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Information technology — Real time locating systems — Test and evaluation of localization and tracking systems

Technologies de l'information - Systèmes de localisation en temps réel - Essais et évaluation des systèmes de localisation et de suivi

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Contents

Foreword vii
Introduction viii
1 Scope 1
2 Normative references 1
3 Terms and definitions 1
4 Abbreviated terms 1
5 LTS taxonomy 3
5.1 Types of location sensors 3
5.1.1 Unimodal systems 4
5.1.2 Multimodal systems 5
5.2 Reliance on pre-existing networking / localization infrastructure 5
5.2.1 LTSs requiring infrastructure 5
5.2.2 LTSs capable of infrastructure-less operation 6
5.2.3 Real-time deployment of nodes facilitating localization 6
5.2.4 Opportunistic use of infrastructure/environment 6
5.3 Off-line, building-specific training 6
5.3.1 LTSs requiring off-line training 6
5.3.2 LTSs not requiring off-line training 7
5.4 Ultimate consumer(s) of location information 8
5.4.1 Introduction 8
5.4.2 The ELT 8
5.4.3 The tracking authority 8
5.4.4 Both the ELT and the tracking authority 8
6 LTS privacy and security considerations 8
6.1 Privacy 8
6.2 Security 9
7 T&E methodology taxonomy 10
7.1 System vs. component testing 10
7.1.1 System testing 10
7.1.2 Component testing 10
7.2 Knowledge of LTS inner-workings 10
7.2.1 T&E designed with full knowledge of LTS inner-workings 10
7.2.2 Black-box testing 10
7.3 Repeatability 11
7.3.1 Repeatable testing 11
7.3.2 Non-repeatable testing 11
7.4 Test site 11
7.4.1 Building-wide testing 11
7.4.2 Laboratory testing 11
7.5 Ground truth 11
7.5.1 Off-line determination of test point locations 11
7.5.2 Reference LTS 13

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8 LTS performance metrics 16
8.1 Introduction 16
8.2 Mathematical terminology for accuracy metrics 16
8.3 Primary/required accuracy metrics 16
8.3.1 Means of various error magnitudes 16
8.3.2 RMS values of various error magnitudes 17
8.3.3 Metrics guaranteeing certain level of accuracy 17
8.3.4 Uncertainty analysis 18
8.4 A closer look at localization error 22
8.4.1 Contributing factors 22
8.4.2 Basic analysis 22
8.5 Secondary/optional accuracy metrics 23
8.5.1 Coverage 23
8.5.2 Availability 24
8.5.3 Relative accuracy 24
8.5.4 Walking distance [11] 25
8.6 Alternative accuracy metrics for “simple” buildings 25
8.6.1 Introduction 25
8.6.2 Floor detection probability 26
8.6.3 Zone detection probability 26
8.6.4 Floor detection confusion matrix 27
8.6.5 Weighted cost functions 27
8.7 Non-accuracy metrics 27
8.7.1 Latency 27
8.7.2 Set-up time 28

9 LTS T&E procedure 29
9.1 Introduction 29
9.2 Main use cases of localization and tracking 29
9.3 Buildings for LTS testing 30
9.3.1 Introduction 30
9.3.2 Wooden structure single-family home 31
9.3.3 Medium-size brick & concrete office building 31
9.3.4 Warehouse/factory 31
9.3.5 High-rise steel structure 32
9.3.6 Subterranean structure 32
9.3.7 Other buildings/structures of interest 32
9.4 The effects of mobility 32
9.4.1 Introduction 32
9.4.2 Stationary object/person 33
9.4.3 Walking 33
9.4.4 Using a wheeled transporter 33
9.4.5 Running 33
9.4.6 Backward walking 33
9.4.7 Sidestepping 33
9.4.8 Crawling 33
9.5 Failure modes and vulnerabilities of location sensors 33
9.6 LTS testing scenarios 34
9.7 LTS testing levels 36
9.8 T&E flowchart and table 36
9.9 Other considerations 37
9.10 Testing of visual SLAM systems 38

