International Association of Oil & Gas Producers

REPORT
373-05

NOVEMBER
2018

Geomatics Guidance Note 5
Coordinate reference system definition – recommended practice

Acknowledgements

Geomatics Committee

Photography used with permission courtesy of
© sturti/iStockphoto and © alexsl/iStockphoto (Front cover)

REPORT
373-05

NOVEMBER
2018

Geomatics Guidance Note 5 Coordinate reference system definition – recommended practice

Revision history

VERSION	DATE	AMENDMENTS
3.0	November 2018	Added Well-Known-Text example and revised references/terminology
2.1	January 2009	In example c) corrected value for inverse flattening
2.0	April 2006	References to EPSG updated
1.2	November 2001	Revised to accord with ISO 19111 terminology
1.1	June 2000	Minor revisions
1.0	April 1997	First release

Contents

1. Introduction 5

2. Types of coordinate reference systems 5

3. Methods for defining a coordinate reference system 6

4. Minimum parameters required for georeferenced coordinate reference system definition 7

5. Examples 9

1. Introduction

Coordinates define a position unambiguously only when the coordinate reference system to which those coordinates belong has been identified. This guidance note describes recommended practice for defining a coordinate reference system.

2. Types of coordinate reference systems

Coordinate reference systems (CRSs) can be classified in one of two categories: those that can be related to the earth through a rigorous geodetic definition (georeferenced) or those that cannot be directly related to the earth with geodetic rigour (non-georeferenced). Unless there is a special circumstance, coordinates should be georeferenced.

Location is most frequently described through one of the following types of coordinate reference systems:

Coordinate reference system type	**Description**
Geographic	A georeferenced coordinate reference system in which position is specified by geodetic latitude, geodetic longitude and (in the three-dimensional case) ellipsoidal height. *Note: GPS receivers typically indicate location in this manner.*
Projected	A coordinate reference system derived from a geographic coordinate reference system by applying a map projection. *Note: Geodetic latitude and geodetic longitude coordinates are projected to easting and northing. The axes may be given in any prescribed order and may be referred to by abbreviation as, for example, E and N, or in an alternative case, as X and Y.*
Vertical	A one-dimensional geo-referenced coordinate reference system that is dependent on the Earth's gravity field. *Note: This refers to, amongst others, orthometric height and Normal height, which are both approximations of the distance of a point above the mean sea level. The distance from the reference surface may follow a curved line, not necessarily straight, as it is influenced by the direction of gravity.*
Compound	A coordinate reference system using at least two independent coordinate reference systems. *Note: Coordinate reference systems are independent of each other if coordinate values in one cannot be converted or transformed into coordinate values in the other. Example: A geographic 2D or projected coordinate reference system combined with a vertical coordinate reference system.*
Engineering	A non-georeferenced coordinate reference system based on a local reference *Example: A local grid for a well site.*

3. Methods for defining a coordinate reference system

For all types of CRSs, there are four options for defining it:

3.1 By giving a recognised EPSG coordinate reference system name (or abbreviation if one is available), code[1], and dataset version from IOGP's EPSG Geodetic Parameter Dataset.

This is the most compact option. By providing the EPSG Dataset coordinate reference system code and dataset version, all the defining parameters and the coordinate reference system units are implicit. They can be determined from the EPSG Dataset of that version. Some systems with long names have an abbreviation. Where these exist, they may be given as an alternative to the full name. Because the names and abbreviations are often in common use, the provision of names or abbreviations alone does not mean that all parameters are intended. The associated EPSG dataset code and dataset version for that name gives confidence that the provider is conversant with the EPSG Dataset contents as they were at that time.

3.2 By giving a recognised EPSG Dataset coordinate reference system name and dataset version, together with the minimum defining parameters as described in section 4 below and taken from the EPSG Dataset. This explicitly gives the coordinate reference system definition.

3.3 If the coordinate reference system is not part of the EPSG Dataset, or if one or more components (for example, the axes units) vary from the EPSG Dataset reference, thereby making it a different coordinate reference system, all minimum defining parameters (as described below in section 4) need to be explicitly given. Some of these may be available from the EPSG Dataset.

3.4 If the coordinate reference system is not part of the EPSG Dataset a good alternative is also to use Well-Known Text (WKT) definitions (see example in section 5f)).

[1] The EPSG Dataset of geodetic information includes coordinate reference systems and their component parameters. It is maintained by the geodesy subcommittee of the IOGP Geomatics Committee. The Dataset can be accessed through www.epsg-registry.org or indirectly from the IOGP website at www.iogp.org/geomatics or from the EPSG Dataset website at www.epsg.org.

