# European Spatial Reference Systems – Frames for Geoinformation Systems –

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#### Abstract

The European initiative for a common spatial reference including the standardization activities will be described. Activities of EUREF and CERCO will define a common vertical European datum and establish an information system of national CRS and their relationship to ETRS89.

### 1. Introduction

One of the basics of geoinformation systems is to guarantee an unambiguous spatial reference of the stored information. The spatial reference can be given by coordinates or by geographic identifiers. Coordinates are unambiguous when the reference system to which those coordinates are related has been fully described. The standardisation activities since the nineties in the frame of the European standardisation organisation CEN and of the international standardisation organisation ISO for geographic information systems included the spatial reference aspect as a central topic. The realization of geoinformation systems needs conventions for the use of geodetic reference systems. On behalf of the European Commission (EC) at the end of 1999 a Spatial Reference Workshop was organized by MEGRIN to recommend common European reference systems for geoinformation systems and data of the EC and for the member states. The IAG Subcommission for Europe (EUREF) works for over 10 years actively and continuously together with the national mapping agencies for the realization of the ETRS89 and since 1995 on the United European Levelling Network. Therefore, EUREF wasso well prepared and able to answer the requests. EUREF and the Working Group VIII of the Comité Européen des Responsables de la Cartographie Officielle (CERCO) were asked to prepare relevant information describing the systems and the transformation from the national reference frames to the European one.

# 2. European initiative for common spatial reference

The Spatial Reference Workshop, 29-30 November 1999 in Marne-La-Vallée was organised by MEGRIN on a request of the Joint Research Centre on behalf of the EC. Due to the participation of relevant geodesy and standardisation experts as well as institutional cross-border GI users the workshop was successful.

It was recognised that the ETRS89 is accepted by the National Mapping Agencies (NMAs) and the scientific community as the most appropriate European geodetic datum for continental spatial referencing tasks. The geodetic datum ETRS89 derived from GPS campaigns and the European GPS Permanent Network (EPN) are part of the geodetic basic networks of EU member states. The Spatial Reference Workshop recommended that the European Commission:

- Adopts ETRS89 as the geodetic datum for the georeferenced coordinates of its own data;
- Includes ETRS89 in the future specifications of the products to be delivered to the EC, within projects, contracts, etc;
- Promotes the wider use of ETRS89 within all member states, by appropriate means (recommendations, official statements, ...).
- The coordinates for expressing positions related to ETRS89 datum will normally be ellipsoidal (geodetic latitude, geodetic longitude, and if appropriate ellipsoidal height).

The Workshop defined its various needs for map projections and to obtain further expert advice to determine the appropriate projections.

It was recognized that the European Vertical Network (EUVN) and the United European Levelling Network (UELN) projects form the basis for a vertical reference in Europe. The workshop recommended that the EC:

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- Adopts the results of the EUVN/UELN initiatives when available, as definitions of vertical datum and gravityrelated heights;
- Includes the EUVN reference system so defined for the specifications of the products to be delivered to the EC, within projects, contracts, etc;
- Future promotes the wider use of the European vertical reference system within all member states, by appropriate means (recommendations, official statements, ...).

Both the ETRS89 and the current national coordinate reference systems for spatial reference and both a European vertical datum and the current national height systems for height reference will continue for many years in parallel. From this point of view the workshop recommends to the NMAs that transformation parameters and algorithms to and from ETRS89 providing coordinates of an accuracy level of 1 - 2 m should be placed in the public domain.

This paper gives an overview about the standardisation approach and the status of the action following the spatial reference workshop.

#### 3. Standardisation Activities

The European standardisation activities in the field of geographic information systems started in 1993 with its technical committee CEN/TC 287 Geographic information with 5 Working Groups (WG). The Working Group 4 Position was chaired by H. Seeger and accompanied by various active members of the EUREF community. The work was finished in 1999 with 8 European pre norms (ENV) and 4 reports (R): Overview (R), Definition (R), Query and update (R), Rules for application schema (ENV), Position (ENV), Geographic identifiers (ENV), Transfer (ENV), Metadata (ENV), Quality (ENV), Spatial schema (ENV), Reference model (ENV), Conceptional schema language (R).

CEN/TC 287 decides to continue its activity with the following objectives:

- to provide a technical body for reaching consensus on revision of ENVs and reports, and adoption of IS when becoming available;
- to review requirements for European standards leading possibly and eventually to the definition of a new work programme;
- to provide a forum for discussion of issues of common concern.

The ISO/TC 211 Geographic Information started with its works in the field of standardization of digital geographic

information in 1994 (1<sup>st</sup> plenary Nov. 1994, Oslo) and has now 5 WGs and more than 20 work items (WI).

This work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations.

This work shall link to appropriate standards for information technology and data where possible, and provide a framework for the development of sector-specific applications using geographic data.

