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Intelligent transport systems - Location referencing harmonization for Urban ITS - Part 1: State of the art and guidelines

Intelligente Verkehrssysteme - Ortsreferenzierungsharmonisieung für Urbane ITS - Teil 1: Stand der Technik und Richtlinien

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Intelligent transport systems - Location referencing harmonization for Urban ITS - Part 1: State of the art and guidelines

Intelligente Verkehrssysteme - Ortsreferenzierungsharmonisieung für Urbane ITS - Teil 1: Stand der Technik und Richtlinien

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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (CEN/TR 17297-1:2019) has been prepared by Technical Committee CEN/TC 278 “Intelligent transport systems”, the secretariat of which is held by NEN.

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Introduction

Location is an ever-present feature of travel-related data and information services. Systems and services are deployed and evolve using a myriad of ways of defining and describing locations. As we move towards more sophisticated ITS services benefits will be accrued in the urban environment by the provision of multimodal offerings to the traveller. This often combines data from the different modes, which in turn will involve the harmonization of location referencing. Further strong trends are emerging with the drive towards greater levels of open data, regulated obligations for access to travel data under various European Union initiatives, and the almost ubiquitous expectation on instant access to travel data by users via the smartphone or other connected devices. Historically, it is appreciated that many of the services will have their bespoke location referencing systems that suit their applications well, and that it would never be successful to oblige city authorities to change their legacy systems, without significant cost, disruption and risk. Therefore, it is preferable to set out a vision towards greater integration, including encouraging cities to consider a standardized location referencing system when they develop or commission new services but support them integrating all systems, both legacy and new.

This document pulls together the many existing referencing systems, classifies them, and then describes them in selected scenarios with use cases, looking at the advantages and disadvantages and the challenges. The primary intended purpose of this document is to act as a kind of “handbook” or “primer” for city engineers and urban administrators who need to combine data from all the transport services that are in the city domain and those transport services that come into the city, to allow a truly multimodal offering, be it traveller information, traffic control, urban logistics, public transport, etc. However this document can be of high interest for every actor dealing with location referencing.

This document has been produced by the CEN/TC 278/WG 17 Project Team 1703 - Location Referencing Harmonization. The project was formed because in the CEN/TC 278/WG 17 PT 1701 report on U-ITS (PD CEN/TR 17143), in which location referencing harmonization was the most supported requirement among the stakeholders consulted. Despite the name of this project, its purpose is not to invent new location referencing systems or to create a “super set” of location references to achieve harmonization; that would not be worthwhile. This document is complemented by a Part 2 that normatively specifies methods for managing the identified challenges, e.g. translating between selected location referencing methods.

Development of this document was based on an outreach to organizations across Europe to identify what is being presently used and to ensure that today's requirements are captured; this document also reflects on emerging application and service requirements and potential foreseeable future needs.

Due to evolving standardization works on indoor location determination and referencing, reference to these are not yet included in this document. Indoor location determination and referencing are likely to be considered in future standards.

At the time of production of this document, referencing to precise road-related location referencing, which is sometimes referred to as lane level referencing, is not yet mature enough to be included.

The audience of this document is those who need to combine data which use different location referencing methods due to their different applications, modes or vendors.

1 Scope

This document presents:

— a concise tutorial on location referencing methods;

— applicable location referencing specifications, standards and directives;

— an introduction into challenges given by a multiplicity of different location referencing systems.

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:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
data set
set of road and traffic data (provided by the data owner)

[SOURCE: SPA - Coordinated Metadata Catalogue]

3.2
geographic identifier
identifier of a geographic location, e.g. a street name with house number

4 Symbols and abbreviations

AVM	automatic vehicle monitoring
CRS	coordinate reference system
CS	coordinate system
EPSG	European Petroleum Survey Group
ETRS	European terrestrial reference system
EU	European Union
GALILEO	name of the European satellite navigation and time reference system
GIS	geographic information system
GLONASS	Global Navigation Satellite System NOTE 1 Russian: globalnaja nawigazionnaja sputnikowaja sistema. NOTE 2 Name of the satellite navigation and time reference system of the Russian Federation.
GLR	geographic location referencing
GML	geography markup language

