
**Smart community infrastructures —
Smart transportation for parking lot
allocation in cities**

*Infrastructures urbaines intelligentes — Transport intelligent pour
l'attribution des aires de stationnement dans les villes*

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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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 268, *Sustainable cities and communities*, Subcommittee SC 1, *Smart community infrastructures*.

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

Automobiles satisfy people's desire to move by themselves at their convenience to anywhere they need or want to go, as explained in ISO 37154. Most cities, especially those that were or are being developed rapidly in a short time, have the same experiences and issues currently or in their history relating to difficulties in finding parking lots or car parks with available spaces.

The limited number of parking lots in a city should be shared by more vehicles more frequently. The low availability of parking lots has unexpectedly caused other city issues besides the difficulty in finding parking lots with available spaces in some cities. It has resulted in irritated drivers, time being wasted and increased fuel consumption. Drivers' attention is taken up while searching, causing collisions to happen more often. Such incidents and slow driving result in traffic congestion. While driving an automobile at a low speed, more pollutants, particle materials (PMs) and greenhouse gases are emitted into the atmosphere. There is nothing positive about the low availability of parking lots in a city. Citizens, including drivers and people living next to public roads, experience such situations all the time.

ITU-T Y.4456^[6] suggests ideal parking lot facilities and outlines technical aspects regarding unoccupied parking spaces, parking space reservation, vehicle automatic access control, self-service parking fee payment and vehicle reverse search, from the viewpoint of enhancement of conventional parking lot services. The concept and goals of smart transportation designated in this document to allocate parking lots to drivers are different from those of ITU-T Y.4456, which mentions parking lot reservation work but lacks the concept and procedure to increase parking lot availability that smart transportation aims at for providing more parking lots to drivers. Finding parking lots that have not yet been offered to the public and allocating to drivers all parking lots already available and recently found will basically increase the availability. ITU-T Y.4456 manages only parking lots currently available to the public. Thus, the issue of parking lot shortage cannot be completely solved. From the viewpoint of city development investments, civil engineering construction is planned, designed, arranged and operated with limited budgets. Digging up and activating unrecognized or unused or unoffered parking lots is still a realistic and easy way to increase the total capacity of parking lots in a city without additional installation. This strategy avoids capital cost preparation for unnecessary parking lot construction.

The availability of parking lots can be increased by another method that effectively allocates and reallocates parking spaces to more drivers more frequently by sharing data as described in ISO 37156 and part of ITU-T Y.4456. With data exchange networks, information on which parking lots have spaces, until what time they are available or unavailable, where they are located and so on is easily collected and immediately shared, resulting in increasing parking lot availability.

Nowadays, protection of people's privacy is a top priority in any service. This document also describes how such privacy should be protected in the services by applying high security, which is not mentioned in ITU-T Y.4456.

This document describes the concept of smart transportation to efficiently allocate parking lots to drivers in cities and outlines installation and organization of the services. This document also contributes to achieving the United Nations Sustainable Development Goals, in particular goal 3: "Good health and well-being", goal 7: "Affordable and clean energy", goal 8: "Decent work and economic growth", goal 9: "Industry, innovation and infrastructure", goal 11: "Sustainable cities and communities", goal 12: "Responsible consumption and production", goal 13: "Climate action" and goal 15: "Life on land".

In the development of this document, ISO Guide 82 has been taken into account in addressing sustainability issues.

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Smart community infrastructures — Smart transportation for parking lot allocation in cities

1 Scope

This document specifies procedures for installing and organizing smart transportation for parking lot allocation for drivers in cities. It is intended to apply to cities, especially those having a shortage or low availability of parking lots. This smart transportation aims to provide a solution to the city issue of drivers having difficulty in quickly finding parking lots with available spaces. It also aims to address other city issues such as traffic accidents, congestion and energy consumption.

This document clarifies the concept and goals of smart transportation by referring to the technical aspects suggested by ITU-T Y.4456^[6].

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 terminological databases for use in standardization at the following addresses:

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

3.1

parking lot

car park

area to park vehicles which are allowed to run on public roads

Note 1 to entry: Vehicles are listed in ISO 37154:2017, 2.5.4, but this document targets automobile-size vehicles privately or personally used (e.g. automobiles, tuk-tuks, manually driven cycle-rickshaws).

Note 2 to entry: 'Parking lot' is preferred to 'car park' in this document as it is more widely used.

3.2

parking lot allocation

suggesting spaces in *parking lots* (3.1) to drivers by finding the best match between drivers' requests or parking preferences and current or expected parking lot availability

Note 1 to entry: Drivers' requests include access routes from current locations, preferred places to park, preferred time to start parking, parking duration, the number of vehicles to be parked and vehicle characteristics, limits of parking fees payable and payment methods.