4. Minimum parameters required for georeferenced coordinate reference system definition

4.1 The minimum parameters required to define a **geographic** coordinate reference system are:

- geographical coordinate reference system name.
- geographical coordinate reference system axes units
- geodetic datum name, if this is different from the geographic CRS name[2]
- ellipsoid name
- ellipsoid defining parameters:
  - semi-major axis value
  - semi-major axis units name
  - inverse flattening value

If the prime meridian is not Greenwich, the following must also be given:

- either the prime meridian name (from the EPSG Dataset) or the Greenwich longitude of the prime meridian

If the geographic coordinate reference system is three dimensional, the following must also be given:

- units for ellipsoid height

4.2 The minimum parameters required to define a **projected** coordinate reference system are:

- projected coordinate reference system name
- geographic coordinate reference system as described in 4.1 above, except that the geographic coordinate reference system axes units are not required
- map projection (coordinate conversion) name
- name of map projection (coordinate operation) method
- map projection (coordinate operation) parameters, values and units

  The set of parameters required varies with map projection method. For "Transverse Mercator" or "Lambert Conic Conformal (1SP)" projections[3], the five parameters required are:
  - latitude of natural origin
  - longitude of natural origin
  - scale factor at natural origin
  - false easting, in grid units
  - false northing, in grid units

[2] In most cases the EPSG Geodetic Parameter Dataset conventionally uses the geodetic datum abbreviation (if applicable) or name as the name of the geographic CRS. See IOGP Geomatics Guidance Note 7, part 1. Where these are the same, the geodetic datum name may be omitted from the minimum requirement for geographic CRS definition.

[3] Coordinate Operation methods are defined within the EPSG Dataset and IOGP Geomatics Guidance Note 7, part 2.

- projected coordinate reference system axes units name, and if not metres the unit conversion to be applied to the units to convert to metres[4]

4.3 The minimum parameters required to define a **vertical** coordinate reference system are:

- coordinate reference system name

The coordinate reference system name should state explicitly whether the coordinate reference system is a height or a depth system

- vertical datum name, if this is different from the vertical CRS name[5]
- vertical coordinate reference system axis units name, and if not metres the unit conversion to be applied to the units to convert to metres

4.4 The minimum parameters required to define a **compound** coordinate reference system are:

- horizontal coordinate reference system definition as in either 4.1 or 4.2 above
- vertical coordinate reference system definition as in 4.3 above

4.5 Generally, an **engineering** coordinate reference system is not georeferenced. However, an engineering 2D coordinate reference system can be indirectly georeferenced if both of the following are true:

- an affine or similarity transformation[6] to a projected coordinate reference system is defined
- the projected coordinate reference system is defined as in 4.2 above

To define the affine transformation, the coefficients for the transformation from projected coordinate reference system to engineering grid are required. The set of parameters required varies with transformation method. An example showing input and output coordinates should also be given. General methodology is described in IOGP Geomatics Guidance Note 7, part 2. For specific application to 3D seismic surveys the IOGP publication "IOGP P6/11 Seismic bin grid data exchange format" gives full details of appropriate practice.

[4] Recognised names of units with their conversion to s.i. units are given in the EPSG Geodetic Parameter Dataset.

[5] In most cases EPSG conventionally uses the vertical datum abbreviation (if applicable) or vertical datum name as the name of the vertical CRS. Where these are the same, the vertical datum name may be omitted from the minimum requirement for vertical CRS definition.

[6] Transformation methods are defined within the EPSG Dataset and IOGP Geomatics Guidance Note 7, part 2.

5. Examples

a) Geographic 2D coordinate reference system given in the EPSG Dataset.

Short form definition method as per 3.1 above.

EPSG coordinate reference system name:	ED50
EPSG coordinate reference system code:	4230
EPSG Dataset version	6.1

b) User-defined compound coordinate reference system.

Short form definition method as per 3.1 above: both CRS components given in the EPSG Dataset.

User-defined coordinate reference system name:	ED50 / UTM zone 31N + MSL height

Horizontal coordinate reference system:	
EPSG geographic coordinate reference system name:	ED50 / UTM zone 31N
EPSG coordinate reference system code:	23031
EPSG Dataset version	6.1

Vertical coordinate reference system:	
EPSG vertical coordinate reference system name:	MSL height
EPSG coordinate reference system code:	5714
EPSG Dataset version	6.1

c) User-defined compound coordinate reference system.

Full form definition method as per 3.2 above: both CRS components given in EPSG Dataset.

Compound coordinate reference system name:	ED50 / UTM zone 31N + MSL height

Horizontal coordinate reference system:	
EPSG coordinate reference system name:	ED50 / UTM zone 31N
EPSG coordinate reference system code:	23031
EPSG Dataset version:	6.1
Geographic coordinate reference system name:	ED50[7]
Ellipsoid name:	International 1924
ellipsoid semi-major axis:	6378388 metres
ellipsoid inverse flattening:	297.0
Map Projection name:	UTM zone 31N
Map Projection method name:	Transverse Mercator
Map Projection parameters:	
latitude of natural origin:	0 degrees
longitude of natural origin:	3 degrees
scale factor at natural origin:	0.9996
false easting:	500000.00 metres
false northing:	0.00 metres
Projected CRS axes units name:	metre[8]

Vertical coordinate reference system:	
EPSG coordinate reference system name:	MSL height
EPSG coordinate reference system code:	5714
EPSG Dataset version:	6.1
Vertical datum name:	Mean Sea Level
Vertical CRS axis units name:	metre

[7] As this is the same as the geodetic datum abbreviation, the geodetic datum name is not required. Additionally, as it is based on the Greenwich meridian, the prime meridian details are not required.

