REETS

REETS-TEN

Activity 3:
Key Performance Indicators

D 3.2 Description of KPI measurement methods

Definition of Toolbox KPIs for EETS

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Content

1 Introduction

1.1 Scope, objective and Structure of the Document

The scope of this deliverable is to document the outcome of sub-activity 3.2 within the REETS project. Specifically the deliverable describes the measuring methodologies for the toolbox of KPIs, which have been developed through the work of sub-activity 3.1..

The objective of the document is to define measuring methodologies for each KPI which has been defined in deliverable 3.1 and which can be used within contracts between Toll Chargers and Service Providers, in order to monitor the performance within the main business processes required for EETS operation.

The remaining chapters of the deliverable provide:

- a description of the structure used to describe the measuring methodology of each KPI
- a list of definitions for abbreviations used
- a list of the KPIs included in the Toolbox
- descriptions for measuring methodologies for each KPI according to their applicability to either DSRC or GNSS based Toll domains or both technology options.

2 Structure of the measuring Methodology description

The document is structured with a section for each of the KPIs defined in the toolbox.

All KPIs which were defined in the toolbox are enlarged by the following items:

a. *What could impact process performance?*
b. *What are the consequences?*
c. *Variables needed for the calculation*
d. Calculation
e. *Measuring period (largely depending on the actual number of transactions and events)*
f. *Population, sample size, statistical properties (largely depending on the actual number of transactions and events and further properties of the system)*

3 Abbreviations and Glossary

CN	Cellular Network
DSRC	Dedicated Short Range Communications
SP	Service Provider
GNSS	Global Navigation Satellite System
KPI	Key Performance Indicator
OBE	OnBoard Equipment
RSE	Roadside Equipment
TC	Toll Charger
WP	Work Package
LAC	Location Augmentation Communication

4 KPI Measurement

The D3.2 “Measuring Methodology for KPIs” defines methods for measuring KPIs as specific as possible and to provide tools for the quality and performance measurement which can be used in different toll domains by different SPs and TCs within their quality management or their SLAs. Three categories of KPIs were identified:

- Technology independent KPIs
- DSRC-System specific KPIs
- GNSS/CN-System specific KPIs

Within these categories the measurement methodologies are defined in a technology agnostic, purely functional way. That means that e.g. independent of the technology of the back-office interface (web-services, FTP file exchange etc.) between SP-back-office and TC-back-office the KPI speaks about a sender and a recipient indicating who (sender) has to provide information packages to whom (recipient). Based on this functional approach it is transparent to everybody who is responsible for the delivery of a specific service which is monitored via a KPI.

Within this responsibility based approach the measuring methodology excludes parameters which cannot be influenced by the service delivery party from the calculation of the KPI.

Therefore it is necessary to define each variable very specifically for the calculation of the KPI corresponding to the process.

Generally, when the KPIs are expressed as a percentage rate, it is recommended to express the value as a success rate, i.e. “successful events / all events”.

However, it shall be noted that not all KPI values are expressed as percentage rates. Another type of KPI measurement is a ratio, where two measured values are set in relation to each other.

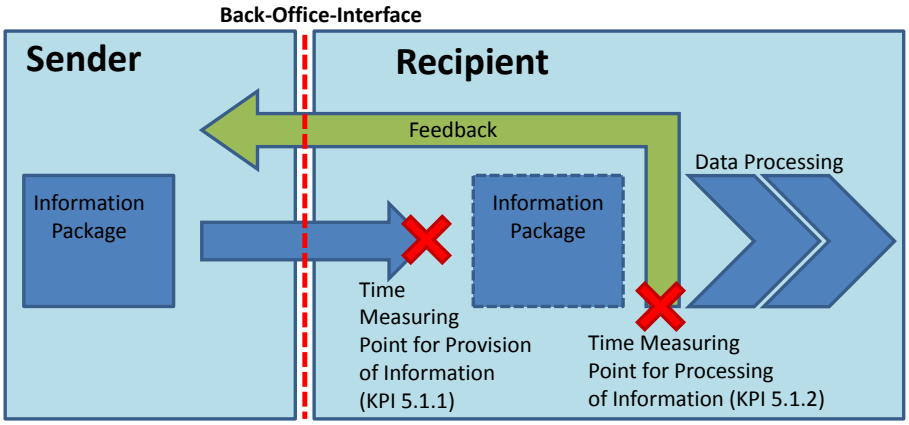
5 Technology Independent KPIs

5.1 EETS Interface Service Quality (Timeliness)

Looking the exchange of data at the back-office-interface the timeliness of data exchange can be distinguished based on two perspectives:

- Perspective of the recipient who wants to have specific data available at a specific time
- Perspective of the sender who wants that the recipient takes the responsibility for processing of specific data at a specific time

The following two KPIs (5.1.1 and 5.1.2) are created to measure this.



5.1.1 EETS Interface Service Quality on timeliness of provision

KPI	EETS Interface Service Quality on timeliness of provision
Aim of the KPI	The aim of this KPI is to monitor the timeliness of the information packages communicated via an interface as an indicator of service quality provided on the EETS Interface. Note : Together with the KPI described in section 5.2, the overall aim of the KPI is also to provide a harmonised approach to the monitoring of EETS interface performance by introducing 'timeliness' and 'correctness' as parameters to measure the performance of the interface rather than measuring 'availability' as link on / off events. The KPI applies to the measurement of the performance from the perspective of the recipient (either TC or SP) of provided information units.
Description of process	The process to be monitored by this KPI is the exchange of information using the defined interface between SP and TC in order to support the required business processes for EETS in a specific Toll Domain. Specifically, this KPI applies to transmission processes, which are mainly important for the recipient..
What will be monitored?	The KPI should monitor the quality of the back office interface in supporting the business processes required for EETS within the specific Toll Domain. Specifically this KPI will monitor the timeliness of the provision of information across the interface according to the requirements agreed between the SP and TC in the specific Toll Domain to support the identified business processes (see REETS Deliverable D4.1).
Definition of	The KPI is defined as B/A (expressed as a percentage) where