3.3

parking lot allocation system

arrangement for *parking lot allocation* (3.2) using databases to exchange and share information including parking lot location, parking time recording, navigation to *parking lots* (3.1) and suggestions for parking fee payment procedures and necessary services

4 Concept of smart transportation for parking lot allocation

4.1 General

This subclause describes the general criteria required for smart transportation for parking lot allocation in cities. To solve the city issue of drivers having difficulty in finding parking lots with available spaces, the allocation should be organized and performed to provide more opportunities for drivers to quickly find available spaces and book in parking lots that meet their demands and preferences. This service can be made possible by increasing parking lot availability in a city. Smart transportation has its own goals and aspects different from those of ITU-T Y.4456. Parking lot availability in a city should be increased:

- to provide a greater absolute number of parking lots to citizens and city visitors;
- to offer parking lots to citizens and city visitors more frequently.

To ensure its high performance, smart transportation has:

- high security for driver and parking lot owner identification and privacy, parking fee payment, data transfer and avoidance of rule violations by illegal smart transportation users;
- terminal-to-terminal communication that is decentralized to achieve fast processing and reduce organizational, operational and maintenance costs while maintaining high security.

Since smart transportation results in drivers taking less time to find parking lots with available spaces, it indirectly achieves the following additional benefits by increasing the number of vehicles in a city within the allowable parking lot capacity increased by smart transportation:

- more visitors can be accommodated by a city;
- business can be created and introduced to a city;
- the number of vehicle collisions and traffic accidents can be reduced;
- traffic congestion can be eased;
- discomfort to drivers and people living next to busy roads can be suppressed;

NOTE Slow driving could make drivers bored due to the monotonous operation and irritate residents with low frequency noise and vibration.

- synergy between parking pricing and policy measures can reduce the time to search and complete parking.

There is a variety in the kinds of vehicles that are headed for their individual destinations at different locations in a city. The establishment of safe and steady data exchange and sharing platforms is key to successfully organizing parking lot allocation services. Through communication based on the network, information required to immediately allocate parking lots appropriately to drivers is processed and shared among drivers and parking lot owners who have joined a parking lot allocation system. Drivers' requests should best match the conditions of parking lots that currently have spaces or will be available in the time frame requested or preferred by drivers.

To support communication and data sharing, instruments and equipment such as detectors or sensors, telecommunication devices, signboards and displays should also work effectively. Communication and data sharing should satisfy the following conditions:

- communication directly from terminal to terminal;

NOTE A "terminal" is an end instrument or equipment used for communication [e.g. mobile phone, interphone, tablet, PC, point-of-sale (POS) system, onboard unit].

- communication without time lag (e.g. fewer processing steps for users' identification);

- traceable communication;
- offers of large selections for parking lots;
- easy management of the services.

Solar parking lots aim at coupling clean solar electricity and electric mobility deployment. Solar panels provide shade and generate electricity to charge parked electric vehicles. In a vehicle-to-grid approach, the vehicles may also feed the grid and support with ancillary services. Solar parking lots:

- offer environmental and technical benefits;
- decrease injected solar power into a grid and maximize revenues;
- provide incentive schemes that include parking lot stakeholders.

4.2 Applicable city issues and expected advantages

The criteria for smart transportation described in this document are appropriate to address the city issue of difficulty for drivers in finding parking lots with available spaces in a city. As stated in [4.1](#), the introduction of smart transportation will also bring other advantages besides the solution to this problem. Although smart transportation aims to achieve these advantages, they should not be the top priorities or the main reason for introducing smart transportation because smart transportation does not achieve these directly. Well-organized and well-managed parking infrastructure can also reduce the problem of random parking in unauthorised public places like walkways. Moreover, land is scarce and valuable in cities. Considerately designed and operated parking infrastructure can lead to optimal utilization of parking space.

5 Planning to implement smart transportation for parking lot allocation

To properly implement smart transportation for parking lot allocation and operate it successfully as planned, the following parameters shall be confirmed in advance of implementation:

- traffic patterns in the target city or region;
- traffic volume in the target city or region;
- traffic capacity on public roads in the target city or region;
- number of existing parking lots available;
- location of existing parking lots available;
- area or capacity of existing parking lots available;
- number of parking lots planned;
- location of parking lots planned;
- capacity of parking lots planned;
- mass limits of parking lots allowed;
- dimension limits of parking lots allowed (e.g. clearance);
- payment methods for parking lots available;
- information on novel types of vehicles being used in the city.

6 Adoption and operation of smart transportation for parking lot allocation

6.1 Objectives

As mentioned in [4.2](#), smart transportation can help directly address the issue of difficulty for drivers in finding parking lots with available spaces in a city. Smart transportation shall be adopted and implemented by following [6.3](#).

