Technical Report

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Intelligent transport systems — Seamless positioning for multimodal transportation in ITS stations —

Part 1: General information and use case definition

Systèmes de transport intelligents — Positionnement homogène pour le transport multimodal dans les stations ITS —
Partie 1: Informations générales et définition de cas d'utilisation

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Foreword

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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 document 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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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

A list of all parts in the ISO 6029 series can be found on the ISO website.

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

As new forms of mobility service (e.g. e-mobility, delivery robot, autonomous driving) are emerging in the intelligent transport systems industry, the nomadic device is acquiring an indispensable role.

One use of nomadic devices is in positioning systems, in which mobility service platforms use the position data gathered via the nomadic devices of passengers. Current positioning systems rely on Global Navigation Satellite System (GNSS) technology. The functionality of such systems is occasionally constrained by network interference, a GNSS-denied environment or data loss. A seamless positioning system enables interoperability between ITS domains for the provision of a seamless location-based service.

The main objective of the seamless positioning system described in the ISO 6029 series is to support the development of a robust and ubiquitous indoor and outdoor seamless positioning solution for a mobile user (e.g. multimodal transportation) so that anyone can benefit from mobility services, regardless of location, environment and disability.

The seamless positioning system consists of three domains:

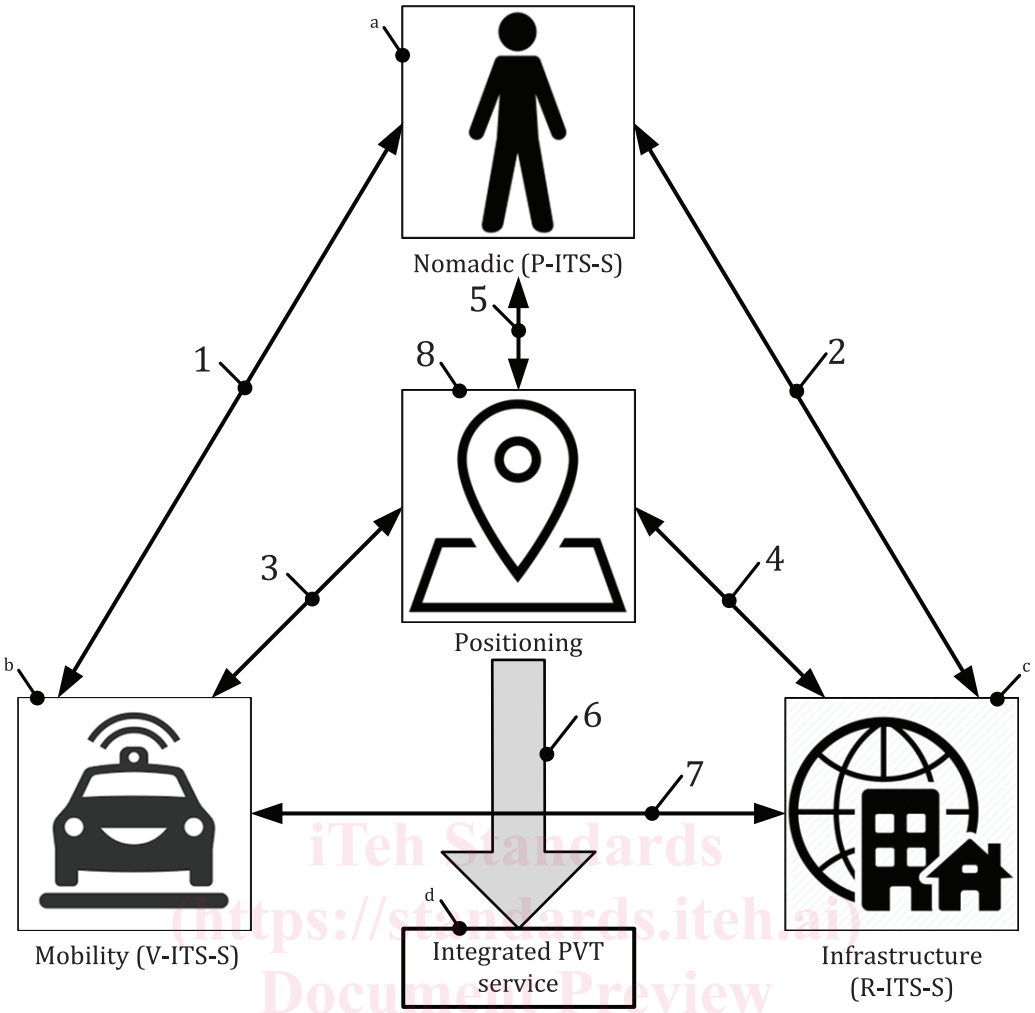
— nomadic device [e.g. personal intelligent transport system station (P-ITS-S)],

