
**Electronic fee collection — Pre-study
on the use of vehicle licence plate
information and automatic number
plate recognition (ANPR) technologies**

*Perception de télépéage — Pré-étude sur l'utilisation des
informations de la plaque d'immatriculation du véhicule et la
technologie de la lecture automatique des plaques minéralogiques
(LAPI)*

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 278, *Intelligent transport systems*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document endeavours to foster a common understanding in the context of electronic fee collection (EFC) systems of the use of vehicle licence plate information, and of automatic number plate recognition (ANPR) technologies.

This document notably seeks to advance the common understanding and definitions in the following areas:

- information associated with the licence plate number (LPN);
- information exchanges over open interfaces;
- outline of specification of exchanges between actors, notably the toll service provider (TSP), the toll charger (TC), vehicle registration authorities, etc;
- technologies regarding the ANPR.

The outcome is intended to contribute to more effective and efficient EFC schemes using vehicle LPN, obtained by means of ANPR technology and any associated information (including make and model) as a primary means to identify the user via the LPN, or a complementary means to augment the reliability and the robustness of their dedicated short-range communication (DSRC)-based or global navigation satellite system/cellular network (GNSS/CN)-based systems (including degraded mode, trip reconstitution, etc).

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Electronic fee collection — Pre-study on the use of vehicle licence plate information and automatic number plate recognition (ANPR) technologies

1 Scope

This document provides an analysis of the use of licence plate number (LPN) information and automatic number plate recognition (ANPR) technologies in electronic fee collection (EFC), through the description of the legal, technical and functional contexts of LPN-based EFC. It also provides an associated gap analysis of the EFC standards to identify actions to support standardized use of the identified technologies, and a roadmap to address the identified gaps.

The gap analysis in this document is based on use cases, relevant regulations, standards and best practices in the field of EFC, based on the European electronic toll service (EETS)^[27] model.

Examples of licence plate number (LPN)-based tolling schemes are given in [Annex A](#).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

3 dimensional

3D

computer graphics that define an object by its width, length and depth

[SOURCE: ISO/TS 23541-1:2021, 3.1.1, modified — Note 1 to entry removed.]

3.2

automatic number plate recognition

technology to automatically read vehicle registration plates

Note 1 to entry: A vehicle registration plate typically contains the indicator or the code of the country that issued the vehicle registration plate.

Note 2 to entry: Optical character recognition techniques are typically part of the technology associated with automatic number plate recognition.

Note 3 to entry: Automatic licence plate recognition (ALPR) is a synonym to ANPR.

[SOURCE: ISO/TS 17573-2:2020, 3.18, modified — Note 3 to entry has been added.]

**3.3
artificial intelligence**

<engineered system> set of methods or automated entities that together build, optimize and apply a model so that the system can, for a given set of predefined tasks, compute predictions, recommendations, or decisions

Note 1 to entry: AI systems are designed to operate with varying levels of automation.

Note 2 to entry: "Predictions" can refer to various kinds of data analysis or production (including translating text, creating synthetic images, or diagnosing a previous power failure). The term does not imply anteriority.

**3.4
country code**

identification of the issuing country of a licence plate, formatted in accordance with the United Nations Distinguishing Signs of vehicles in International traffic regulation

Note 1 to entry: In accordance with the United Nations Distinguishing Signs of vehicles in International traffic regulation,^[33] the CC contains 1, 2 or 3 alphabetical characters.

Note 2 to entry: A "human-readable country code" is defined as a licence plate number where human inspection can determine the issuing country from syntax, font and other characteristics of licence plates.

**3.5
error rate**

ratio between the absolute error and the reference value of all transactions

**3.6
false negative**

incorrect reporting of a failure when in reality it is a pass

[SOURCE: ISO/IEC TR 29119-11:2020, 3.1.34, modified — Note 1 to entry and Example removed.]

**3.7
false positive**

incorrect reporting of a pass when in reality it is a failure

[SOURCE: ISO/IEC TR 29119-11:2020, 3.1.34, modified — Note 1 to entry and Example removed.]

**3.8
false negative error rate**

ratio between the false negatives and the reference value of all transactions

**3.9
false positive error rate**

ratio between the false positives and the reference value of all transactions

**3.10
false recognizable error rate**

ratio between the false recognizable transactions and the reference value of all processed transactions

**3.11
infrared**

optical radiation for which the wavelengths are longer than those for visible radiation

Note 1 to entry: For infrared radiation, the range between 780 nm and 1 mm is commonly subdivided

**3.12
intelligent transport system**

transport system in which advanced information, communication, sensor and control technologies, including the Internet, are applied to increase safety, sustainability, efficiency and comfort

[SOURCE: ISO/TR 17465-2:2015, 2.2]

3.13**licence plate image**

digital image on which a vehicle licence plate is visible

Note 1 to entry: A "human-readable licence plate image" is defined as a licence plate image with a human-readable licence plate number and country code.

3.14**licence plate number**

number of the registration plate of a vehicle

3.15**manual number plate recognition**

process of determining the licence plate number and country code by human inspection of a digital image

3.16**on-board unit**

electronic unit on-board a vehicle for performing specific electronic fee collection (EFC) functions and for communication with external systems

[SOURCE: ISO/TS 17573-2:2020, 3.127]

3.17**optical character recognition**

technique where characters are recognized and converted into binary code

[SOURCE: ISO 12651-1:2012, 4.100, modified — Note 1 to entry removed.]

3.18**payment means**

means accepted by the service provider, that gives the user the right to use provided services

[SOURCE: ISO/TS 17573-2:2020, 3.134, modified — Example removed.]

3.19**toll domain statement**

statement setting out the general conditions for European electronic toll service (EETS) providers for accessing a toll charger's toll domain.

Note 1 to entry: The definition is based on the EU directive 2019/520^[27] on the recast of the European electronic toll service (cf. Article 6(2)).

3.20**user account**

centrally or on-board stored transport-related service rights of the user in relation to a service provider

[SOURCE: ISO/TS 17573-2:2020, 3.228]

3.21**vehicle registration authority**

authority responsible for the registration and maintenance of vehicle registers, including details of legal owners

4 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

ISO/TR 6026:2022(E)

AI	artificial intelligence
ALPR	automatic licence plate recognition
ANPR	automatic number plate recognition
BD	billing details
BO	back-office
CC	country code
CS	central system
OBE	on-board equipment
OBU	on-board unit
OCR	optical character recognition
EEA	European Economic Area
EETS	European electronic tolling service
EFC	electronic fee collection
EU	European Union
EUCARIS	European car and driving licence information system
HGV	heavy goods vehicle
IR	infrared
ITS	intelligent transport system
LP	licence plate
LPN	licence plate number
MNPR	manual number plate recognition
PAN	primary account number
RFID	radio frequency identification
SA	service area
SCC	specific commercial conditions
SU	service user
TC	toll charger
TI	technical interface
RSE	roadside equipment
TDS	toll domain statement
TSP	toll service provider
VIN	vehicle identification number
VRA	vehicle registration authority

5 Legal context of LPN information

5.1 Regulated licence plate

The format of the number plate is usually defined in a jurisdiction by specific legislative acts, allowing LPN information to be used in many applications. The following is a non-exhaustive list of examples of such applications:

- a) indication of registered vehicle;
- b) indication of conformity to vehicle safety regulations at the time of registration;
- c) certificate of usual vehicle parking location;
- d) verification of vehicle insurance contract, or vehicle-related tax;
- e) identification of vehicle usage types such as personal, commercial, rental, emergency, military;
- f) toll collection;
- g) enforcement, e.g. in case of traffic violation, car theft, crime.

These acts also specify the design and placement of the plate when mounted on the vehicle and the obligations of the vehicle owner. Each jurisdiction has its own specifications for the plate design as dictated by national priorities and use. As such, plate designs and placement typically differ between jurisdictions. ANPR systems need to be capable of dealing with all potential characteristics of the detected plates, such as:

- fixed position, angle, rotation, visible on vehicle;
- colour and painting and reflecting material of character and base plate;
- character alphabet;
- size and dimensional characteristics of characters (e.g. font width).

In principle, the TC can obtain the above information applicable to a given vehicle if the registration jurisdiction is known to it.

5.2 Physical characteristics of the licence plate

5.2.1 General

The LPN is a human- and machine-readable set of characters, represented in an image, which serves as a reference to the information of a licensed vehicle. As an example, in Europe the format for number plates follows the requirements listed in the Vienna Convention on Road Traffic.^[23] Under the Vienna Convention, road vehicles carry their registration number on the front and back, even if legislation in the registration jurisdiction does not require a front vehicle registration plate on road vehicles.

The registration numbers:

- consist either of numerals or of numerals and letters;
- use capital Latin characters and Arabic numerals (can optionally be displayed in a different alphabet);
- carry (on the rear plate) a distinguishing sign of the registration jurisdiction.

The requirement to display said distinguishing sign is mutually waived between some countries, for example (the list is not exhaustive):

- within the European Economic Area (EEA), for road vehicles with licence plates in the common European Union (EU) format (which satisfies the requirements of the Vienna Convention on road traffic, and which is also valid in those non-EU countries that signed the convention) issued in EU member states;
- between Canada, the United States and Mexico, where the province, state, or district of registration is usually embossed or surface-printed on the vehicle registration plate.

5.2.2 Licence plate characteristics in Europe

The common EU format for the licence plates for vehicles is defined as a blue section on the extreme left with the EU circle of stars and the country code. This was introduced by European Council Regulation (EC) No 2411/98.^[24] According to [Article 3](#) of this regulation, the distinguishing sign showing the State of registration placed at the extreme left of the registration plate is to be recognized in all Member States that require such information to be shown in vehicles registered in another Member State.

According to the Vienna Convention on Road Traffic,^[23] vehicles in cross-border traffic are obliged to display a distinguishing sign of the country of registration on the rear of the vehicle (note that it is not common for ANPR-based systems to detect the country sign of the country of registration). This sign can either be placed separately from the registration plate or, pursuant to the amendments to the convention in 2006, can be incorporated into the vehicle registration plate. One of the main benefits of the convention for motorists is the obligation on signatory countries to recognize the legality of vehicles from other signatory countries. The Vienna Convention on Road Traffic lays out the following provisions concerning driving outside the country of registration:

- The physical requirements for the separate sign, defined in its Annex 3, state that the letters are to be written in black on a white background having the shape of an ellipse with the major axis horizontal. The distinguishing signs are not to be affixed in such a way that it could be confused with the registration number or impair its legibility.
- When the distinguishing sign is incorporated into the registration plate, it also appears on the front registration plate of the vehicle and can be supplemented with the flag or emblem of the national state, or the emblem of the regional economic integration organization to which the country belongs.

After approval of the EU directive 2019/520^[27] on the recast of the European electronic toll service (EETS), the Commission implementing regulation (EU) 2020/204^[29] was adopted. This regulation introduces ANPR among the EETS interfaces.

5.3 Licence plate properties

ISO 7591 specifies the performance of a retro-reflective registration plate. It specifies the minimum performance for a durability measurement of:

- photometric properties;
- uniformity of retro-reflection;
- colorimetric properties for day and night use;
- temperature resistance;
- adhesion to substrate;
- impact resistance;
- bending resistance;
- water resistance;

- cleanability specifically when soiled by oil and graphite;
- resistance to fuel;
- resistance to saline mist.

The aim of ISO 7591 is to ensure plate readability by humans and machines for the lifespan of the plate. However, the duration of the readability is not specified. Common warranties for retro-reflective sheeting, inks and foils are between 5 and 10 years. This value is important, since the average age of vehicles exceeds 10 years, which means that plates can degrade over time and become difficult to read.

NOTE 1 Some countries have adapted ISO 7591 into a national standard, e.g. DIN 74069.

Besides plate age, the following aspects, often induced by the vehicle owner/driver, also influence plate readability:

- delamination of the sheeting due to surface pits, cracks, and cuts, often the result of normal use due to stones and bumps;
- dirt, mud, and snow on the plates. Studies indicate that natural dirt formed on the top edges of embossed plates have an additional negative impact on read accuracy;
- paints, particularly infrared blocking plates, which obscure infrared reading of plates;
- plate-fastening screws and rivets which are placed strategically to trick the optical character recognition (OCR) system;
- plate covers, which act as filters, either by design or by aging;
- plate frames which encroach on the plate characters causing OCR systems to fail;
- other retro-reflective decals, marks and characters, which have been shown to reduce the ANPR ability to identify the plate on the vehicle;
- towbars, bike racks, cables, straps, etc., which obscure the line-of-sight;
- plates tilted to make it difficult for overhead cameras to read the plate. This typically happens on motorcycles.

Lastly, weather and lighting conditions play an important role in the read performance of a plate. For this reason, EFC operators often provide additional lights and weather protection to improve the ANPR.

With the widespread usage of traffic cameras, enforcement cameras, surveillance cameras and ANPR cameras, commercially available plate-detection-avoidance products are becoming increasingly available, such as plate-flippers, covering foils and sprays. Few countries have explicit regulations in place to deal with unreadable plates, plate tampering and aging.