GNSS	global navigation satellite system
GPS	global positioning system NOTE 3 Name of the satellite navigation and time reference system of the United States of America.
INSPIRE	infrastructure for spatial information in Europe NOTE 4 Name of a directive of the EC; aims at creating a European Union spatial data infrastructure.
IOGP	International association of oil and gas producers
ITRS	international terrestrial reference system
ITS	intelligent transport systems
LRM	location referencing method
LRS	location referencing system
OEM	original equipment manufacturer
OGC	open geospatial consortium
TN-ITS	transport networks for ITS
U-ITS	urban ITS
UTM	universe transverse Mercator

5 Overview

The CEN/TC 278 PT1701 final technical report recommended over 100 actions needed to support the coordination of "Intelligent Transport Systems" (ITS) services in the urban environment. The most requested action concerned location referencing and the need to be able to combine both real-time, historic and planned data to provide coordinated multi-modal services in an urban environment.

Nearly all ITS applications need some form of location determination and referencing to put the data or information into a spatial context. Unfortunately, the historical technical evolution of services resulted in existing legacy systems based on different location referencing methods (LRMs), each of them being optimized for the specific purposes. These silo approaches impose challenges to the users, e.g. urban administrators, where data from different silos need to be merged together, or where data from one silo needs to be used in another silo, as direct transformation between location referencing systems (LRSs) are not necessarily possible with sufficient location accuracy.

NOTE The terms LRM and LRS are explained in 6.2. Classes of LRMs are presented in Clause 7.

A way to face these challenges is, first to identify the characteristics of location referencing and then evolve:

a) a conversion strategy for short term usage, and

b) a migration strategy for the long-term usage;

with constant pressure on budgets in urban administrations, this represents a major challenge.

This document presents:

— a tutorial on location referencing covering:

  1) basics of location referencing, i.e. LRMs, and the difference to location mapping;

2) LRSs of the identified LRMs;

3) identification of standards and industry specifications on LRMs and LRSs;

— a description of the data exchange scenarios that typify the need for location referencing transformations:

1) bi-lateral exchange between two actors;

2) data-warehousing – data aggregation;

— a description of use cases with a linkage to LRSs.

6 Introduction to location referencing

6.1 Maps

Before discussing location referencing, it is helpful to make a distinction between location references and maps.

NOTE "Location referencing" is a process whilst "map" is an object.

Most of us have exposure to various forms of maps throughout our daily lives. Although historically maps were typically drawn or printed on paper, the greatest exposure to maps for many people today is in the form of a digital spatial data set that provides some spatial context, against which things are referenced by some form of location referencing – these maps are often rendered on the screens of smartphones, digital devices and computers.

The nature of maps will differ dependent on their intended purpose, the expectation of how they will be rendered and used, which organization creates and distributes them, how they are created and maintained, as well as their geographic coverage and data content, e.g. is this a road map, a map of waterways, a topological land features map, etc.?

As the creation of spatial data sets can be expensive and time-consuming, there are often costs associated with the purchase, use or distribution of map content. For the local authority transportation officer, the nature and scale of these costs is often a deciding factor in which data set to use.

6.2 Basic concepts of location referencing

Nearly all ITS applications need some form of description of the location of features (physical objects, restrictions, events, etc.) in a spatial context, both in absolute relationship to the surface of the Earth, and in relation to other features. 6.2 describes the basics of such location referencing.

The term "location" has been defined in various ways, e.g. in several standards and deliverables from ISO and CEN. A very basic definition is provided by EN ISO 19111 as "*identifiable geographic place*". A "place" is defined in ISO 19155:2012, 4.8 as an "*identifiable part of any space*". Such a part may be a single point, a segment, an area, a volume or any other part that the space in question may be divided into. The terms "location" and "position" can also be confusing. According to ISO 19155, a "place" is referred to as a "*position*" when that place is identified using coordinates, while a "place" is referred to as a "*location*" when that place is identified using geographic identifiers. Note that a location with a given shape will also have a position, i.e. the reference position of the shape. In this document, the term "location" will be used as defined in ISO 19155. In comparison, ISO 17572-1:2015, 2.1.23 defines in a more general way a location as a "*simple or compound geographic object to be referenced by a location reference*".

EN ISO 19111 or other standards from ISO/TC 211 do not have a definition of the term "location reference", but the term "spatial reference" is defined as a "*description of position in the real-world*" (EN ISO 19111:2007, 4.43). Based on this and the definition of the term "location", a definition of the term "location referencing" would be "*description of an identifiable geographic place*". ISO 17572-1:2015, 2.1.25 defines a location reference as a "*label which is assigned to a location*", while ISO/TS 21219-7:2017, 3.3 TPEG2-LRC defines location referencing as "*means to provide information that allows a system to identify accurately a location*".

