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Foreword

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This document was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

A list of all parts in the ISO 19161 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

This document provides the basic information and definitions related to the International Terrestrial Reference System (ITRS), its realizations and how to access these realizations. These are consistent with the conventions adopted by the international scientific organizations that created this concept, which are the International Union of Geodesy and Geophysics (IUGG), specifically its association in charge of geodesy, the International Association of Geodesy (IAG), and the International Astronomical Union (IAU).

The various realizations of ITRS are then presented as crust-based reference frames, which are global, regional or local, and as satellite ephemerides, such as those broadcasted by satellite navigation systems.

Annex A of this document describes the access methods to ITRS and the various processes required to determine positions expressed in this system.

Geographic information — Geodetic references —

Part 1:
International terrestrial reference system (ITRS)

1 Scope

This document provides the basic information and the requirements related to the International Terrestrial Reference System (ITRS), its definition, its realizations and how to access and use these realizations.

This document:

— describes ITRS following the definitions and terminology adopted by the International Union of Geodesy and Geophysics (IUGG), the International Association of Geodesy (IAG) and the International Astronomical Union (IAU);

— describes different categories of ITRS realizations: its primary realization, labelled the International Terrestrial Reference Frame (ITRF), other existing realizations of reference systems that are mathematically derived from the ITRS, and realizations that are aligned to the ITRF, such as GNSS-specific reference frames;

— categorizes procedures for realizing the ITRS.

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
coordinate system
set of mathematical rules for specifying how coordinates are to be assigned to points

[SOURCE: ISO 19111:2019, 3.1.11]

3.2
geocentric terrestrial reference system
GTRS
system of geocentric space-time coordinates within the framework of General Relativity, co-rotating with the Earth and related to the Geocentric Celestial Reference System by a spatial rotation which takes into account the Earth's orientation parameters

[SOURCE: IAG and IUGG resolutions of 1991 and 2007]

3.3
positioning process
computational process that determines, directly from measurements, the geodetic coordinates of points (absolute positioning), or that derives geodetic coordinates of points from previously determined geodetic coordinates (relative positioning)

3.4
satellite ephemeris
numerical representation of the trajectory of the centre of mass of an Earth orbiting artificial satellite expressed in an Earth centred *terrestrial reference frame* (3.5)

3.5
terrestrial reference frame
TRF
realization of a *terrestrial reference system* (TRS) (3.6), by specifying its origin, orientation, scale, and its time evolution

Note 1 to entry: The realization is achieved through a set of physical points with precisely determined coordinates in a specific *coordinate system* (3.1), which may include the rate of coordinate change.

Note 2 to entry: The realization is called static when no rates of coordinate change are defined, and kinematic when rates of coordinate change are defined without considering the underlying forces causing the motion. The realization may be called dynamic when these external forces are considered. "Dynamic" is also used colloquially to describe both the dynamic and kinematic cases without distinction.

[SOURCE: IERS Conventions 2010]

3.6
terrestrial reference system
TRS
set of conventions defining the origin, scale, orientation and time evolution of a spatial reference system co-rotating with the Earth in its diurnal motion in space

Note 1 to entry: The abstract concept of a TRS is realized through a *terrestrial reference frame* (3.5).

Note 2 to entry: In such a system, positions of points attached to the solid surface of the Earth have coordinates which undergo only small variations with time, due to geophysical effects (tectonic or tidal deformations). In the Newtonian framework, the physical space is considered as a Euclidean affine space of dimension 3, with an origin, a scale and an orientation.

[SOURCE: ISO 19111:2019, 3.1.66 — modified: Note 1 to entry has been modified, Note 2 to entry has been added from IERS Conventions 2010]

4 Symbols and abbreviated terms

BeiDou	Chinese satellite-based navigation system
BIH	Bureau International de l'Heure
CGCS2000	China Geodetic Coordinate System 2000
CTRS	Conventional Terrestrial Reference System
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite
EOP	Earth Orientation Parameter(s)
EUREF	IAG Sub-Commission 1.3a, Reference Frame Sub-Commission for Europe
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema

GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GTRF	Galileo Terrestrial Reference Frame
GTRS	Geocentric Terrestrial Reference System
IAG	International Association of Geodesy
IAU	International Astronomical Union
IERS	International Earth Rotation and Reference Systems Service
IGS	International GNSS Service
ITRF	International Terrestrial Reference Frame
ITRS	International Terrestrial Reference System
IUGG	International Union of Geodesy and Geophysics
JGS	Japan Satellite Navigation Geodetic System
LLR	Lunar Laser Ranging
PCV	Phase Centre Variations
PPP	Precise Point Positioning
PSD	Post-Seismic Deformation
PZ-90	Parametry Zemli 1990
QZSS	Quasi-Zenith Satellite System
RTK	Real Time Kinematic
SLR	Satellite Laser Ranging
TRF	Terrestrial Reference Frame
TRS	Terrestrial Reference System
VLBI	Very Long Baseline Interferometry
WGS 84	World Geodetic System 1984

5 ITRS: overview

The ITRS is defined jointly by the IAU and the IUGG. It is the spatial three-dimensional part of a specific Geocentric Terrestrial Reference System (GTRS) for which the orientation is maintained in continuity with past international agreements (the so-called BIH orientation).

