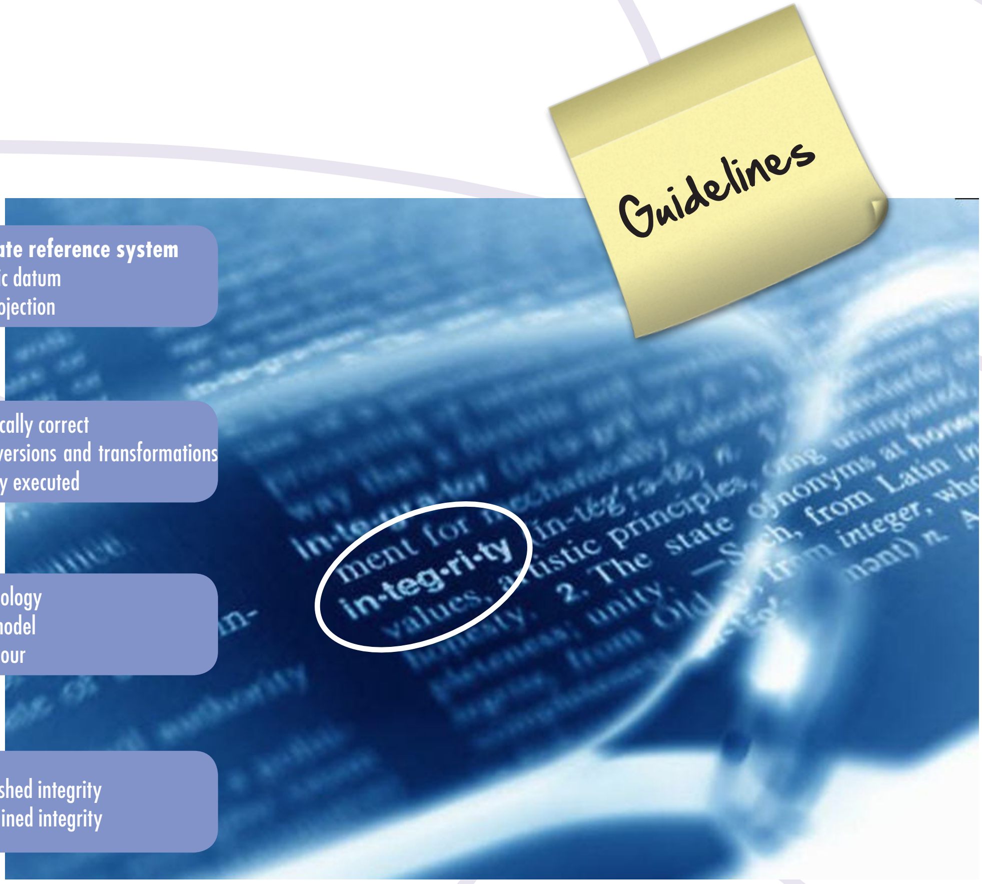
OGP

Geospatial Integrity of Geoscience Software
Part 1 – GIGS guidelines

Report No. 430-1

September 2011



Complete:
Coordinate reference system
- Geodetic datum
- Map Projection

Correct:
- Numerically correct
- All conversions and transformations correctly executed

Consistent:
- Terminology
- Data model
- Behaviour

Verifiable:
- Established integrity
- Maintained integrity

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Preface

The purpose of this guidance note is to provide geoscience software developers and users with recommended industry best practice to evaluate the capabilities of their software with respect to establishing and maintaining geospatial data integrity. The guidance note is a response to significant concern and user experiences of violations of geospatial integrity of data when using geoscience software, leading to incorrect results, inconsistent understanding and misleading information for the user community.

In 2008 this led to the formation of a joint industry project (JIP) sponsored by OGP to review the situation and produce a series of recommendations, a supported set of standard test data, and procedures for undertaking software review utilising that test data. OGP has taken the results of this Geospatial Integrity of Geoscience Software (GIGS) JIP and incorporated them in this guidance note which is in three parts:

1. *Part 1 – GIGS Guidelines* (OGP report № 430–1, this document), describing the GIGS process;
2. *Part 2 – GIGS Software Review* (OGP report № 430–2), containing a software review checklist to enable structured testing of geoscience software; and
3. *Part 3 – User guide for the GIGS Test Dataset* (OGP report № 430–3).

This guidance note is supplemented by a number of companion electronic files:

- *Software review checklist* – an MS-Excel spreadsheet intended to facilitate the execution of a geoscience software review and capture its results;
- *GIGS Test Dataset* – a series of data files to be used for testing of the algorithms and data exchange capabilities of the geoscience software.
- *Sample MS PowerPoint slides* – explaining GIGS process and business benefits.

The above digital documents and files are available from the OGP Geomatics Committee website – http://info.ogp.org.uk/geomatics.

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1 – Introduction

1.1 Background

The modern E&P industry makes extensive use of software in the quest to find, develop and produce hydrocarbons and other energy sources. A wide variety of seismic, well, and cultural data are brought into these software packages where they are studied, manipulated and exported to other software, shared with other users, and interpreted to form the basis for major operational and investment decisions. Such data sets, which we will call geoscience datasets, are referenced to the real world by means of geospatial data. Typically the geospatial data are in the form of coordinates, together with the coordinate reference system being used and other essential geospatial metadata.

A casual survey of the market shows upwards of five hundred different software packages are available for use in the E&P business. It has been estimated that a typical project will involve 90-100 transactions where data are moved or manipulated. The users of these applications require them to be interoperable, exchanging data as needed and without introducing errors.

If all the geospatial data are complete, consistent, correct and verifiable, and remain so during any data manipulations, then geospatial integrity has been maintained. If geospatial integrity and data quality are compromised, the validity of any decisions made with the geoscience datasets may be compromised.

In the petroleum industry, users experience on an almost day-to-day basis violations of the geospatial integrity of geoscience datasets. Sometimes this can be attributed to a lack of understanding or knowledge of the person who deals with the data, but in other cases it can be traced to deficiencies or failings in the available geoscience software tools.

1.2 Scope

This guidance note is intended for wide use within the E&P industry. It specifically addresses the developers, vendors and suppliers of geoscience software. It is also intended to guide users of this software in discussions with both company internal or commercial geoscience software vendors, regarding current products and future enhancements.

In this guidance note the term geoscience software includes any computer package used in geoscience activities, including applications, processing packages, underlying databases and their user interfaces. It also includes software components or layers, such as geodetic computation engines, extensions and middleware.

This guidance note applies especially to the software functions that address spatial data import, creation, merging, processing, coordinate operations, map projections, visualisation, and export, although it is also relevant for existing product maintenance and to new product design, testing and production support.

It does not address raw data processing methods (e.g. wellbore curve calculation methods) or surface engineering software, though the general principles are still valid; nor does it address the quality of the geoscience datasets themselves. The focus of this guidance note is on the preservation of referential integrity and on maintenance of geospatial quality that is inherent within the original data set.

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2 – Technical background to geospatial integrity

2.1 Definition

Geospatial integrity is defined as the adherence of geospatial data to the following criteria:

Completeness	Geospatial data must be associated with the appropriate coordinate reference system (CRS), which should defined fully unambiguously. Where coordinate operations are performed on the data, these operations must be defined unambiguously. Coordinate reference systems and coordinate operations are referred to as geospatial metadata.
Correctness	Applications must honour the precision of the coordinates: • no apparent precision may be suggested by the addition of decimal places; • coordinate operations must be executed commensurate with the precision of coordinates and the accuracy of the algorithm. The defining parameters of CRSs and coordinate operations must be free from numerical and terminological errors.
Consistency	Data model and terminology must be applied consistently through the application or application suite.
Verifiability	The user must be able to ascertain that completeness, correctness and consistency have been achieved and maintained.

2.2 Geospatial dataset

The conceptual model showing the relationship of geospatial data is shown in Figure 1 below.