6.2 Target vehicles

All vehicles that can be parked in parking lots in cities.

6.3 Procedure to adopt smart transportation

6.3.1 General

Smart transportation shall be adopted in a city by following the procedures in [6.3.2](#) to [6.3.8](#).

NOTE ITU-T Y.4456:2018, Clauses 6 and 7 provide some tips on parking lot service contents.

6.3.2 Information elements to be collected

To allocate parking lots to drivers, information shall be collected for the arrangement, the elements of which are as follows:

a) Parking lots

- location;
- formation or structures (e.g. on the ground, underground, inside a building, on a bridge, on a public road);
- size or capacity (i.e. size or capacity large enough for standard private cars);
- allowable parking time (e.g. 15 min, 30 min, 1 h, half a day, one full day, one week, one month, half a year, one year);
- parking service time frame (e.g. only during the daytime, even at night, overnight);
- parking frequency (e.g. just one time, temporarily for a limited period, regular interval use);
- ownership (e.g. public, exemption, private, shared);
- facilities (e.g. roof, valet parking service, power charging, refuelling, car washing services);
- map of the area served by smart transportation;
- parking fees (e.g. amounts, discount or cooperative programs).

b) Drivers

- gender;
- age;
- specific conditions (e.g. disabilities, with babies or small children);
- current location;
- destinations;

- vehicle characteristics (e.g. standard private cars, dimensions including length, width, height and weight);
- requested or expected parking time duration (e.g. 15 min, 30 min, 1 h, half a day, one full day, one week, one month, half a year, one year);
- preferred payment procedures [e.g. cash only, credit card, digital payment (d-payment), bank transfer, online or offline payment transaction).

c) Other

- current weather conditions on the way to the parking lot and at the place itself (e.g. sun, cloud, rain, snow, wind speed and direction, humidity, visibility, specific weather conditions).

6.3.3 Information collection

To collect the information designated in [6.3.2](#), the following instruments and equipment should be installed and operated:

- car sensors in parking lots (e.g. to check if car present or absent, parking lot vacancy or occupancy);
- monitors for security in parking lots;
- traffic congestion monitors (e.g. on the way to and in the area around the parking lot);
- atmospheric condition sensors (e.g. to check ambient temperature, humidity);
- weather monitors (e.g. to check rainfall, snowfall, wind speed and direction, visibility);
- software to collect the data and process (e.g. data collection, data transfer, data processing, parking charge, parking fee collection);
- apps (e.g. for drivers, for parking lot owners, for traffic departments, for related and additional services).

6.3.4 Data transfer

To transfer to parking lot allocation system databases, drivers and parking lot owners the data listed in [6.3.2](#) and [6.3.3](#), communication shall be organized by the following means:

a) Between parking lot owners and parking lot allocation databases

- mobile or smart phones;
- apps applicable to mobile and smart phones;
- security gateways (e.g. identified authentication, data encryption, access control and restriction);
- internet;
- online and offline communication (e.g. local area networks, ad hoc networks, near-field communication).

b) Between drivers and parking lot allocation databases (in addition to the requirements and functions designated in a)

- identification and tracking using tags (e.g. radio or ultra-high-frequency identification).

6.3.5 Information provided to drivers

In order to help drivers choose a parking lot from options best matching their requests or preference by considering where, what time and for how long to park their vehicles, the following information shall be provided to drivers:

- location;
- available time frame (e.g. from what time to what time or to which day);
- allowable parking time (e.g. 30 min, 1 h, half a day, one day, one week, one month, half a year, one year);
- access routes;
- estimated time of driving from the driver's current location;
- parking fees (e.g. per hour, day, week, month or year);
- availability of charging facilities for automobile batteries;
- available day and time (e.g. workdays, weekend, holidays, daytime or night time);
- road conditions on the way or nearby (e.g. traffic congestion, weather conditions, accidents, roadwork);
- parking fee payment manner (e.g. cash only, credit card, d-payment, bank transfer, online and offline payment);
- additional information helpful to drivers (e.g. nearby shops, restaurants, public bathrooms, gas stations).

6.3.6 Allocation of parking lots

To successfully allocate parking lots to drivers, their requests or preference and parking lot availability are compared, especially regarding the following information. Options suggested to drivers of the best-matched parking lots will be kept until the parking lot reservation is confirmed.