KPI	B = the quantity of information exchanges which are verified as received in accordance with the timing requirements agreed between the SP and TC for a specific interface and where A = the total quantity of information exchanges which should have been provided by the sender. The method for measuring the quantity of information exchanges included within the KPI calculation shall be determined by the SP and TC. The information exchange types shall include for example those associated with the exchange of: 1) Toll Context Data 2) Toll Declarations 3) Billing details 4) Exception lists 5) User Details 6) Payment Claims
Mitigation ideas	• improve / enforce service level agreement for communication link e.g. availability of communications link. • Improve delay of back-office processing of information required for transmission • Modify packet size of transmitted information
What could impact process performance?	• The Interface is not available • The messages were provided too late, due to e.g. not available back-office system
What are the consequences?	Late messages can be the reason, that defined processes cannot be executed at the right time or in case of blacklists a shift of liabilities can take place depending on the contractual agreements.
Variables needed for the calculation	A = the total quantity of information units which are received or should be provided (based on the schedule) using the interface B = A – (D – E) D = the total quantity of information units (functional units, e.g. black list, transactions, list entries etc.) which were received not within the agreed period of delivery time E = the total quantity of information units (functional units, e.g. black list, transactions, list entries etc.) which were received not within the agreed period of delivery time due to not availability of the receiving interface or back-office (the interface and the back-office are monitored) or other reasons not in the responsibility of the sender preventing the reception of information. A trouble ticket is generated, when the interface or the back-office system is not available and the trouble ticket is closed when the interface or the back-office system is available again. All messages have to be sent even it was not possible to send them at the right time.
Calculation	$EETS\ Interface\ Timeliness = \frac{B}{A}$
Measuring period	One month
Population, sample size, statistical properties	All messages received at the recipient and messages, which should be received based on the schedule, are counted.

5.1.2 EETS Interface Service Quality on timeliness of processing

KPI	EETS Interface Service Quality on timeliness of processing
Aim of the KPI	The aim of this KPI is to monitor the *timeliness* of information packages communicated via an interface as an indicator of service quality provided on the EETS Interface. In this case the information has to be received and accepted (hand shake procedure) by the recipient of the information. Note : Together with the KPI described in section 5.2, the overall aim of the KPI is also to provide a harmonised approach to the monitoring of EETS interface performance by introducing 'timeliness' and 'correctness' as parameters to measure the performance of the interface rather than measuring 'availability' as link on / off events. The KPI applies to the measurement of the performance from the perspective of the sender (either TC or SP) of provided information units.
Description of process	The process to be monitored by this KPI is the exchange of information using the defined interface between SP and TC in order to support the required business processes for EETS in a specific Toll Domain. Specifically, this KPI applies to transmission processes, which are mainly important for the sender.
What will be monitored?	The KPI should monitor the quality of the back office interface in supporting the business processes required for EETS within the specific Toll Domain. Specifically this KPI will monitor the timeliness of the processing of information provided across the interface according to the requirements agreed between the SP and TC in the specific Toll Domain to support the identified business processes (see REETS Deliverable D4.1).
Definition of KPI	The KPI is defined as B/A (expressed as a percentage) where B = the quantity of information exchanges which are acknowledged as received by the recipient in accordance with the timing requirements agreed between the SP and TC for a specific interface and where A = the total quantity of information exchanges which are provided by the sender. The method for measuring the quantity of information exchanges included within the KPI calculation shall be determined by the SP and TC. The information exchange types shall include for example those associated with the exchange of: 1) Toll Context Data 2) Exception lists 3) User Details 4) Payment Claims
Mitigation ideas	• improve / enforce service level agreement for communication link e.g. availability of communications link. • Improve delay of back-office processing of information required for transmission • Modify packet size of transmitted information
What could impact process performance?	• The Interface is not available • The messages were transmitted too late, due to e.g. not available back-office system • The information unit could not be processed by the recipient (no hand-

	shake)
What are the consequences?	Late messages can be the reason, that defined processes cannot be executed at the right time or in case of blacklists a shift of liabilities can take place depending on the contractual agreements.
Variables needed for the calculation	A = the total quantity of information units which are received or should be provided (based on the schedule) using the interface B = A – (D – E) D = the total quantity of information units (functional units) which were processed not within the agreed period of delivery time measured based on the feedback E = the total quantity of information units (functional units, e.g. black list etc.) which were provided not within the agreed period of delivery time due to not availability of the interface or back-office (the interface and the back-office are monitored) of the sender. A trouble ticket is generated, when the interface or the back-office system is not available and the trouble ticket is closed when the interface or the back-office system is available again. All messages have to be provided even it was not possible to provide them at the right time.
Calculation	$EETS\ Interface\ Timeliness = \frac{B}{A}$
Measuring period	One month
Population, sample size, statistical properties	All messages received at the recipient are counted.

5.2 EETS Interface Service Quality (Correctness)

KPI	EETS Interface Service Correctness
Aim of the KPI	The aim of this KPI is to monitor the correctness of information packages communicated via the interface as an indicator of service quality provided on the EETS Interface. Note : Together with the KPI described in section 5.1, the overall aim of the KPI is also to provide a harmonised approach to the monitoring of EETS interface performance by introducing 'timeliness' and 'correctness' as parameters to measure the performance of the interface rather than measuring 'availability' as link on / off events. The KPI applies to the measurement of the performance from the perspective of the recipient (either TC or SP) of transmitted information packages.
Description of process	The process to be monitored by this KPI is the exchange of information using the defined interface between SP or TC in order to support the required business processes for EETS in a specific Toll Domain. This KPI is therefore bi-directional i.e. it is applied to information sent by either SP or TC according to the relevant elements of the applicable business processes.
What will be monitored?	The KPI should monitor the quality of the back office interface in supporting the business processes required for EETS within the specific Toll Domain. Specifically this KPI will monitor the correctness of the provision of information across the interface according to the requirements agreed between the SP and TC in the specific Toll Domain to support the identified business processes (see REETS Deliverable D4.1).
Definition of KPI	The KPI is defined as B/A (expressed as a percentage) where B = the quantity of information exchanges which are verified as received in accord-