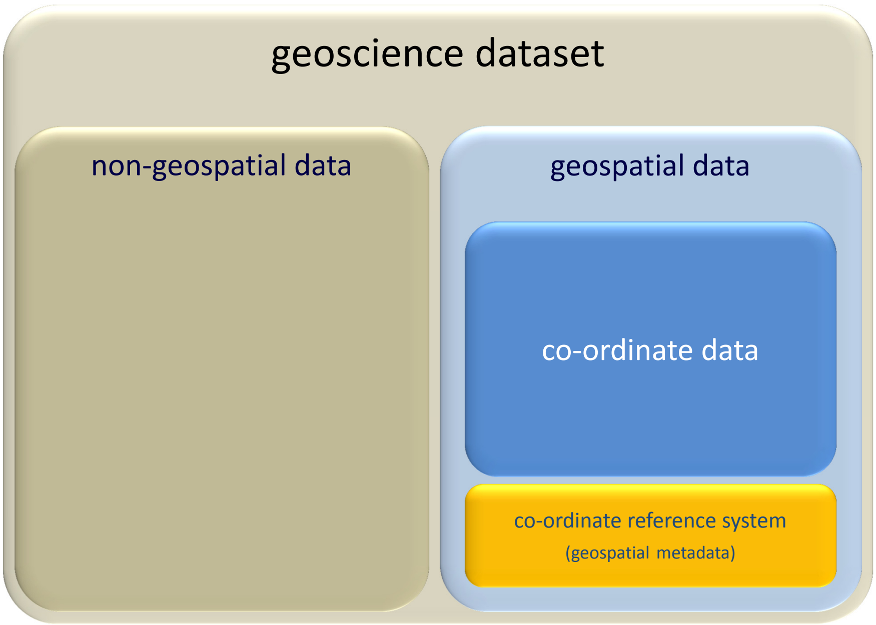

Figure 1 – Conceptual model - geospatial data

A geoscience dataset is referenced to the real world by its geospatial data, which consist of two principal elements that are inextricably linked:

- The coordinate dataset ('the coordinates') and
- The coordinate reference system (in this guidance note sometimes referred to as part of the 'geospatial metadata')

If the coordinates are presented in the absence of their geospatial metadata, the resulting positions are ambiguous and should be considered unreliable.

Assuming both the coordinate dataset and all the geospatial metadata are provided, geospatial integrity can then be quantified using the four principal measures listed in the previous section.

If any of the four criteria in section 2.1 above are not met, geospatial integrity is flawed and the geospatial data should be regarded as ambiguous. Note that verifiability does not imply perfect data but that the degree of imperfection is understood both by the software and by the user. Likewise, a slight misuse of nomenclature does not mean that the data is no longer useable. The degree to which geospatial integrity can be assured has a direct impact on the quality of a geoscience dataset, its fitness for a defined purpose and portfolio risk level of the project. Where a geoscience dataset contains complete, consistent, correct, and verifiable geospatial data, geoscience software should be able to correctly, completely, consistently and verifiably process, merge, correlate, visualise, map, and transfer that data.

Clearly, from a geospatial perspective, these concepts represent a future state to which the E&P industry should aspire.

As shown in Figure 2 below, a coordinate dataset consists of a collection of positions, each described by a sequence of coordinate values. Each position represents one point in the coordinate dataset, which is referenced to its geospatial metadata.

A *coordinate tuple* is an ordered sequence of scalar values that together define the location of a point. Each scalar value in the tuple is called a *coordinate* and the tuple itself is commonly referred to by the term 'coordinates'. It is stressed that the ordering of the coordinates in the tuple is essential. The order of the coordinates is defined as part of the coordinate reference system.

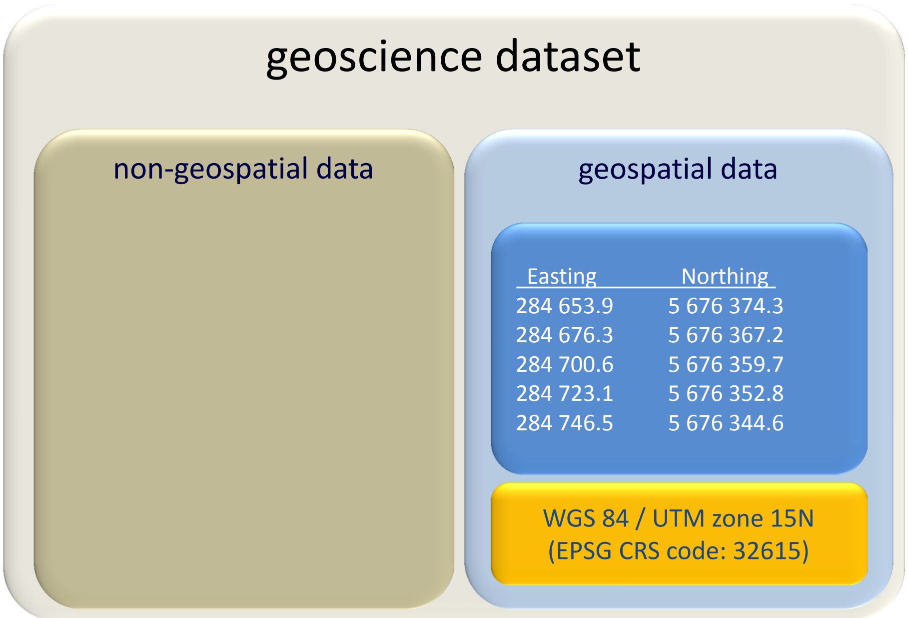

Figure 2 - Example: coordinate tuples with their coordinate reference system

For the coordinates (or coordinate tuple) to be complete and unambiguous, they must be associated with their geospatial metadata, which includes the definition of all the components of their coordinate reference system.

The coordinate reference system consists of several components. The most important component is the datum; this expresses how coordinates are associated with points on the physical earth. Another component is the coordinate axes frame, which, together with the axis names, abbreviations, and unit(s) of measure, constitutes the concept coordinate system. For map grid coordinates a third component, the map projection definition, is required. All these concepts are defined in International Standard ISO 19111[1].

1 *ISO 19111: Geographic information - spatial referencing by coordinates*

OGP publication no. 373-05: *Coordinate reference system definition – recommended practice*[2] contains further background on the CRS basic concept, and examples of typical CRSs in the E&P industry.

2.3 Key geodesy concepts

In order to fully understand geospatial integrity, and the solutions proposed here, it is necessary to understand the conceptual background of geodetic referencing. The subject is too large to be treated completely in this document and has already been addressed in large part by OGP elsewhere. Software developers and users alike are strongly urged to consult OGP publication no. 373: *Geodetic awareness guidance note*[3] , which provides more detail and develops the following key concepts:

- Coordinates are ambiguous unless the coordinate reference system (CRS) to which they are referenced is identified.
- Latitude and longitude or geographical coordinates are typically used to map on the curved surface of the earth or ellipsoid; a latitude and longitude graticule can however be plotted on a two-dimensional map.
- The choice of a reference ellipsoid does not define a geodetic datum; a specific ellipsoid can be the basis for many geodetic datums.
- A geodetic datum can have only one reference ellipsoid; identifying a specific datum implies that ellipsoid and no other.
- Easting and northing coordinates are typically used to map on a projected plane.
- Map projection formulae distort the true curved surface of the earth in area, shape, orientation, and scale, by representing it on a two-dimensional flat map surface.
- Map coordinates are not unique unless qualified with all parameters of the projected CRS (including specification of its base geographic CRS, its map projection and its coordinate system).
- Heights are not unique unless the CRS to which they are referenced, including the vertical datum, is identified.
- Azimuths and bearings are not unique unless qualified with a heading reference.
- Length and angular parameter values are not unique unless qualified with a unit identification.

