed together with the other cash of the shop. No additional cost is created.

9.6.3.2. Requirements fulfilled?

YES ***During shop opening hours***	Issuing of OBUs to occasional users or setting up of an account depending on the scenario
YES	Collecting any OBU deposits as the scenario may require
YES	Topping up the account or making a post-payment
YES	Accepting of OBU returns or account deletions as the scenario may offer
YES	Refunding of unused funds and deposits in the same way the last payment has been made
YES	Operation with bank accounts, bank cards, credit cards, petroleum cards, km-pricing specific cards, cash (this includes also refunding large amounts of cash if such a payment has been made before)
YES	Entry of number plate data and/or odometer status as a scenario may require
YES	Immediate access to a call-center helpdesk
YES	Multilingual

9.6.3.3. Description of Investment components

(See accompanying spreadsheet for EURO values and more detailed breakdown)

- Smart phone with QWERTZ or equivalent touch screen and charger
- Signage
- Setting up location and training of local personnel
- Locker for OBU stock

9.6.3.4. Operations cost components

(See accompanying spreadsheet for EURO values and more detailed breakdown)

- Monthly cost of SIM with unlimited SMS tariff.
- Share in rental of space, cash register infrastructure, cash protection and transport
- Share in shopkeeper salary
- Occasional manager's visit
- Equipment maintenance

9.6.4. Payment Terminal Type "2": Smart Terminal – No Cash

9.6.4.1. Description of equipment and processes

Desktop or shelf-top multilingual touch screen terminals are located in existing shops, making use of the existing payment infrastructure and processes in the shop. A printer is included, as well as a magnetic stripe and smart card reader, and a speakerphone for contacting a help-desk if required.

A shop may provide collection of the money and stocking/storing of OBUs if any. The user will fill in an electronic form at the terminal (in many languages). The terminal is connected online to the back office via a GPRS link.

The new account is represented by a credit card sized paper card which will be printed and where the user will be able to see the account number. The number plate, country and class of the vehicle are also printed on the card.

For new accounts, the back office will recognize the entry of a new number plate and the online terminal will ask for confirmation that this is a new account.

For making payments by card, the cards are swiped or inserted, as well as any PIN codes that may be required/available with the card.

For making payments by cash, the user will procure a recyclable-once use smart card at the counter with a predefined value (e.g. EUR 20 or EUR 500), which will then be used at the terminal like any other card. The cards are then dropped in a drop box for routing back to the central system and reloading. It is not permitted to enter cash payment, and then pay later at the cash register. The result would be that people enter the cash payment then walk away without having made the payment.

For topping up existing accounts, the user will provide his account number or number plate (plus country), and then follow the same process.

The terminal is capable of printing a tax-invoice on the same format as the account card (train ticket style credit card sized receipt)

Issuing of OBUs if any will be done as follows: The OBU serial number is on a detachable paper, which can be taken to the terminal when setting up the account. After successful set-up, the shopkeeper will hand out the OBU on presentation of the invoice and an ID document.

9.6.4.2. Requirements fulfilled?

YES ***During shop opening hours***	Issuing of OBUs to occasional users or setting up of an account depending on the scenario
YES	Collecting any OBU deposits as the scenario may require
YES	Topping up the account or making a post-payment
YES	Accepting of OBU returns or account deletions as the scenario may offer
YES	Refunding of unused funds and deposits in the same way the last payment has been made
YES	Operation with bank accounts, bank cards, credit cards, petroleum cards, km-pricing specific cards, cash (this includes also refunding large amounts of cash if such a payment has been made before)
YES	Entry of number plate data and/or odometer status as a scenario may require
YES	Immediate access to a call-center helpdesk
YES	Multilingual

9.6.4.3. Description of Investment components

(See accompanying spreadsheet for EURO values and more detailed breakdown)

- Terminal with touch screen, printer, multi-card reader and speakerphone (GSM/GPRS)
- Signage
- Installation and training of local personnel
- Locker for OBU stock or open shelf space as the shop policy may be

9.6.4.4. Operations cost components

(See accompanying spreadsheet for EURO values and more detailed breakdown)

- Monthly cost of SIM with unlimited SMS tariff.
- Share in rental of space, cash register infrastructure, cash protection and transport
- Share in shopkeeper salary
- Occasional manager's visit
- Equipment maintenance

9.6.5. Payment Terminal Type “3”: All Payments Including Cash In/Out

9.6.5.1. Description of equipment and processes

Standalone terminals providing all data entry options and accepting all means of payment including cash and giving change. Versions 3a and 3b are for indoor and outdoor use but otherwise identical. A printer is included, as well as a speakerphone for contacting a help-desk if required.