[8] As the units are metres, the unit conversion of 1.0 exactly is implicit and is not required to be given.

d) User-defined projected coordinate reference system.

Explicit definition method as per 3.3 above.

Projected coordinate reference system name:	User-defined projection based on NAD83.
Coordinate reference system code[9]:	45678
Geographic coordinate reference system name:	NAD83[10]
Ellipsoid name:	GRS 1980
ellipsoid semi-major axis:	6378137 metres
ellipsoid inverse flattening:	298.257222101
Map Projection name:	Pseudo UTM zone 15 in feet
Map Projection method name:	Transverse Mercator
Map Projection parameters:	
latitude of natural origin:	0 degrees
longitude of natural origin:	-93 degrees
scale factor at natural origin:	0.9996
false easting:	1640416.67 US survey feet
false northing:	0.00 US survey feet
Projected CRS axes units name:	US survey foot
Axis unit conversion to metre:	0.30480060960121924

[9] This information is above the minimum. EPSG dataset codes are within the reserved range 1 to 32767. Users assigning their own codes should use values outside this range to avoid conflicts with EPSG dataset codes.

[10] As this is the same as the geodetic datum abbreviation, the geodetic datum name is not required. And as it is based on the Greenwich meridian, the prime meridian details are not required.

e) Engineering coordinate reference system related to a projected coordinate reference system.

Full form definition of transformation as per 3.3 above with reference to short form CRS as per 3.1 above.

Engineering coordinate reference system name:	Platform grid

Reference projected coordinate reference system:	
EPSG coordinate reference system name:	ED50 / UTM zone 31N
EPSG coordinate reference system code:	23031
EPSG Dataset version:	6.1

Transformation to reference CRS:	
EPSG transformation method name:	Similarity transformation
EPSG transformation method code:	9621
EPSG Dataset version:	6.1

Transformation parameters:	
Ordinate 1 of evaluation point in target CRS	654321.0
Ordinate 1 of evaluation point in target CRS	5678901.2
Scale difference	0 ppm
Rotation angle of source coordinate system axes[11]	35.2 degrees

Example:	
Plant grid coordinates:	1057.01n 322.78e
Reference CRS coordinates:	655370.79E 5678555.66N

[11] Anti-clockwise angle to bring local axes into coincidence with reference axes. Refer to IOGP Geomatics Guidance Note 7, part 2 for details.

f) Example of WELL-KNOWN TEXT

Example of WKT definitions for a projected coordinate reference system used in example 5 c). To ensure the correct syntax, it is advisable to use the existing WKT of an entity with a similar definition generated from any 'reliable' source (one being the EPSG online Registry) which is then edited to suit user requirements.

Horizontal CRS WKT

```
PROJCRS["ED50 / UTM zone 31N",
  BASEGEODCRS["ED50",
    DATUM["European Datum 1950",
      ELLIPSOID["International 1924",6378388,297,LENGTHUNIT["metre",1.0]]]],
  CONVERSION["UTM zone 31N",
    METHOD["Transverse Mercator",ID["EPSG",9807]],
    PARAMETER["Latitude of natural origin",0,ANGLEUNIT["degree",0.01745329252]],
    PARAMETER["Longitude of natural origin",3,ANGLEUNIT["degree",0.01745329252]],
    PARAMETER["Scale factor at natural origin",0.9996,SCALEUNIT["unity",1.0]],
    PARAMETER["False easting",500000,LENGTHUNIT["metre",1.0]],
    PARAMETER["False northing",0,LENGTHUNIT["metre",1.0]]],
  CS[cartesian,2],
    AXIS["easting (E)",east,ORDER[1]],
    AXIS["northing (N)",north,ORDER[2]],
    LENGTHUNIT["metre",1.0],
  ID["EPSG",23031]]
```

Vertical CRS WKT

```
VERTCRS["MSL depth",
  VDATUM["Mean Sea Level"],
  CS[vertical,1],
    AXIS["depth (D)",down],
    LENGTHUNIT["metre",1.0],
  ID["EPSG",5715]]
```

Registered Office
City Tower
40 Basinghall Street
14th Floor
London EC2V 5DE
United Kingdom

T +44 (0)20 3763 9700
reception@iogp.org

Brussels Office
Bd du Souverain,165
4th Floor
B-1160 Brussels
Belgium

T +32 (0)2 566 9150
reception@iogp.org

Houston Office
16225 Park Ten Place
Suite 500
Houston, Texas 77084
United States

T +1 (713) 338 3494
reception@iogp.org

www.iogp.org

Coordinates define a position unambiguously only when the coordinate reference system to which those coordinates belong has been identified. This guidance note describes recommended practice for defining a coordinate reference system.