	ance with the quality requirements for correctness agreed between the SP and TC and where A = the total quantity of information exchanges which are transmitted using the interface following a corresponding request for information from the recipient. The method for measuring the quantity of information exchanges included within the KPI calculation shall be determined by the SP and TC. The information exchange types shall include for example those associated with the exchange of: 1) Toll Context Data 2) Toll Declarations 3) Billing details 4) Exception lists 5) User Details 6) Payment Claims
Mitigation ideas	• utilise error checking in transmission process • Implement technical safeguards within interface design and security poilicies • intensify interface tests (for next interface update) • train operations team
What could impact process performance?	• A wrong file format was used for generating the message • The values which were transmitted to the recipient are wrong • The wrong parameters are displayed within the file • The information unit is corrupt due to an error during the file generation or transmitting process
What are the consequences?	The consequences depend on the specific messages that were received incorrect. So the range can be between nearly no negative consequences up to financial loss.
Variables needed for the calculation	All messages received by the recipient are checked formally. Messages, which are not correct or corrupted, are flagged and a feedback including the findings of the formal check. A = the total quantity of information packages (functional unit) which are retrieved using the interface B = A-C C = the total quantity of information packages (functional unit) which are flagged as not correct or corrupted; this could be: i. Incorrect format ii. Incorrect value iii. Incorrect parameter iv. Corrupted file
Calculation	$\text{EETS Interface Correctness} = \frac{B}{A}$
Measuring period	One month
Population, sample size, statistical properties	All messages received at the recipient are counted.

5.3 Payment settlement delay

KPI	Payment settlement delay
Aim of the KPI	The aim of this KPI to provide an effective measurement of the performance of **SPs** in transferring Toll Payments to the Toll Charger.
Description of process	The KPI is concerned with the specific process of payment settlement by the SP to the TC, following the issue of required documentation (for example invoice, billing details or toll declarations as agreed in the specific Toll Domain) by the TC to the SP.
What will be monitored?	This KPI will monitor the time taken to transfer toll payments to the TC by the SPs and specifically any delays arising within this process.
Definition of KPI	The KPI focuses on payments which have been settled within the measurement period. This KPI is equal to the number of days of delay occurring for the payment settlement, either punctually or during a monitoring period. Alternatively it can be expressed as a percentage.
Mitigation ideas	• Process improvements by SP for example the usage of workflow systems for approval and release of payments • Provision of correct and complete information by TC
What could impact process performance?	• TC: The Payment Claim was transmitted too late. • SP: The Billing Details were transmitted too late • SP: The payment was executed too late
What are the consequences?	• Cash flow issues due to late payment settlement
Variables and Calculation for Alternative 1	The KPI "payment settlement delay" is equal to • '0': the payment settlement has been performed during the validity period for payment settlement or • '1' (late payment settlement) : the payment settlement has been performed (or finished in case of multiple payment settlements for one Payment Claim) after the validity period for payment settlement
Variables and Calculation for Alternative 2	The variable "payment settlement delay" is equal to the total number of days that have elapsed between the due date and the actual payment date of all payments settled within the measurement period. Time frame (days, weeks..) of delay in payment of SP. $\frac{\sum_N^1 payment\ settlement\ delay}{N} \leq delay\ stated\ in\ contract$ N: number of payments settled within the measurement period.
Measuring period	One month
Population, sample	All payments paid in the measurement period

size, statistical properties	

5.4 Correctness of OBE Personalisation Data

KPI	Correctness of OBE Personalisation Data
Aim of the KPI	The aim of the KPI is to assure the quality of data within the process of SPs personalising on board equipment (based on information provided by users).
Description of process	The process being monitored is the correct personalisation of the on-board unit by the SP (based on information provided by users) to ensure that the correct data (for example emission class) is stored in the OBE, thereby ensuring correct charging and enforcement operations result. Note that the requirement for users to register in each Toll Domain is not mandatory and requirements for registration vary according to the individual requirements of each Toll Domain.
What will be monitored?	To improve the performance of the personalisation process, the correctness of data held in OBE shall be monitored by SPs using this KPI. The data that are required to be correctly personalised by the SP during the personalisation process could include for example: • the license plate (incl. country of registration), • vehicle class (UNECE vehicle class) and number of axles of the vehicle • vehicle EURO emission class (if required) • vehicle weights • any other required data This means that the SP must carry out checks on the information and data provided by the user, the registered user and vehicle data and on the data stored in the onboard equipment, if agreed in the contract between SP and TC. The TC should inspect the SP's operational processes in order to verify the correct interpretation, collection and storage of data provided by users. In the course of a regular inspection, it is determined how many of the OBEs issued by the SP and registered on the TC's network deviate in one of these features from the features actually identified in the inspection process. The SP must send the TC information of proof on any deviations found. If the personalisation of the OBE matches the information of proof, then the deviation was caused by the misbehaviour of the User. If a deviation between the personalisation of the On-Board Equipment and the information of proof is established during the inspection, then the deviation was caused by the misbehaviour of the SP. The basis for the distinction of responsibilities is EU Decision 2009/750 art.4 item 5 and art.9 item 2. The metric CM-UA-5 defined in ISO/TS 17444-1 is directly applicable to the measurement of this KPI.
Definition of KPI	The KPI is defined as B/A (expressed as a percentage) where B = the number of incorrectly personalised items of On-Board Equipment (based on data provided at personalisation by users) and where A = the total number of items of On-Board Equipment in the corresponding sample.
Mitigation ideas	Improved checking by SP during personalization process:

	• User: The user is not declaring the correct data • SP: The SP has erroneous data within his database
What could impact process performance?	• User: The user is not declaring the correct data • SP: The SP has erroneous data within his database
What are the consequences?	E.g. wrong Emission class information causes less or more revenue or generated complaints and a less good customer satisfaction index.
Variables needed for the calculation	A = Number of checked OBEs per SP B = Number of OBEs with erroneous content (incorrectly personalized) per SP
Calculation	The KPI is calculated as follows: **Correctness of OBE Personalisation Data** $= 1 - \frac{B}{A}$ The SP is required to store information that is sent to the SP by SUs for the purpose of personalising OBEs The SP is further required, at the request of the TC, to furnish information of proof on certain Users selected by the Toll Charger for the purpose of checking the personalisation data.
Measuring period	Per calendar month
Population, sample size, statistical properties	To be defined by the respective Toll Charger Recommendation: The sample shall include at least 100 OBE, that will be checked. The sample should be selected relatively small in order to limit the efforts, as this KPI will require manual checking. If the KPI value for the sample is in a critical range, then an increased (additional) sample should be taken in order to verify the results.