— mobility [e.g. vehicle intelligent transport system station (V-ITS-S)], and

— infrastructure [e.g. roadside intelligent transport system station (R-ITS-S)].

The system integrates multiple data from different domains and provides positioning data [e.g. position, velocity, time (PVT service implemented in the ITS-S)] in a seamless manner.

Figure 1 shows the seamless positioning system described in the ISO 6029 series.



Key

1 exchange of data between P-ITS-S and mobility containing mobility/personal data and network environment
2 exchange of data between P-ITS-S and infrastructure containing personal data and infrastructure information
3 exchange of data between mobility end and sensor-fusion positioning application
4 exchange of data between infrastructure end and sensor-fusion positioning application
5 exchange of data between P-ITS-S and sensor-fusion positioning application
6 seamless positioning calculation
7 positioning exchange use cases
8 positioning domain of all devices in P-ITS, V-ITS and R-ITS domain
a The P-ITS domain is represented by ITS-compliant nomadic devices carried by human beings.
b The V-ITS domain is represented by ITS-compliant vehicles.
c The R-ITS domain is represented by ITS-compliant roadside infrastructure devices.
d Outcome is the integrated position, velocity and time service provision.

Figure 1 — Seamless positioning system

The objective of the seamless positioning system is based on:

— extensibility, e.g. artificial intelligence, block-chain, sensor-fusion technology;

— simplification, e.g. standardized message format based on ISO/TS 21184 (GTDM), IEC 61162[6] and NMEA 0183;[7]

— reliability, e.g. system reliability, data precision, fast first to fix, dilution correction factors;

— application, e.g. the ISO 17438 series, autonomous driving features, location-based service, safety-related industry.

Intelligent transport systems — Seamless positioning for multimodal transportation in ITS stations —

Part 1: General information and use case definition

1 Scope

This document describes use cases related to seamless positioning systems for multimodal transportation in ITS stations. The use cases define the effectiveness of the seamless positioning concept model based on the P-ITS-S to conclude basic PVT service results using available sensors when mobility is moving indoor and outdoor in a network on/off situation. Use cases are provided for each stage in different environments, e.g. indoor, outdoor, tunnel and out-of-network area when travelling starts or ends. Within the use cases, the nomadic device implements a personal ITS station (P-ITS-S) to achieve compatibility with other ITS stations as referenced in this document.

The main purpose of this document is to describe the overall concept model, which specifies:

— the concept model and actors for each domain;

— the relationship of actors under the material domain;

— the message sequence diagrams for each domain; and

— the data transmission list for each actor to provide a seamless indoor and outdoor positioning system through sensor data fusion.

In addition, this document provides:

— basic principles used in its drafting; and

— a gap analysis, consisting of a formal study of:

  — the status of seamless positioning technology and implementations,

  — how seamless positioning technology intends to evolve, and

  — how to close the gap between current and future technology and implementations.