2 *http://ww.ogp.org.uk/pubs/373-05.pdf*
3 *http://www.ogp.org.uk/pubs/373-01.pdf*

2.4 Coordinate operations

Coordinate operations change the coordinate values of a coordinate dataset, so that the dataset becomes referenced to a different CRS. The process of coordinate operations is illustrated in Figure 3 below. A coordinate operation may be a coordinate conversion or a coordinate transformation.

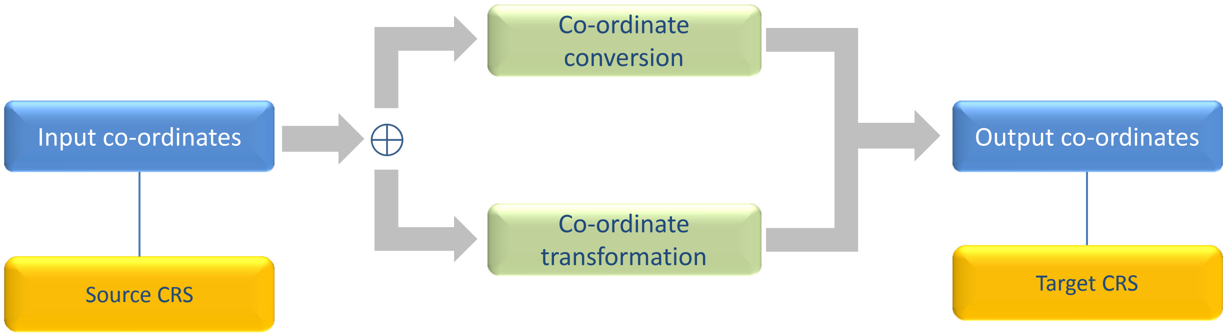

Figure 3 – Change of CRS through a coordinate operation

Here, the input coordinates, referenced to the source CRS, are changed to output coordinates, referenced to the target CRS. In the process, the different geodetic parameter values for the source and target CRSs are applied in the coordinate operation. Two categories of coordinate operation are distinguished:

- A *coordinate conversion* changes coordinates between CRSs referenced to the same datum. Conversion parameters have precise, defined values. Typical conversions include map projections, which change latitude and longitude, which are referenced to a geographic 2D CRS, to easting (E) and northing (N), referenced to a projected CRS, or vice-versa. A typical example is converting WGS 84 latitude and longitude (geographic 2D CRS) to WGS 84 / UTM zone 15N easting and northing (projected CRS). There is only one set of parameters that describes this conversion process. The projected CRS is referenced to the same geodetic datum and hence the same ellipsoid as the base geographic CRS on which it is based.
- A *coordinate transformation* changes coordinates between CRSs referenced to different datums. Transformation parameter values are normally derived empirically, based on sample data, and will have some uncertainty depending on the sample data and empirical methods used. A typical example is transforming WGS 84 latitude and longitude to NAD27 latitude and longitude coordinates. Both WGS 84 and NAD27 are geographic 2D CRSs. There are several accepted methods and parameter sets that can be used to accomplish this transformation, each of which yields slightly different results. The uncertainty in the transformation parameter values manifests itself as a loss of accuracy in the output CRS coordinates.

Sometimes multiple processes are applied to the coordinate dataset, which can be considered an extension of the two processes listed above:

- Concatenated coordinate transformations involve the chaining together of successive coordinate operations. In this way, coordinates referenced to a Source CRS are transformed, or converted, to one or more intermediate CRSs, and then to the Target CRS, through two or more concatenated operation steps. A typical example is the transformation of geographic coordinates (i.e. latitude and longitude) from Geographic 2D CRSs 'SAD69' to 'Aratu'. The first step is a transformation from SAD69 to WGS 84, using one of the several available coordinate transformations between these geographic 2D CRSs and then the second, concatenated, step is to convert from WGS 84 to Aratu geographic coordinates using one of the several available coordinate transformations between WGS 84 and Aratu geographic CRSs.

2.5 The EPSG Geodetic Parameter Dataset

The EPSG Geodetic Parameter Dataset, or EPSG Dataset in short, is a de facto global standard repository with definitions of:

- Coordinate reference systems and their component elements. This includes the definition of map projections, which are part of the definitions of projected CRSs.
- Coordinate transformations and conversions, including the associated parameter values and the description of the algorithm associated with each coordinate operation.

The EPSG Dataset is based on a profile[4] of the ISO 19111 data model. All EPSG geodetic data objects (coordinate reference systems, their associated datums, coordinate transformations etc.) have been allocated an EPSG code for reference purposes. The EPSG code is a unique identifier for CRSs and coordinate transformations. This allows unambiguous specification of any CRS or transformation from the EPSG code alone. For identification of component parts of the model the EPSG code is unique within that entity type, e.g. datum. Some code overlap may occur for their components entities. The EPSG Dataset is available as a free online registry at: http://www.epsg-registry.org/ with documentation at: http://www.epsg.org/.

The EPSG Dataset is the de facto global standard for geodetic parameters used within the E&P industry. However, it is also possible that an E&P operator may have established its own proprietary CRS or transformation and therefore will have parameter sets that are not held in the EPSG Dataset. Software should also make provision for dealing with these user-defined parameters, and for allocating company codes, which are extensions of the EPSG codes.

2.5.1 Deprecation

As a matter of policy, records are never deleted from the EPSG Dataset. Records requiring minor correction, which do not impact computational results, are amended directly. Records in which significant errors have been detected (for which computational results would change with the correction) have their *deprecation* flag set to 'True', and new records created to contain the correct values (with Deprecation flag set to 'False'). Deprecated records have a trail, which documents the date and reason for deprecation and contains a link to the replacement record(s).

Records that have been deprecated should normally not be used, except to replicate the results of older legacy data that utilised these erroneous records in the past and possibly correct such data.

It is important to note that EPSG codes can only be deprecated by OGP. Software which uses EPSG codes should take care to automatically populate the parameters for a given code directly from the EPSG Geodetic Parameter Dataset, or should rigorously audit the transfer of the parameters to ensure correctness. If a mistake or typing error is made, then the software vendor will face the dilemma of having to deal with deprecating a code number which is not deprecated by OGP and is still in use or changing the error without leaving an audit trail.

Further details on Rules for Deprecation in the EPSG Dataset can be found in OGP publication no. 373-07-1: *Using the EPSG Geodetic Parameter Dataset*[5].

4 *A 'profile' in this context is an internally consistent sub-model*
5 *http://www.ogp.org.uk/pubs/373-07-1.pdf*

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3 – GIGS Software Review

3.1 What is a GIGS software review?

A GIGS software review is a structured approach to evaluating the geospatial integrity aspects of software and consists of:

- a qualitative evaluation of the software's geospatial capability by means of a series of checklists;
- a quantitative evaluation of the software's capabilities by means of test data.

Both software developers and users (i.e. both software vendors and clients) may execute such a GIGS software review and both will benefit from its results. To geoscience software vendors it provides a means of self-certification or self-validation of the geospatial capabilities of the software. It enables the vendor to market its product more effectively by communicating the results of the review to (prospective) clients and helps the vendor to identify development needs and prioritise improvements in the software. Furthermore a GIGS software review provides an opportunity for education in this geodetic niche discipline and offers structure in communications with customers.

Users of geoscience software may conduct GIGS software reviews in their own organisation. The reviews may assist in establishing whether the software meets business and technical requirements. They are a key tool in the establishment and maintenance of geospatial data integrity in the business by optimising workflows, taking advantage of both the strong and the weak points of geospatial data handling of relevant software.

Software vendors and client companies are encouraged to share the results of any GIGS software reviews they conducted, with others in the industry.