Since 1988 both the monitoring of the definition of ITRS and the determination of its primary realizations, known as ITRF, have been the responsibility of the International Earth Rotation and Reference Systems Service (IERS).

A more detailed description of the ITRS, together with its effective origin, scale and orientation is available in Annex B (informative).

6 Realizations of ITRS

6.1 Description of a realization of ITRS

A realization of ITRS is any TRF product containing the required numerical information (e.g. a set of static coordinates, or coordinates and velocities) satisfying the definition of origin (centre of mass of the Earth), orientation (no net rotation with respect to the motions of the Earth's surface) and scale (based on the speed of light and the Earth's gravitational constant) of the ITRS and its time evolution.

EXAMPLE 1 A realization of ITRS consists of a set of static coordinates or a set of coordinates and their time evolution, of physical points on the topographical surface of the earth.

EXAMPLE 2 The coordinate sets in a realization of ITRS can refer to each satellite in a constellation.

6.2 Classification of realizations

6.2.1 General

Current ITRS realizations are obtained through processing and analysing datasets sourced from space geodetic techniques. Realizations may be determined using one or more of these techniques. All current realizations consist of a set of identifiers of physical points, with corresponding numerical coordinate information, expressed in a coordinate system (e.g. Cartesian, ellipsoidal).

In this document, the following categories of realizations are distinguished:

6.2.2 Primary realization of ITRS

It is a product created by the IERS under the generic name ITRF. This document does not define these primary realizations nor give any requirements for them, as they are the sole responsibility of IERS[3][5]. Only a general explanation is provided (see Annex B).

6.2.3 Secondary realization of ITRS

It is any of the other terrestrial reference frames that are aligned to the ITRF.

Alignment to a TRF uses a 7- or 14-parameter similarity transformation in which all parameter values are zero to give a solution with the same origin, scale, orientation and time evolution as an existing TRF.

For a TRF represented by a data set of estimated station positions, a 7-parameter similarity transformation is used, where the parameters represent the differences in the origin, orientation and scale with respect to an existing TRF.

For a TRF represented by a data set of estimated station positions and velocities, a 14-parameter similarity transformation is used, where the parameters represent the differences in the origin, orientation, scale and their time evolution with respect to an existing TRF at one or more given epoch(s).

Secondary realizations shall be realized or derived from an existing primary or secondary realization that is compliant with this document. They can be referred to as an "implementation" or a "densification" of ITRF.

Annex C summarizes some of these secondary realizations.

6.3 Types of TRF

6.3.1 General

A realization of ITRS may be represented as coordinates of points valid at a specified epoch, as time series of coordinates at regular epochs (e.g. daily, weekly), or as coordinates given as a function of time following linear and/or non-linear models. The two types of TRF are:

6.3.2 Crust-based TRF

In a crust based TRF, points refer to objects located on the topographic surface of the earth, e.g. geodetic markers or tracking instruments. The set of objects comprising a given TRF defines a geodetic network, which may have global, regional or national coverage.

6.3.3 Satellite Ephemerides based TRF

A satellite-ephemerides-based TRF refers to any numerical representation of the trajectory of the centre of mass of one or more Earth orbiting artificial satellites, expressed in the ITRS.

6.4 Methods for secondary realizations of ITRS

In all secondary realizations of the ITRS, the main criterion to judge that they are compatible with the ITRS consists of demonstrable evidence that they are aligned to a primary or secondary ITRS realization that is compliant with this document.

The methods for determining a secondary realization are specified in the normative Annex A.

7 Conformance of a secondary realization of ITRS

This conformance is achieved if the secondary realization of ITRS is consistent with the following requirements.

Requirement 1

Secondary ITRS realizations represented by a data set of estimated station positions and (if kinematic) velocities, whether static or kinematic, shall be aligned to a primary or secondary ITRS realization that is compliant with this document.

For a static secondary realization of ITRS, the numerical values of the 7 similarity-transformation parameters shall be zeros to the equivalent numerical resolution as the estimated station positions. The parameters shall represent the three-dimensional differences in the origin, orientation and scale, with respect to a primary or secondary ITRS realization that is compliant with this document.

For a kinematic secondary realization of ITRS, the numerical values of the 14 similarity-transformation parameters shall be zeros to the equivalent numerical resolution as the estimated station positions and velocities. The parameters shall represent the three-dimensional differences in the origin, orientation and scale and their temporal rates of change, with respect to a primary or secondary ITRS realization that is compliant with this document

Requirement 2

For a secondary kinematic ITRS realization, a time series of at least 2,5 years of daily or weekly position solutions shall be used to reliably estimate station velocities[9].

Requirement 3

For the absolute PPP method of position determination, a set of positions for a globally distributed set of ITRF/IGS stations shall also be estimated for the determination of 7 (for static realizations) or 14 (for kinematic realizations) transformation parameters to confirm alignment with a primary or secondary ITRS realization that is compliant with this document.

Requirement 4