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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

Page

**Foreword** ..... **v**

**Introduction** ..... **vi**

**1 Scope** ..... **1**

**2 Normative references** ..... **1**

**3 Terms and definitions** ..... **1**

**4 Abbreviated terms** ..... **2**

**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 ..... 5

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 ..... 7

5.4.1 Introduction ..... 7

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** ..... **9**

7.1 System vs. component testing ..... 9

7.1.1 System testing ..... 9

7.1.2 Component testing ..... 9

7.2 Knowledge about 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 ..... 10

7.3.1 Repeatable testing ..... 10

7.3.2 Non-repeatable testing ..... 10

7.4 Test site ..... 10

7.4.1 Building-wide testing ..... 10

7.4.2 Laboratory testing ..... 11

7.5 Ground truth ..... 11

7.5.1 Off-line surveyed test points ..... 11

7.5.2 Reference LTS ..... 11

**8 LTS performance metrics** ..... **12**

8.1 Introduction ..... 12

8.2 Floor detection probability ..... 13

8.3 Zone detection probability ..... 13

8.4 Means of various errors ..... 13

8.5 Covariance matrix of the error vector ..... 14

8.6 Variances of magnitudes of various errors ..... 14

8.7 RMS values of various errors ..... 15

8.8 Absolute mean of the error vector ..... 15

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8.9 Circular Error 95% (CE95) and Circular Error Probable (CEP) 15
8.10 Vertical Error 95% (VE95) and Vertical Error Probable (VEP) 16
8.11 Spherical Error 95% (SE95) and Spherical Error Probable (SEP) 16
8.12 Coverage 16
8.13 Relative accuracy 17
8.14 Latency 17
8.15 Set-up time 18
8.16 Optional performance metrics 18
8.16.1 Location-specific accuracy 18
8.16.2 Availability 19

**9 Optional performance metrics for LTS use in mission critical applications 19**
9.1 Introduction 19
9.2 Susceptibility 20
9.3 Resilience 20

**10 T&E considerations and scenarios 20**
10.1 Building types 20
10.1.1 Introduction 20
10.1.2 Wooden structure single-family house 20
10.1.3 Medium-size brick & concrete office building 21
10.1.4 Warehouse/factory 21
10.1.5 High-rise steel structure 21
10.1.6 Subterranean structure 21
10.2 Effects of mobility 21
10.2.1 Introduction 21
10.2.2 Stationary object/person 22
10.2.3 Walking 22
10.2.4 Running 22
10.2.5 Backward walking 22
10.2.6 Sidestepping 22
10.2.7 Crawling 22
10.3 Failure modes and vulnerabilities of location sensors 23
10.4 T&E scenarios 23

**11 T&E reporting requirements 30**
11.1 Introduction 30
11.2 Test place and date 33
11.3 Environmental conditions 33
11.4 LTS product tested 33
11.5 Equipment used by the LTS 33
11.6 ELTD features 33
11.7 Location data format 34
11.8 Location update rate and system capacity 34
11.9 RF emission and interference issues 34
11.10 Set-up procedure 35
11.11 Building information needed by the LTS 35
11.12 LTS GUIs 36
11.12.1 ELTD GUI 36
11.12.2 Tracking authority GUI 36
11.13 Maintenance 36
11.14 Floor plans of test buildings 37
11.15 Characterization of T&E scenarios involving entities in motion 37
11.16 Presentation of numerical T&E results 38
11.17 Visualization of T&E results 43

**Annex A** (normative) **Conversions between local Cartesian and WGS 84 coordinates 47**

**Annex B** (informative) **Location sensors and their failure modes 64**

**Bibliography 76**

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# Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC 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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

ISO/IEC 18305 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques.*

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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;

— smart phones / 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 by 2020. 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 determine whether these systems meet the users' 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 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 applications. Examples of these applications 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 applications have more stringent localization accuracy and latency requirements than other applications 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 applications 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 applications of localization and tracking, but the minimum performance requirements typically vary from one application to

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another. This document deals with T&E only; it does not set minimum performance requirements for any localization and tracking applications.

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.

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) tags, 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 general public usage scenarios. 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 applications 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 results of the T&E effort. 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 particular building(s) used in the T&E procedure, but at least there will be a standardized way of doing the T&E, and if multiple LTSs are evaluated according to the 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 it is hard for users to ascertain whether LTS products meet their requirements and LTS vendor claims are hard to verify, 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.

As a final note, the term "localization and tracking" has been used to denote the types of systems this document is meant to be applied to. 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 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,

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"locating" is for tracking and accountability purposes. There is also the possibility that a system needs to provide both "positioning" and "locating" functionalities (see 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/object's movements over a period of 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 down in a burning building, 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 to navigate a person/object to some destination point, it is necessary to know the person/object's starting location at a minimum. In case of navigating 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 direct line from the starting 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.

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 person/object's location, but also 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.


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

**IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.**

## 1 Scope

This document identifies appropriate performance metrics and test & evaluation scenarios 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 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.

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:

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

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