5.5 Service User Claim Response

KPI	Service User Claim Response
Aim of the KPI	The aim of the KPI is to measure the performance of the process of providing responses to Service Users. In particular, this KPI aims to measure the performance of TCs in supporting SPs inquiry process on user claims relating to Toll Statements.
Description of process	The SP is the main contact for his users/customers in case of complaints on the invoice and the toll statement. The TC solely decides to accept or refuse the user complaint on applied toll charges. After first review by the SP, the SP is responsible for transmitting the user's complaint with all necessary justifications to the TC for instruction and decision. The KPI measures the conditions and quality of the process in respect to the agreed time frame between the SP and the TC for user claims instruction.
What will be monitored?	Number of transmitted requests by the SP towards the TC in comparison to number of correctly and timely answered requests by the TC Metrics for this KPI are not defined in ISO/TS 17444-1.
Definition of KPI	The KPI is defined as follows: 1) A= Number of claims per month, B=Number of tolled km or number of passages in a DSRC operated tolling system: The Ratio A/B gives by comparison with other comparable toll domains, an indication on the difficulties felt by user to get the right toll charges. This could lead to improving the quality of the information delivered to users or the way the toll charges are determined for a certain category of users. 2) C= Number of accumulated days taken by the TC to answer to open claims, D= Number of open claims transmitted to the TC The Ratio C/D defines the average number of days taken by the TC to answer claims and is compared to the TC commitment set in the Contract. 3) E= Number of claims by the TC, F= Number of claims sent to the TC for which instruction is closed Ratio E/F gives an indication of the quality of the pre-processing made by the SP and the flexibility of the TC in accepting claims.
Mitigation ideas	• Improvements in SP reviewing claims before forwarding to TC • Improvements in details relating to claim provided by SP to TC • Note the above mitigations relate to SP processes and not to TC processes but TC performance in responding to claims is largely dSPendant on the information provided by the SP • Temporarily or permanently increase resources in treating claims or train resources at SP and/ or TC. • Process improvement TC
What could impact process performance?	User justifications are incomplete or inappropriate: claim is rejected TC does not receive the claim: acknowledgement procedure to be put in place between EP and TC The claim is addressed to the wrong TC: claim is rejected The claim is out of time and cannot be instructed: claim is rejected
What are the consequences?	User dissatisfaction which could affect their behaviour regarding the toll system or lead to a court case. Additional work for the TC if claims are not properly pre-instructed by the EP Additional work for both the SP and the TC if recurrent claims are made by users for the same issue. Actions from the TC have to be taken to increase the acceptance again.
Variables	**Claims**: counted claims are those transmitted by the EP and received by the TC.

needed for the calculation	One claim corresponds to one transaction or one line in the billing details, even if the user makes only one global complaint including several transactions or billing details lines. Each transaction or billing details line should have its own instruction procedure **Open claims** are claims which have not yet been answered by the TC for decision **Closed claims** are claims which the TC has notified the SP its decision **Claims of the month** are either still open claims at the end of the month or claims which the TC has closed during the month **Time for instruction taken by the TC**: is the time counted in calendar days from the date of receiving the claim by the TC until the date when a decision is taken by the TC and received by the SP **Time of instruction of the claims of the month**: at the end of the month, the SP counts the number of claims which remain open and the time counted for instruction for these open claims is the time in calendar days between the dates of reception of the claim by the TC until the end of the current month. To this time is added the time in calendar days calculated for each claim closed during the past month from the date it has been received by the TC until the day the answer is received by the SP to close the claim. The time of instruction of the claims of the month is the result of the addition of these two times. **Number of accepted claims**: is the number of accepted claims during the period of observation (generally since the beginning of the year)
Calculation	KPI 5.5: Average time for instruction **KPI 5.5=** $\frac{Time\ of\ instruction\ of\ the\ claims\ of\ the\ month}{Number\ of\ open\ claims}$
Measuring period	Measured on a monthly basis
Population, sample size, statistical properties	All claims are considered:

6 DSRC-related KPIs

6.1 OBE DSRC Transaction Quality

The following KPI shall be applicable in multi-lane free flow DSRC tolling systems, as well as in DSRC tolling systems with barriers and in GNSS tolling systems for Compliance Checking Communication if a statistically significant reference group is available**.**

Note the SP Front-End may have additional real time information, using the GNSS/CN facility of the OBE, related to incorrect DSRC transactions which can be used to identify the origin of the malfunction and to determine the right ratio of toll. The bilateral agreement between the TC and the SP can define how to use these complementary data for toll determination process improvement.

KPI	**OBE DSRC Transaction Quality**
Aim of the KPI	Monitor the transaction quality between the RSE and the DSRC interface of OBE from any SP. The KPI is therefore applicable to monitoring of **SP**s (OBE performance) by TCs.
Description of process	The process being monitored by this KPI is the process of completing a DSRC transaction or Compliance Checking Communication (if applicable) between OBE and RSE. In ETC systems where DSRC communications between OBE and RSE are used to generate Toll Transactions, correctly completed DSRC transactions are necessary in order to correctly identify the vehicle and SP to which the corresponding billing details should be sent by the TC.
What will be monitored?	The KPI will monitor the performance of the DSRC transactions of a specific group (= e.g. all OBE of one SP) or type of OBE within and compared to a statistically representative group of reference OBE circulating in a specific Toll Domain. The comparison with a reference group can help to statistically eliminate the influence of Road Side Equipment errors and Service User errors occurring during the measurement period. The monitoring of this KPI will be done by calculating an overall DSRC Error Ratio (=KPI 1). This overall error ratio shall be based on monitoring of the ratio of occurrence of different types of transactions as defined in the following section. Sub-KPIs may be implemented for individual transaction types to provide more detailed monitoring. Metrics for this KPI are not defined in ISO/TS 17444-1 explicity at this level of detail although consequences may be covered by other metrics.
Definition of KPI	The KPI is defined as B/A (expressed as a percentage) where : B = the total number of Complete DSRC transactions recorded for the sample group in the measurement period and A = the total number of Complete DSRC transactions recorded for the sample group in the measurement period plus the total number of Incomplete and missing transactions which can be associated with the SP (note no transaction shall be counted twice). The sample group is either the specific group (e.g. all OBE of one SP) or the statistically representative group of reference OBE. Parameter definitions: • Complete transactions: those transactions for which data transmission was complete and error-free. • Incomplete transactions: all DSRC transactions detected as incomplete / incorrect (for which the required communication cycle was not properly terminated, insofar as an incomplete transaction can be confirmed as

relating to a specific OBE unit).