Furthermore, a location reference is described using a location referencing method (LRM), and within a location referencing system (LRS) based on the LRM. These terms are well defined in ISO 17572-1:2015, 2.1.26 and 2.1.27; a "location referencing method" is a "*methodology of assigning location references to locations*", and a "location referencing system" is a "*complete system by which location references are generated, according to a location referencing method (…)*".

From these definitions, it follows that location referencing is about describing a location within an LRS, according to an LRM. Applying location referencing to a feature results in a description of that feature's location.

Figure 1 illustrates the concepts of location referencing. In Figure 1, two LRMs are given, i.e. LRM_A and LRM_B, each with two LRSs, i.e. LRS_{A1} and LRS_{A2} according to LRM_A, and LRS_{B1} and LRS_{B2} according to LRM_B. Two real-world locations are described, i.e. L_α and L_β. As shown in Figure 1, the same location can be described with location references in different LRSs. Both, $LR_{A1,\alpha}$ and $LR_{B2,\alpha}$ with different LRSs and LRMs, describe location L_α; and both, $LR_{A1,\beta}$ and $LR_{B1,\beta}$, describe location L_β. Of course, different locations can be described with location references from the same LRS; Both L_α and L_β are described with location references ($LR_{A1,\alpha}$ and $LR_{A1,\beta}$) from LRS_{A1}.