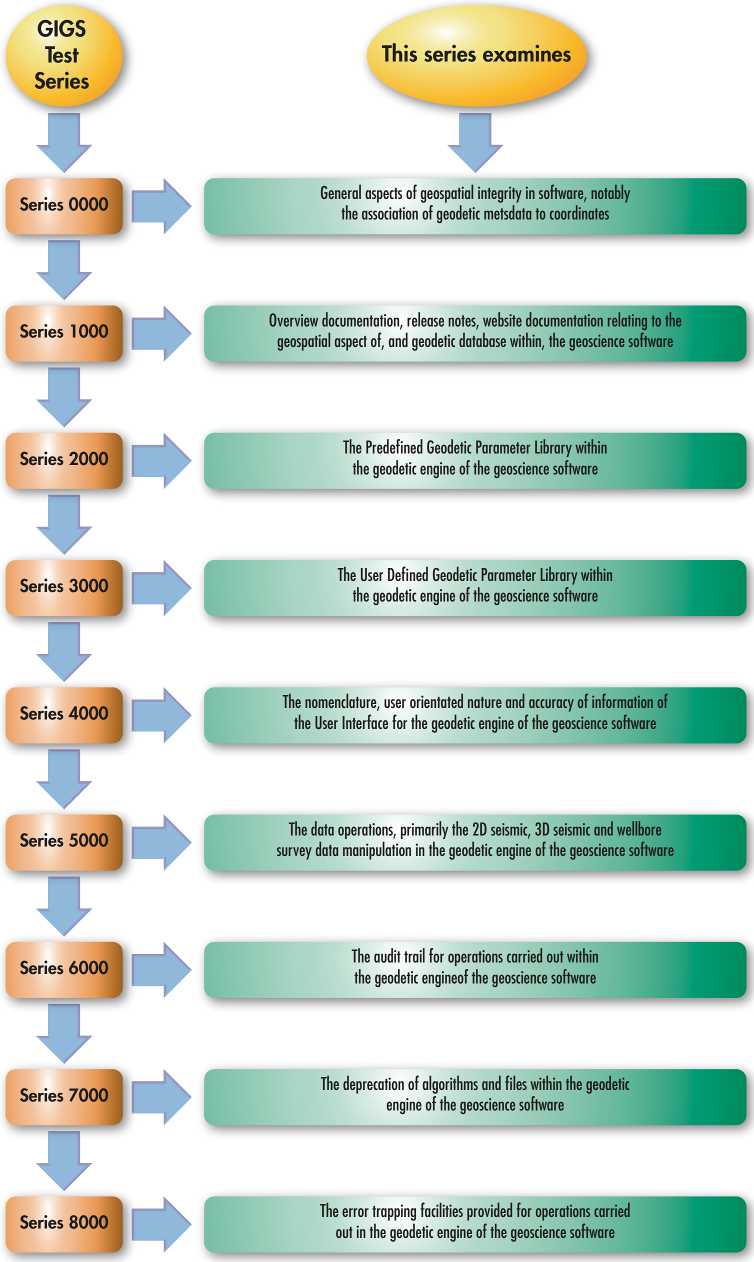
3.2 Review process

To facilitate ease of understanding, the review process has been split into a number of aspects, for each of which a series of tests has been defined:

- 0000 – Coordinates and their Geodetic Reference
- 1000 – Documentation and Release Notes
- 2000 – Pre-defined Geodetic Parameter Library
- 3000 – User-defined Geodetic Parameter Library
- 4000 – The User Interface
- 5000 – Data Operations
- 6000 – Audit Trail
- 7000 – Deprecation (related to use of EPSG Dataset – see section 2.5.1)
- 8000 – Error Trapping

These aspects are reflected in groupings, referred to as Test Series. For example, Series 5000 covers all aspects of Data Operations, and is further subdivided into Test Series 5100, 5200, 5300, 5400 and 5500. The individual tests are numbered for the purpose of reporting. The tests are described in Part 2 of this guidance note, *Software Review* (OGP publication no. 430-2)[6].

6 *http://www.ogp.org.uk/pubs/430-2.pdf and http://www.ogp.org.uk/pubs/430-2a.zip*



3.3 Classification of software evaluation results

The interpretation of the evaluation results of geospatial aspects of the software will depend on the scope of the software. Different software packages may have implemented functionality and reference data relating to geospatial integrity in different ways. In order to make a meaningful comparison possible, this guidance note distinguishes four levels of compliance. These levels are identified by the following terms:

1. *Elementary*
   Intended for software without the capability of performing coordinate operations; this level indicates that the software satisfies minimum requirements for this category of software.
2. *Bronze*
   Intended for software with a limited capability to perform coordinate operations;this level indicates that the software satisfies minimum requirements to achieve a basic level of geospatial integrity.

3. *Silver*
   Intended for software with a full capability to perform coordinate operations; this level indicates that the software establishes and maintains geospatial integrity to a fully satisfactory degree, based on industry best practices. The software is suitable for global deployment in the E&P industry.
4. *Gold*
   Intended for software with an extensive capability to perform coordinate operations; this level indicates software performance that exceeds the geospatial integrity capabilities of the *silver* level by incorporating additional software features that expand the range of applicability and/or reduce the probability of geospatial integrity violations.

The *bronze*, *silver* and *gold* compliance levels are progressively inclusive, in the sense that the *silver* level implies compliance to the *bronze* level and *gold* implies that the *silver* level is also achieved. The exception is the *elementary* level, which applies to software without coordinate operation capability, which cannot be implied in software that does have this capability.

Geospatial integrity was defined in section 2.2 as compliance to four aspects: completeness, correctness, consistency and verifiability. The degree of compliance in the four levels listed in this section leads to a specific definition of each aspect, appropriate to the level of compliance, as shown in the table overleaf.

3.4 A brief note on the terms 'early binding' and 'late binding'

Geospatial metadata is defined in this guidance note as the coordinate reference system to which geospatial data is referenced, extended by the definition of any coordinate operations when relevant. This extension becomes relevant when the current coordinates have been derived from coordinates defined in another CRS by means of a coordinate transformation, so that it is necessary to know how that was done in order to fully control geospatial integrity. The reason for this is that, as the values of coordinate transformation parameters are based on sample data, there may be multiple ways, i.e. by means various coordinate transformations, of transforming coordinates from one CRS to another.

Some software resolves the so-called 'multiplicity' problem by associating one coordinate transformation only with each CRS. The relevant coordinate transformation is even treated as part of the definition of the CRS. This solution to the problem of multiplicity is referred to as 'early binding', as it binds a coordinate transformation to the CRS before it is associated with any geospatial data.

'Late-binding' software solutions to the multiplicity problem will only require the specification of a coordinate transformation at the time the coordinates are required to be transformed, i.e. after the association of geospatial data and CRS has taken place.

The solution that has been chosen for any given geoscience software package is fundamental to its behaviour with respect to geospatial integrity.

Both solutions have advantages and disadvantages and both are valid ways of controlling geospatial integrity. In this guidance note preference is expressed for the late-binding solution, provided the specific disadvantage of this solution, is resolved in the software.