This document compares desired and actual outcomes and pinpoints opportunities for improvement.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 21177, *Intelligent transport systems — ITS station security services for secure session establishment and authentication between trusted devices*

ISO 21217, *Intelligent transport systems — Station and communication architecture*

ISO/TS 21184, *Cooperative intelligent transport systems (C-ITS) — Global transport data management (GTDM) framework*

ISO/TS 21176, *Cooperative intelligent transport systems (C-ITS) — Position, velocity and time functionality in the ITS station*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21217, ISO 21177, ISO/TS 21184, ISO/TS 21176 and the following 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
infrastructure communication
I-COMM
infrastructure (R/C-ITS-S) data exchange

3.2
infrastructure location profile handler
I-LPH
infrastructure location-based positioning data profile function

3.3
infrastructure floor profile handler
I-FPH
infrastructure triangulation measurement-based positioning data profile function

3.4
motion
change in the position of an object over time, represented by change of coordinate values with respect to a particular reference frame

[SOURCE: ISO 19116:2019, 3.18, modified — the Example has been removed.]

3.5
motion positioning station gateway
M-PSG
ITS-based positioning device

3.6
motion registration information
M-RI
motion-based registration information

3.8
motion status profile handler
M-SPH
motion detection and status profile function

3.9
multimodal
involving several modes, modalities, or maxima

3.10
personal floor profile handler
P-FPH
P-ITS-S-based altitude positioning data profile function

3.11
personal location profile handler
P-LPH
P-ITS-S-based positioning data profile function

3.12
personal registration information
P-RI
user profile-based registration information

3.13
personal status profile handler
P-SPH
P-ITS-S-based motion activity profile function

3.14
positioning
POS
moving object position data

3.15
positioning accuracy profile handler
POS-APH
positioning data precision profile function

3.16
positioning fusion profile handler
POS-FPH
positioning data fusion profile function

3.17
positioning status profile handler
POS-SPH
positioning data status profile function

3.18
positioning velocity profile handler
POS-MPH
positioning data-based velocity profile function

4 Abbreviated terms

BP	basic principle
GLONASS	Russian global navigation satellite system
GNSS	global navigation satellite system
GPS	global positioning system
GW	gateway
I-COMM	infrastructure communication
IEEE	Institute of Electrical Engineers
I-FPH	infrastructure floor profile handler
IMU	inertial measurement unit

I-LPH	infrastructure location profile handler
ITS	intelligent transport system
KPI	key performance indicator
LaaS	logistics as a service
M-PSG	motion positioning station gateway
M-RI	motion registration information
M-SPH	motion status profile handler
MaaS	mobility as a service
MAC	media access control
ND	nomadic device
P-FPH	personal floor profile handler
P-ITS-S	personal intelligent transport system station
P-LPH	personal location profile handler
P-RI	personal registration information
P-SPH	personal status profile handler
POS	positioning
POS-APH	positioning accuracy profile handler
POS-FPH	positioning fusion profile handler
POS-SPH	positioning status profile handler
POS-MPH	positioning velocity profile handler
PVT	position, velocity, time
RFID	radio-frequency identification
R-ITS-S	roadside intelligent transport system station
RSSI	received signal strength indicator
TaaS	transportation as a service
TTFF	time to first fix
UWB	ultra-wide band
V-ITS-S	vehicle intelligent transport system station

5 Gap analysis of seamless positioning systems

5.1 Key performance indicator (KPI)

5.1.1 Current KPIs

The applicable KPIs for the ISO 6029 series are based on SAE J2945/7.[5]

5.1.2 Future KPIs

The future KPIs are based on the tiers that are listed in the performance requirements of SAE J2945/7. Since the seamless positioning system operates based on network data, future KPI development considers the data attributes. Table 1 defines the KPIs for the ISO 6029 series.