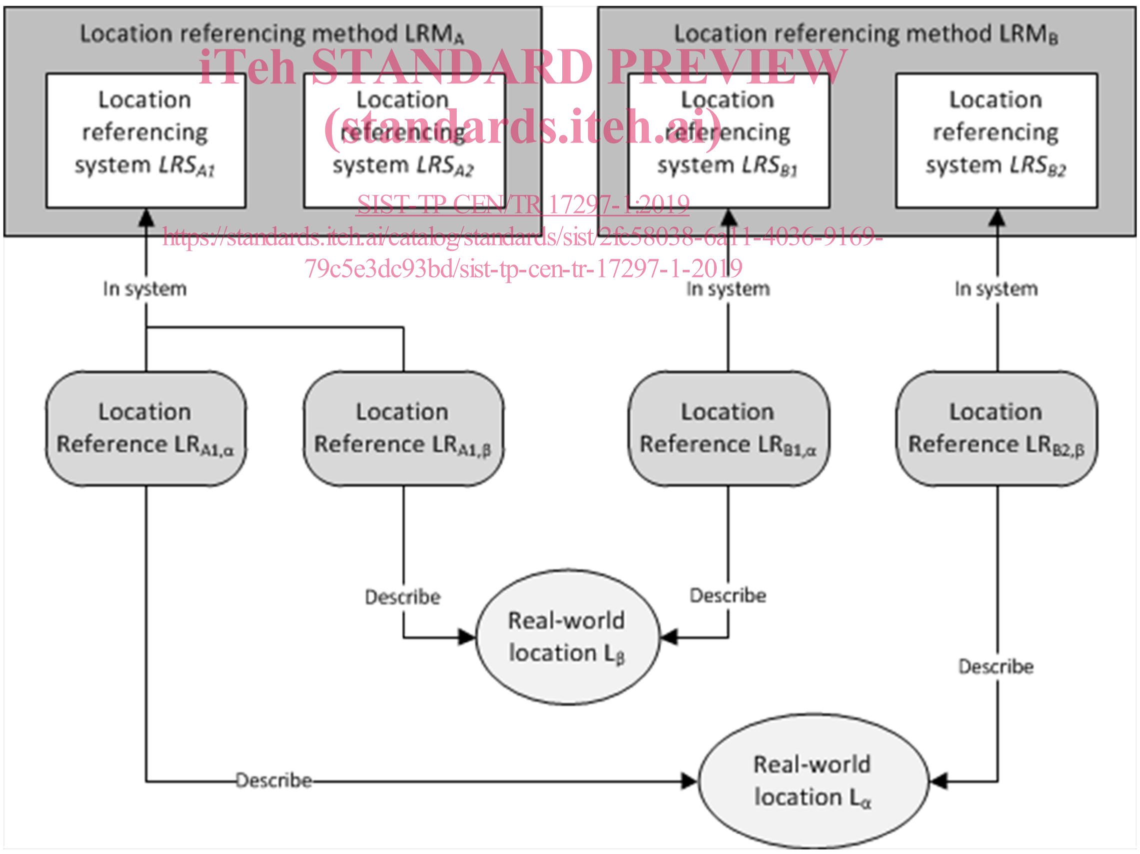

Figure 1 — Location referencing concepts

In the ITS domain, a feature can be a physical object like a vehicle, a pedestrian, a road side unit or a road sign; it can be a restriction or regulation such as speed limits or access restrictions; it can be an event like a traffic incident or a road closure; it can be a physical road condition such as black-ice, and so on. Location referencing of these features results in descriptions where these features are in relation to each other and in relation to the real world.

7 Profiles of location referencing methods

7.1 General

Three profiles of location reference methods containing various methods are distinguished in this document:

— location referencing by coordinates, see 7.2;

— pre-coded location referencing, see 7.3;

— dynamic location referencing, see 7.4.

7.2 Location referencing by coordinates

7.2.1 General

The most common, well-known and understood methods for describing locations probably are by using names by humans, and by using coordinates by machines. The concepts for using coordinates are defined in EN ISO 19111 and EN ISO 6709.

7.2.2 Coordinates, coordinate tuples and coordinate sets

Three basic elements in location referencing by coordinates are coordinates, coordinate tuples and coordinate sets. According to EN ISO 19111:2007, 4.5 and 4.12, a coordinate is "*one of a sequence of* n *numbers designating the position of a point in* n*-dimensional space*", and a coordinate tuple is a "*tuple composed of a sequence of coordinates*". The number of coordinates in the coordinate tuple equals the dimension of the coordinate system defined in 7.2.3; the order of coordinates in the coordinate tuple is identical to the order of the axes of the coordinate system. In other words, a coordinate tuple can be used to describe the position of a point in one to several dimensions, from a one-dimensional position on a line to a three-dimensional position, or even more complex systems adding also a time reference. If the location to be described is a line, area, volume, etc., rather than a single point, a set of coordinates may be used. A coordinate set is defined as a "*collection of coordinate tuples related to the same coordinate reference system*", and can for example be a collection of two coordinate tuples representing the coordinates at two points of a line.

Figure 2 illustrates the concepts of coordinates, coordinate tuples and coordinate sets and how they relate to coordinate reference systems defined in 7.2.3. A coordinate reference system is defined, and all coordinates in Figure 2 are given in this system. A single coordinate tuple with three coordinates represents a point, and a coordinate set with n coordinate tuples represents a line with *n* points.