[Figure 1](#) shows the general process that results in the LPN from the image.

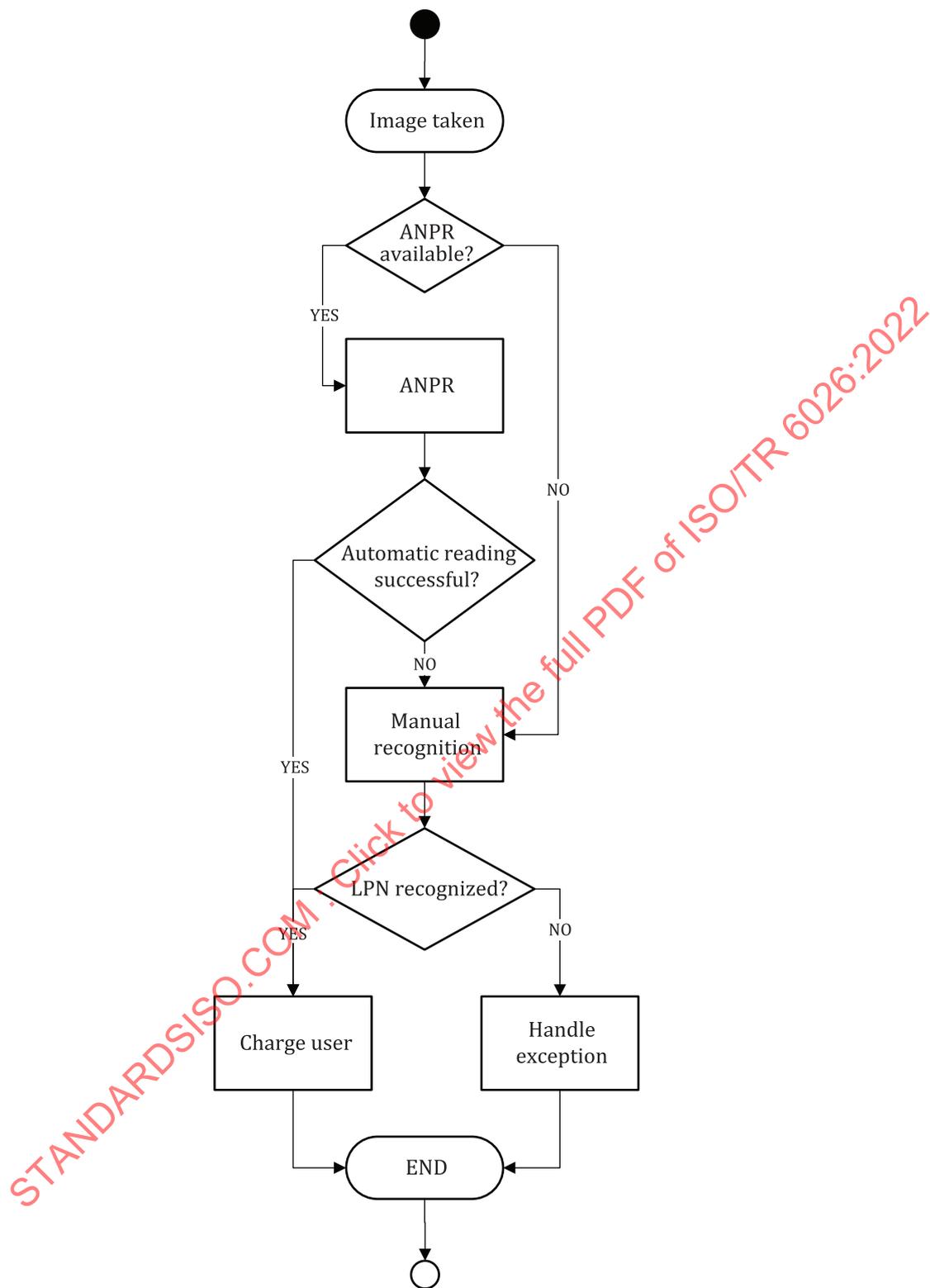


Figure 1 — From image to LPN

NOTE 2 The automatic recognition can occur at the roadside processing unit or/and in the back-office (BO). Usually, the roadside ANPR system employs fewer computational resources, for the sake of speed of elaboration, and typically provides lower accuracy and success rate than BO ANPR. An efficient ANPR process can involve both, in order to exploit the speed and real-time features of the roadside processing, and use BO processing as backup, whenever the previous fails.

5.4 Illegal licence plates

The use of illegal plates is a globally increasing problem, particularly due to the increased use of ANPR and traffic surveillance cameras. As previously highlighted, cameras have difficulties authenticating a licence plate. However, especially when alternative routes to toll roads are available, rather than avoiding paying a toll, the intention of users of illegal plates is typically to try to avoid fines and penalties. Therefore, illegal plates are perceived to be of low importance for fee collection operators. Emerging tolling strategies and fee collection areas, like congestion zones and road-use charging, will increase the impact of illegal plates, especially for conformity checking of users through interrogation of on-board equipment (OBE) in autonomous tolling schemes. The ability to verify the authenticity of licence plates will increase in importance.

There are three types of illegal licence plate (LP):

- counterfeit plates: there exist many methods to manufacture plates outside of the regulated and controlled channels. As an example, the Internet offers many opportunities to obtain a counterfeit plate, often through a legitimate channel like offerings of custom/novelty plates. However, custom/novelty plate vendors operate in the open; as such, they are policed in many countries. Home-made plates are increasingly diffused, since the plate raw materials are easily available. Even the embossing of plates is not a hurdle due to the ease and cost efficiency of modern 3D printing. Embossing dies can easily be 3D-printed from a plate image. Counterfeit plates may be used for a long time. Such plates are only detected when the owner of the cloned plate reports it due to an unsought fee collection or transgression fine. Cases of innocent people implicated in crime due to counterfeit plates have been reported in the press;
- stolen plates: these are typically used in an opportunistic manner since stolen plates are reported when the vehicle owner detects the missing plates. The usefulness of a stolen plate is therefore limited in time;
- expired/terminated plates; these plates are typically plates salvaged from vehicles which are written-off due to a crash.

To reduce the chance of detection, perpetrators typically use an LPN of a legitimate vehicle of similar make, model and appearance. A strategy of using illegal plates in different jurisdictions than the original one also reduces the chance of detection. Typically, perpetrators will have several sets of plates which they will swap periodically.

Plate migration is the general term for when a legitimate LP is used on another vehicle. Plate migrations are executed by:

- a third party: effective measures are necessary for deterring, detecting and reporting such plate theft. Generally, the theft is detected at some point and is reported, allowing such plates (the plate number) to be listed, often to the inconvenience of the legitimate vehicle owner;
- by the vehicle owner/driver: typically, the LP of a low fee vehicle is used on a higher fee vehicle. For example, it has been reported that the plates of a pickup are being used on a truck. The ability to fit the plate to the correct class of vehicle will deter plate migration, though the class-of-vehicle information is available at the detection point.

6 LPN information for EFC

6.1 General principles

The licence plate number (LPN) is used as a primary vehicle identifier (in a recognition process that makes direct use of the LPN as recognition means) and a secondary vehicle identifier (in a process where another method, namely DSRC, is used as primary means of recognition) allowing the identification of the relevant user account or the owner of the vehicle. The LPN serves as a reference to the regulatory controlled licence information of a vehicle. This ensures the correct fee to be charged and, in case of non-payment, a fee recovery process to be acted.

The regulatory licence information of the vehicle [e.g. vehicle identification number (VIN), make and model] which includes observable characteristics of the vehicle (e.g. shape, make, model, colour, size and number of axles), the usage of the vehicle (e.g. freight, emergency and public transport) and non-observable characteristics of the vehicle (e.g. type of power source, EuroClass, weight limits and ownership type – private vs business) can influence the fee and assist in detecting vehicle identity counterfeit LPs.

The user recognition and payment fulfilment can be pursued via several paths:

- directly: the user and the associated vehicle are contracted with the TC. Payment modality and fulfilment of amount due is directly with the user;
- via a third party: the user's vehicle is contracted with a payment fulfilment third party, typically a TSP, who cooperates with the TC and can be local or foreign to the TC's State;
- not contracted, but licensed: the user and associated vehicle is contracted with neither a TC nor a TSP. User information is obtained from the assumed VRA, which can be local or foreign. The relevant VRA is obtained by recognizing the country code;
- not contracted, with licensing information not available: the user information is not available through an assumed licensing department, the information is perhaps in doubt, or the use is challenged by an identified user. These cases are treated as enforcement processes depending on the relevant legal context, which can include specific interventions on the vehicle/user by the entities in charge.

6.2 Limitations of the LPN

The most relevant information on the identity of the licensing department of a vehicle's plate can be obtained from the state identifier on the LP or be derived from the LPN format. Both cases can be a challenge. First, the state identifier is not easily recognizable using current imaging methods. Then, many licensing departments use the same LPN formats. However, the plate country can be identified by using specific algorithms and/or by human review of the licence plate image.

6.3 LPN recognition process (ANPR)

The term ANPR is used for the automatic recognition of the vehicle number plate, i.e., localizing the plate in digital captured images of the front or rear of a vehicle and extracting the information available on the plate (digits, letters, specific characters).

The ANPR process starts with a camera which captures an image of the LP. The image is described in [Figure 2](#); the blocks are explained below [Figure 2](#) and [3](#).

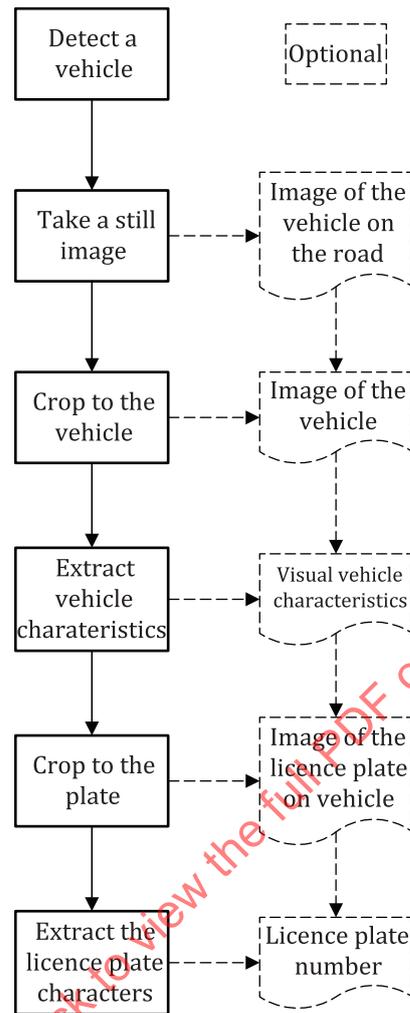


Figure 2 — Schematic process of extracting LPN information

— Detect a vehicle:

Classic systems point the camera where the vehicle is expected to be. When movement is detected in the frame, one or more still images are taken. This movement can be detected using another sensor, like an inductive loop, or the image sensor itself.

Modern systems use a video stream and process the video stream and images roadside. Modern systems typically recognize and track all the vehicles in the video stream. These systems process and correlate several images to improve the detection results.

— Take a still image:

Classic systems typically take one still image and transmit it to a remote processor for LPN recognition. Cameras are typically placed close to face-on to the licence plate. This placement is often difficult to achieve in open road conditions without overhead structures.

Modern systems use high-definition video from which multiple still images are extracted for processing (Figure 3). The image of the vehicle on the road provides context in the case of a dispute. Modern high-definition traffic cameras are capable for tolling use.

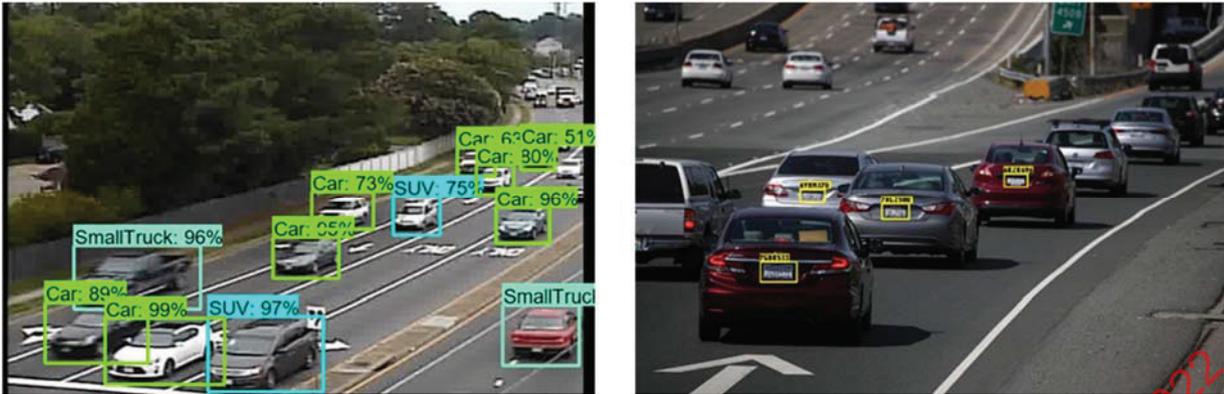


Figure 3 — Multiple vehicle detection

Still images are often taken in both the natural light and infra-red spectrums. The infrared spectrum often provides better night vision but cannot detect colour.