A shop may provide for stocking/storing of OBUs if any. The user will fill in an electronic form at the terminal (in many languages). The terminal is connected online to the back office via a GPRS link.

The new account is represented by a credit card sized paper card which will be printed and where the user will be able to see the account number. The number plate, country and class of the vehicle are also printed on the card.

For new accounts, the back office will recognize the entry of a new number plate and the online terminal will ask for confirmation that this is a new account.

For making payments by card, the cards are swiped or inserted, as well as any PIN codes that may be required/available with the card.

For making payments by cash, there is a coin and notes acceptor, and a change return function.

For topping up existing accounts, the user will provide his account number or number plate (plus country), and then follow the same process.

The terminal is capable of printing a tax-invoice on the same format as the account card (train ticket style credit card sized receipt)

Issuing of OBUs if any will be done as follows: The OBU serial number is on a detachable paper, which can be taken to the terminal when setting up the account. After successful set-up, the shopkeeper will hand out the OBU on presentation of the new account card, the payment invoice and an ID document.

9.6.5.2. Requirements fulfilled?

YES ***During shop opening hours***	Issuing of OBUs to occasional users or setting up of an account depending on the scenario
YES	Collecting any OBU deposits as the scenario may require
YES	Topping up the account or making a post-payment
YES	Accepting of OBU returns or account deletions as the scenario may

	offer
YES	Refunding of unused funds and deposits in the same way the last payment has been made
YES	Operation with bank accounts, bank cards, credit cards, petroleum cards, km-pricing specific cards, cash (this includes also refunding large amounts of cash if such a payment has been made before)
YES	Entry of number plate data and/or odometer status as a scenario may require
YES	Immediate access to a call-center helpdesk
YES	Multilingual

9.6.5.3. Description of Investment components

(See accompanying spreadsheet for EURO values and more detailed breakdown)

- Terminal with touch screen, printer, multi-card reader, cash and notes acceptor and issuer and speakerphone (GSM/GPRS)
- Installation and training of local personnel
- Signage
- Locker for OBU stock or open shelf space as the shop policy may be

9.6.5.4. Operations cost components

(See accompanying spreadsheet for EURO values and more detailed breakdown)

- Monthly cost of SIM with unlimited SMS tariff.
- Share in rental of space, cash register infrastructure, cash protection and transport
- Share in shopkeeper salary
- Occasional manager's visit
- Equipment maintenance
- Daily visit with cash transport vehicle to remove cash (outdoor version)

9.6.6. Payment Terminal Type "4": All Means of Payment, In/out, Issues OBUs and Accepts OBU Returns

9.6.6.1. Description of equipment and processes

Standalone terminals providing all data entry options and accepting all means of payment including cash and giving change. The special feature of this device is the capability to issue and accept returns of OBUs. Versions 4a and 4b are for indoor and outdoor use but otherwise identical. A printer is included, as well as a speakerphone for contacting a help-desk if required.

This machine could be a combination of the type “3” terminal as above, and a separate apparatus to store, deal out and accept returns of OBUs.

The user will fill in an electronic form at the terminal (in many languages). The terminal is connected online to the back office via a GPRS link.

The new account is represented by a credit card sized paper card which will be printed and where the user will be able to see the account number. The number plate, country and class of the vehicle are also printed on the card.

For new accounts, the back office will recognize the entry of a new number plate and the online terminal will ask for confirmation that this is a new account.

For making payments by card, the cards are swiped or inserted, as well as any PIN codes that may be required/available with the card.

For making payments by cash, there is a coin and notes acceptor, and a change return function.

For topping up existing accounts, the user will provide his account number or number plate (plus country), and then follow the same process.

The terminal is capable of printing a tax-invoice on the same format as the account card (train ticket style credit card sized receipt)

Issuing of OBUs will take place if a new account has been set up. The OBU has an intelligent label which will be read by an RFID antenna in the issuing apparatus and which will be connected to the account. The process has some restrictions because no ID documents can be presented. The alternative to include a biometric reader is technically and cost – wise easy but creates a big brother atmosphere – it is therefore assumed that no such identification is required.

