Guidance Note

for

Geodetic and Cartographic Applications

(Precision and Presentation)

Revision history:

Version	Release Date	Amendments
1.0	15 November 2006	Initial Release
1.1	16 January 2007	Corrections and expansions in symbology suggested at November 2006 annual meeting.

Contents

Introduction

Rather than specifically define or stipulate the following objects, identities, terminology or algorithms as guidelines, APSG recommend that the EPSG database and its scope of terminology, identity and definitions be used as a source for compliance.

APSG recognize that this guideline serves as a basis for future development or software revision and may not be practical for existing systems or software. The guideline is offered as best practice.

Any statement about precision and presentation for geodetic and cartographic applications has to address the following subjects and their associated metadata:

1. Objects and References
2. Basic Object Identities
3. Terminology
4. Algorithms
5. Binary Data Representation
6. Character Data Representation and Presentation

Objects

All of the following object types should be supported:

1. Linear Units.
2. Angular Units.
3. Ellipsoids.
4. Prime Meridians.
5. Geodetic Datums.
6. Geographic Coordinate Reference Systems.
7. Projected Coordinate Reference Systems.
8. Geographic Coordinate Reference Systems
9. Engineering Coordinate Reference Systems (sometimes called "local", "grid" or "company" coordinate systems.
10. Vertical Coordinate Reference Systems.
11. Compound Coordinate Reference System.

This implies that a large variety of mathematical methods also be supported:

1. Geodetic Coordinate Transformations
2. Map Projections / Coordinate Conversions.

Basic Object Identities

- Units (Linear and Angular).
- Ellipsoids.
- Geodetic Datums.
- Geographic Coordinate Reference Systems
- Vertical Datums.
- Vertical Coordinate Reference Systems
- Compound Coordinate Reference Systems
- Geodetic Transformation Methods.

- Geodetic Transformation Instances (Methods and Parameters), including both direct and concatenated transforms.
- Vertical Transformation Methods.
- Vertical Transformation Instances (Methods with Parameters).
- Map Projection (Coordinate Conversion) Methods.
- Map Projection Instances (Methods with Parameters).
- Projected Coordinate Reference Systems (Map Projection instances coupled with source Geographic Coordinate Reference Systems (thus Geodetic Datums)

Terminology

APSG recommend that the EPSG database and its usage of terminology for methods and parameters be used as a source for compliance.

Algorithms

APSG recommend that the EPSG database and its published algorithms be used as a source for compliance.

APSG recognizes that special algorithms may need to be adapted for specific use and application and although basic mathematics as presented by EPSG/OGP are considered acceptable, other algorithms may be equally acceptable as long as they meet acceptable criteria.

Basic Precision Goals

Location information should retain a suitable precision for its intended use as it is processed with software, stored on electronic media and presented to petroleum industry personnel in text form.

Metadata should retain enough precision to sustain the location information requirement. Metadata are information about information (e.g., map projection parameters).

The following standards are a refined and focused attempt to achieve these goals.

Numerical Drift

Any reversible transformation or conversion implementation, following 1000 forward-inverse iterations, should not exhibit location drift of more than 6mm . This requirement applies to locations inside the geographic area over which the implementation is applicable (i.e. are within the geographic domain of the implementation). Any location that an implementation accepts and returns with an "OK" return code is deemed to be within the geographic domain of the implementation. This is to say that software is tasked with protecting users against mathematical contradictions.

Minimum "useful range" shall be deemed to be equivalent to the Area of Use as defined for the specific object within the EPSG dataset (or a suitable industry alternative for objects that are not contained within the EPSG dataset.

The above numerical drift requirement shall be maintained over the above defined "useful range" for the object. That is, the requirement shall pertain to the "functional domain" as opposed to "mathematical domain" of the algorithm. If programmers wish to develop algorithms that are more precise ***outside*** of the specified "Area of Use" for the object, they may do so but such is not required or expected.

Binary and Character Data Rendering

When geodetic and cartographic data is written in character form, it is possible that a format will not contain enough significant right decimal places to preserve the essential precision of the information. Let it be understood that there are few recognized limits for left decimal precision.

Internal binary representations and external character representations of all positional data coordinates (horizontal and vertical) shall support a precision capable of representing the equivalent of a preferred distance of 6 millimeters in the subject CRS. Numeric values should be derived and, or carried internally in double precision. Character rendering of those values should be appropriate to represent the needed precision.

If the application or usage requires that the general precision be less than the preferred, then all units shall be degraded an equivalent factor as suggested by the following tables.

The following tables specify the minimum acceptable number of right decimal places that must be specified to preserve essential precision for various units:

Angular Measurements

Unit	Right Decimal Places (1-6mm)	Right Decimal Places (6 to 60 cm)
Decimal Degrees	8	6
Decimal Minutes following Integer Degrees	6	4
Decimal Seconds following Integer Degrees and Minutes	4	2
Radians	10	8
Grads	8	6

Note: When angles are expressed in formats other than decimal degrees (e.g., either minutes or seconds), the expression must also contain a hemisphere character.