— Cropping:

Cropping is performed to focus the pattern recognition in order for it to work optimally. The first crop is to the vehicle, to have only one vehicle in the frame. The next crop is to the plate, to only have the plate in the frame.

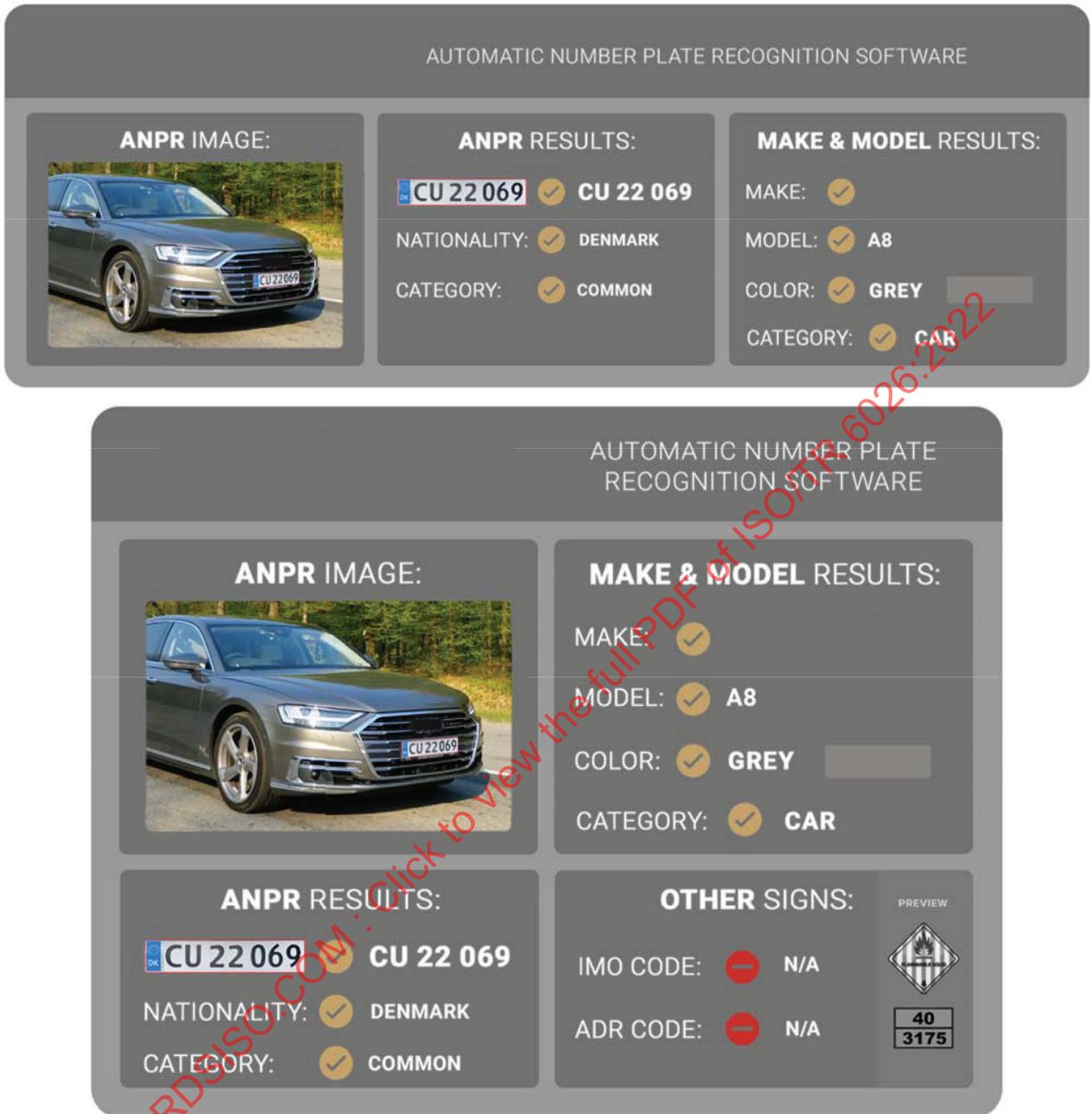
— Extract vehicle characteristics:

Classic ANPR systems are limited in extracting vehicle characteristics.

Modern systems, using artificial intelligence (AI), seem to have a higher accuracy rate. It is notable that side cameras have a better view of the vehicle shape and wheels and as such are more successful at the job, although the view on the plates is limited. Combining side view cameras with wide angle cameras to look downwards is a good strategy where the system can link the tracked vehicle between the cameras. Installations have shown that a well-placed modern roadside camera can perform both tasks. Recent camera technologies allow for high quality images at longer ranges making the placement at the side of the road feasible.

— Extract the LPN:

The ANPR system provides the LPN, and additionally the country code where requested, with the recognized information and confidence values to the fee fulfilment system. See an example in [Figure 4](#), where a sample is given of the information gathered for a given vehicle after BO processing.



SOURCE Adaptive Recognition, reproduced with the permission of the authors

Figure 4 — Example of information collected for a vehicle

The above information and images can be validated by a human operator.

6.4 Limitations of LPN recognition process (ANPR)

A key aspect of ANPR performance is the fact that the character recognition process is not exact and can make mistakes. Processes in the roadside equipment (RSE) and in BO always have a level of confidence for any given recognition results. The level of confidence is used to determine if the available information is useful and if a human operator is required to validate the LPN and the associated vehicle characteristics.

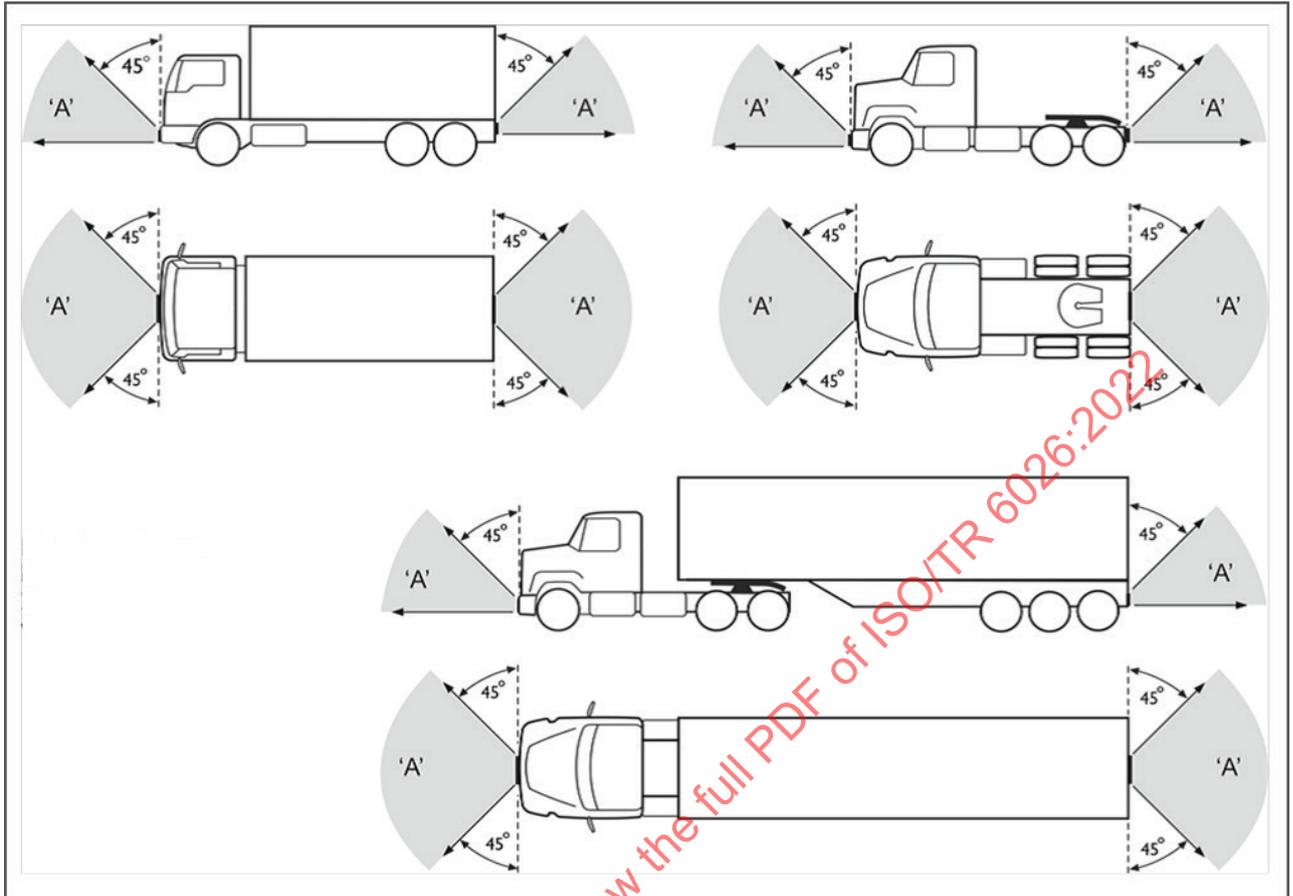
Depending on camera angle, LP conditions, weather, availability of images front and rear of the vehicle, ANPR software training and requirements on false positives, the expected recognition rate is between 80 % and 98 %. The expected threshold also depends on the level of confidence at which ANPR reading is considered correct, which has to be balanced with the accepted level of false positives. However, matching these quantitative requirements can be difficult for open road tolling systems and generic traffic cameras.

Typically, a recognition mistake (false positive) is only detected when disputed or when the plate is compared with other information related to the vehicle (size, dimensions, etc., sometimes referred to as the vehicle fingerprint), which is not often available. Modern AI pattern algorithms provide a confidence factor for the recognition, which assists in the decision to enact a manual LPN extraction intervention.

The following aspects impact the performance of ANPR:

- a) imaging alone cannot detect a counterfeit plate;
- b) imaging has great difficulties in detecting the country of origin;
- c) visibility due to weather, e.g. mist, dust, heat waves, rain and snow;
- d) poor ambient light impacts the quality of the image and the colour pallet. Auto-white balancing assists in the latter situation, but cannot make up for absence of blue light, for example;
- e) old plates where retro reflectivity decay and delamination, colour fading and decolouring render the plate difficult to read;
- f) dirty plates, often due to weather conditions;
- g) damaged plates;
- h) mounting screws, plate frames and coverings disfiguring the characters;
- i) line of sight obstruction;
NOTE 1 Most countries regulate the line of sight not to be obstructed within 45° from the face-on angle ([Figure 5](#)).
- j) placement of plates to lean forward or backward and/or in an unexpected position on the vehicle;
NOTE 2 Most countries regulate the placement of the plate to be within 10° of the vertical, to be horizontal and within a certain zone at the front and rear of the vehicle ([Figure 5](#)).
- k) tail gating, often in heavy traffic, especially for a vehicle following a truck, can also obscure the line of sight;
- l) objects (e.g. bicycles) carried behind the vehicle can obscure the number plate from being read.

A manual LPN detection process is typically triggered where the vehicle is detected but no LPN recognized or where the confidence values is below a determined threshold.



NOTE LPs are to be clearly visible from 20 m at all points within arcs labelled 'A'.

Figure 5 — LPN positioning

6.5 LPN validation

The LPN is just an identification of a vehicle or of its owner, with a first assumption to be licensed within the local vehicle licensing department. Notably, all vehicle licence plates are a regulatory controlled "vehicle identification document". A vehicle can not use public roads without legitimate LPs.

An error in the LPN recognition or detection process of a foreign vehicle, a counterfeit plate or a stolen plate only becomes apparent when the LPN appears to be not licensed or where the use is disputed. These data are proceeded with as receivable transactions until the recovery process is completed, in the same fashion as a non-contracted payment transaction. This is a cumbersome and costly process.

This burden can be reduced if additional information about the vehicle, specifically the vehicle characteristics, is readily available. This information can be made available through four processes:

- through a participating entity;
- as a direct lookup with the licensing departments (some countries provide such service under varying levels of control and fees);
- as a lookup via a trusted third party, provided that legislative directives are complied with, e.g. concerning privacy. The EUCARIS^[32] database of vehicles, recently implemented and activated in Europe and being used by a subset of member states, is an example;
- from a radio frequency identification (RFID) chip embedded in the plate. Such a chip can carry the information as specified by ISO 14816. Such chip can also provide counterfeit detection like a

modern credit card (modern bank cards are counterfeit resistant due the chip). Such an RFID chip can enact an auto-validation of the plate for specific applications, e.g. tolling. Some countries use ISO/IEC 18000-63 for the wireless technology and ISO/IEC 20248 for a secured and verifiable data structure.