Returning of the OBU will take place as follows: The user may drop the OBU in a slot, which has a slide inside. Depending on the type of temporary OBU used, there may be various ways to check the OBU:

- Is the OBU truly an OBU and not just any object
- Is there any money left on the OBU (for scenarios where the last status of the account is in the OBU only)
- Is the OBU defective

Depending on the OBU solution, there may be a variety of facilities to check the OBU:

- A 12 V socket and an infrared reader
- A contact-less smart card reader
- A video camera where a service center person can remotely judge the condition of the OBU
- An internal slide with a 5.8 GHZ reader

It is assumed that all solutions will be similar in cost and therefore the technical solution is not discussed further at this stage.

9.6.6.2. Requirements fulfilled?

YES	Issuing of OBUs to occasional users or setting up of an account depending on the scenario
YES	Collecting any OBU deposits as the scenario may require
YES	Topping up the account or making a post-payment
YES	Accepting of OBU returns or account deletions as the scenario may offer
YES	Refunding of unused funds and deposits in the same way the last payment has been made
YES	Operation with bank accounts, bank cards, credit cards, petroleum cards, km-pricing specific cards, cash (this includes also refunding large amounts of cash if such a payment has been made before)
YES	Entry of number plate data and/or odometer status as a scenario may require
YES	Immediate access to a call-center helpdesk
YES	Multilingual

9.6.6.3. Description of Investment components

(See accompanying spreadsheet for EURO values and more detailed breakdown)

- Terminal with touch screen, printer, multi-card reader, cash and notes acceptor and issuer and speakerphone (GSM/GPRS), and OBU issuing/return unit
- Installation
- Signage
- OBU stock

9.6.6.4. Operations cost components

(See accompanying spreadsheet for EURO values and more detailed breakdown)

- Monthly cost of SIM with unlimited SMS tariff.
- Share in rental of space, cash register infrastructure, cash protection and transport
- Share in shopkeeper salary
- Occasional manager's visit
- Equipment maintenance
- Daily visit with cash transport vehicle to remove cash (outdoor version)

9.7. Cost of Collecting Cash

If cash is an option for autonomous payment terminals, this is an attractive target, and people are highly inventive about getting hold of this money. The cash must therefore be removed on a daily basis. The cost of doing that is tremendous:

An armoured vehicle specially designed for transport of money is required, and it must be manned by 2 persons. If the average visit takes about 1 hour, and the cost including the cost of the special vehicle is EUR 200, the cost per machine would be EUR 200 x 365 = 73000 per year, or 730,000 in 10 years; or EUR 3,650,000,000 if there are 5000 terminals placed. The number can be optimized by a certain factor, as 1 hour is probably not true when the cash collection vehicle is also visiting other customers. The correction can, however, hardly be lower than 20% since one visit in 5 days is required for refilling paper, change etc.

The minimum cost of the cash collection operation would therefore be EUR 730,000,000 if 5000 terminals were placed across the country.
The scenario is relevant in order to compare to attended operation where a person would collect the cash.

9.8. Option of non-personalized OBUs

It is possible to build a system with anonymous OBUs by using equipment that only plugs into the cigarette lighter and use anonymous scratch cards or pre-paid chip cards. The OBU can be issued at vending terminals in such a case.

It is also possible to have a completely anonymous OBU where the chip cards may be placed for charging in a device that only determines the charge. It is, however, required in such a case to have a very good random enforcement operation.

Given the fact that OBU cost is typically higher in price than one could reasonably ask for as a deposit, there may be a negative business case due to lost OBUs with foreigners.