- Missing transactions:.
  - **Reconstructed transactions**: in the event of gaps between two or sometimes also more toll transactions, missing toll transactions can be synthetically reproduced (retroactively calculated) following a plausibility check of the driving time between the toll sections preceding and following the gap. Such transactions can be used within the KPI calculation to determine the number of missing DSRC transactions.
  - **Missing transactions** detected by enforcement equipment: a missing transaction of an OBE exists when a vehicle passing a stationary or mobile enforcement equipment without a complete or incomplete transaction has a valid contract with an SP, the OBE was not blocked and the visual inspection by the Toll Charger showed that the OBE was mounted correctly.
  - **Video based transactions** (in a Free flow ETC lane) defined as a Transaction created (in back office systems) based on:
    1. extraction of an registration number from a picture taken in a Lane (RSE)
    2. subsequent lookup of data about the service provider.
  - **Manually keyed in transactions** defined as a Transaction where the OBE Primary Account number (PAN) is keyed in manually.
    Manually keyed in transactions are an indicator that no DSRC transaction occurred.

The reference group will be determined by the respective Toll Charger for his Toll Domain, whereby it is recommended that the reference group either consists of all OBE types that are actively operated in post-pay mode in the respective Toll Domain or at least of those OBE types that are mainly (with a high population) used in the Toll Domain to make the reference group sufficiently big and statistically representative.

In certain Toll Domains a further division of the DSRC Error Ratio is necessary as the effects of the above listed incomplete and missing transactions differ. Whilst e.g. incomplete, reconstructed, manually keyed and video based transactions do not lead to a loss of tolling income, the missing transactions detected by enforcement equipment do lead to a loss of income in the tolling system if they cannot be fully recovered by a degraded mode system (e.g. a video based recognition at every toll point).
In addition to that, the effort for a Toll Charger to reconstruct types of incomplete or missing transactions is different for the individual transaction types. All or some of the following individual sub-KPIs, will therefore be calculated in order to have the possibility of an individual and different assessment:

The envisaged sub-KPIs are:

- **Ratio of incomplete transactions (= KPI 1a)**
- **Ratio of reconstructed transactions (= KPI 1b)**
- **Ratio of missing transactions detected by enforcement equipment (= KPI 1c)**
- **Ratio of video based transactions (= KPI 1d)**
- **Ratio of manually keyed transactions (= KPI 1e)**

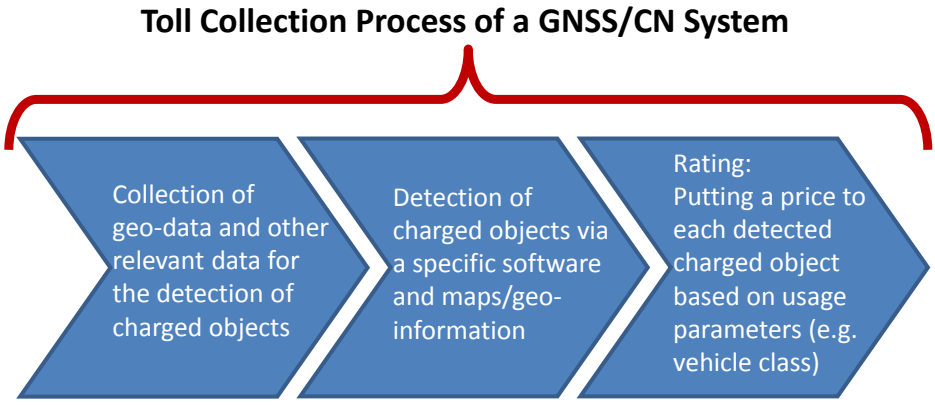
	Similar to the general DSRC Error Ratio, also those individual sub-KPIs will be calculated for the OBE issued by an SP as well as for the reference OBE (reference group) and compared.
Mitigation ideas	In case one OBE type has an issue: • Improved OBE development and test processes • Improved OBE manufacturing process quality In case most of the OBE types have an issue: • Modify the RSE • Modify RSE software to improve detection
What could impact process performance?	• User: Wrongly mounted OBE • TC: Not accurately working Beacon • EP: OBE is not working well
What are the consequences?	• Incomplete transactions • Missing transactions
Variables needed for the calculation	In general the following data are required for calculating the DSRC Error Ratio as well as the sub KPIs (depending on which type of transactions actually occur in the respective toll domain): • Number of complete transactions • Number of incomplete transactions • Number of missing transactions detected by enforcement equipment • Number of video based transactions • Number of manually keyed in transactions
Calculation	The general **DSRC Error Ratio (= KPI 1)** is calculated as follows: • DSRC Error Ratio = $\frac{incomplete\ transactions+missing\ transactions}{complete\ transactions}$ The number of missing transactions consists of reconstructed, missing transactions detected by enforcement equipment, video based transactions and manually keyed in transactions, dependent on which type of transctions actually occur in the respected toll domain. The number of "missing transactions detected by enforcement equipment" needs to be multiplied by a factor "**x**", as those transactions are only detected on tolling gantries with stationary or portable enforcement equipment, but were also possibly missing at "normal" tolling gantries without enforcement equipment, This factor "**x**" represents the ratio of "normal" tolling gantries to tolling gantries with enforcement equipment. **x** = number of normal tolling gantries / number of tolling gantries with stationary or portable enforcement equipment The envisaged sub KPIs (= KPI 1a, KPI 1b, KPI 1c, KPI 1d and KPI 1e) are calculated as follows:

	• **KPI 1a: Ratio of incomplete transactions** = $\frac{incomplete\ transactions}{complete\ transactions}$ • **KPI 1b: Ratio of reconstructed transactions** = $\frac{reconstructed\ transactions}{complete\ transactions}$ • **KPI 1c: Ratio of missing transactions detected by enforcement equipment** = $\frac{x * missing\ transactions\ detected\ by\ enforcement\ equipment}{complete\ transactions}$ • **KPI 1d: Ratio of video based transactions** = $\frac{videobased\ transactions}{complete\ transactions}$ • **KPI 1e: Ratio of manually keyed in transactions** = $\frac{manually\ keyed\ in\ transactions}{complete\ transactions}$
Measuring period	One month
Population, sample size, statistical properties	Total number transactions performed by the OBEs of the SP which appeared within the charged network of the Toll Domain during the measuring period

7 KPIs for GNSS/CN Systems

The following KPI are specifically applicable to toll domains using GNSS/CN technology.