7 Scenario — ANPR-based EFC

7.1 Description of the scenario

The ANPR-EFC scenario describes the process of fee collection for a generic usage. The process is made possible by the identification of the vehicle through a relevant set of data, including LPN. Without loss of generality, the acquisition of LPN images is made in the correspondence of relevant charging points, which can be at the entry or exit of the controlled infrastructure, or along it. For a closed tolling system based on entry and exit stations, vehicle identification at both entry and exit is essential for calculating the correct fee.

This scenario includes the case in which ANPR technology is used to enforce fee collection by DSRC transaction or by cash payment. The actors involved are:

- TC: the entity which operates the toll domain, in terms of the collection of the toll.
- TSP: the entity that provides EFC services to road users. Typically, the services provided are accessible via subscription, after which the TSP gathers the relevant information from the subscribing user, like LPN, vehicle characteristics, payment means, etc.
- SU: a user (private or a company) that uses the infrastructure and pays a fee related to the usage. The user can have a subscription at a TSP, but this is not mandatory.
- VRA: a database, usually public, where all circulating vehicles are uniquely identified by an LPN. A registry typically contains additional vehicle information such as make, model, colour, engine type, axles, overview images, etc.

7.2 Use cases

The scenario includes the following use cases:

- define toll context;
- register user;
- recognize user and charge road usage;
- enforce payment;
- handle exceptions (errors).

7.3 Business processes

[Figures 6 - 13](#) show processes and relations in the EFC field. [Figures 8 - 13](#) use the following colour code for mutual relations between entities:

- Green = contractual interface.
- Blue = financial interface.
- Red = operational interface (including batch or real-time interaction).
- Yellow = initialization interface (generically, used at registration or upon update of user data).

[Figure 7](#) describes the business process of identifying the user. The process starts from the front-end system and ends when the user is recognized, via BO operation and manual operation. The user is identified by matching the machine-reading of the LPN with an account database or with the VRA database, or both. Since machine-reading of the LPN is not 100 % accurate, human operator LPN recognition and the manual selection of the correct LPN among a possible list of candidates are used as the recovery operation. When an LPN cannot be identified, the recovered information is typically used for enforcement operations. To guarantee a stable performance of the user-identification processing, key-performance-indicators can be defined, such as end-to-end user payment rate, LPN machine recognition rate, account database matching rate, vehicle registration matching rate and manual recognition rate.

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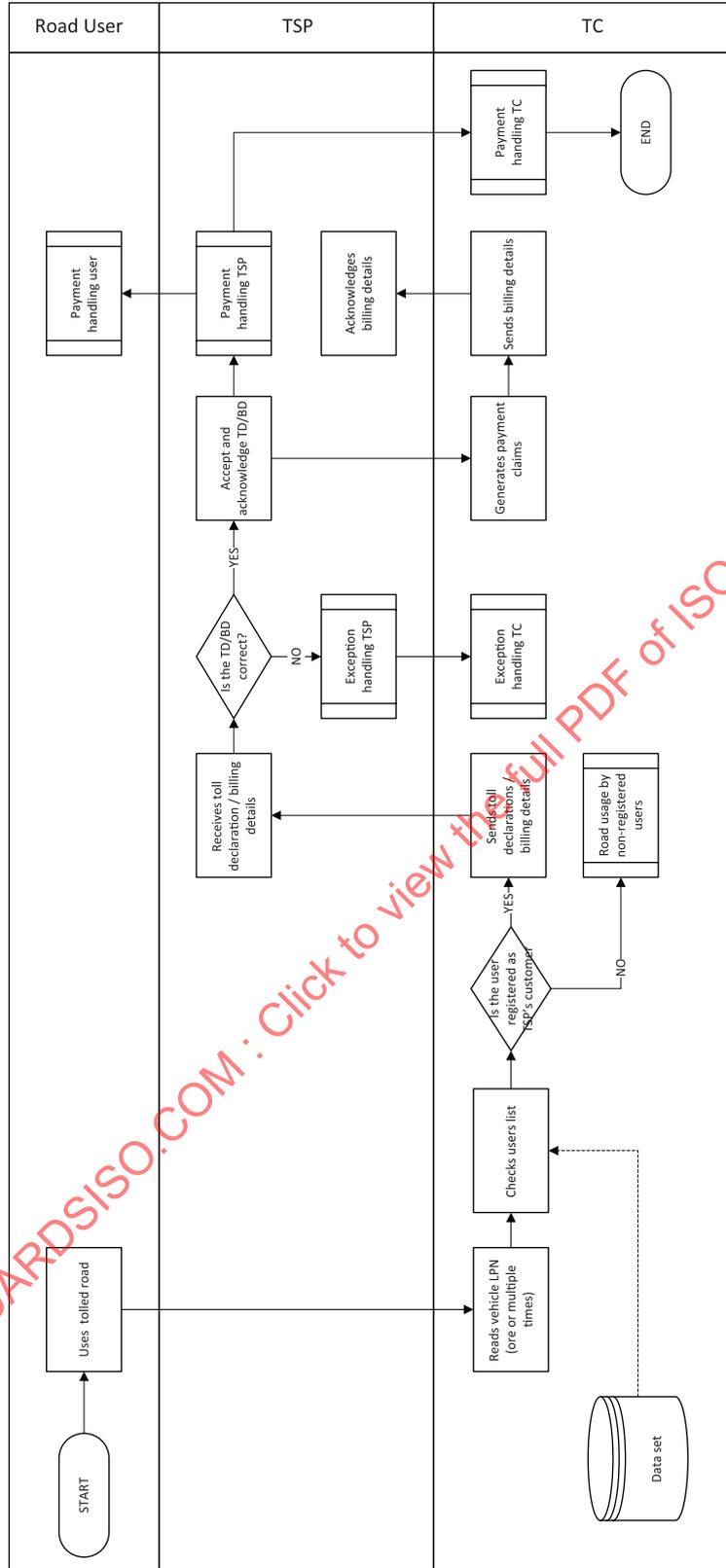


Figure 6 — LPN-based EFC general process

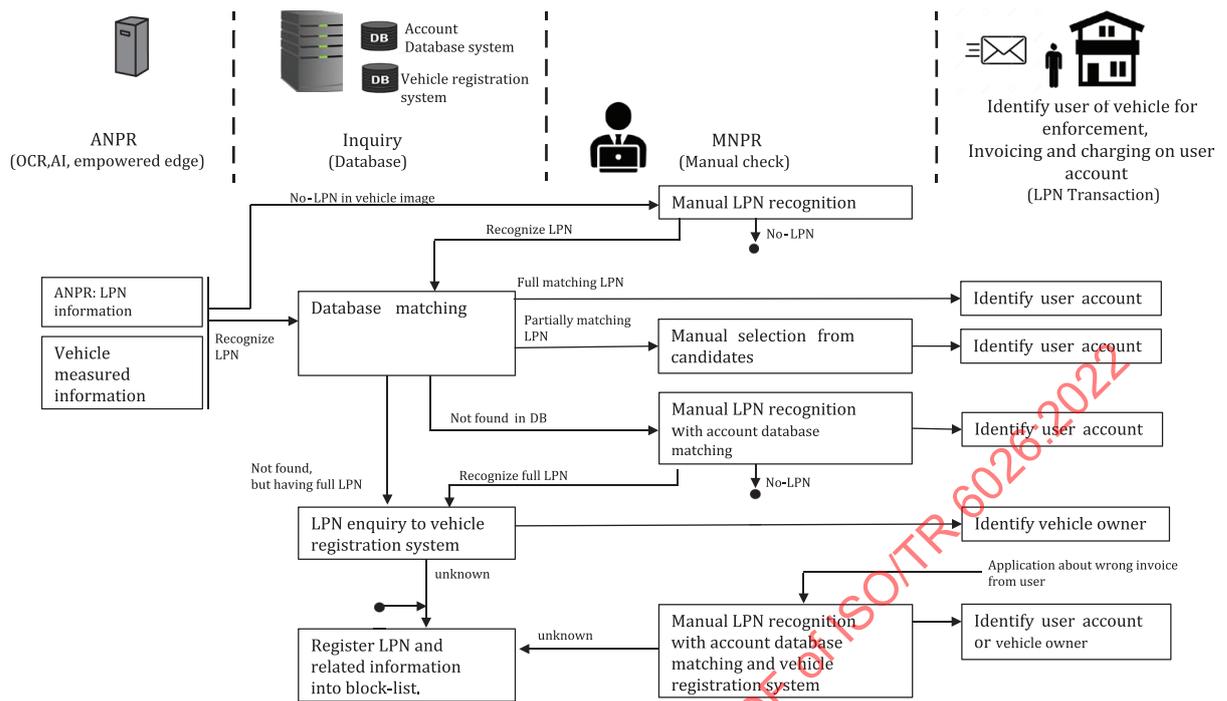


Figure 7 — User identification process

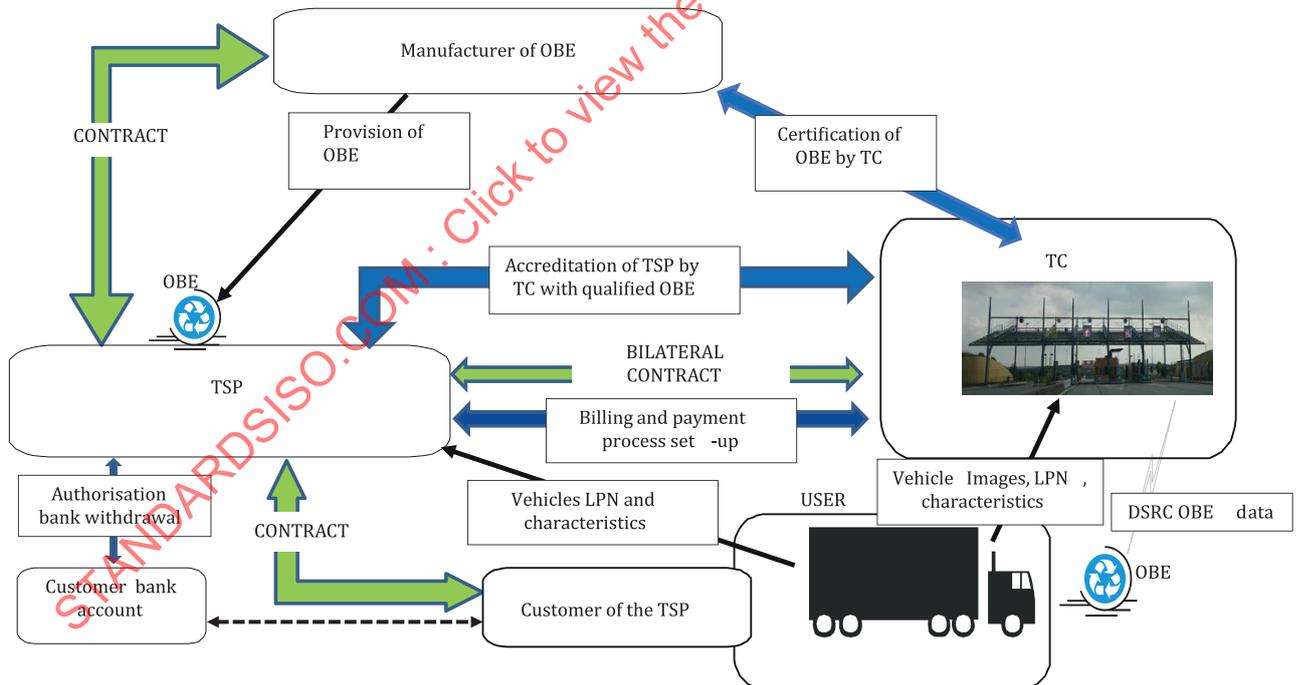


Figure 8 — DSRC-based schemes - Typical set-up

In a general perspective of a typical DSRC-based EFC scheme, the stakeholders and their respective duties are the following.

- Manufacturers:
 - design, manufacturing, delivery of interoperable OBE;

- qualification by TSP and TC, according to their specifications and rules, for acceptability in various toll domains/toll contexts.
- TSP:
 - procurement and personalization of OBE to be delivered to their customers;
 - setting-up of processes allowing handling of billing and payment claims received from TC, with payment guarantee;
 - customer management (contract, vehicles registration, invoicing, payment, etc.);
 - databases: Customer/user, Vehicles, LPN, primary account number (PAN), OBE, etc.
- TC:
 - implementing the RSE and BO systems;
 - identifying the users with their OBE, associated to vehicles characteristics and licence plate;
 - implementing processes for billing and payment claims sent to the relevant TSP.
- Customers:
 - customer identification;
 - vehicles;
 - payment modalities references.