9.9. Payment Infrastructure – Conclusions

9.10. Summary Table and Discussion

The below table shows the summary of all options that were discussed:

	Option	TOTAL I 1UNIT INITIAL	TOTAL D 1UNIT 10Y	TOTAL O 1UNIT 10Y	TOTAL 1 UNIT 10Y	TOTAL 500 UNITS 10Y	TOTAL 5000 UNITS 10Y
A	Type 1 Terminals (QWERTZ Cellphone)	1.000	2.000	8.500	11.500	5.750.000	57.500.000
B	Type 2 Terminals (No Issue and Return of OBUs, All Means of Payment Except Cash)	10.000	20.000	23.500	53.500	26.750.000	267.500.000
C	Type 3 Terminals (No Issue and Return of OBUs, All Means of Payment and Refund)	50.000	100.000	227.000	377.000	188.500.000	1.885.000.000
D	Type 4 Terminals (Issues and Accepts Return of OBUs, All Means of Payment and Refund)	90.000	180.000	287.000	557.000	278.500.000	2.785.000.000
E	Cost of Attendant - in System Scheme Own Shop	65.200	55.400	1.212.000	1.332.600	666.300.000	6.663.000.000
F	Cost of Attendant - in Existing 24/7 Shop	1.000	0	88.659	89.659	44.829.680	448.296.804
G	Cost of Attendant - in Existing (6-20; 6 days) Shop, WE HAVE TO PAY FOR THE MISSING	1.000	0	772.395	773.395	386.697.260	3.866.972.603

According to this,

- The *most expensive solution* is to establish own shops (E). This only makes sense in locations where 24/7 100% utilization of personnel is given.
- The *cheapest solution accepting cash* at any time is establishment of the service in an existing 24/7 facility (F). (F) Is about 4 times lower in cost than any outdoor cash terminals based version as of (C).
- It would be cheaper to use OBU issuing terminals (D) in places where there are no existing 24/7 facilities, but given the technical problems with OBU handling, this is not really an option. In addition, the number of such locations is expected to be small, so for this case Option (G) will be chosen for few places.

The workshops and infrastructure providing services for OBU fitment to domestic and frequent users (and bank/credit card automated payment services) do not need to be considered in this comparison as the above is de-facto exclusively required for the occasional user.

9.11. Decision for All Scenarios

The following approach will therefore be adopted for *ALL scenarios*:

- There are about 350 possibilities to cross the border, and about 100 are substantial enough that they should be equipped with a 24/7 facility according to Option (F) or (G).
- For those places where there is no point of sale, a sign at the border will direct people to the next 24/7 shops.
- No person will need to drive more than 15 minutes in order to reach the next 24/7 facilities.
- For those places where there is no facility according to (F) available, Option (G) will be chosen. This will be the case in about 20 locations only.
- Furthermore, all locations will be equipped with terminals according to (B) for better customer service and also saving time at the counter.
- (B) Also offers a wide variety of other services to customers like route planning, toll prediction, and potentially even Internet access when idling.
- About 1,000 points of sale will be equipped with Option (B) in order to make intermediate payments anywhere in the country. These will be operated during normal office hours only. Targets are restaurants and gas stations.

The conclusion is also based on estimates from viewing and counting all borders on an Internet map provided by www.viamichelin.nl, and experience of the team conducting the study.

The table below explains the total cost of the ***optimized payment and OBU issuing field services for occasional users***:

OPTION		NUMBER	TOTAL I 1UNIT INITIAL	TOTAL D 1UNIT 1Y	TOTAL O 1UNIT 1Y	TOTAL 1 UNIT 10Y	TOTAL ALL UNITS 10Y
B	Type 2 Terminals (No Issue and Return of OBUs, All Means of Payment Except Cash)	1100	10.000	2.000	2.350	53.500	58.850.000
F	Cost of Attendant - in Existing 24/7 Shop	80	1.000	0	8.866	89.659	7.172.749
G	Cost of Attendant - in Existing (6-22; 6 days) Shop, WE HAVE TO PAY FOR THE MISSING	20	1.000	0	77.239	773.395	15.467.890
TOTAL 10 YEARS			**11.100.000**	**2.200.000**	**4.839.064**	**81.490.639**	**81.490.639**

The values that will be used in the total system calculation will be:

		Total	Per annum	Per annum
Declaration and Customer Care		*Initial costs*	*Operational costs ex depreciation*	*Depreciation*
Occasional User System		**€ 11.100.000**	**€ 4.839.064**	**€ 2.200.000**

10. Risk Register

Please see the attached table identifying the risks involved in implementation of each of the scenarios. *The following results have been derived from the analysis:*

10.1. Top 10 Biggest Risks for All Scenarios

(A) Ranked for all scenarios, the most important risk mitigation to be done is

- to work with the European commission to accept an alternative system, which would save billions of Euros.
- To design user processes that are easy to understand and use by foreigners (high likelihood of not understanding) and domestic users (high revenue impact).