Criteria for Geospatial Integrity		Elementary	Bronze	Silver	Gold
		The software does handle spatial data but has no 'geodetic engine' that performs coordinate conversions and transformations	The software has limited capability to perform coordinate transformations and satisfies a basic level of geospatial integrity, defined by the criteria below. Geospatial integrity is only maintained within the bounds of the software. Integration or interaction with other geosciances software is likely to lead to loss of geospatial integrity.	Software satisfies the requirements for the previous level, but has a number of additional features that will facilitate integration or interaction with other geosciences software by adhering to a number of industry standards or best practices.	Software satisfies the requirements of the Silver level and has additional features regarding geospatial integrity.
Completeness	Geospatial data must be associated with appropriate geospatial metadata, which consists of an unambiguous definition of the Coordinate Reference System (CRS). Where coordinate operations are performed on the data, these operations must be defined unambiguously.	Coordinates are complete, unambiguously defined and are appended with a CRS identification, specified as a unique reference of the CRS in an (external) geodetic library or dataset.	Coordinates have a complete and correct CRS identification, updated when transformed/converted within the software. The software has an internal geodetic library with correct geodetic parameters within the confines of the software	Geodetic library consists of (a complete and consistent subset of) the EPSG dataset. Support of other industry standards and best practices may be software scope-dependent. All methods from test dataset are supported. EPSG data model has been partly implemented; some variations are acceptable, e.g. 'early binding' model. Concept of 'deprecation' is supported.	Geodetic library consists of (a complete and consistent subset of) the EPSG dataset. Availability of metadata fields from EPSG dataset other than 'deprecation'. More operation methods are supported than are provided in the test dataset. Late-binding mechanism for coordinate transformations, supported by assistance to end user to reduce transformation multiplicity, or supported by a software tool facilitating selection of correct transformation.
Correctness	Software must honour the precision of the coordinates: • no apparent precision may be suggested by the addition of decimal places; • coordinate operations must be executed commensurate with the precision of coordinates and the accuracy of the algorithm. The defining parameters of CRSs and coordinate operations must be free from numerical and terminological errors.	Merging and co-visualisation of spatial datasets referenced to different CRSs in the software's workspace with imported data are blocked. The CRS identification is appended to any exported data.	Some methods of the test dataset are covered, transformation and conversion results are correct as per test dataset criteria.	User can define new geodetic entities. Geodetic entities are protected by a system of user privileges.	EPSG data model has been implemented. Functionality for following deprecation trail is present. (Semi-) automatic synchronisation with new releases of EPSG dataset.
Consistency	Data model and terminology must be applied consistently through the software or software suite.	Unambiguous use of geodetic terminology, in scope limited to CRS as a minimum.	Unambiguous use of geodetic terminology. Consistent geodetic data model.	Terminology adheres to EPSG naming conventions and ISO 19111 regarding CRS, Datum and coordinate transformation. Some variations acceptable but must be consistently applied.	Terminology as per EPSG conventions and to ISO 19111 terminology.
Verifiability	The user must be able to ascertain that completeness, correctness and consistency have been achieved and maintained.	Geospatial capabilities and limitations of the software are described clearly. CRS reference of a geoscience dataset can be inspected at any time during usage of the software.	CRS reference of spatial datasets and the contents of the geodetic library can be inspected at any time. The coordinate transformation applied to any data is identifiable and can be inspected by the user.	Audit trail is available to user enabling verification of Original CRS of data and coordinate transformation applied to Project CRS.	Extensive audit trail available to user enabling verification of Original CRS of data and coordinate transformation applied to Project CRS.

3.5 Software review workflow

Key steps in the review process can be identified as:

- Define scope
- Prepare workplan
- Quantify time requirements
- Identify and obtain expertise and resources
- People, equipment, software and data
- Execute review
- Prepare report(s)

3.5.1 Define scope

Not always will a full GIGS software review be required. A new release version of a software tested before may only require an update of the existing test reports by updating what has changed. At the other end of the spectrum a user may wish to test a complex geoscience software in an integrated architecture where geospatial integrity is influenced by interactions with other software packages and data stores. GIGS does not address software testing in such integrated environments, but the methodology can easily be extended by analogy.

3.5.2 Prepare workplan

The levels of effort and difficulty in planning and executing a GIGS software review depend on the complexity of the software to be reviewed and the detailed scope of the review. A full GIGS software review for complex integrated geoscience software may take an elapsed time of 3-4 months comprising 650 to 850 hours of combined effort once software licensing and installation issues had been resolved[7]. For smaller and/or simpler software, reduced scope or focused reviews are likely to take significantly less time to review and report. The resources reserved for the review may have to include an element of training or familiarisation with the software.

3.5.3 Identify resources

Resources required for the review can be divided into:

- Expertise
- IT equipment and software licences
- Test data

A GIGS software review requires contributions from several subject matter experts:

1. IT expertise related to the software architecture & systems development, network support, security privileges and software licence issues;
2. Geodetic and geospatial data management expertise (e.g. data loading);
3. Domain and workflow expertise for the deployment of the software;
4. Software support staff familiar with the software;
5. The range and required level of skills are generally not found in a single person, so a team of several individuals will probably be required.

A GIGS software review should preferably be done in the context of a user's typical operating environment, using a typical hardware platform. This would indicate that the review should be done onsite under actual installed conditions. However, there can be advantages to an offsite review, where specific corporate IT infrastructure or security issues would not influence the application's performance.

7 *These durations were experienced during the execution of the GIGS pilot project, however those reviews did not have teh benefit of the final version of the GIGS checklists and test procedures.*

Depending on the scope of the review, specific datasets, i.e. not included in the GIGS Test Dataset, should be collated and made available to the review team.

3.5.4 Execute Review

The review team will carry out the evaluation based upon the specific scope and will use the checklist provided in Part 2 of this guidance note. The scope of the checklist may be modified – either increased or decreased – depending on the purpose of the review.

Numerical testing of the software's capabilities and behaviour, by subjecting test data to the software's functionality, should preferably be executed before the evaluation by checklist; when executed in parallel or after the review by checklist, the checklist will have to be revisited to record the results, including any issues that have been identified during numerical testing.

3.5.5 Prepare reports

Summary Report

The results of the review are lists of compliant and non-compliant checklist responses for the software under test. A summary score per Test Series is automatically calculated in the spreadsheet and provides an overview of the capabilities of the geoscience software with respect to the GIGS geospatial integrity requirements. This summary result may form the basis for a Summary Report, suitable for management reporting and communications with end users. From the perspective of the software vendor the Summary Report can be used for marketing purposes and it may be used to identify the strong and weak points of the software's geospatial capabilities, to be used to underpin an internal development programme for the software.

Full Report, Conclusions and Recommendations

After conducting a software review as described herein, a full report should be created. The report should detail conclusions drawn in the following categories and depending on which party conducted the review. When the review has been conducted by the vendor, the following aspects need to be covered in the report.

- Which of the geospatial integrity requirements does the software fully meet, partially meet, or does not meet?
- Requirements that are not met should be clearly delineated, with unresolved issues requiring user warnings and/or workarounds. It is very important that key geospatial integrity problems that might cause user errors are flagged and documented for circulation as part of the report on the product. For example, nomenclature in the software that may be incorrect or misleading should be clearly communicated to users and potential users of the geoscience software.
- Enhancements that may be considered by the developer for addition to subsequent release(s).

When the review has been conducted by the user of the software the following aspects should be covered:

- Overall degree of geospatial integrity of the geoscience software and best practices observed.
- Unresolved issues, requiring user warnings and/or workarounds. It is very important that key problems that might cause user errors are flagged and documented by the reviewers for circulation throughout the company's user community. For example, nomenclature that may be wrong or misleading should be clearly communicated to users.
- Critical problems which may require urgent attention by the vendor, and possibly suspension of its use within the company should be clearly documented and passed to appropriate authorities within the company.
- Enhancements which may be proposed to the vendor for their consideration in future releases.
- User guidance related to any of the above for further distribution within the company.
- Best practices observed in the geoscience software.
- Comparisons with other relevant geoscience software packages known to the reviewers, as appropriate. The following terms and acronyms are used throughout this publication and are defined here for clarity.

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Glossary of terms

The use of italics in the definition column refers to another term in the Glossary.

Additional text providing clarification of the definition or an example are shown in smaller font.

The source of the definition is indicated in italics and square brackets where relevant and when the source is used several times. The following sources are used:

[GIGS]:	*Definition as applied to the term in the GIGS documentation.*
[ISO/TC211]:	*Definition from ISO/TC211 website or the 'ISO/TC211 Multi-Lingual glossary of terms':* http://www.isotc211.org/TC211_Multi-Lingual_Glossary-2010-06-06_Published.xls.
[NGA]:	*Definition from National Geospatial Intelligence Agency. See* http://www1.nga.mil.
[OGP]:	*Definition from the International Association of Oil and Gas Producers.*

Accuracy *[ISO/TC211]*
Closeness of agreement between a test result and the accepted reference value.

Affline operation *[GIGS]*
Coordinate operation on plane coordinates involving an origin shift and separate rotations and/or scale/unit changes affecting the two axes.