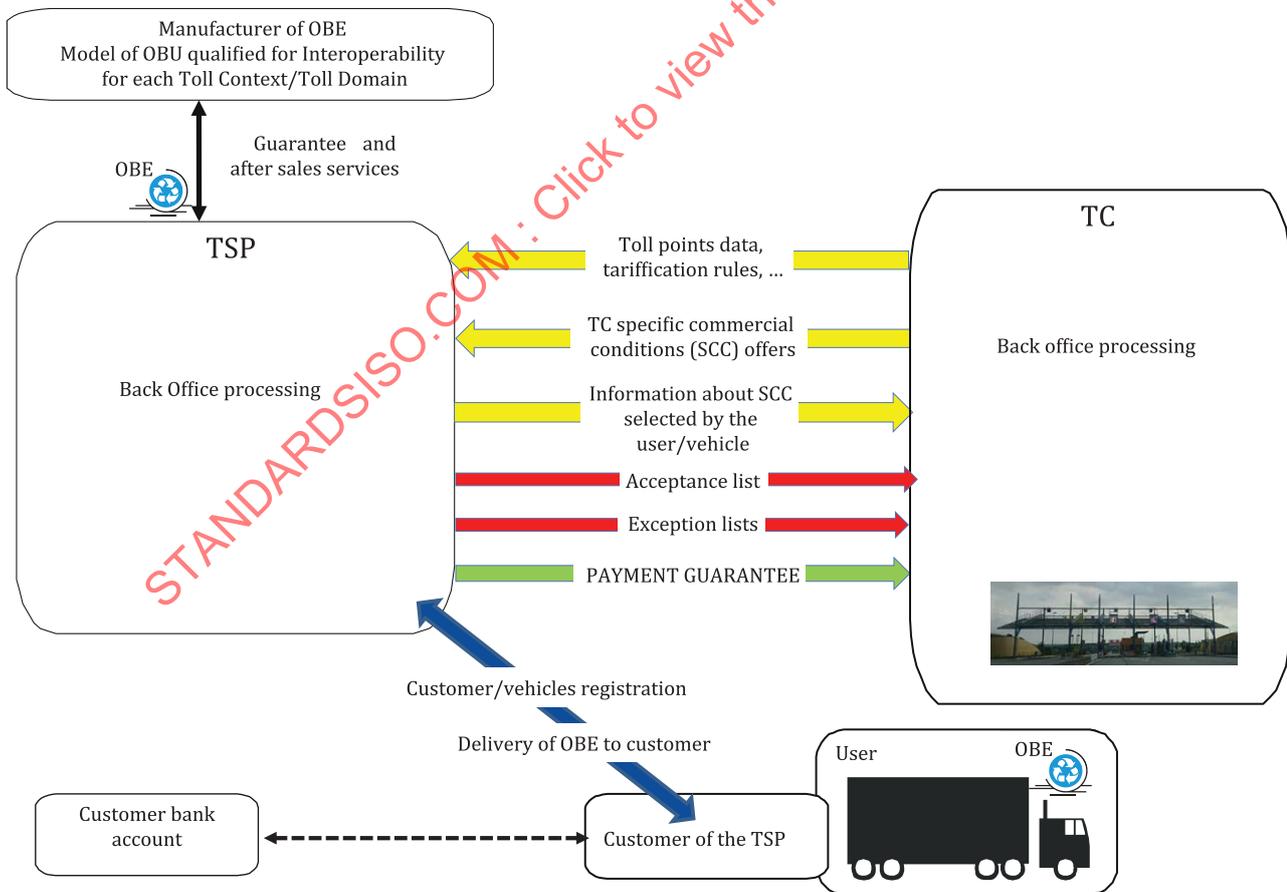


Figure 9 — DSRC-based schemes - Data exchanges

Data exchanges between stakeholders in a generic DSRC tolling scheme are the following:

- TSP ← Manufacturer
 - delivery of certified OBE to TSP.
- TSP ← TC
 - toll points data (localization, characteristics);
 - pricing rules;
 - TC-specific commercial conditions (SCC) depending on vehicle.
- TSP → TC
 - exception lists (LPN context mark, PAN, etc.);
 - acceptance lists (LPN, vehicle characteristics, PAN, LPN context mark, validity dates, etc.);
 - exception lists and acceptance lists allow contractual "Payment Guarantee" from TSP to TC.
- TSP ↔ Customer
 - customer registration, contract subscription, bank references;
 - vehicles registration: LPN, make/model, characteristics, images;
 - delivery of OBE to customer for their vehicles.

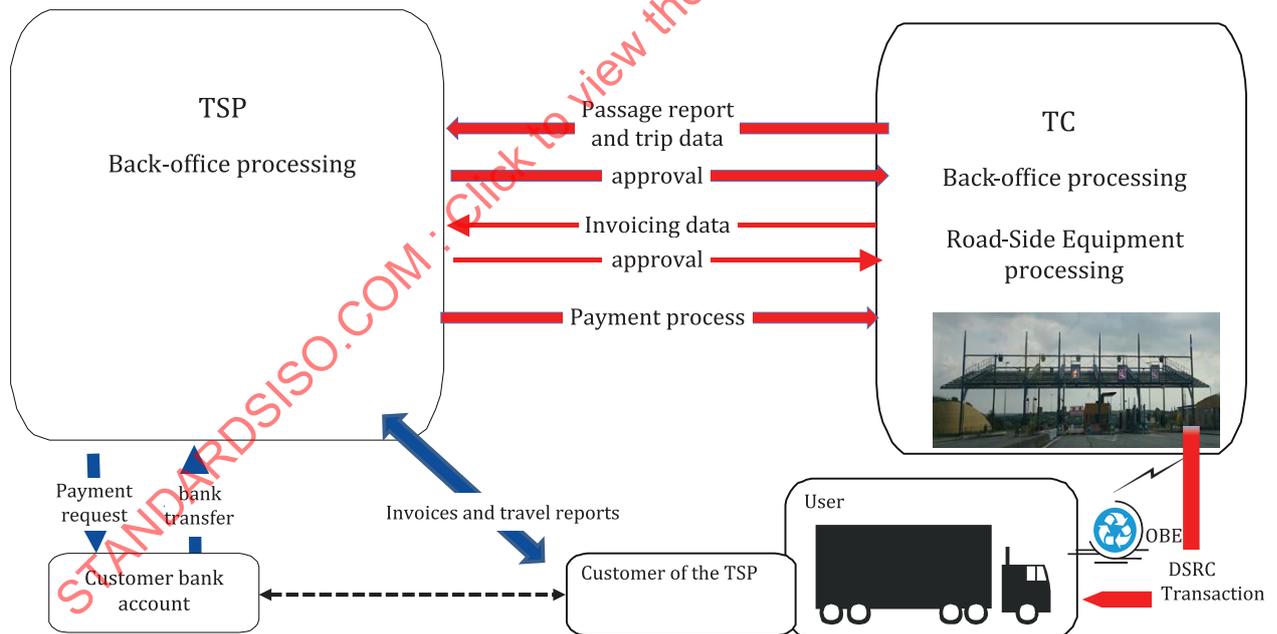


Figure 10 — DSRC-based schemes — Billing and payment principles

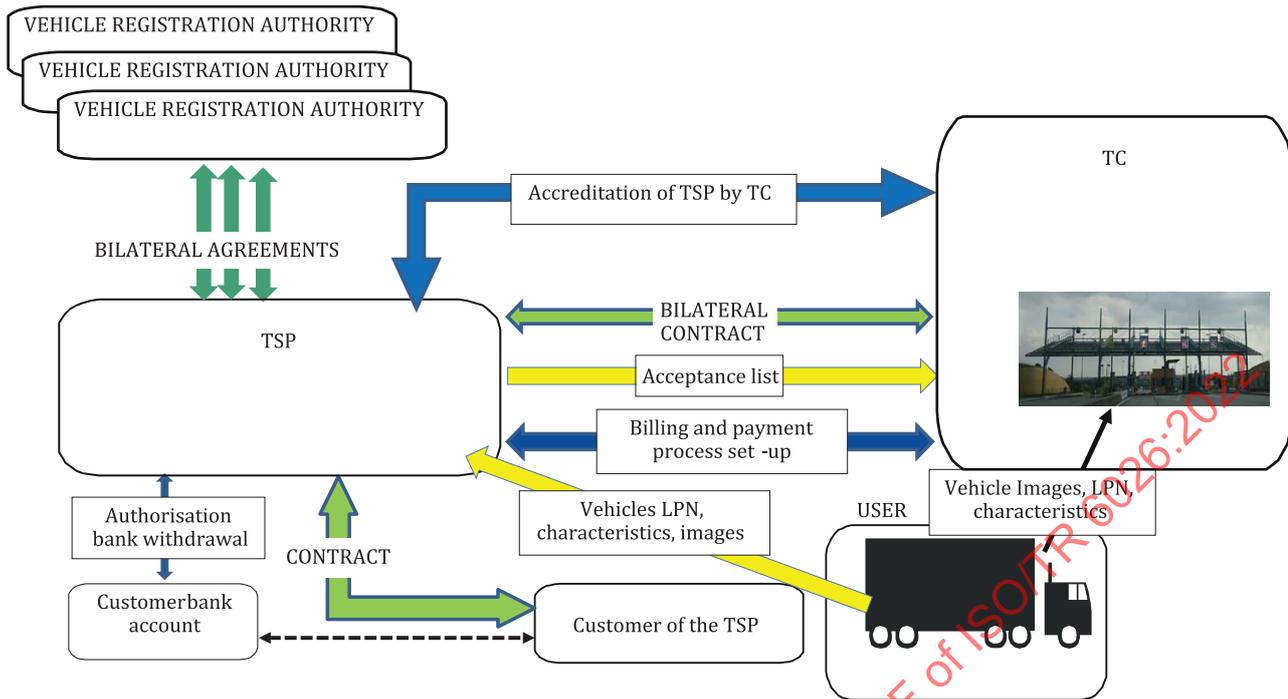


Figure 11 — ANPR based schemes — Typical set-up (LPN toll context)

In the general perspective of a typical ANPR-based EFC scheme, the stakeholders and their respective duties are the following:

- VRA
 - allowing validation/securing of the LPN and vehicle characteristics;
 - securing the identification of the toll liable vehicle.
- TSP
 - setting-up of processes allowing handling of billing and payment claims received from TC, with payment guarantee;
 - customer management (contract, vehicles registration, invoicing, payment, etc.);
 - managing data bases: user, vehicles, LPN, payment means;
 - delivering acceptance list to TCs for each vehicle (LPN, make, model, vehicle characteristics, <images, etc.) associated with a PAN and LPN context mark.
- TC
 - implementing the RSE and BO systems;
 - identification of users with their vehicles' LPN and vehicle characteristics, associated to PAN;
 - implementing processes for billing and payment claims sent to the relevant TSP.
- Users
 - customer identification;
 - vehicles;
 - payment references.

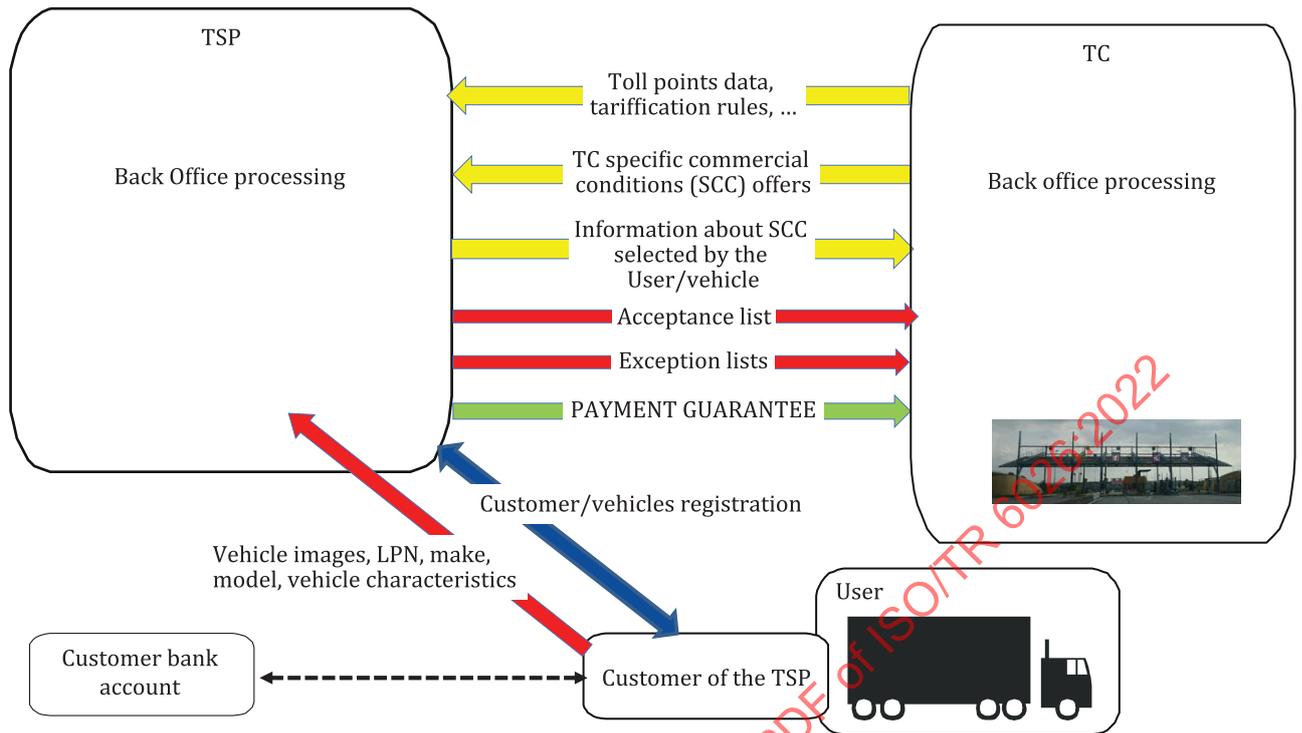


Figure 12 — ANPR-based schemes — Data exchanges

Data exchanges between stakeholders in a generic ANPR-based tolling scheme are the following:

- TSP ← TC
 - toll points data (localization, characteristics);
 - pricing rules;
 - TC-SCCs, depending on vehicle.
- TSP → TC
 - exception lists (LPN context mark, PAN, etc.);
 - acceptance lists (LPN, vehicle characteristics, PAN, LPN context mark, validity dates, etc.);
 - exception lists and acceptance lists allow contractual "Payment Guarantee" from TSP to TC.
- TSP ↔ Customer / vehicles
 - customer registration, contract subscription, bank references;
 - vehicle registration: LPN, make/model, characteristics, images, etc.