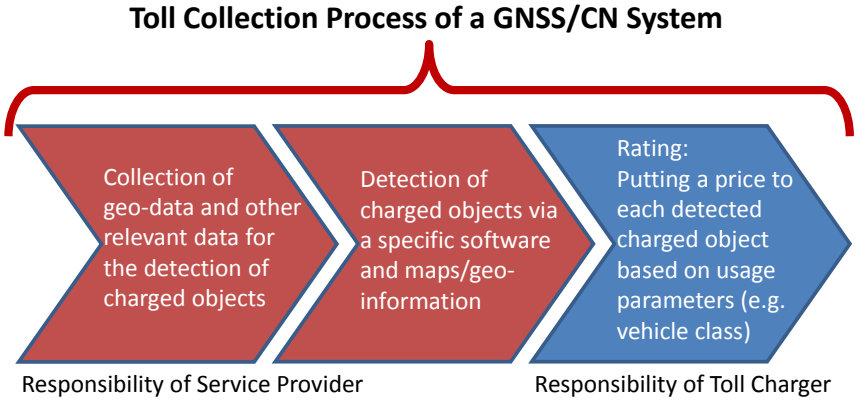
A GNSS/CN technology based tolling system collects the toll more or less based on three process steps which can be executed by the SP or the TC. It is necessary to understand this process and the split of responsibility between SP and TC to understand the following KPIs.



7.1 Detection Performance

7.1.1 Missed Recognition Events

Note: this KPI is applicable for discrete charging systems (see EN ISO 17444)
Reference EN ISO/TS 17444: “TD – TSP Event Detection” (CM – TD – 4)



The here defined KPI is based on the split of responsibility as follows:

- The SP is responsible for the collection of geo-data and other data which are required by the algorithm for detecting charged objects
- The SP is responsible for the detection of charged objects
- The TC is responsible for the rating of toll declaration data based on the detected chargeable events (vehicle passages at a chargeable event) and other usage data

In the German Toll Domain this KPI is used even that the rating process step shall be executed as well by the SP.

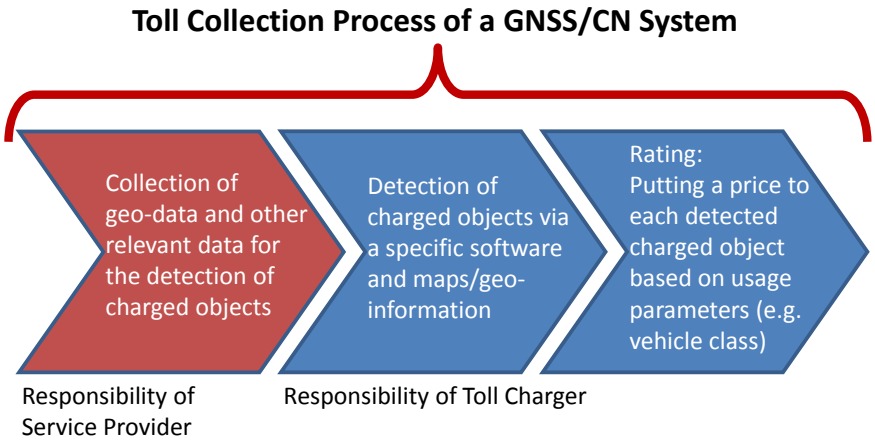
KPI	**Missed Recognition Events**
Aim of the KPI	Measure the quality of a service with respect to capture all Chargeable Events (e.g. passages of segments, entry and exit of a zone) of vehicles within the responsibility of the SP on the charged road network of the Toll Domain.
Description of process	A vehicle is passing a Charged Object (any object that is part of the toll context description that may be charged for its use under certain conditions e.g. Segments) and has to capture the passage and has to collect all data necessary to charge this passage.
What will be monitored?	Detection of all Chargeable Events of vehicles which are within the responsibility of an SP performed at the charged network of the Toll Domain. Impact factors of the Toll Charger (Erroneous toll context data – the erroneous toll context data should be detected during the tests which have to be performed before going in production with the toll context data) and of the User (wrong mounting of the OBE and willing manipulation) are excluded..
Definition of KPI	A: Chargeable Events detected for the usage of the tolled network divided by B: the total number of Chargeable Events that should have been detected.
Mitigation ideas	• mount additional LAC • improve detection algorithm • modify the Toll Context Data by improving the definition of some Charge Objects or their localization
What could impact process performance?	• User: Wrongly mounted OBU (including power supply) • TC: Wrongly defined Toll Context Data • EP: OBE/proxy is not working well
What are the consequences?	Missing Chargeable Events (even after adding Chargeable Events generated in the back-office System of the EP)
Variables needed for the calculation	A: Total number of the sample of detected GNSS Chargeable Events including the Chargeable Events generated in the back-office System of the SP The SP is notifying the TC about the charged objects which were used by his fleet during the measuring period. B: Total number of DSRC Events of OBEs of the SP which can be linked to the

	charged objects of the sample
Calculation	$Rate\ of\ Recognized\ Events = \frac{A}{B}$
Measuring period	• One month
Population, sample size, statistical properties	To get a representative sample the following criteria have to be respected: • The sample has to be generated once a month • The definition of the sample has to be done randomized • The sample can be generated on any chargeable objects • The sample is generated via all compliance checking instruments of the TC excluded mobile enforcement equipment

Note: the determination of chargeable events is dependent on the correct definition and implementation of the toll context data, the localization and the precise definition of Charging Objects, the presence of LAC, algorithms for determining the chargeable events from the information collected by OBE, level of precision of the OBE. The level of precision of the OBE is also verified during the accreditation process. The toll context data need to take into account the average performances of all accredited OBE.

7.1.2 Data provision for Detection of Charged Objects

Note: this KPI is applicable for discrete charging systems (see EN ISO 17444)



KPI 7.1.2 is based on the following split of responsibilities:

- The SP is responsible for the collection of geo-data and other data which are required by the algorithm for detecting charged objects
- The TC is responsible for the detection of charged objects
- The TC is responsible for the rating of toll declaration data based on the detected chargeable events (vehicle passages at a chargeable event) and other usage data

In the ECOTAX Toll Domain the detection of charged objects is executed by Ecomouv' on behalf of the TC.

