International Association of Oil & Gas Producers

Surveying & Positioning Guidance note 5

Coordinate reference system definition — recommended practice

Revision history

Version	Date	Amendments
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

1 Introduction

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

2 Types of Coordinate Reference System

Coordinate reference systems 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 3D	a georeferenced 3D system with axes of latitude, longitude and ellipsoidal height. GPS receivers typically indicate location in this manner.
Geographic 2D	a georeferenced 2D system with axes of latitude and longitude. This is the horizontal subset of a geographic 3D coordinate reference system.
Projected	a georeferenced cartesian 2D system with axes of easting and northing. The axes may be referred to as for example E and N or in an alternative case as X and Y, and may be given in any prescribed order. Projected coordinates result from the conversion of geographic 2D coordinates through a map projection.
Vertical	a georeferenced 1D system with axis called for example orthometric height, elevation or depth. Heights and depths are measured along the direction of the local gravity field.
Compound	a geographic 2D or projected coordinate reference system combined with vertical coordinate reference system. The horizontal and vertical components are independent, unlike a geographic 3D coordinate reference system.
Engineering	a non-georeferenced coordinate reference system in 1, 2 or 3 dimensions. An engineering 2D coordinate reference system has horizontal axes i and j, an engineering 1D coordinate reference system has a vertical axis k. Engineering 2D coordinate reference systems include engineering site grids and 3D seismic binning grids.

3 Methods for defining a coordinate reference system

For all types of coordinate reference system (CRS) there are three 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 OGP's EPSG geodetic parameter dataset.

This is the most compact option. By providing the EPSG dataset coordinate reference system code and dataset version, all of the defining parameters and the coordinate reference system units are implicit. They can be determined from the EPSG database of that version. Some systems with long names have an abbreviation. Where this exists it may be given as an alternative to the full name. Because the names and abbreviations are often in common use, provision of name or abbreviation 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 database 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 database. 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 in section 4 below need to be explicitly given. Some of these may be available from the EPSG database.

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, and
  - inverse flattening value.

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

- either prime meridian name (from EPSG database) or Greenwich longitude of prime meridian.

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

- units for ellipsoid height.

1 *The EPSG database of geodetic information includes coordinate reference systems and their component parameters. It is maintained by the OGP Surveying & Positioning Committee. It can be downloaded at no charge from the OGP website at http://info.ogp.org.uk/geodesy or from the EPSG dataset website at http://www.epsg.org..*

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 OGP Surveying & Positiong Committee guidance note number 7 part 1. Where these are the same, the geodetic datum name may be omitted from the minimum requirement for geographic CRS definition.*

4.2 The mimimum 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)"[3] projections, 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.
- 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.
- If the coordinate reference system name does not make it clear whether the coordinate reference system is a height or a depth system, this information should be explicitly stated.
- 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 **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:

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

To define the affine transformation, the coefficients for the transformation from engineering grid to projected coordinate reference system are required. The set of parameters required varies with projection transformation method. An example showing input and output coordinates should also be given. General methodology is described in OGP S&P guidance note number 7 part 2. For specific application to 3D seismic surveys the UKOOA publication "Guidelines for the Definition of 3D Seismic Binning Grids with a Format for Data Exchange, P6/98" gives full details of appropriate practice.

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3 *Coordinate Operation methods are defined within the dataset and OGP Surveying & Positioning Committee (S&P) guidance note number 7 part 2.*

4 *Recognised names of units with their conversion to s.i. units are given in the EPSG geodetic parameter data set.*

5 *In most cases EPSG conventionally uses the vertical datum abbreviation (if applicable) or vertical datum name as the name of the vertical CRS. See S&P guidance note number 9. 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 S&P geodetic parameter data set and S&P guidance note number 7.*

5 Examples

a) Geographic 2D coordinate reference system given in EPSG geodetic parameter database.

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 EPSG database

User-defined coordinate reference system name:	ED50 / UTM zone 31N + mean sea level 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:	mean sea level 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 database.

Compound coordinate reference system name:	ED50 / UTM zone 31N + mean sea level 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:	mean sea level 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. And as it is based on the Greenwich meridian, the prime meridian details are not required.*

8 *As the unit is metre, 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:	298.2572221
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

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.

Axis unit conversion to metre:	0.304800609601219

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 OGP S&P guideline number 7 part 2 for details.

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