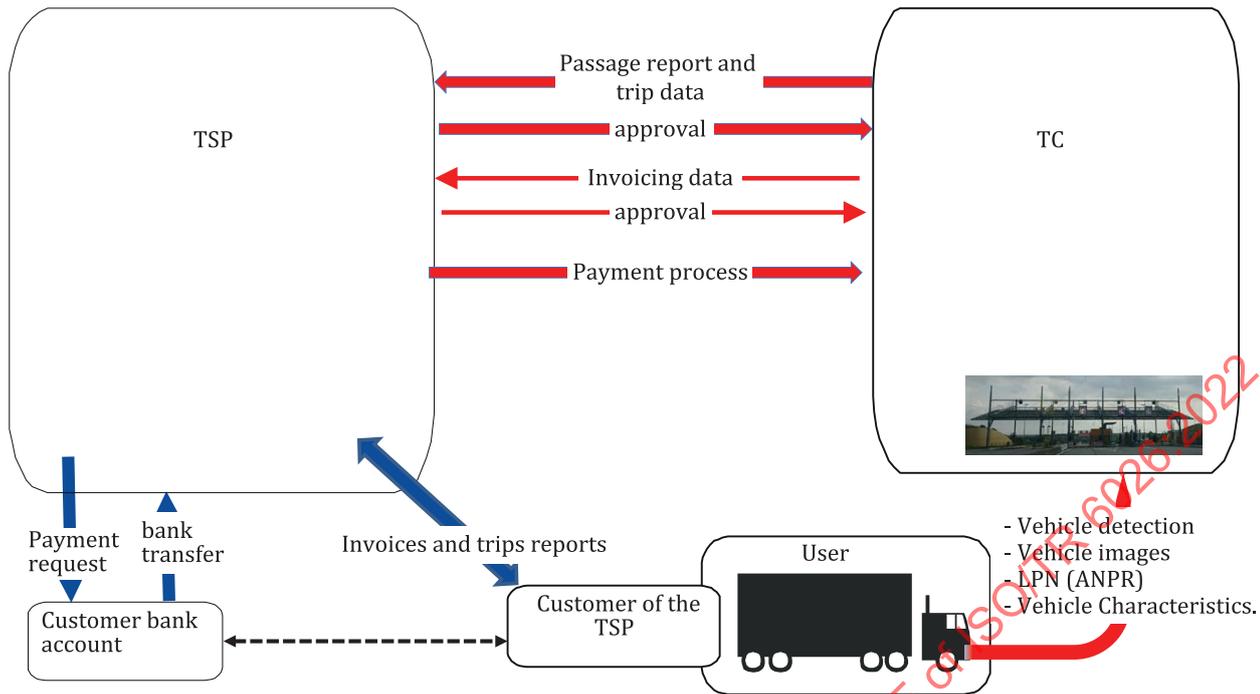


Figure 13 — ANPR-based schemes — Billing and payment principles

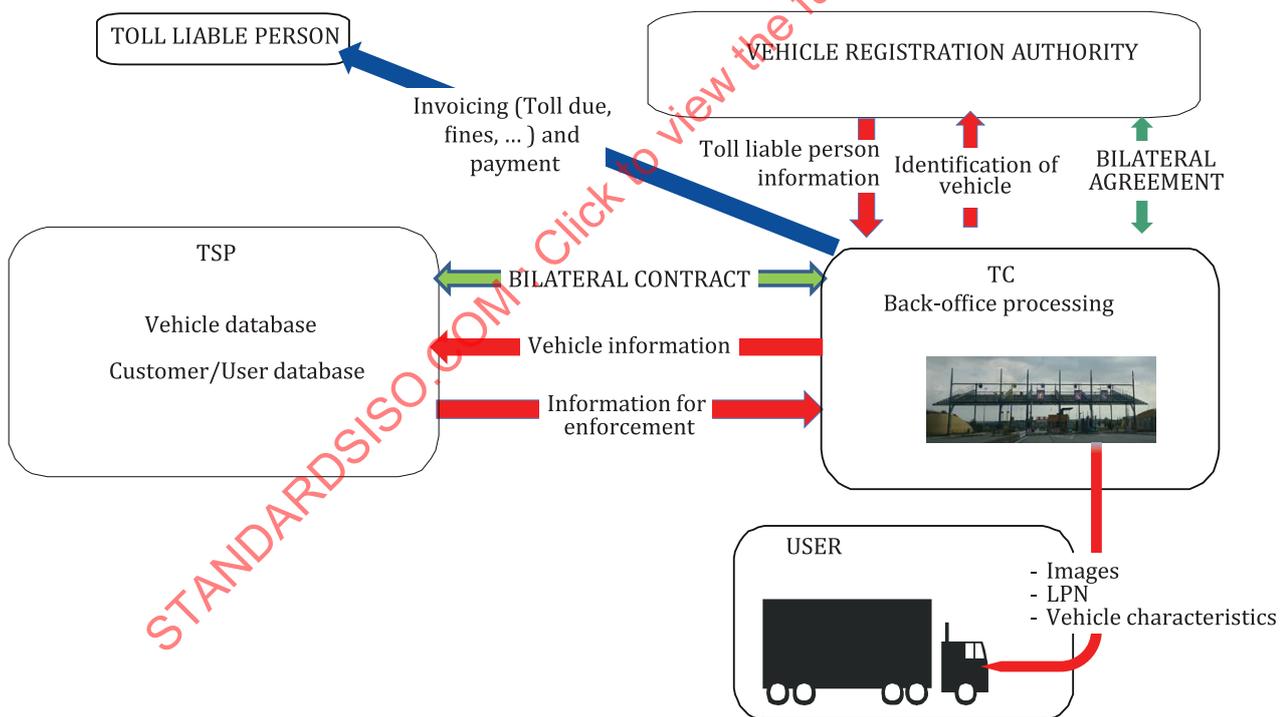


Figure 14 — Typical enforcement for ANPR, DSRC or GNSS schemes

7.4 Technical interfaces (TI)

Table 1 lists the technical interfaces that pertain to this use case and which require specific ANPR definitions in terms of data to be exchanged, controls to be performed, security, non-repudiation, and interoperability.

Table 1 — Technical interfaces in LPN-based EFC

Interface code	Short description	Interactions
TI-1	Toll context definition	(TC -> TSP)
TI-2	User registration	(User -> TSP)
TI-3	Users lists exchange	(TSP -> TC)
TI-4	LPN reading & image processing for user recognition	(User -> TC)
TI-5	Billing	(TC <-> TSP or TC <-> User)
TI-6	Access to register of vehicles for user data retrieval	(TSP <-> Register or TC <-> Register)
TI-7	User list exchange	(TC <-> TSP)

8 Use cases

8.1 Define toll context

This use case represents the technical specification of the information that constitutes the toll context, including the variables that contribute the calculation of the tariff, or the methods for the exchange of data between TC and TSP, for example (process in [Figure 15](#)).

Examples of toll schemes:

- closed toll scheme (i.e. tariff-based on at least entry and exit point). At least two records are necessary to obtain a complete tolling record (or charge object). In case of multiple routes, more recordings can be necessary;
- open toll scheme (i.e. tariff based on a single transit). One ANPR record is enough for a complete tolling record (or charge object);
- free-flow;
- with toll plaza.

Priority between ANPR and DSRC, if present, is defined in the toll domain statement (TDS). More specifically, if interoperability is to be offered to both ANPR and DSRC systems, a process is required to handle users for which DSRC or ANPR or both are used for recognition. An example of the prioritization process is:

- priority 1 - DSRC transaction;
- priority 2 - Reading of LPN as back-up for a faulty DSRC transaction;
- priority 3 - Reading of LPN with a valid ANPR contract.

There are alternatives for distinguishing between different types of transactions. Tolling transactions can be defined as follows:

- a correct interrogation on a valid OBE in a DSRC toll domain;
- the reading of a registered LPN connected to a valid ANPR contract in an ANPR toll domain;
- the reading of an LPN connected to a valid DSRC contract, when an OBE cannot be read.

The process in [Figure 15](#) is the combined DSRC and ANPR process using the priority 2 alternative. It is noted that:

- it is the responsibility of the TC to define the transaction receiving priority. If the SU has both a DSRC and an ANPR contract, in combined DSRC/ANPR toll domains, the TC is to specify which one is used;
- if the TC detects more than one ANPR contract for an LPN, it can inform the TSP and the SU about the multiple occurrence; in all cases, it is up to the TC to decide upon which contract to debit;
- any contract with discounted fares should take precedence over other contracts owned by a user.