KPI	Data provision for Detection of Charged objects
Aim of the KPI	Measure the quality of a service with respect to capture all charged objects that are passed by vehicles within the responsibility of the SP on the charged road network of the Toll Domain.
Description of process	A vehicle is passing through a charged object (any area described in the toll context data) and has to capture the passage and has to collect all data according to the rules determined by the TC e.g. in the toll domain statement.
What will be monitored?	Detection of all charged objects (including the required data) passed by vehicles which are within the responsibility of an SP in the charged network of the Toll

	Domain. Impact factors of the Toll Charger (Erroneous toll context data – the erroneous toll context data should be detected during the tests which have to be performed before going into production with the toll context data) and of the User (wrong mounting of the OBE and willing manipulation) are excluded.
Definition of KPI	A: charged objects detected for the usage of the tolled network with correct and complete data (according to the requirement) divided by B: the total number of charged objects that should have been detected.
Mitigation ideas	• mount additional LAC • improve detection algorithm • modify the Toll Context Data by improving the definition of some Charge Objects or their localization
What could impact process performance?	• User: Wrongly mounted OBE (including power supply) • TC: Wrongly defined Toll Context Data • EP: OBE/proxy is not working well
What are the consequences?	Missing Chargeable Events
Variables needed for the calculation	A = total quantity of charged objects for which the provisioning of data quantity and quality for each charged object was according to the contractual requirements B = the total number of charged objects that have been detected by the TC; for detection of charged objects the TC can add measurements which are not directly or not dependent of the data provided by the SP e.g. CCC transactions, subsequent toll charging transactions etc.
Calculation	$Rate\ of\ Detection\ of\ Charged\ Objects = \frac{A}{B}$
Measuring period	One month
Population, sample size, statistical properties	All detected charged objects

Note: the detection of charged objects is dependent on the correct definition and implementation of the toll context data, the presence of LAC and the level of precision of the OBE.

7.1.3 Accuracy of usage parameters

Note: this KPI is applicable for continuous charging systems (see EN ISO 17444)

The KPI 7.1.3 can be applied at Switzerland and Belgium. The SP is required to provide the distance driven within the Toll Domain, even if the whole distance is not charged by the TC (e.g. Belgium).

KPI	**Accuracy of usage parameters**
Aim of the KPI	Measure the accuracy of the measured usage parameters.
Description of process	A vehicle is passing through an area defined in the Toll Context Data and has to capture the charging parameters according to the rules determined by the TC e.g. in the toll domain statement.
What will be monitored?	The Accuracy of the measured charging parameter, representing the usage of the tolled network or area.
Definition of KPI	A: Usage parameter effectively measured for a specific charge event (e.g. trip) divided by B: the usage parameter correctly measured for this specific charge event.
Mitigation ideas	• mount additional LAC

	• improve measurement algorithm
What could impact process performance?	• User: Wrongly mounted OBE (including power supply) • EP: OBE/proxy is not working well
What are the consequences?	Missing Chargeable Events
Variables needed for the calculation	When a vehicle is entering the toll domain the OBE has to detect the entry and has to record the actual mileage with the timestamp. When the vehicle exits the toll domain the OBE detects the exit and records the mileage of the vehicle at that moment. The entry mileage and the exit mileage with the timestamp have to be declared to the TC. A = Total distance driven in the toll domain of all vehicles of the sample within a defined time period declared by the SP to the TC B = Total distance driven in the toll domain calculated based on positioning data provided by the SP of vehicles which make part of the sample and other additional events of these vehicles (e.g. CCC-Events)
Calculation	$Ratio\ of\ Accuracy\ of\ Usage\ Parameters\ (in\%) = \frac{A}{B}$
Measuring period	One month
Population, sample size, statistical properties	The sample is defined by the TC in accordance with the SP.

Note: the accuracy of measuring the usage parameters is dependent on the presence of LAC, algorithms for determining the usage parameters and the level of precision of the OBE.

7.2 False Positive Events

Reference to EN ISO/TS 17444: “TD – TSP False Positive”, (CM-TD-5)

KPI	False Positive Events
Aim of the KPI	Measure the quality of a service with respect to the declaration of False Positive Events of vehicles within the responsibility of the SP.
Description of process	A vehicle is passing a road section that is not part of the charged network and the SP should not declare this passage as Chargeable Event to the Toll Charger of this Toll Domain.
What will be monitored?	The declaration of False Positive Events.
Definition of KPI	A: False Positive Events declared to the Toll Charger (tolled network was not used) divided by B: the total number of correctly detected GNSS Chargeable Events of the SP.
Mitigation ideas	• mount additional LAC • improve detection algorithm
What could impact process performance?	• User: Wrongly mounted OBE (including power supply) • TC: Wrongly defined Toll Context Data • EP: Not working capturing process (OBE and proxy)
What are the consequences?	False positive GNSS Chargeable Events
Variables needed for the calculation	A: The total number of GNSS Chargeable Events of the SP which were successfully complained by the user within a measuring period related to false positive events B: The total number of not complained GNSS Chargeable Events of the EP within a measuring period
Calculation	$Rate\ of\ False\ Positive\ Events = \frac{A}{B}$
Measuring period	One month
Population, sample size, statistical properties	Based on all Chargeable Events

Note: the determination of toll events are dependent on the correct definition and implementation of the toll context data, the presence of LAC, algorithms for determining the chargeable events from the information collected by the OBE’s, level of precision of the OBE.

7.3 DSRC Compliance Checking Communication Performance

The following KPI measures the performance of the DSRC compliance checking communication of the OBE. This KPI was created in addition to OBE (Toll Charging) DSRC Transaction Quality KPI (section **Fehler! Verweisquelle konnte nicht gefunden werden.**) because it is within the current system setup of the German toll domain not possible to establish the same approach like specified in section 6.1 based on a significant reference group.