Length Measurements

EPSG Unit	Right Decimal Places (~1-6 mm)	Right Decimal Places (6 to 60 cm)
Meter (International and German Legal meters)	3	1
Bin width 12.5 meters	4	2
Bin width 165 US survey feet	4	2
Bin width 25 meters	4	2
Bin width 3.125 meters	3	1
Bin width 330 US survey feet	5	3
Bin width 37.5 meters	4	2
Bin width 6.25 meters	5	3
Bin width 82.5 US survey feet	4	2

Chain [all definitions: US Survey chain, Clarke's chain, British chain (Sears 1922), and British chain (Benoit 1895 A and Benoit 1895 B)]	4	2
Link [all definitions: US Survey link, Clarke's link, British link (Sears 1922), and British link (Benoit 1895 A and 1895 B)]	2	0
Foot [all definitions: International foot, US Survey foot, Clarke's foot, British foot (Sears 1922), British foot (Benoit 1895 A and B), British foot (1865), British foot (1936), Indian Foot, Indian foot (1937), Indian foot (1962), Indian foot (1975) and Gold Coast foot]	2	0
Yard [all definitions: Clarke's yard, British yard (Sears 1922), British yard (Benoit 1895 A and B), Indian Yard, Indian yard (1937), Indian yard (1962) and Indian yard (1975)]	3	1
Fathom	3	1
Kilometer	6	4
Mile (Nautical Mile, Statute Mile, US Survey Mile)	6	4

Scale Factor

One cartographic parameter is unitless (*i.e.*, scale factor, which is often expressed as parts per million). Eleven (11) right decimal places of the decimal equivalent are necessary to preserve essential precision.

Repeating Zeros

Repeating zeros at on the right end of an expression can be deleted and expressions that fall short of the recommended number of right decimal places are considered to be padded out with zeroes. This is to say that repeating decimals must be carried out to the stated precisions, except when the numbers are zeros they may be deleted.

Formats for presentation of positional data

The following section addresses the presentation formats for coordinate information.

The order of Latitude ,Longitude, Easting and Northing should be clearly defined, documented and presented to the user in a consistent manner.

NOTE: *Generally speaking, implied decimals should not be used for presentation or exchange. However, should there be a specific requirement for using implied decimals, then either documentation, coding or other metadata should exist to indicate its usage. Such ancillary information should be retained with the character data as long as an implied decimal presentation method is utilized.*

Geodetic / Geographic formats for character presentations:

Preferred:

Degrees, minutes, seconds and decimal seconds, hemisphere code

DDD° MM' SS.ssss" H (e.g., 029° 34' 12.3405" N 095° 15' 12.1605" W)
[for precision to 0.6 to 6.0 mm]

or

DDD° MM' SS.ss" H (e.g., 029° 34' 12.34" N 095° 15' 12.16" W)
[for precision to 6 to 60 cm]

Alternate:

Signed decimal degrees (e.g., negative (-) west longitudes and positive (+) north latitudes). s=sign +/-, D=degrees and d=decimal of degrees.

sDDD.dddddddd (e.g., 029.57009402 -95.25337827)
[for precision to 0.6 to 6.0 mm]

or

sDDD.dddddd (e.g., 029.570094 -95.253378)
[for precision to 6 to 60 cm]

Note: The number of significant digits to the right of the decimal place in either of the above formats may be changed, as needed to provide any required precision.

Alternative representations for geographic coordinates:

Degrees (D) and decimal minutes (M), hemisphere code (H): DDDMM.mmmmmH or Decimal degrees, hemisphere code (e.g., DDD.dddddddH)

See table under "Angular Measurements" for appropriate decimal places for a given precision.

Grid formats for character presentations:

Grid formats should be presented with sign (s), whole and fractional coordinate followed by an Easting (E) or Northing (N) designator. Precision will be *as needed* for a given projection, units and user requirements. If Easting or Northing designators are not shown, clarification as to the symbol definition and which precedes the other is required (e.g., E, N or N, E). X, Y designators are not recommended by APSG, however if used, both the order (e.g., X, Y or Y, X) and identity (e.g, X = Easting and Y = Northing or X = Northing and Y = Easting) should be included and defined.

Preferred:

[For precision of one centimeter (0.01 m)

s123456789012.01 ftUS E	s123456789012.01 ftUS N
s123,456,789,012.01 ftUS E	s123,456,789,012.01 ftUS N

Or, where for a system in which it has been appropriately documented that E, N is the expected order and units are clearly defined:

s12345678901.01	s12345678901.01
s123,456,789,012.01	s123,456,789,012.01

Note: The precision may be extended, as needed by increasing the number of significant digits to the right of the decimal place. Units abbreviation should be supplied.

Alternative representations for projected coordinates:

In many European systems, a comma is used as the decimal delimiter, with a period as thousands separator, as follows:

s123.456.789,01 m E	s123.456.789,01 m N

These and other variants of coordinate representation are currently in use and as such, documentation, coding or other metadata should exist with which to indicate their usage and structure to the user. It is the intent of APSG to recommend the preferred presentation methods, while recognizing variants do exist and the need for users and software to be able to identify such. It is not within the scope of this guideline to indicate methodology.