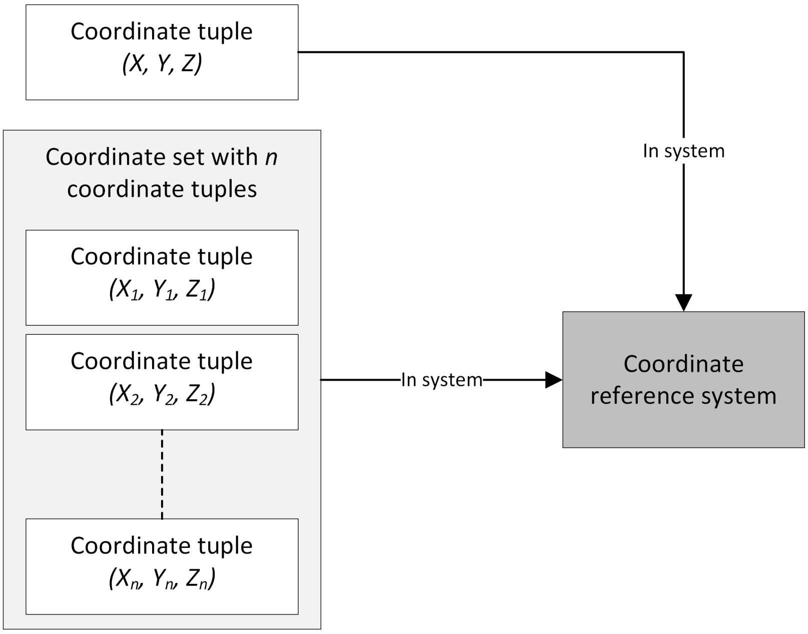

Figure 2 — The concepts of coordinates, coordinate tuples and coordinate sets

7.2.3 Coordinate systems and coordinate reference systems

Coordinates have no meaning unless the system to which they are related to has been defined. Therefore, EN ISO 19111:2007, 4.10 and 4.8 defines the terms "Coordinate system" and "Coordinate reference system". A coordinate system is defined as "*set of mathematical rules for specifying how coordinates are to be assigned to points*" while a coordinate reference system is a "*coordinate system that is related to an object by a datum*". With this definition, also a "datum" needs to be defined, being a "*parameter or set of parameters that define the position of the origin, the scale, and the orientation of a coordinate system*". A datum will then relate the coordinate reference system to the Earth or to another object. For example; ETRS89 is a geographic 2-dimensional coordinate reference system. It is related to the Earth through the datum European Terrestrial System 1989, that defines the shape of the Earth as an ellipsoid, and with positions "*fixed to the stable part of the Eurasian continental plate and consistent with ITRS at the epoch 1989.0*", and it is using an ellipsoidal two-dimensional coordinate system with coordinates in latitude/longitude.

Figure 3 shows how this coordinate reference system is based on a datum and a coordinate system.

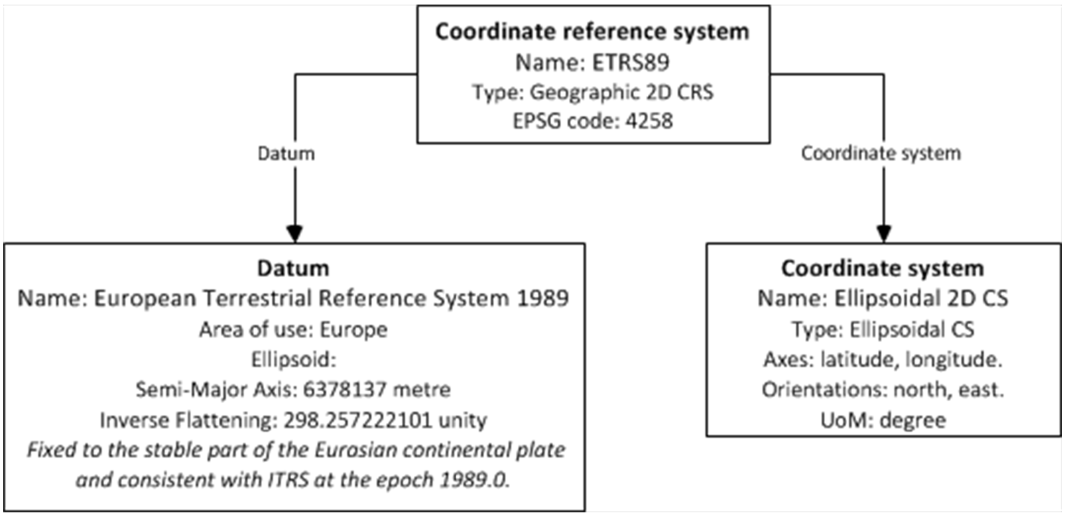

Figure 3 — Relations between a coordinate reference system, a datum and a coordinate system

NOTE In this example, the names of the datum and of the coordinate reference system are similar, but they are different concepts, as shown in Figure 3.

7.2.4 Map projections

The Earth is almost a sphere, but with a very irregular surface. For calculations and presentations of location, it is considerably easier to work in plane rectangular coordinates than with complex spherical coordinates. For this purpose, coordinates in relation to the Earth are often presented in a projected coordinate reference system, where a selected area of the Earth is considered as flat. Coordinates in a projected coordinate system are given in a Cartesian coordinate system, with perpendicular axes. A projected coordinate reference system is defined in EN ISO 19111:2007, 4.39 as "*coordinate reference system derived from a* [geographic] *coordinate reference system by applying a map projection*", and a map projection is defined in EN ISO 19111:2007, 4.33 as a "*coordinate conversion from an ellipsoidal coordinate system to a plane*".