> *Note: this type of operation is often called an affine transformation, but it may exist either as a coordinate conversion or as a coordinate transformation. In the first case the operation parameters have defined values, such as with a seismic bin grid; in the second case these values are empirically determined from survey data, such as for an engineering plant grid.*

ASCII
American Standard Code for Information Interchange.

> *Note: See* http://www.ascii.cl.

Audit Trail *[GIGS]*
The facility provided by a software package to permit independent review and verification of the integrity of its datasets, by tracking and logging each of the operations performed on the dataset.

Auxiliary Metadata *[GIGS]*
Data captured to support the *audit trail*; in particular, data about all *coordinate operations* (*conversions* & *map projections*, *coordinate transformations*) and *CRS* applied to the geoscience dataset over time, from its original *CRS* through to the final *CRS* used in each module.

Azimuth *[GIGS]*
Angle between the North reference and the direction from a point to another point, clockwise positive.

> *Note: the North reference may be 'grid North', 'true North', 'magnetic North' or 'local North'.*

Base geographic CRS *[GIGS]*
Geographic CRS from which a *projected CRS* is defined by applying a map projection to the associated geographical coordinates.

Cartesian coordinate system *[ISO/TC211]*
Coordinate system which gives the position of points relative to n mutually perpendicular axes.

Compliance *[GIGS]*
Agreement to a norm, either precisely or within an acceptable tolerance

Note: 'compliance' may refer to terminology as e.g. specified in ISO 19111 or the 'EPSG Dataset', in which case agreement needs to be precise; or it may refer to numerical equivalence to tests specified in the GIGS Test Dataset.

Compound CRS *[ISO/TC211]*
Coordinate Reference System using at least two independent *Coordinate Reference Systems.*

Note: in the context of GIGS a 'compound CRS' is always a union of a 'geographic 2D CRS' or a 'projected CRS', or a horizontal 'engineering CRS' with a 'vertical CRS'. A 2D horizontal 'engineering CRS', combined with a 1D vertical 'engineering CRS' is not a 'compound CRS', but an 'engineering 3D CRS'.

Concatenated coordinate operation *[ISO/TC211]*
Coordinate operation consisting of sequential application of multiple coordinate operations.

Note: a 'concatenated coordinate operation' usually consists of a sequence of 'coordinate transformations', i.e. no 'coordinate conversions' included in that sequence. For that reason is has become customary to speak of a 'concatenated coordinate transformation'.

Concatenated coordinate transformation *[GIGS]*
Concatenated coordinate operation consisting of sequential application of multiple *coordinate transformations*.

Conversion
See *coordinate conversion*.

Coordinate *[ISO/TC211]*
One of a sequence of n scalar numbers designating the position of a point in n-dimensional space.

Coordinate conversion *[ISO/TC211]*
Coordinate operation in which the two *coordinate reference systems* are based on the same *datum*.

Example: a 'map projection'.

Note: 'coordinate conversions' either have no parameters or have defined (i.e. precise) parameter values.

Coordinate dataset
See *coordinate set*.

Coordinate operation *[ISO/TC211]*
Change of coordinates, based on a one-to-one relationship, from one *CRS* to another.

Note: see also 'coordinate transformation' and 'coordinate conversion'.

Coordinate reference system (CRS) *[ISO/TC211]*
Coordinate system that is related to an object by a *datum*.

Note 1: for 'geodetic datum' and 'vertical datum', the object will be the Earth.

Note 2: 'coordinate reference system' is normally abbreviated to CRS.

Note 3: types of CRS distinguished in ISO 19111 are: 'geodetic CRS', 'projected CRS', 'vertical CRS', and 'engineering CRS'. In the EPSG Dataset 'geodetic CRS' is sub-divided into 'geocentric CRS', 'geographic 3D CRS', and 'geographic 2D CRS'.

Coordinate set *[ISO/TC211]*

Collection of *coordinate tuples* related to the same *coordinate reference system*.

Note: identical to 'coordinate dataset'.

Coordinate system *[ISO/TC211]*

Set of mathematical rules for specifying how coordinates are to be assigned to points.

Note: the 'coordinate system' defines what type of quantities the coordinates are and provides an implied reference to the manner in which geometrical quantities such as angles and distances are derived from coordinate values. The coordinate system does this by describing the coordinate axes and their relationships. This is expressed in the type of coordinate system (ellipsoidal 2D & 3D, Cartesian 2D & 3D, vertical). Coordinate system also requires specification of the axes names, their orientation and unit of measure and their order. Coordinates in a coordinate tuple must be provided in the same order as the axes, as specified in the associated coordinate system.

Coordinate transformation *[ISO/TC211]*

Coordinate operation in which the two *coordinate reference systems* are based on different *datums*.

Note 1: a change of coordinates, referenced to one CRS, to become referenced to another CRS, and comprising a different 'datum'.

Note 2: 'coordinate transformations' are known under a variety of alternative names in the E&P industry, e.g. datum transformation, datum shift, datum conversion, geo-transform, etc.

Coordinate tuple *[ISO/TC211]*

Tuple composed of a sequence of coordinates.

CRS

See *coordinate reference system*.

CSV

A comma-separated values or character-separated values (CSV) file is a simple text format for a database table. Each record in the table is one line of the text file. Each field value of a record is separated from the next by a character (typically a comma but some European countries use a semi-colon as a value separator instead of a comma). Implementations of CSV can often handle field values with embedded line breaks or separator characters by using quotation marks or escape sequences.

Note: definition from http://en.wikipedia.org/wiki/Comma-separated_values.

Data exchange format

Defined format for the exchange of digital data.

Note: see OGP, SEG, UKOOA (now known as Oil & Gas UK).

Data Operation *[GIGS]*
Any action performed on spatial data.

> *Note: this may refer to data import, data export, data transfers within the software or between software packages or any other data manipulation, including specifically 'coordinate operations'.*

Dataset *[ISO/TC211]*
Identifiable collection of data.

> *Note: In GIGS a dataset is interpreted as a collection of data produced by a softwarepackage; it may be used for output, export or as input to another part of the same software.*

Datum *[ISO/TC211]*
Parameter or set of parameters that define the position of the origin, the scale, and the orientation of a *coordinate system*.

> *Note: see also 'geodetic datum', 'vertical datum' and 'engineering datum'.*

Deprecation *[GIGS]*
Process of rendering a data item invalid or obsolete by removing or flagging the item. In the EPSG Dataset deprecation is achieved by setting a flag associated with the data item.

Depth
See *gravity-related height (or depth).*

Early binding *[GIGS]*
A priori association of a *coordinate transformation* with a *geodetic CRS*.

> *Note: the association is usually made at start-up of the session or project, as that is defined in the software, but always before any data is associated with the 'CRS'. In general the 'coordinate transformation' specified uses the 'CRS' of the data as the source 'CRS' and WGS 84 as the target 'CRS'.*

Easting *[ISO/TC211]*
Distance in a *coordinate system*, eastwards (positive) or westwards (negative) from a North-South reference line.

> *Note: easting may be designated e.g. by E, x or y; this is defined in the 'coordinate system' in use with the specific 'CRS'.*

Ellipsoid *[ISO/TC211]*
Surface formed by the rotation of an ellipse about a main axis.

> *Note: in ISO 19111 and the 'EPSG Dataset' ellipsoids are always oblate, meaning that the axis of rotation is always the minor axis.*

Ellipsoidal coordinate system *[ISO/TC211]*
Coordinate system in which position is specified by *geodetic latitude*, *geodetic longitude* and (in the three-dimensional 3D case) *ellipsoidal height*.

> *Note 1: Only used as part of a three-dimensional ellipsoidal coordinate system and never on its own.*
>
> *Note 2: Ellipsoidal height is commonly designated by h.*
>
> *Note 3: See also 'gravity-related height'.*

Engineering CRS *[ISO/TC211]*
Coordinate reference system based on an *engineering datum*.