Rank	Scenario	Risk	Rating
1	Scenario 3: IR-EVI, Solar Powered IR Receivers	EU EETS will be defined and system is incompatible	8,75
2	Scenario 3: IR-EVI, Solar Powered IR Receivers	European Commission insists on use of technology mentioned in the directive	7
3	Scenario 3: IR-EVI, Solar Powered IR Receivers	Laws may be created/detected that make the system illegal (e.g. privacy)	5,25
4	Scenario 6: GSM Cell ID Recording by PHONE	Blackmailing by monopolistic parties	4,5
4	Scenario 6: GSM Cell ID Recording by PHONE	EU EETS will be defined and system is incompatible	4,5
4	Scenario 8: GPS, display, IR communication	EU EETS will be defined and system is incompatible	4,5
7	Scenario 1: Logbook with Verification	Process too complicated for domestic users	4
7	Scenario 6: GSM Cell ID Recording by PHONE	Process too complicated for domestic users	4
9	Scenario 1: Logbook with Verification	Process too complicated for foreign users	3,75
9	Scenario 6: GSM Cell ID Recording by PHONE	Process too complicated for foreign users	3,75
9	Scenario 6: GSM Cell ID Recording by PHONE	Reduced payment reliability due to insufficient GSM cell coverage in rural areas	3,75
9	Scenario 8: GPS, display, IR communication	DSRC beacon site acqusition problems	3,75

10.2. Biggest Risk No. 1 and 2 Per Scenario

(B) Ranked per relevant scenario, the most important risk mitigation to be done is

- to work with the European commission to accept an alternative system, which would save billions of Euros.
- To design user processes that are easy to understand and use by foreigners (high likelihood of not understanding) and domestic users (high revenue impact).

Rank	Scenario	Risk	Rating
1	Scenario 1: Logbook with Verification	Process too complicated for domestic users	4
2	Scenario 1: Logbook with Verification	Process too complicated for foreign users	3,75
1	Scenario 3: IR-EVI, Solar Powered IR Receivers	EU EETS will be defined and system is incompatible	8,75
2	Scenario 3: IR-EVI, Solar Powered IR Receivers	European Commission insists on use of technology mentioned in the directive	7
1	Scenario 6: GSM Cell ID Recording by PHONE	Blackmailing by monopolistic parties	4,5
2	Scenario 6: GSM Cell ID Recording by PHONE	EU EETS will be defined and system is incompatible	4,5
1	Scenario 8: GPS, display, IR communication	EU EETS will be defined and system is incompatible	4,5
2	Scenario 8: GPS, display, IR communication	DSRC beacon site acqusition problems	3,75

10.3. Conclusion

In both cases, working with the EU to accept systems that may be different but save billions of Euros and the user friendliness of the system and processes has been identified as the highest risk, which needs to be addressed.

Please see the very detailed report in the attached table.

11. Some Items That May be of Impact But Were Not Addressed

During the process, it was not possible to address certain items for reasons of time or they were omitted because they do not make a difference between systems. The Impact on Cost is defined as

"Impact on Invest + 10 Years Operation:
<€50 m low
<€500 m medium
>€ 500 m high"

Item	Impact on Cost	Rationale/Mitigation
Gasoline stations typically charge very high margins when selling products in the shops.	Medium – It may be required to use other types of partners, e.g. restaurants	The approach here is a cost based, margins have to be negotiated at a later stage. Some room has been allowed by using conservative estimates for shop assistant and shelf space cost.
Effect of collecting deposits	Medium – affects the number of OBUs (churn rate) and KM payments lost to occasional users who just disappear.	Not possible to determine a useful limit at the moment – this is government policy, not cost optimization.
Liability for OBU churn	Medium	There has to be a definition about whose liability it is if an OBU has to be replaced due to loss or age. Example: if the OBU is defective before 5y and not damaged, liability: government. If damaged; liability user. (Apply e.g. same policy as for number plate).
Unclear of how to add up *depreciation*, *churn rate* and *maintenance*	High	There is a policy required who pays for what, but looking at the total economy, all three truly happen, so they must be costed.
Allocation of costs for follow-up	Medium	People who do not pay should right away pay for the costs that were caused by them. Not the community.
Soiled plates	Medium	Soiled number plates cause cost in the back office. If they can be read properly,