10 T&E reporting requirements 39

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10.1 Introduction 39
10.2 Test place and date 41
10.3 Environmental conditions 41
10.4 LTS product tested 41
10.5 Equipment used by the LTS 41
10.6 ELTD features 42
10.7 Location data format 42
10.8 Location update rate and system capacity 43
10.9 RF emission and interference issues 43
10.10 Set-up procedure 44
10.11 Building information needed by the LTS 44
10.12 LTS GUIs 45
10.12.1 ELTD GUI 45
10.12.2 Tracking authority GUI 45
10.13 Maintenance 45
10.14 Floor plans of test buildings 45
10.15 Characterization of T&E scenarios involving entities in motion 46
10.16 Presentation of numerical T&E results 47
10.17 Visualization of T&E results 49
Annex A (informative) Diagnostic tools and optional LTS performance metrics for non-users 52
A.1 Introduction 52
A.2 Diagnostic tools for LTS designers and developers 52
A.3 Diagnostic tools for LTS installers 53
A.4 Optional performance metrics for LTS use in mission-critical use cases 54
A.4.1 Susceptibility 55
A.4.2 Resilience 55
Annex B (normative) Conversions between local Cartesian and WGS 84 coordinates 57
B.1 Introduction 57
B.2 Establishing a local 3D Cartesian coordinate system and other preliminaries 57
B.3 Conversion from WGS 84 coordinates to local 3D Cartesian coordinates 62
B.4 Conversion from the local 3D Cartesian coordinates to WGS 84 coordinates 63
B.5 Verification and validation of MATLAB coordinate conversion codes 68
Annex C (informative) Location sensors and their failure modes 69
C.1 Introduction 69
C.2 RF-based location sensors 69
C.2.1 General 69
C.2.2 RSS 70
C.2.3 Proximity 71
C.2.4 TOA 71
C.2.5 TDOA 72
C.2.6 AOA 73
C.2.7 Signals of opportunity 74

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C.3 Range/pseudo-range finder 74
C.4 GPS/GNSS 74
C.5 Differential GNSS 75
C.6 Accelerometer 76
C.7 Gyroscope 76
C.8 Magnetometer 77
C.9 IMU 77
C.10 Pedometer 78
C.11 Inclinometer 78
C.12 Altimeter 78
C.13 Acoustic sensor 78
C.14 Imager 79
C.14.1 General 79
C.14.2 Optical 80
C.14.3 Infrared 80
C.14.4 LiDAR 80
Bibliography 82

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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 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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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques.*

This second edition cancels and replaces the first edition (ISO/IEC 18305:2016), which has been technically revised.

The main changes are as follows:

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Introduction

There exists a potentially large market for personnel / asset Localization and Tracking Systems (LTSs) in diverse application domains such as:

— emergency response;

— military;

— law enforcement;

— mining;

— E-911;

— offender tracking;

— personal vehicular navigation;

— smartphones / social networking;

— fleet management;

— asset tracking in factories / warehouses / hospitals;

— tracking the elderly / children; and

— personal navigation in museums / shopping malls.

Some applications of localization and tracking – such as personal navigation, fleet management, and asset tracking in factories / warehouses / hospitals – are commonly referred to as Location-Based Services (LBS). The use of LBS alone is expected to grow dramatically. Yet, lack of standardized Test and Evaluation (T&E) procedures has been an impediment to market growth for LTSs because

i) potential users cannot easily ascertain whether these systems meet their requirements,

ii) it is hard to interpret T&E results when different metrics and procedures are used to evaluate a given system or even worse to evaluate different systems, and

iii) the use of disparate minimum performance requirements by various buyers / jurisdictions forces manufacturers to develop jurisdiction-specific products, thereby raising manufacturing costs.

In contrast with LBS, there are many applications / use cases of localization and tracking that are essentially governmental functions in the sense that the government is the entity that is most concerned about the effectiveness of solutions for such use cases. Examples of these use cases include tracking firefighters entering a burning structure for command-and-control purposes and to launch a rescue mission if a firefighter becomes incapacitated, prevention of friendly fire when soldiers or Special Weapons And Tactics (SWAT) team members enter a building where either hostile forces or armed individuals threatening public safety have taken refuge, and guidance and navigation for missiles and precision-guided munitions. Many of these use cases have more stringent localization accuracy and latency requirements than other use cases of localization and tracking used by the general public, such as navigation in museums / shopping malls, tracking the elderly in nursing homes, ensuring children are not abducted from school grounds, and fleet management for a trucking company.