Map projections involve some degree of deviation from real locations related to the Earth, as it is not possible to map the curved surface of an ellipsoid onto a plane map surface without deformation. Several approaches exist for preserving areas, shapes, directions, bearings, distances or scales. For location references at large scales, which is most relevant for ITS, the most common compromise is to preserve angles and distance ratios, which can be done with a conformal projection. Two commonly used conformal projections are Transverse Mercator and Lambert. When applied on relatively small portions of the Earth, projected coordinate reference systems calculated with these projections have deviations that are considered acceptable for most purposes. However, there are still deviations, and these will increase with the distance from the central axis of the projection. If a projected coordinate reference system is to be used for the most accurate operations, like bridge construction, the covered area is typically smaller than for commonly used topographic maps.

Figure 4 illustrates how a projected coordinate reference system, i.e. ETRS89 / UTM (universe transverse Mercator) Zone 33N, with two-dimensional coordinates in a Cartesian coordinate system is derived from a Geographic two-dimensional coordinate reference system, i.e. ETRS89 (the base coordinate reference system).

NOTE ETRS89 / UTM Zone 33N is used as an example, as it is a projected coordinate reference system that is considered suitable for large and medium scale topographic mapping and engineering surveys, in a restricted geographic zone – such that this projection is considered suitable for the intended purpose within the zone. This zone is between 12°E and 18°E, northern hemisphere between equator and 84°N, onshore and offshore. Projections to other UTM zones derived from the same base CRS are by definition other coordinate reference systems, as the projection parameters are different.

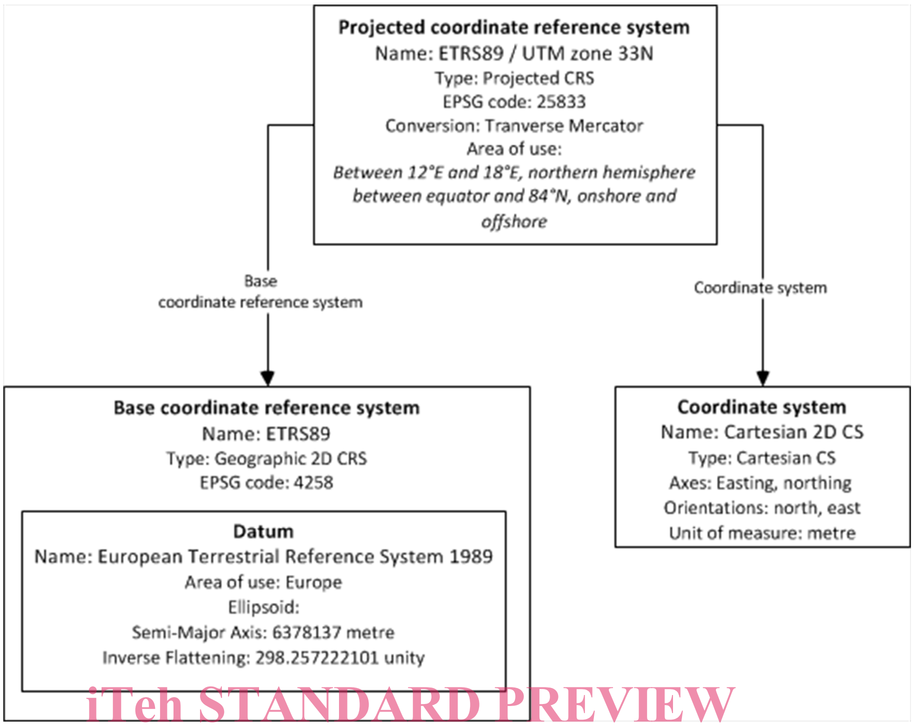

Figure 4 — Example of a projected coordinate reference system

7.2.5 Commonly used coordinate reference systems

The "International Association of Oil and Gas Producers" (IOGP) maintains a registry of coordinate reference systems known as the "EPSG Geodetic Parameter Registry". The registry is based on the conceptual model from EN ISO 19111:2007. Coordinate reference systems are often identified by their identifier from the registry – the EPSG code.

Examples of coordinate reference systems among the most commonly used in Europe are listed in Table 1.

Table 1 — Examples of coordinate reference systems

Coordinate reference system	Description	Comment
ITRS	The International Terrestrial Reference System: — Global geocentric coordinate reference system. — CS: Cartesian three-dimensional. — Axes: X, Y, Z, with the origin in the mass middle point of the Earth, and the z-axis through the North Pole.	In principle, all points on the Earth have variable coordinates because of the drift of the tectonic plates. The ITRS is realized at fixed years with coordinates for a global set of stations, based on observations by several precise satellite-based geodesy technologies.