		then the cost is lower. A “cool” suggestion could be that the law allows keeping the data of anybody whose plate is soiled. Anyway, it is an offence to travel with an illegible plate, so legally it should be OK to keep the image.
Not possible to project the true frequent user number	Low	A general assumption was made that there will be 300,000 frequent users who have such a situation that they would have an OBU fitted to a vehicle and 700,000 per year who would not.
Not possible to tell pattern of 1,000,000 occasional users	medium	Are there at any time 1m occasional users around, which would mean that there are probably 5 million different vehicles. Or are there only 200,000 different vehicles, which create 1m entries per year on average. – Not mitigated.
Any numbers for cellular providers	High	It is very difficult to take a decision on this. Some may say, the network is there anyway and there is no cost, some say there may be a standard tariff, with some mass discount. Typically scenarios using the latter are too expensive, but if they use the first, they are very attractive. It is up to negotiations.

12. Scenarios Which Were Not Short listed and Why

12.1. Scenario "2": Pre-Paid Vignette for Certain Amount of km

Road users obtain a pre-paid sticker for X km (e.g. 100km). The road user enters start odometer reading and number plate at the sticker issuing terminal.

The vending machine is available in many locations inside the country and borders. It has a multi-lingual touch screen, multiple methods for payment, a sticker issuing/printing device and transfers information to central office.

For enforcement, stationary license plate readers match vending data (place, distance) with the enforcement record. Mobile patrols compare odometer and sticker info. Mobile patrols also use portable license plate readers to pre-sort vehicles and do spot checks.

There are no provisions required for occasional users and users with foreign number plates – the system is identical for everybody. There is some dispute possible as no end is entered when the sticker is procured, and unused km are gone when leaving the country – it is bad luck for those that do not plan.

The scenario was *initially considered because* it offers a very cheap "OBU" which is just a paper sticker.

The scenario was *not pursued further because* it turned out to be

- Unhandy for users to buy so many stickers and to constantly monitor if their trips are still valid.
- One of the more expensive scenarios. The main cost driver is the requirement of a daily visit by a an armed vehicle to pick up the expectedly high amount of cash from the required 6500 vending terminals. The high number is required as the service must provide at any place and any time for e.g. a foreign user to buy more km by any means of payment including cash.
- Need to stop at the border for everybody, including NL residents and frequent foreign users.

Scenario	Scenario 2: Prepaid KM-Vignette
INVEST	119.160.959
Operations 1 Year	310.107.877
TOTAL INVEST + 10Y OP.	3.220.239.729
Depreciation Average 1 Year	14.299.315
TOTAL INVEST + 10Y OP+D	3.363.232.880

It is recommended to see the printout of the scenario comparisons of phase D2 for more detail.

12.2. Scenario “4”: 100% Video tolling

In the scenario "Scenario 4: Tolling Based On License Plate Only", license plate readers are placed in strategic locations. Where applicable, front and backshot is taken. The stationary equipment will also determine the class of the vehicle and use the RDW database for further increase of confidence for domestic users before human post processing takes place. The process is well proven and legal for traject controle.

Users are given the option to link their account to a credit card, bank account etc. or pay cash at many shops that are equipped with terminals. Users are given 72 hours to pay. If no payment is made, the number plate is blacklisted. Letters are sent to domestic users and blacklists of foreign users are with the mobile enforcement patrols.

The scenario was *initially considered because* it is the only scenario without OBU.

The scenario was *not pursued further because* it turned out to be

- Expensive (about € 5bn), more than 2 times of any of the chosen scenarios.
- Labour intensive (more than 6,000 people even in the best case of legal boundary conditions and assumptions on most advanced software and computing power)
- Very obtrusive with 5000 video capture sites.

Scenario	Scenario 4: Tolling Based On License Plate Only
INVEST	1.574.500.000
Operations 1 Year	352.577.778
TOTAL INVEST + 10Y OP.	5.100.277.778
Depreciation Average 1 Year	188.940.000
TOTAL INVEST + 10Y OP+D	6.989.677.778

It is recommended to see the printout of the scenario comparisons of phase D2 for more detail.