This document deals with T&E of LTSs. Once standardized T&E procedures have been established, it is possible to set minimum performance requirements for various use cases of localization and tracking. For example, regulations promulgated by a government agency may require coal mine operators to have the capability to track the miners on duty within 5 m accuracy during normal mine operations and 100 m accuracy in the aftermath of a catastrophic incident in the mine, such as an explosion or a roof collapse. It makes sense to separate the T&E issue from minimum performance requirements, because the same T&E standard may be applicable to many use cases of localization and tracking, but the

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minimum performance requirements typically vary from one use case to another. This document deals with T&E only; it does not set minimum performance requirements for any use case of localization and tracking.

T&E of LTSs is challenging for several reasons:

i) Many systems work in a "networked" fashion. That is, several devices would have to communicate with each other in order to estimate the location(s) of one or more such devices. Therefore, the LTS performance is affected by how these devices are situated with respect to each other, i.e. by the network topology, and how they move.

ii) The physical environment in which the devices are situated affects communications between them and functionalities such as ranging or estimating direction of another device and hence LTS performance. For example, Radio Frequency (RF) communications in a single-family house with a wooden structure is very different from that in a large high-rise building with a steel and concrete structure.

iii) Even though it is best to take a "black-box" approach to LTS T&E, one needs to be cognizant of the failure modes of various location sensors (such as Global Positioning System (GPS), RF ranging, RF direction of arrival estimation, accelerometer, gyroscope, and altimeter) that "might" be used in an LTS in order to design a comprehensive T&E procedure.

Yet another difficulty of a different nature is that some systems rely on the availability of a networking infrastructure, such as a Wi-Fi network, or other devices, such as Radio Frequency IDentification (RFID) or Real Time Locating System (RTLS) beacons, to facilitate localization and tracking in a building or structure. Some allow deployment of such devices – sometimes called "breadcrumbs" – as users enter a building. Other systems are designed to function based on the assumption that they cannot get any help with localization and tracking from the building, and breadcrumb deployment is not allowed. Therefore, the T&E procedure has to account for these possibilities or classes of LTSs.

The main purpose of this document is to develop performance metrics and T&E scenarios for LTSs. LBS are envisaged in many application domains in both governmental operations and use cases of interest to the public. Therefore, industry, consumers, trade, governments, and distributors are all affected by this document. Every effort has been made to write this document in such a way that it would be applicable to as many use cases of indoor localization and tracking as possible. This document provides explicit instructions on how to report the T&E results, i.e. what information to document and what kind of tables and figures/plots to include to best visualize the T&E results. LTS T&E is complicated even once this document has been published because there has to be a "network deployment" and testing in at least a few types of buildings. One should not expect that LTS T&E can be done in a laboratory. Performance results can depend on the building(s) used for testing, but at least there will be a standardized way of doing the T&E, and if multiple LTSs are evaluated according to this standard in the same set of buildings, then the performance results can be compared. Localization and tracking technology has not yet matured. New systems and approaches will be developed in the next several years, but the T&E procedure can be standardized regardless of what takes place on the technology front, and it may in fact foster technology development. In the absence of a T&E standard, the present uncertainties in the LTS market, where LTS vendor claims are hard to verify and it is hard for users to ascertain whether LTS solutions meet their requirements, will continue. Therefore, this is indeed the right time for development of this document.

Extensions of this standard to other application domains, such as miners trapped in an underground mine, navigation for submersible vehicles or tiny medical devices moving around inside a human body, may be the subjects of future standards that will be extensions of this "base" standard.