- a) Driver requests and preference
 - current place;
 - preferred places to park;
 - preferred time to start parking;
 - parking duration (e.g. for how many minutes, hours or days);
 - number of vehicles to be parked (e.g. only one vehicle, more than one vehicle);
 - vehicle characteristics (e.g. standard personal-use automobiles, standard-sized business automobiles);
 - parking fee payment manner (e.g. cash only, credit card, d-payment, bank transfer, online and offline payment).
- b) Parking lot services
 - location;
 - number of parking lots available;
 - available parking time frames (e.g. from what time to what time);

- available parking duration (e.g. less than 30 min, 1 h, couple of hours, half a day, one full day, a few days, one week, two weeks, one month, half a year, one year);
- additional services in parking lots (e.g. power chargers, gas stations, bathrooms, convenience stores);
- available facilities around the parking lots (e.g. shops, restaurants, banks and ATMs, hospitals and clinics, stations, bus stops, ferry terminals, airports, hotels, post offices, police departments);
- parking lot security (e.g. security guards, TV monitors);
- parking costs;
- parking fee payment manner (e.g. cash only, credit card, d-payment, bank transfer, online and offline payment);
- availability of charging facilities for automobile batteries.

c) Designated uses

- dedicated space and lane markers identified as “no parking or stopping” to allow for access by emergency vehicles (e.g. fire apparatus, rescue vehicles, police cars, ambulances);
- dedicated spaces and related signage to identify dedicated parking spaces for disabled drivers.

6.3.7 Collection of parking fees

To collect parking fees, the following instruments and equipment shall be installed and operated:

- barrier gates;
- signboards or displays to notify drivers of the parking fee amount estimated or determined;
- signboards or displays to notify drivers of remaining time allowed for parking;
- signboards or displays to instruct the manner of payment of parking fees;
- instruments to collect parking fees (e.g. in cash, for e-payment or d-payment, receipt printers).

6.3.8 Provision of information helpful to parking lot allocation management

To properly organize and manage parking lot allocation systems, the following information shall be obtained:

- illegally parked vehicles (e.g. overtime parking, oversize parking, parking fee evasion);
- vehicles not registered with parking lot allocation services;
- parking fees owed;
- frequent users (e.g. discounts, priority for the next reservation);
- current instrument and equipment conditions;
- instrument and equipment maintenance states and records.

7 Data exchange and sharing management

To properly manage and operate parking lot allocation systems with data exchange and sharing platforms and networks, based on or referred to ISO 37156, all the data collected by following [Clause 5](#), [6.3.2](#) and [6.3.8](#) should be safely stored and correctly processed. The data to be forwarded by following [6.3.3](#) to [6.3.5](#) should be securely transferred.

8 Data security control with smart transportation for parking lot allocation

8.1 General

By following ISO 37156 guidance to organize smart transportation for parking lot allocation and protect private or personal information from use for other purposes besides parking lot allocation system management, all information collected, used, exchanged and shared shall be protected from illegal or unauthorized access, especially by or for the following actions:

- information duplication;
- impersonation;
- tampering;
- information repudiation;
- privacy disclosure.

In contrast, drivers legally registered with parking lot allocation systems through an app can access authenticated information on parking lots.

To achieve such data protection in data processing and transfer, one-time use public-key cryptography is applied. In this way, public and private keys are used dynamically and shall be matched in the same ways, where both public and private keys should be temporarily created by a data sender (e.g. parking lot owners) and a data recipient (e.g. data platform managers). When confirming private and public key matching, a matching field is also temporarily created. A sender's private key created by the sender and the sender's public key created by a recipient using a common algorithm are combined in a matching field also temporarily created by the recipient. In the same way, a field is temporarily created by the sender, where the recipient's private key created by the recipient is combined with the recipient's public key created by the sender in the same algorithm. When both combinations in the two fields are successfully matched, respectively, they recognize each other with higher accuracy.

To obtain such high security, all personal object data or public and private keys and matching fields should be temporarily created and used only once. The security level of this procedure is the highest. To quickly process the procedure, agreements on the procedure to use a common algorithm to temporarily create keys and fields are made in advance among the participants in smart transportation for parking lot allocation. To be technically correct, private keys are not recognizable to any participants except the data sender. Therefore, participants can see only public keys when finding the correct data recipient.

Based on their security, drivers' identified personal information can be combined or related to an authenticated vehicle information through registration with an app. The information shall be encrypted and authenticated to protect from illegal access, including intention and action to disclose privacy. Access to the information shall also be limited.

The data security control concept and procedure in smart transportation to allocate parking lots to drivers are completely different from those described in ITU-T Y.4456, because smart transportation should work for people who strongly request protection of their privacy in all transportation services. In smart transportation, data security control shall achieve the following:

- high security (e.g. privacy protection);
- fast procedures and processing (e.g. effective allocation of parking lots, quick parking fee payment and receipt to avoid congestion at the exit);
- low cost for organization, operation and maintenance (e.g. durability performance).

To meet the requirements for smart transportation, decentralized or terminal-to-terminal communication shall be adopted therein.