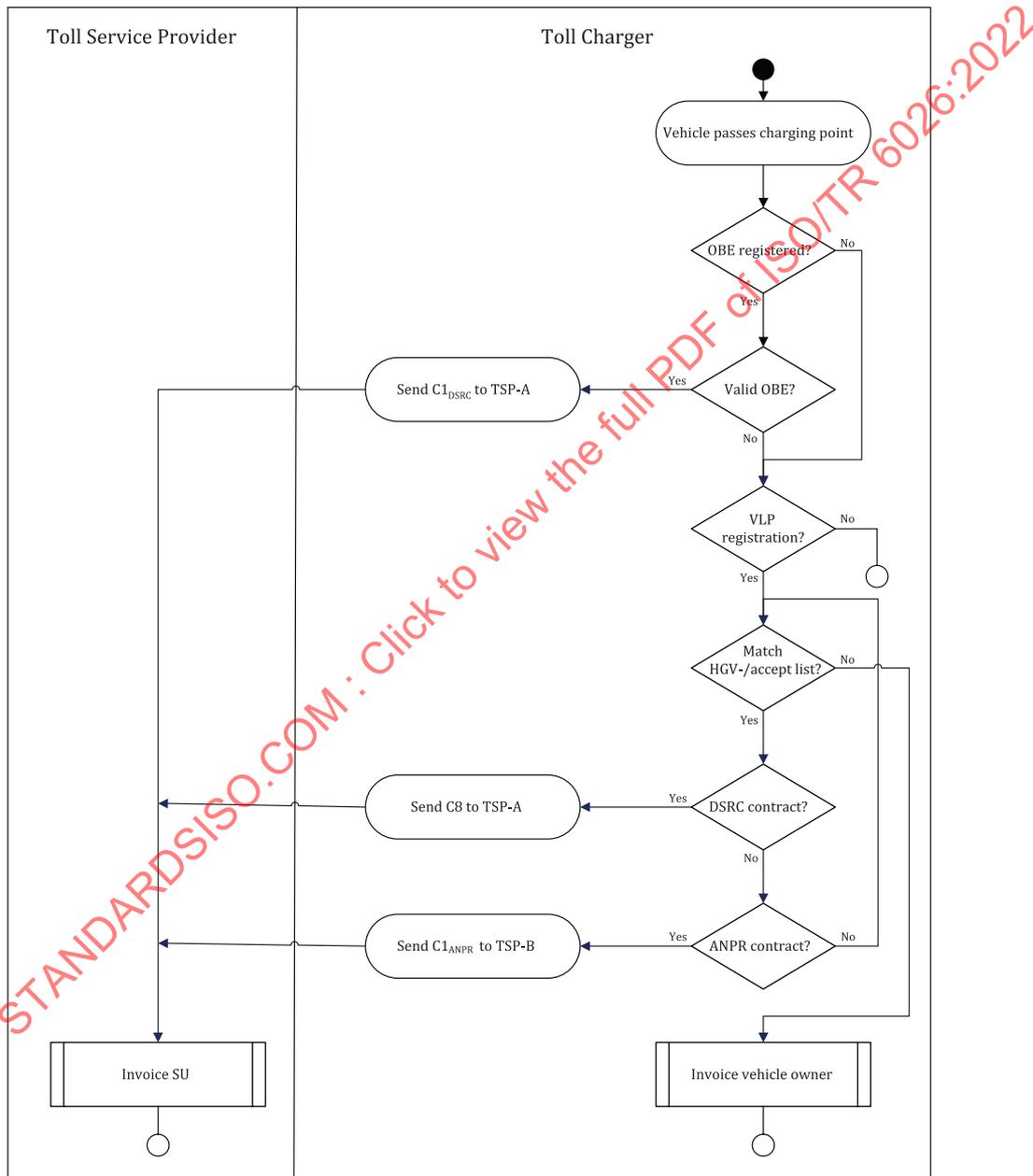


Figure 15 — Roadside process in EasyGo combined DSRC / ANPR toll domains

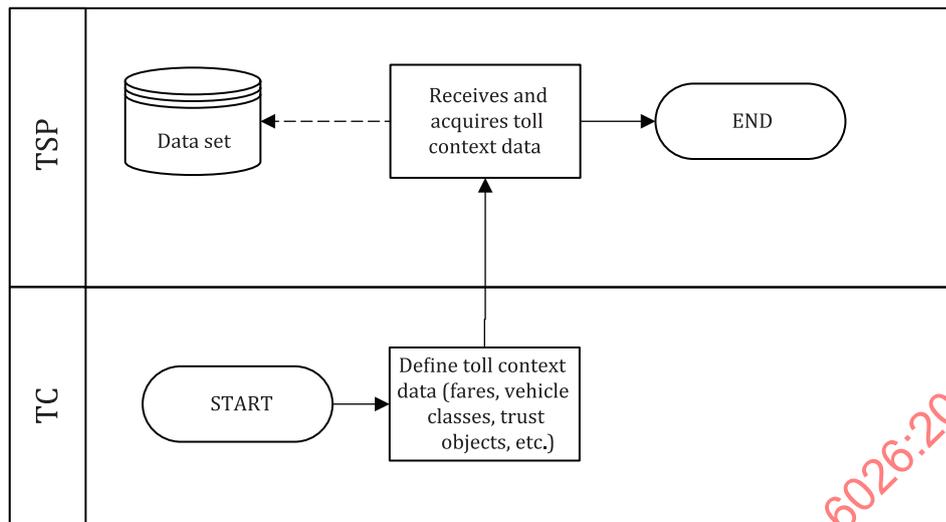


Figure 16 — Define toll context

8.2 Register user

A registration can be not needed for accessing a tolled road. In case a registration is needed, a user can be registered by the TC itself or, as in most contexts (e.g. in the EETS operational frame), by a TSP guaranteeing solvency of the fee to the TC. The following considerations are general and do not depend on a TSP's involvement in the process (see [Figure 16](#)).

- the following documents are usually required for the correct registration of the user:
 - vehicle registration certificate and associated data, including LPN,
 - user's data,
 - pictures of the vehicle;
- the following user information is usually stored in a service provider's database:
 - information related to the calculation of the fee, such as: vehicle class, engine class, etc.,
 - additional information, such as brand, model, colour, dimensions.

For example, EUCARIS^[32] contains the following information in the non-sensitive vehicle section:

- make,
- commercial name,
- engine type,
- fuel type (all-electric, hybrid, etc),
- mass of the vehicle.

Whenever the registration foresees the usage of a DSRC OBE, the OBE's identification data are appended to the registration record. All relevant information, i.e. concurring to the identification of the user and to the calculation of the fee, are stored in the OBU.

User registration information can be exchanged between the TC and TSP over the ISO 12855 BO interface.

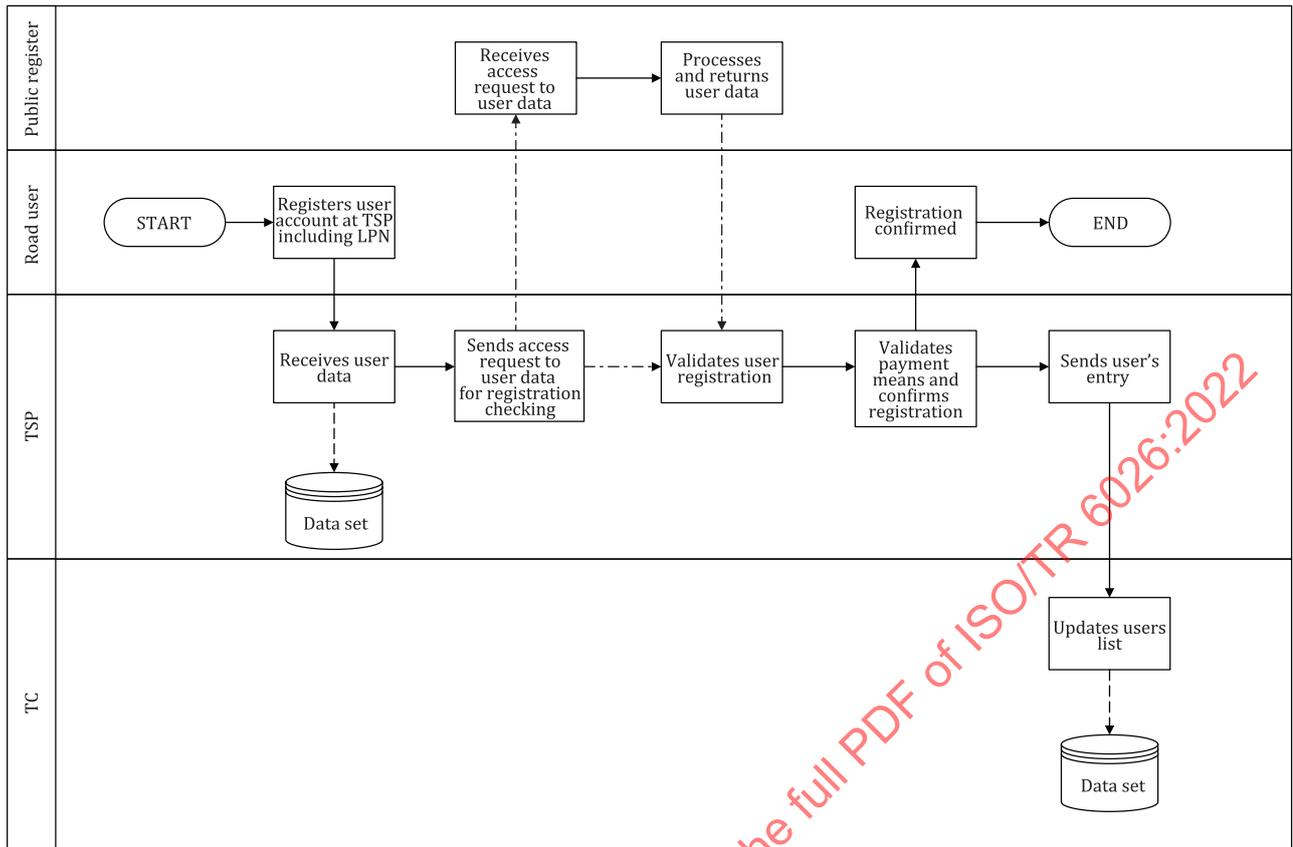


Figure 17 — Register user

8.3 Recognize user with LPN

The user recognition process depends on the correct reading of the LPN. The LPN information can be used in conjunction with other data collected by means of other technologies, such as DSRC, sensors, image recognition, etc.

In general, as already mentioned, an LPN can be registered with more than one TSP, thus resulting in the ambiguity for the TC over which SP to use for charging. The protocol to choose the TSP through which the toll is levied is based on agreements between the TC and the TSP and can depend on specific business models and processes. For the sake of example, the TSP that applies the lower user fee could be used. Although the said aspects are unlikely to be the object of standardization in terms of protocols and models, they are worthy of consideration within the context of extending the interface specifications between the TC and the TSP, to allow a correct attribution and exchange of the parameters enabling the application of the desired rules. For example, in the presence of a user having a contract with more than one TSP, it can be useful to foresee a data flow from the TC towards all of them, to notify the passage and to see whether the contract has/has not been used to clear the payment. Additionally, a priority can be defined in advance and communicated to all interested parties.

8.4 Charge user

The process for charging a user, strictly meant as the sequence of actions for obtaining the due fee from the debtor, upon availability of a complete charging record that includes a correct identification of the payer, does not practically vary among the different possible means of user-recognition systems. In fact, although charging records in an ANPR-based system will differ from those taken in a DSRC-based context, the interactions that follow user identification are basically the same. Hence, no particular update on this interface is expected to be taken in view of an interoperable ANPR-based electronic toll collection system.

Charge records can be exchanged between the TC and the TSP over the ISO 12855 BO interface.

8.5 Enforce payment

The reasons for which a usage fee cannot be levied through a nominal process are typically caused by an error which has occurred in one of the previous processes. For example:

- mismatch between declared and detected number plate, OBU ID, vehicle characteristics;
- unknown vehicle number plate. (No OBE or number plate by a TSP having contract with TC);
- unavailability of a valid payment means.

The required interactions to attempt to recover the fee are different in any case above. There is a common aspect though, that is the need to obtain an irrefutable identification of the user, without which it is impossible to pursue the enforcement.

It is also to be noted that LPN serves as fall-back option in all cases where another means of user identification fails. This is related to the fact that the LPN is the ultimate means for recognizing the vehicle and is present on all vehicles, regardless of whether the user is registered or not for the specific toll context. It is worth mentioning that LPN is the most common means for all law-enforcement applications.

Enforcement records can be exchanged over the ISO 12855 BO interface.

8.6 Handle exceptions (errors)

Several types of errors can occur, which need to be corrected based on agreed procedures. Exceptions can be specifically related to LPN-based EFC, or common to any kind of identification means used in EFC:

Exceptions specifically related to LPN-based EFC:

- LPN not read correctly;
- LPN read correctly, but nationality is wrong;
- LPN not associated to the right vehicle;
- LPN is read correctly, but the LP is wrongly registered in the ANPR contract, deliberately or by accident;
- duplicate detected (possibly enriched with information on geolocation, to detect possible duplicates, though the original cannot be detected);
- counterfeit plate (not reported as stolen);
- stolen plate (reported as stolen).

Common exceptions on SU identification in EFC:

- SU name and address wrongly registered, deliberately or by accident;
- user identification errors, namely due to an obsolete registration record, which typically happens in case of a vehicle having been sold, or being a rental vehicle;
- SU wrongly invoiced by TSP's mistake.

When any of the errors above occur, a process is needed to decide how to proceed. For example, when the error causes an SU to be wrongly debited, the SU is refunded and, if the correct vehicle/contract can be identified, it is invoiced/debited accordingly.

9 Technologies for LPN recognition

9.1 Technologies associated with ANPR

The technologies listed below enable business processes that are associated with or complementary to ANPR EFC, under the listed conditions. The interfaces pertaining exclusively to these technologies are out of the scope of the present document.

- a) DSRC, either as:
 - 1) an alternate method for EFC, when either a DSRC transaction or ANPR generate the charging information, or
 - 2) the primary method for EFC, when only a DSRC transaction generates the charging information, while ANPR is used for enforcement purposes only;
- b) GNSS/CN as primary method for EFC. Although ANPR can theoretically provide an alternate EFC method to GNSS/CN, ANPR in this case it is typically used for enforcement only;
- c) vehicle classification via image processing, laser, radar, etc.

9.2 Components of ANPR system

A generic ANPR system is composed by a detection unit, located on the road, and a central processing unit. The detection unit performs the following functions:

- detection of the presence of vehicles;
 - vehicle classification according to the vehicle's detected characteristics, such as for example length, height, width, mass;
 - acquisition of the vehicle LPN images;
 - recognition of the vehicle LPN through the OCR subsystem;
- NOTE 1 The LP reading function can be implemented both in the local unit and in a central system, according to the architecture adopted.
- data management, date and place of collection;
 - possible management of the lists of authorized LPNs;
 - unambiguous association between vehicle and picture, beyond possible doubt concerning spatial and temporal localization;
 - transfer of the data to a central and processing unit. For special security and confidentiality requirements, the transmission makes use of image encryption and authentication systems.

The central processing unit performs the following functions:

- data acquisition from local units;
- any recognition of the LPs of the vehicles (OCR subsystem) referred to in the images sent by the local units;

NOTE 2 The LP reading function can be implemented both in the local unit and in the central unit, according to the architecture adopted.

- possible management of the LPN (acceptance list) lists of authorized vehicles,
- storage of data.

These two components concur to several key functions: image acquisition, central management, image authentication, communication and human-machine interface.