> *Example: engineering plant grids, well location plants, 3D seismic bin grids, well tracks.*

Engineering Datum *[ISO/TC211]*
Datum describing the relationship of a *coordinate system* to a local reference.

> *Example: Reference points of engineering plant grids, well tracks, etc.*

EPSG *[OGP]*
Acronym of the European Petroleum Survey Group, formerly a forum of chief surveyors and geodetic experts from European-based E&P operators. This forum has been absorbed into the International Oil and Gas Producers Association as the OGP Surveying & Positioning Committee. The acronym EPSG remains associated as a brand name with the *EPSG Geodetic Parameter Dataset*, a product of the original EPSG.

EPSG code *[OGP]*
Numeric code allocated to geodetic data objects in the *EPSG Dataset*.

> *Note: Also see 'EPSG Geodetic Parameter Dataset'.*

EPSG data model *[OGP]*
The data model that underlies the *EPSG Geodetic Parameter Dataset*.

> *Note: the EPSG data model is a profile, i.e. a consistent sub-model, of 'ISO 19111'.*

EPSG Dataset
See *EPSG Geodetic Parameter Dataset*.

EPSG Geodetic Parameter Dataset *[OGP]*
Dataset of *geodetic data objects* with worldwide coverage, published by *OGP*.

> *Note 1: Also known as 'EPSG Dataset'.*
>
> *Note 2: The dataset is distributed through a web-based delivery platform (see 'EPSG Registry'), or in an MS Access relational database and SQL script files. See* http://info.ogp.org.uk/geodesy/.

EPSG Registry *[OGP]*
The *EPSG Geodetic Parameter Registry*, a web-based delivery platform for the *EPSG Geodetic Parameter Dataset*.

> *Note: The EPSG Registry can be accessed in any web browser at:* http://www.epsg-registry.org.

ESRI geodatabase feature classes
ESRI Personal Geodatabase Feature Classes and ESRI File Geodatabase Feature Classes are both recommended, imported/exported to and from ESRI applications.

> *Note: see* http://www.esri.com.

E&P
Exploration & Production (of oil and natural gas).

Geodetic data object *[GIGS]*

A component part of the geodetic data model implemented in the software or the *EPSG data model*.

Example: Geodetic data objects may be CRS, coordinate transformation, datum, ellipsoid, map projection, coordinate system, etc.

Note 1: the term 'EPSG geodetic data object' in this documentation refers to geodetic data objects defined in the 'EPSG Dataset'.

Note 2: see also 'geodetic parameter' and 'parameter value'.

Geodetic parameter *[GIGS]*

Component part of a 'geodetic data model', not itself a geodetic data object.

Note 1: This may be a parameter belonging to a 'coordinate conversion' or 'coordinate transformation', one of the defining parameters of an 'ellipsoid', etc., but it also refers to the attributes of a 'geodetic data object', such as its name and the 'EPSG code' of the object.

Note 2: Where the term, 'EPSG geodetic parameter' is used in this documentation, geodetic parameters as defined in the 'EPSG Dataset' are meant.

Geocentric CRS *[OGP]*

A 'geodetic CRS' using an earth-centred Cartesian 3D 'coordinate system'; the origin of a geocentric CRS is at the centre of mass of the Earth.

Note 1: also known as ECEF (Earth-Centred, Earth-Fixed).

Note 2: associated 'coordinate tuples' consist of X, Y and Z coordinates.

Note 3: definition from 'OGP Guidance Note 7, Part 1: Using the EPSG Geodetic Parameter Dataset', with URL: http://www.epsg.org/guides/docs/G7-1.pdf.

Geodetic CRS *[ISO/TC211]*

Coordinate reference system based on a *geodetic datum*.

Note: see 'geocentric CRS', 'geographic 2D CRS', 'geographic 3D CRS'.

Geodetic datum *[ISO/TC211]*

Datum describing the relationship of a two- or three-dimensional coordinate system to the Earth.

Geodetic latitude *[ISO/TC211]*

Angle from the equatorial plane to the perpendicular to the *ellipsoid* through a given point, northwards treated as positive.

Note: usually just referred to as 'latitude', geodetic latitude is normally designated by φ.

Geodetic longitude *[ISO/TC211]*

Angle from the *prime meridian* plane to the meridian plane of a given point, eastward treated as positive.

Note: usually just referred to as 'longitude', geodetic longitude is normally designated by λ.

Geographic 2D CRS *[OGP]*

A *geodetic CRS* using a 2D *ellipsoidal coordinate system*, where ellipsoidal height is undefined.

Note 1: used when positions of features are described on the surface of the 'ellipsoid' through 'latitude' and 'longitude' coordinates.

Note 2: definition from, 'OGP Guidance Note 7, Part 1: Using the EPSG Geodetic Parameter Dataset', with URL: http://www.epsg.org/guides/docs/G7-1.pdf.

Geographic 3D CRS *[OGP]*
A *geodetic CRS* using a 3D *ellipsoidal coordinate system*, where ellipsoidal height is defined.

> *Note 1: used when positions of features are described on, above or below the surface of the 'ellipsoid' through 'latitude' and 'longitude' coordinates, and 'ellipsoidal height'.*
>
> *Note 2: definition from 'OGP Guidance Note 7, Part 1: Using the EPSG Geodetic Parameter Dataset', with URL:* http://www.epsg.org/guides/docs/G7-1.pdf.

Geographic CRS *[OGP]*
Collective term for any *geodetic CRS* using an ellipsoidal model of the Earth. See *geographic 2D CRS* and *geographic 3D CRS*.

Geographic north *[GIGS]*
Direction from a given location pointing towards the Geographic North Pole.

> *Note: See also 'True north'.*

Geoid *[ISO/TC211]*
Equipotential surface of the Earth's gravity field which is everywhere perpendicular to the direction of gravity and which best fits mean sea level either locally or globally.

Geomatics
Geomatics Engineering is an emerging information technology in the 21st Century. Geomatics deals with the acquisition, modelling, analysis and management of spatial data and includes exciting applications such as positioning by satellites, remote sensing, land surveying, and geospatial information management.

> *Note 1: it includes all forms of land & hydrographic surveying, positioning, mapping, & boundary determination, and is based on the scientific framework of geodesy, applying modern technologies such as GIS, photogrammetry, terrain modelling and cartography.*
>
> *Note 2: definition by University of Calgary, Department of Geomatics Engineering. See:* http://www.geomatics.ucalgary.ca/about.

Geomatics Committee *[OGP]*
OGP Geomatics Committee. One of ten standing committees (at the time of writing) of OGP, comprised of leading specialists in the areas of surveying, geodesy, cartography and spatial data management.

> *Note: the OGP Geomatics Committee aims to help members by:*
>
> - *developing and disseminating best practice through guidelines of relevance in the fields of geodesy, surveying and positioning;*
> - *providing a forum for exchanging experiences and knowledge;*
> - *influencing regulators and standards organisations;*
> - *maintaining international positioning exchange formats and a geodetic parameter database (known as EPSG Geodetic Parameter Dataset);*
> - *liaising with industry associations.*
>
> *See:* http://www.info.ogp.org.uk/geodesy/.

Geoscience *[GIGS]*
All scientific disciplines relating to studies of the subsurface, including Geology, Geophysics, Geodesy, Geomatics, Geotechnical studies and others.

Geoscience software *[GIGS]*
Any computer package used in *geoscience* activities, including applications, along with their user interfaces, processing packages, and underlying databases; also included as applications are geodetic data engines, extensions and middleware.

Geospatial data *[NGA]*
Data concerning the Earth and the manmade features on the Earth that can be shown on maps, navigation charts, and images.

Note: geospatial data includes a 'coordinate dataset' and its 'geospatial metadata'.

Geospatial integrity *[GIGS]*
The extent to which *geospatial data* are complete, correct, consistent and verifiable.

Note: geospatial integrity applies to the software functions which address data import, creation, merging, processing, 'coordinate operations' & 'map projections', visualisation, and export. It is therefore more than a static property of geospatial data.