The term "localization and tracking" has been used to denote the types of systems this document deals with. However, this is not the only term in use for referring to such systems. ISO/IEC JTC 1/SC 31 uses the term RTLS, which also appears in the full name for this document. SC 31, in its deliberations, considered the use of the term "positioning" for the situations in which a person/object equipped with an appropriate device, uses that device possibly in conjunction with others and as part of a system to

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determine its own location. That is, “positioning” is for self-awareness. On the other hand, SC 31 regards “locating” as the appropriate term for the situation in which some other entity needs to determine the location of a person/object remotely. In other words, locating is for tracking and accountability purposes. There is also the possibility that a system needs to provide both positioning and locating functionalities (see Subclause 5.4.4), using the terminology just defined. “Tracking” is another frequently used term that has a time dimension to it. That is, one needs to keep track of a person’s/object’s movements over time. In its simplest form, tracking can be done by invoking a locating capability periodically over the time interval of interest. However, tracking can also take into account the mobility characteristics of the person/object being tracked. For example, it is highly unlikely that a firefighter would move faster than 1 m/s while putting the fire in a burning building down, and this information can be used to do a better job of estimating the firefighter’s location at any given time. “Location System” is another term used in the literature. Yet another term, often encountered in military applications, is “navigation”. In order for a person to navigate to a destination point, it is necessary for the person to know her/his starting location. Navigation may also be used for certain moving objects, such as missiles and munitions. In the case of navigation for a missile or smart bomb, where missing the target or hitting something else can have catastrophic consequences, it is necessary to know the missile’s/bomb’s location continuously so that any deviations from its intended path/course can be corrected. Navigation includes computing a path to the destination. This path is not always the straight line from the present location to the destination. For example, consider navigation in city streets or for providing guidance to a disoriented firefighter to get out of a burning building. Even though this document does not deal with navigation, it does deal with that component of navigation that has to do with where a person/object is at a given time. Finally, positioning is the term used by the 3rd Generation Partnership Project (3GPP), which has expended significant effort to develop and standardize this technology.

This document adopted the term localization to capture both locating and positioning functionalities, because the person/object has to be localized in either case. It also adopted the term tracking to ensure the standard is not just about a snapshot of a person’s / an object’s location, but also it addresses its evolution over time. As a matter of fact, SC 31 has so far focused on purely RF–based systems, but this document considers systems that may use a variety of sensors for localization and tracking, including Inertial Measurement Units (IMUs), whose performance is indeed affected by how the person/object is moving. For all practical purposes, localization and positioning are one and the same. The focus in this standard is on “indoor localization”.

This standard was originally developed during 2012-2016, and it was published in November 2016. The standard was thoroughly revised during 2024-2026. The main goal in the revised version is to make the standard simpler and less expensive to use. To achieve that goal, the T&E procedures have been simplified. In addition, there were too many LTS accuracy metrics in the original version. Reporting on all those metrics could have easily overwhelmed anyone who would look at the test results. The revised version makes computing only three categories of metrics mandatory. Some metrics have been removed altogether. Some have been moved to the new Annex A, where different categories of metrics have been introduced depending on whether they are more useful to LTS designers and developers or LTS installers. Not all metrics are useful to LTS users. Also, the use of confidence intervals for a certain class of metrics has been developed and recommended. However, the most significant change in the standard is that the LTS use case is taken into account when an LTS is tested. This makes it possible to streamline the T&E procedures and employ only tests that are most relevant to the LTS under test.

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Information technology — Real time locating systems — Test and evaluation of localization and tracking systems

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1 Scope

This document identifies appropriate performance metrics and test & evaluation procedures for localization and tracking systems, and it provides guidance on how best to present and visualize the T&E results. It focuses primarily on indoor environments.

2 Normative references

The following documents are referred to in the text in such a way that some or all 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.

There are no normative references in this document.

3 Terms and definitions

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

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

3.1
entity to be localized/tracked
person / autonomous robot that needs to know its location for context-awareness / navigation purposes or person/object whose location is needed by a tracking authority at a given time instance or over a time interval

Note 1 to entry: See the abbreviation ELT in Clause 4.

3.2
location sensor
device that measures a physical quantity to facilitate estimating the spatial coordinates of a person/object in a reference coordinate system

3.3
entity localization/tracking device
equipment carried by a person or affixed to an object comprising one or more location sensors that facilitates estimating the location of the person/object at a given time instance or over a time interval

Note 1 to entry**:** See the abbreviation ELTD in Clause 4.

4 Abbreviated terms

3GPP 3rd Generation Partnership Project

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