9.3 Image acquisition

The image authentication function is performed by ANPR systems to guarantee that the association between vehicle image, instance of detection and place of detection is unambiguous and not manipulated.

The image acquisition functionality takes care of the following aspects:

- collect one or more images of vehicles in transit on a road section controlled by the system;
- recognize those types of vehicles for which the application does not require control;
- operate the system in different lighting conditions (day, night, etc.), e.g. by using artificial lighting without compromising road safety;
- connect to the OCR subsystem for the automatic identification and recognition of the LPs;
- encode the images, by using appropriate compression algorithms, if it is necessary to save transmission time or space in the archive memory.

The OCR subsystem has the following minimum characteristics:

- it independently reports any anomalies in reading the characters of the LPN;
- it operates in a flexible way regardless of the size of the images.

9.4 Central management

The central management is in charge of the following activities:

- communications with local detection units;
- data system;
- infringement verification;
- communication and data sharing with the entities responsible for toll collection;
- data protection, authentication and confidentiality.

9.5 Image authentication

The image authentication guarantees that the association between vehicle image, date of detection and place of detection is unambiguous, not able to be manipulated, and not accessible by unauthorized personnel, and that the association to the vehicle is performed in real-time and in such a way as not to affect the general performance of the image acquisition subsystem.

9.6 Communication

The communication pertains the transmission of data and images from the local unit to the central unit, guaranteeing their security, integrity and confidentiality.

9.7 Human-machine interface

The human-machine interface allows:

- displaying of images. In addition to the vehicle LPN images (or/and context images if required), this interface shows the date and place of the detection;

- validation of the LPN readings as well as the correction of potential errors of the OCR subsystem and the related assessment of the legality of the transit, whenever it is required by the process, namely to ascertain a violation;
- dynamic management of the configuration of all system parameters;
- management and maintenance of violation archives;
- management and maintenance of historical archives;
- remote control management of the activities of the entire system.

The human-machine interface can be updated with reference to the graphic component and any bug fixing.

9.8 Challenges in the identification process

9.8.1 Accuracy

An OCR software utilizes confidence scores on various levels down to each character in the string, which implies that an amount of uncertainty is involved. A high confidence score indicates that the OCR software believes that the recognition result is correct. The process can benefit from the usage of deep learning algorithms.

Deep learning is a subfield of machine learning algorithms that works with artificial neural networks, designed to imitate how humans learn by example. These algorithms can ingest and process unstructured data like images and automate feature extraction as well as determine distinguishing features. Real world images are required to train the model. A high volume of reference data provides a small margin of error.

The requirement of determining not only the LPN, but also the country of origin to get a complete recognition result is an additional challenge. It is possible that the string of characters alone will not provide sufficient evidence since many countries use the same syntax. In addition to syntax, additional characteristics are useful like font, space, tax marks and national rules of characters used on LPs.

Vanity plates offer a certain challenge since the number of characters often varies.

9.8.2 Margin of error

Uncertainty and margin of error is involved in the ANPR identification process. The ANPR system can only suggest a recognized LPN and country of origin with a high degree of confidence, but it always falls within a margin of error.

For example, a Swedish LP could be determined as Belgian, Finnish or Lithuanian, so that the LP recognition can result in a false positive (see [Table 2](#) for possible cases). In case of a false positive, the real SU does not receive the invoice, which is possibly sent to a different vehicle owner.

Another case is when an LP image presents an LPN and a country of origin that are human-readable, but the ANPR suggest that the image is non-recognizable and therefore disposed, causing revenue loss.

Table 2 — Recognition result

Recognition result	Actual	
	Positive	Negative
Positive (recognized)	True positive	False positive
Negative (non-recognizable)	False positive	True positive

There is a balance between recognition rate and false positive. The ANPR system owner can determine the balance. Manual number plate recognition (MNPR) is a supporting process that can receive the portion of images that the ANPR system is not able to process with an acceptable confidence.

To save MNPR costs, the ANPR recognition rate can be set to a high tolerance value, in order to accept more false positives.

10 Gap analysis

10.1 General

This clause considers gaps in the body of EFC standards that need to be filled in order to support LPN-based tolling based on the considerations in the previous clauses of this document.

The gap analysis considers the life cycle of the interfaces, that is, design with functional and technical specifications, and validation, with test specifications.

Within the specifications, the relevant security aspects are also included, and considerations about the underlying regulatory framework are mentioned, e.g. regarding privacy.

[Subclause 10.2](#) shows the standards that are expected to be available to allow ANPR EFC over each interface.

In [subclause 10.3](#) the specific gaps are described that are expected to be filled in the standards. This section provides qualitative information on the effort to be put into future standardization work, further elaborated in the roadmap in [Clause 11](#).

10.2 Technical interfaces

10.2.1 TI-1 Toll context definition

The definition of the toll context is typically represented by a unilateral exchange from the TC to the TSP, where the former gives comprehensive and unambiguous indications regarding the conditions in which tolls are levied in the tolling context.

In an ANPR-based toll context, either using the LPN as a stand-alone technique or in combination with other technology, there does not seem to be the need to define additional protocols, but rather to adapt existing standards in accordance with the LPN requirements.

It is important to note that, for said requirements to be clearly expressed and hence for the standards related to TI-1 to be ready for the evolution, it is necessary to define aspects related to the other operational interfaces, like TI-2 user registration and TI-3 ANPR reading and user recognition. These interfaces require the exchange of additional information, to be defined in advance and taken into account in the extension of the toll-context-definition interface.

For the sake of readability and to allow a comprehensive view of the criteria used to outline the priorities between the interfaces and the data they use, [Table 3](#) shows:

- the activity which is part of the lifecycle of the interface;
- the standards available for the activity;
- the readiness of said standards to enable the interface towards LPN-based EFC;
- the dependencies from other standards, also referring to other interfaces.

Table 3 — Standards on interface TI-1

TI-1 Toll context definition				
Activity number	Activity	Standards available	Readiness for LPN	Dependencies
A1	Specifications for BO interface	ISO 12855	Addendum required	A6
A2	Specifications for BO interface - EU profile	CEN/TS 16986	Addendum required	A1
A3	Test for BO interface	None	—	A1
A4	Test for BO interface - EU profile	The CEN/TS 17154 series	Update required	A2
A5	Definition of performance metrics	none – The ISO 17444 series does not cover TI-1	Major update required	A1, A6, A7
A11	Electronic fee collection - Security framework	ISO 19299	Update required	A1, A2, A6
A12	Electronic fee collection - Guidelines for security protection profiles	ISO/TS 17574	Update required	A1, A2, A6

There are no additional security or privacy aspects directly related to the exchange of LPN-related toll context data.

10.2.2 TI-2 User registration

User registration typically happens either when a TSP is present or, in a more general view, the TC requires the registration for the user to access the paid infrastructure. The entity, either the TSP or the TC, enters into relation with the user over the interface TI-2, where all the relevant information is exchanged.

Table 4 shows:

- the activity which is part of the lifecycle of the interface;
- the standards available for the activity;
- the readiness of said standards to enable the interface towards LPN-based EFC;
- the dependencies from other standards, also referring to other interfaces.

Table 4 — Standards on interface TI-2

TI-1 User registration				
Activity number	Activity	Standards available	Readiness for LPN	Dependencies
A1	Specifications for BO interface (User <-> TSP)	None; proprietary interface	See 10.2.1	—

Being a proprietary interface, security aspects are mandated to the specific implementations. Privacy-wise, the TSP can have to request consent from the user to manage personal data.

10.2.3 TI-3 User list exchange

The exchange of user lists occurs over the BO interface between TSP and TC. Table 5 shows

- the activity, which is part of the lifecycle of the interface;

- the standards available for the activity;
- the readiness of said standards to enable the interface towards LPN-based EFC;
- the dependencies from other standards, also referring to other interfaces.

Table 5 — Standards on interface TI-3

TI-3 User list exchange				
Activity number	Activity	Standards available	Readiness for LPN	Dependencies
A1	Specifications for BO interface	ISO 12855	See 10.2.1	—
A2	Specifications for BO interface - EU profile	CEN/TS 16986	See 10.2.1	—
A3	Test for BO interface	None	See 10.2.1	—
A4	Test for BO interface - EU profile	The CEN/TS 17154	See 10.2.1	—
A5	Definition of performance metrics	The ISO 17444 series	Major update required	A1, A6, A7
A11	Electronic fee collection - Security framework	ISO 19299	See 10.2.1	—
A12	Electronic fee collection - Guidelines for security protection profiles	ISO/TS 17574	See 10.2.1	—

10.2.4 TI-4 User recognition

User recognition is the activity where the direct acquisition of the LPN occurs, through automatic or manual recognition over the image of the vehicle. It is expected that most gaps in EFC standards are related to this interface. [Table 6](#) shows:

- the activity which is part of the lifecycle of the interface;
- the standards available for the activity;
- the readiness of said standards to enable the interface towards LPN-based EFC;
- the dependencies from other standards, also referring to other interfaces.

Table 6 — Standards on interface TI-4

TI-4 User recognition				
Activity number	Activity	Standards available	Readiness for LPN	Dependencies
A1	Specifications for BO interface	ISO 12855	See 10.2.1	—
A2	Specifications for BO interface - EU profile	CEN/TS 16986	See 10.2.1	—
A3	Test for BO interface	None	See 10.2.1	—
A4	Test for BO interface - EU profile	The CEN/TS 17154 series	See 10.2.1	—
A5	Definition of performance metrics	The ISO 17444 series	See 10.2.3	—

Table 6 (continued)

TI-4 User recognition				
Activity number	Activity	Standards available	Readiness for LPN	Dependencies
A6	Content of the LPN-based information	None	Standards required	—
A7	Performance for the acquisition of LPN image	None	Standards required	A6

10.2.5 TI-5 Billing

The billing interface is intended as the relation between TC and TSP where charging information is exchanged. Without loss of generality, this would also apply to the case where the user account is managed directly by the TC.

[Table 7](#) shows:

- the activity which is part of the lifecycle of the interface;
- the standards available for the activity;
- the readiness of said standards to enable the interface towards LPN-based EFC;
- the dependencies from other standards, also referring to other interfaces.

Table 7 — Standards on interface TI-5

TI-5 Billing				
Activity number	Activity	Standards available	Readiness for LPN	Dependencies
A1	Specifications for BO interface	ISO 12855	See 10.2.1	—
A2	Specifications for BO interface - EU profile	CEN/TS 16986	See 10.2.1	—
A3	Test for BO interface	None	See 10.2.1	—
A4	Test for BO interface - EU profile	The CEN/TS 17154 series	See 10.2.1	—
A5	Definition of performance metrics	The ISO 17444 series	See 10.2.3	—
A11	Electronic fee collection - Security framework	ISO 19299	See 10.2.1	—
A12	Electronic fee collection - Guidelines for security protection profiles	ISO/TS 17574	See 10.2.1	—

10.2.6 TI-6 User data retrieval

The interface for the retrieval of user data foresees the interactions between the TC and the registers that allow the correlation of the information of the vehicle to the responsible user.

[Table 8](#) shows:

- the activity which is part of the lifecycle of the interface;
- the standards available for the activity;

- the readiness of said standards to enable the interface towards LPN-based EFC;
- the dependencies from other standards, also referring to other interfaces.

Table 8 — Standards on interface TI-6

TI-6 User data retrieval				
Activity number	Activity	Standards available	Readiness for LPN	Dependencies
A8	Specifications for interface with registers of vehicles	None	Standard advised	—
A9	Test for interface with registers of vehicles	None	Standard advised	A1
A10	Performance metric for the interface with registers of vehicles	None	Standard advised	A1, A2
A11	Electronic fee collection - Security framework	ISO 19299	See 10.2.1	—
A12	Electronic fee collection - Guidelines for security protection profiles	ISO/TS 17574	See 10.2.1	—

10.2.7 TI-7 Enforcement

The enforcement interface is used after the detection of any case of usage that does not comply with the regular process, for several reasons: vehicle not correctly recognized, impossibility to invoice the user, payment not received or incorrectly received, etc. [Table 9](#) shows:

- the activity, which is part of the lifecycle of the interface;
- the standards available for the activity;
- the readiness of said standards to enable the interface towards LPN-based EFC;
- the dependencies from other standards, also referring to other interfaces

Table 9 — Standards on interface TI-7

TI-7 Enforcement				
Activity number	Activity	Standards available	Readiness for LPN	Dependencies
A1	Specifications for BO interface	ISO 12855	See 10.2.1	—
A2	Specifications for BO interface - EU profile	CEN/TS 16986	See 10.2.1	—
A3	Test for BO interface	None	See 10.2.1	—
A4	Test for BO interface - EU profile	The CEN/TS 17154 series	See 10.2.1	—
A5	Definition of performance metrics	The ISO 17444 series	See 10.2.3	—
A11	Electronic fee collection - Security framework	ISO 19299	See 10.2.1	—