Table 1 — Future KPI

Properties	KPI	Measure (unit)	Notes
time	latency	ms	Measure of delay to retrieve positioning data from other positioning handler.
	packet delivery time	ms	Measure of positioning data propagation and transmission time between positioning handlers.
	TTFF	ms	Measure of the first position fixed time. This is required for position initialization.
accuracy	position	cm, m	Measure of the level of positioning data accuracy. The level of accuracy varies for various sources of positioning data.
	time	ms	Measure of time accuracy for data received.
throughput	coordinate data	bit/s	Data throughput is sorted by the data source. The KPI is determined by the amount of data processing per second.
	RSSI data	bit/s	
	IMU data	bit/s	
	image sensor data	Mbit/s	

5.2 Market applicability

The following is a list of prospective areas where the ISO 6029 series is applicable.

— Logistics (e.g. LaaS, last mile delivery).

— Autonomous driving technology (e.g. indoor driving, passing tunnel, basement).

— Multimodal transit service (e.g. bus, taxi, subway, shared mobility, MaaS, TaaS).

— Disabled and elderly person pick-up service (e.g. where person needs to be picked up directly from the facility).

5.3 Market benefits

ISO 6029 series benefits all mobility-related areas with respect to service quality and efficiency:

— efficiency (e.g. less driving, less energy consumption, short-cut routing etc);

— time saving (e.g. delivery, transfer, wait time, etc);

— expansion of the driving territory of an autonomous vehicle (e.g. parking lot, basement, tunnel, etc).

6 Basic principles and use cases overview

6.1 Basic principles

Basic principles (BPs) have been established for the development of this document.

— BP1: Seamless positioning use cases describe the positioning data handover process between positioning data handlers.

— BP2: Seamless positioning use cases of the same subject are combined in one seamless positioning use case group.

— BP3: Seamless positioning use cases are described from a P-ITS-S and V-ITS-S point of view.

— BP4: Dataset and data exchange within seamless positioning systems are developed to provide flawless and continuous positioning data in a stable manner.

— BP5: All communication messages are compatible with ISO/TS 21184.

— BP6: All data definitions are compatible with ISO/TS 21184.

— BP7: All security-related statements are compatible with ISO 21177.

— BP8: All access control policy-related statements are compatible with ISO 21177 and ISO/TS 21184.

— BP9: The gap analysis addresses current versus future performance of seamless positioning systems.

6.2 Use case groups and associated use cases

Table 2 provides an overview of the main use case groups and associated use cases.

Table 2 — Use case groups (UCG) and associated use cases (UC)

#	UCG name	UC name reference
1	Nomadic device (ND) — Positioning	UC 1.1 — Indoor positioning based on network connected environment
		UC 1.2 — Indoor positioning based on network disconnected environment
		UC 1.3 — Outdoor positioning based on network connected environment
		UC 1.4 — Outdoor positioning based on network disconnected environment
2	Mobility — Positioning initialization	UC 2.1 — Initial positioning when mobility is on the move outdoors
		UC 2.2 — Positioning data validation in radio-shadow/distorted areas (outdoor)
		UC 2.3 — Positioning data update based on RSSI (indoor)
3	Mobility — Tunnel	UC 3.1 — Positioning in tunnel based on map data
		UC 3.2 — Positioning calibration in tunnel based on the latest location
4	Mobility — Entrance point (from outdoor to indoor)	UC 4.1 — Indoor positioning using wireless communication network
		UC 4.2 — Indoor positioning using IEEE 802.11 wireless LAN
		UC 4.3 — Indoor positioning using short-range wireless network
5	Mobility — Exit point (from indoor to outdoor)	UC 5.1 — Map-based positioning when vehicle is on the move to outdoors
		UC 5.2 — The latest location-based positioning when vehicle is on the move outdoors
6	Mobility — Shadow zone (indoor)	UC 6.1 — Positioning in indoor shadow zone (spiral structure)
		UC 6.2 — Positioning in indoor shadow zone (straight vertical)
7	Mobility — Distorted area of positioning data	UC 7.1 — Distorted area with positioning support system (outdoor)
		UC 7.2 — Distorted area without positioning support system (outdoor)