The ISO/TC 211, WI 11 - Spatial referencing by coordinates (ISO 19111) standard - was not made for geodetic experts, it was made for producers and users of GIS. Therefore the structure shall be clear and easy - but correct on a common level of abstraction.

WI 11 (Chairman H. Seeger, Editor J. Ihde) describes the conceptual schema and defines the description for a minimum data to two cases for which 1-, 2- and 3-dimensional coordinate reference system information shall be given:

- Case A: A coordinate reference system to which a set of coordinates is related;
- Case B: A coordinate operation (coordinate transformation, coordinate conversion, concatenated coordinate operation) to change coordinate values from one coordinate reference system to another.

#### Coordinate Reference Systems

The coordinate reference system (CRS) is an aggregate class with the component classes datum and coordinate system, geodetic datum, vertical datum and engineering datum are subclasses to the datum:



The following schema contains the definitions of CRS, datum and coordinate system:



Annex 1 contains the schema with the elements describing a CRS (example: ETRS89/Cartesian coordinates).

The horizontal and vertical components of the description of a position in the space may sometimes come form different CRS. This shall be handled through a compound coordinate reference system (CCRS). The CCRS describes the position through two independent coordinate reference systems.

An unambiguous European spatial reference system could be described as a CCRS:

(IRandllinien weglassen!)

#### **Coordinate Operations**

A coordinate operation is a change of coordinates, from one coordinate reference system to another. Coordinate transformations and coordinate conversions are subtypes of coordinate operations:



Annex 2 contains the schema with the elements describing a coordinate operation in the case of coordinate transformation (example: transformation from German geodetic datum DHDN to ETRS89).

A coordinate conversion is a change of coordinates, from one coordinate system to another based on the same datum, for example between the geodetic and the cartesian coordinate systems or between geodetic coordinates and projected coordinates, or change of units such as from radians to degrees or feet to meters. A coordinate conversion uses parameters which have constant values:



A coordinate transformation is a change of coordinates from one coordinate reference system to another coordinate reference system based on a different datum:



(T)

A coordinate transformation uses parameters which may have to be derived empirically by a set of points common to both coordinate reference systems. The formula of the 7 Parameter Helmert Transformation shall<del>to</del> be used for all coordinate transformations:



(S)	Source Datum
$T_1, T_2, T_3$	geocentric X/Y/Z translations [m]
$R_1, R_2, R_3$	rotations around X/Y/Z axis [radian]
D	correction of scale [ppm]
(Remark: the rotations R1, R2, R3 must be small.)	

Target Datum

The change of coordinates from one coordinate reference system to another coordinate reference system may follow from a series of operations consisting of one or more transformations and/or one or more conversions. A concatenated operation records a change of coordinates through several transformations and/or conversions. There is no upper limit to the number of steps a concatenated operation may have. Each step is an operation described in the normal way. The figure shows a two-step concatenated operation:



The relationship between coordinates in a European coordinate reference system, a national coordinate reference system, and a European projection represents as following:



Under the head of ISO/TC 211 it is not planned to standardise a special CRS for worldwide GIS users, e. g. ITRS. A new work item with geodetic relevance *Geodetic codes and parameters* started in the year 2000 but cannot take over the function of a standard CRS. It is the task of political, technical and scientific organisations or commissions to define reference systems as defacto standards for GIS applications, as to be done by the spatial reference workshop, EUREF and CERCO with their activities.

## 4. Activities of EUREF and CERCO

Two EUREF activities were initiated from the urgent requests of the Spatial Reference Workshop. EUREF was asked to define a European vertical datum based on the EUVN and UELN initiatives in the year 2000 (see Ihde and Augath). Furtherance the TWG EUREF was asked together with the Working Group VIII of CERCO to manage the collection of relevant transformation data, and its publication in the year 2001.

A common letter (Annex 3) of CERCO and EUREF was send out to the NMAs of CERCO/EUREF countries in May 2000 for gathering the information of national European coordinate reference systems defined by a national datum and a coordinate system and of the relations (operations) between national and a conventional European coordinate reference system (between the datums - as coordinate transformation - and between the coordinate systems - as coordinate conversion). The letter includes the available information about national coordinate reference systems and the information about the coordinate transformation to ETRS89. The information are stored in a relational data base regarding the conventions and tables of ISO 19111 standard. With the response of the countries the information system will be updated and more information will be added. In a public domain the information should be available through Internet.

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Annex 1: Schema for describing a coordinate reference system (Remark: The elements mandatory (M), optional (O) or conditional (C))



Annex 2: Schema of describing a coordinate operation (Remark: The elements mandatory (M), optional (O) or conditional (C))



Annex 3: Letter of CERCO and EUREF to the European National Mapping Agencies



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