12.3. Scenario “5”: Toll Included in Fuel Price

It was considered to just increase the fuel tax instead of introducing a toll system, which would have the effect of taxing not only per km, but also differentiating between “smart, lean consumption” and “bad, high consumption” vehicles (e.g. small 1000cc car vs. 4 liter 4X4 SUV); and driving style.

Instead of having a cost, this option would have the implication of people filling up vehicles outside NL. The “cost” is therefore based on an estimate of taxes lost from liters switching to other countries. The detail data in the attachment contain assumptions about driving to the foreign petrol station including km cost and utility cost of private time, and estimates of how much is to be gained. Thereby, everybody living within 20km of the border would travel to the foreign station to fill up.

The scenario was *initially considered because* it basically comes for free. It was of importance to verify its economics against the other options.

The scenario was *not pursued further because* it turned out that

- The operations costs (fuel tax losses) are very high, so this is not an economical solution
- The “Political Chance” for this option is not very high according to a comment we received from the ministry.

Scenario	Scenario 4: Toll Included in Fuel Price
INVEST	0
Operations 1 Year	600.000.000
TOTAL INVEST + 10Y OP.	6.000.000.000
Depreciation Average 1 Year	0
TOTAL INVEST + 10Y OP+D	6.000.000.000

It is recommended to see the printout of the scenario comparisons of phase D2 for more detail.

12.4. Scenario “7”: GSM Cell ID Recording by Network

GSM networks have the capability to track cellular phones as they travel from tower to tower. It was therefore considered to use the track of cell phones fro toll data purpose. The phone would be a phone that is anyway carried by everybody. In this case, there would be a need for a clear one-to-one relationship between the phones and vehicles and the need to de-register temporarily as the . Alternatively, the government could procure old phones and hand them out to people. Alternatively, a downgraded phone for very low cost e.g. just a GSM send-only unit connected to the mains could be procured.

The scenario was *initially considered because* it would allow the utilization of an existing vast infrastructure without any modifications to the infrastructure, allowing OBUs, which possibly come for free, or, with some creativity, at very low cost.

The scenario was *not pursued further because* it turned out that

- The cell sizes of the GSM networks have a wide variety, from below 100 meters to up to 40km. So the precision is not good enough.
- Many people make their daily movements under 2km, which could be inside the same cell, paying too low. Another one 5km to the north might have the same pattern where he constantly changes between two cells, paying too high.
- Options to obtain low-cost cell phones are possible but considered “too creative”

Scenario	Scenario 7: GSM Cell ID Recording by NETWORK
INVEST	70.500.000
Operations 1 Year	242.653.600
TOTAL INVEST + 10Y OP.	2.497.036.000
Depreciation Average 1 Year	8.460.000
TOTAL INVEST + 10Y OP+D	2.581.636.000

It is recommended to see the printout of the scenario comparisons of phase D2 for more detail.

12.5. Scenario “9”: Dedicated Ministry Own Radio Network

The option was discussed but it turned out that there will be no advantage in cost as all solutions have similar set-ups.

13. Contact Details of the Team for Questions

The team of EFKON consisted of the following persons

- Max Staudinger, Marketing Director EFKON AG, m.staudinger@efkon.com
- Wolfram Tuchscheerer, Product Manager of Efkon Mobility, wtuchscheerer@efkon-mobility.de
- Matthias Lydike, CEO and Head of Development of Efkon Mobility, mlydike@efkon-mobility.de
- Wolfgang Boh, Technical Director, EFKON AG, w.boh@efkon.com
- Bernd Streitberger, b.streitberger@efkon.com

Mr. Lydike and Tuchscheerer were the lead authors for scenarios **1**, **6**, (7) and **8**. Mr. Staudinger was the lead author for scenarios (2), **3**, 1+3, (4), (9), the enforcement system and the payment services field infrastructure, and the overall editor for all documents. Mr. Boh was a main contributor in creation, architecture and selection of the solutions, while Mr. Streitberger assisted in project management and was the lead editor for item (5).

Should there be any questions with regard to the study, or any wish to elaborate on parts of it, or to provide new material about similar subjects, please don't hesitate to contact any one of the abovementioned persons.

All of us can also be reached easily at +43 316 695 675 – 0 (Switchboard).

14. Attachments

14.1. Attachment 1: Detailed Costing

14.2. Attachment 2: Risk Register

14.3. Attachment 3: Tabular Detailed Comparison of All Scenarios as Submitted under D2