KPI	DSRC CCC Performance
Aim of the KPI	Measure the performance of the DSRC compliance checking communication of the OBE.
Description of process	A vehicle is passing a fixed or portable compliance checking station and is generating a compliance checking communication event.
What will be monitored?	The performance of the OBE with respect to the DSRC Compliance Checking Communication. The KPI is based on a sample (time period) measuring.
Definition of KPI	A: The total number of DSRC Compliance Checking Events (at a specific compliance checking station during a defined time period) which can be linked to a GNSS Chargeable Event of the SP divided by B: the total number of Chargeable Events of an SP at the compliance checking station within a defined time period. (The time and the compliance checking stations have to be communicated to the SP)
Mitigation ideas	• Instruct users of better/ correct mounting of OBE • Modify installation of RSE for CCC
What could impact process performance?	• User: Wrongly mounted OBE (including power supply) • TC: The compliance checking stations are nor working correctly • TC: The beacon is not mounted correctly or has changed its position • TC: The security-keys of the SP are not known by the compliance checking stations • EP: OBE is not working correctly
What are the consequences?	• No compliance checking event is processed
Variables needed for the calculation	A: A sample of correct and complete DSRC Compliance Checking Events (at a specific compliance checking station during a defined time period) which can be linked to a GNSS Chargeable Event of the SP B: The total number of Chargeable Events of a Service Provider at the compliance checking station within a defined time period. (The time and the compliance checking stations have to be communicated to the Service Provider)
Calculation	$Rate\ DSRC\ CCC\ Performance = \frac{A}{B}$
Measuring period	One month
Population, sample size, statistical properties	Sample is defined by the TC together with the SP

Annex A Glossary

Glossary V2.0

No.	Terminus	Ab-brev.	(short) description
1	Service Provider	SP	Company / Entity offering the services of an EETS-Provider but not necessarily formally registered as an EETS-Provider. Since the REETS Project shall facilitate the transition to EETS, it is recommended, to generally use "Service Provider (SP)", except if "EETS-Provider shall be explicitly addressed (e.g. in the context of registration).
2	EETS-Provider	EP	A legal entity fulfilling the requirements of Art 3 and registered in a Member State where it is established, which grants access to EETS to an EETS user (see Art 2 b) Decision 2009/750/EC).
3	Member State	MS	EU Member State
4	European Electronic Toll Service	EETS	The abbreviation EETS stands for European Electronic Toll Service. It is a service that enables the payment of tolls with a single contract at a single EETS provider and just one on-board unit throughout the European Union.
5	Regional European Electronic Toll Service	REETS	The REETS-TEN project aims at deploying EETS compliant services in a cross-border regional project. The Project shall cover the electronically toll network of 7 Member States (Austria, Denmark, France, Germany, Italy, Poland and Spain) and Switzerland.
6	Toll Charger	TC	Public or private organisation which levies tolls for the circulation of vehicles in a toll domain (see Art 2 k) Decision 2009/750/EC)
7	User		Physical or legal person who subscribes a contract with a Service Provider in order to have access to EETS compliant services (see Art 2 c) Decision 2009/750/EC).

8	On Board Equipment	OBE	The complete set of hardware and software components required for providing EETS compliant services which is installed in a vehicle in order to collect, store, process and remotely receive/transmit data (see Art 2 e) Decision 2009/750/EC)
No.	**Terminus**	**Abbrev.**	**(short) description**
9	Interoperability constituents		Any elementary component, group of components, subassembly or complete assembly of equipment incorporated or intended to be incorporated into EETS upon which the interoperability of the service depends directly or indirectly, including both tangible objects and intangible objects such as software, see Article 2 of the EETS Decision. Examples of interoperability constituents are on-board equipment (including connected back office systems), roadside equipment (including charging beacons, localization augmentation beacons and enforcement devices), EETS Providers' and Toll Chargers' back-office data exchange systems.
10	Toll		A charge, tax or duty levied in relation with circulating a vehicle in a toll domain (see Art 2 j) Decision 2009/750/EC)
11	Toll domain		An area of EU territory, a part of the European road network or a structure (such as a tunnel, a bridge, a ferry,..) where toll is collected (see Art 2 n) Decision 2009/750/EC).
12	Tariff class		The set of vehicles treated similarly by a Toll Charger (see Art 2 g) Decision 2009/750/EC).
13	Vehicle classification parameters		The vehicle related information according to which tolls are calculated based on the Toll Context Data (see Art 2 q) Decision 2009/750/EC).
14	Certification		Certification is defined as an EETS Provider's or its representative's official written statement that its interoperability constituents comply with the associated specified (technical) requirements.

15	Technical accreditation		Technical accreditation covers the technical aspects of the accreditation of an already registered EETS Provider in individual toll domains under responsibility of a Toll Charger (or a cluster of Toll Chargers).
16	Technical requirements for registration		Requirements defined by the Member State responsible for the registration to check against Article 3b of the EETS decision
No.	**Terminus**	**Abbrev.**	**(short) description**
17	Toll domain independent specifications		Technical specifications for interoperability constituents that are defined by technical standards or other regulations or specifications independently from individual toll domain requirements
18	Toll domain specific specifications		Technical specifications for interoperability constituents that comprise requirements that are specific to the needs of a toll domain
19	Security Policy		A Security Policy is a set of requirements and applicable counter measures specified by the party responsible for the security in a system exposed to threats. These counter measures are based upon a risk analysis of the system in order to protect those data exposed to threats in the relationships between TC and SP.

20	Cluster		A cluster of ETC Toll Domains is a set of Toll Domains, interconnected or not, which feature the same or very similar ETC toll collection context(s) in a contractual framework like Memorandum Of Understanding or any other agreement between the Toll Domain representatives, *i.e.* the Toll Chargers. This agreement specifies the rules regarding interoperability and its management within that cluster of ETS Toll Domains; it includes references to mutually agreed and shared detailed contractual, procedural and operational documentation as well functional and technical specifications (particularly, interfaces for OBU // RSE and for Toll Charger // Service Provider central systems). A cluster of Toll Domains may have a unique representative for some common subjects. Relationship between Toll Domains and Service Providers are fixed by bilateral contracts. Common validity periods of bilateral contracts with a given ETC Provider allow the interoperability for the global cluster.
No.	**Terminus**	**Abbrev.**	**(short) description**
21	Accreditation		The Accreditation covers the whole procedure (contractual and technical) to be successfully fulfilled by a Service Provider in order that its technical system could be accepted on a Toll Domain and that the TC entrusts the SP with the toll collection and the invoicing process to the SU. When the Accreditation is successfully completed, the Service Provider is “accredited” in the relevant Toll Domain.