Geospatial metadata *[GIGS]*
The *CRS* to which the *coordinate dataset* is referenced, extended by the definition of any *coordinate operations* when relevant.

Note:'coordinate operation' information is relevant when the geospatial data was originally collected in a different 'CRS'. It is not relevant when the 'geospatial data' is not (going to be) merged with 'geospatial data' that is referenced to another 'CRS'.

GeoTIFF
Data exchange format for geo-referenced raster imagery. Current version is *v1.0*.

Note: see: http://trac.osgeo.org/geotiff/.

GIGS *[OGP]*
A Joint Industry Project, under the auspices of *OGP* (JIP 24), created to produce industry guidelines for the evaluation of the capabilities of geoscience software regarding *geospatial integrity*.

GIGS guidelines *[OGP]*
Public-release products from the GIGS Joint Industry Project, published as OGP Publications 430-1, 430-2 and 430-3.

Note: see: http://www.ogp.org.uk/publications.

GIGS JIP
See *GIGS* and *JIP*.

GIGS Test Dataset *[OGP]*
A dataset created to enable tests of *coordinate operations*; based on use of the *EPSG Dataset*, and using methods and formulae outlined in 'OGP Guidance Note 7, Part 1: Coordinate Conversions and Transformations including Formulas'.

Note: http://www.epsg.org/guides/docs/G7-2.pdf.

Gravity-related height (or depth) *[ISO/TC211]*
Height (or *depth*) dependent on Earth's gravity field.

Note 1: See also 'ellipsoidal height'.

Note 2: Gravity-related height is normally designated by H, and depth by D.

Grid north *[OGP]*
The direction from a given location pointing along a line of equal *easting* (or *westing*) in a projected *CRS*.

Note: also known as *map north*.

Height
See *gravity-related height* and *ellipsoidal height*.

International Standard
Standard published by the International Organization for Standardization.

Note: International Organization for Standardization is commonly abbreviated as ISO.

ISO 19111
International Standard describing a *data model* for *geospatial metada*.

Note 1: Its full title is: 'Geographic information – Spatial referencing by coordinates'. See: http://www.isotc211.org.

Note 2: See 'EPSG Data Model'.

ISO/TC211
ISO Technical Committee 211. Its scope is defined as: "standardisation in the field of digital geographic information.
Note: 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."

Note: see http://www.isotc211.org.

JIP *[OGP]*
Joint Industry Project, a commonly used term to describe a project which is jointly funded by a number of companies who share a specific technical problem, and wish to propose industry-wide solutions for the betterment of all parties.

Latitude
See *geodetic latitude*.

Late binding *[GIGS]*
Association at run time of a *coordinate transformation* with a *CRS*.

Note: late binding allows the user to select the appropriate transformation upon import of 'geospatial data' or merge of two geospatial datasets. This means that, in cases where there are multiple existing transformations, the user can choose the appropriate one, possibly aided by additional information.

Local north *[OGP]*
Arbitrarily chosen reference direction for azimuths for local usage.

Note: use of nocal north is not always associated with an 'engineering CRS'.

Example: the angle between 'rig north' may be defined along the axis of a rig regardless of its relationship to earth orientation.

Longitude
See *geodetic longitude*.

Magnetic north *[OGP]*
Direction of the projection of magnetic field lines to the horizontal plane, pointing approximately towards the Earth's magnetic north pole.

Map grid *[OGP]*
The realisation of a *projected CRS*.

Map projection *[ISO/TC211]*
Coordinate conversion from an ellipsoidal *coordinate system* to a plane.

> *Note: Also see coordinate conversion.*

MD
Measured Depth, in well log data.

Metadata *[ISO/TC211]*
Data about data.

> *Example: 'CRS' metadata gives all the parameters which are necessary to interpret the meaning of 'coordinate data', and correlate them with other 'coordinate datasets'.*

Nomenclature *[GIGS]*
Names, definitions and terminology applied to given class of data. Used particularly with reference to *geodetic data objects* and their associated *geodetic parameters* in the *EPSG Dataset*.

Northing *[ISO/TC211]*
Distance in a *coordinate system*, northwards (positive) or southwards (negative) from an East-West reference line.

> *Note: Northing may be designated by e.g. N, y or x depending upon the 'coordinate system' in use with the relevant 'CRS'.*

OGC
The Open Geospatial Consortium, Inc.® - a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial and location-based services.

> *Note: see* http://www.opengeospatial.org/.

OGP *[OGP]*
The International Association of Oil & Gas Producers - encompasses most of the world's leading publicly-traded, private and state-owned oil & gas companies, oil & gas associations and major upstream service companies.

> *Note: see* http://www.ogp.org.uk.

P1/84 *[OGP]*
Industry standard seismic post plot positioning data exchange format previously established by *UKOOA* (now Oil & Gas UK) and currently maintained by *OGP*.

Note: current version is P1/11 but the P1/84 version is still important with legacy data. See http://www.epsg.org/p-formats.html.

P1/90 *[OGP]*
Industry standard seismic post plot positioning data exchange format previously established by *UKOOA* (now Oil & Gas UK) and currently maintained by *OGP*.

Note 1: current version is P1/11 but P1/90 version is still important with legacy data. See http://www.EPSG.org/p-formats.html.

Note 2: Q records are utilized for bin-centre input data in 3D seismic surveys, even though such records do not represent the final navigation bin-centre locations.

P1/11 *[OGP]*
Industry standard geophysical positioning data exchange format scheduled for release by OGP Geomatics Committee Q4 2011.

Note: see http://www.EPSG.org/p-formats.html.

P5/94 *[OGP]*
Industry standard pipeline position data exchange format previously established by *UKOOA* (now Oil & Gas UK) for use on the UKCS and currently maintained by *OGP*.

Note 1: current version is P5/94. See http://www.EPSG.org/p-formats.html.

Note 2: pipeline data is only considered here as an input for mapping purposes.

P6/98 *[OGP]*
Industry standard format for the definition of 3D Seismic Binning Grids and the associated data exchange, previously established by *UKOOA* (now Oil & Gas UK) and currently maintained by *OGP*. Current version is P6/98, revised in 2000 and currently under review (see Note 2 below).

Note 1: see http://www.EPSG.org/p-formats.html.

Note 2: an OGP task force is currently undertaking a review of P6 with a new version expected to be published Q4 2011 or Q1 2012.

P7/2000 *[OGP]*
Industry standard well deviation data exchange format previously established by *UKOOA* (now Oil & Gas UK) and currently maintained by *OGP*.

Note 1: current version is Rev 5, /2000. See http://www.EPSG.org/p-formats.html.

Note 2: contains description of well curve data, through wellbore survey measurement data (measured depth, inclination and azimuth) or calculated positions.

P-EPSG *[OGP]*
'EPSG Coordinate Reference System Description in UKOOA P-Formats', maintained by OGP.

Note 1: see http://www.EPSG.org/p-formats.html.

Note 2: contains detailed information on compiling 'CRS' information in the other P-Formats.

Parameter value *[OGP]*
Value allocated to one specific instance of *geodetic parameter*.

Example: a parameter value of 6,378,137 is allocated to the geodetic parameter with the name 'semi-major axis' of a geodetic data object with the name 'ellipsoid'. The same object has the parameter value 'WGS 84' for its 'name' attribute.

> *Note: where the term 'EPSG parameter value' is used in this documentation, parameter values as recorded in the 'EPSG Dataset' are meant.*

Polar coordinate system *[ISO/TC211]*
2-dimensional *coordinate system* in which position is specified by distance and direction from the origin.

Precision *[ISO/TC211]*
Measure of the repeatability of a set of measurements.

Prime meridian *[ISO/TC211]*
Meridian from which the longitudes of other meridians are quantified.

> *Note: this is usually the Greenwich prime meridian, but usage of other prime meridians, Ferro, Bogota, Paris, Jakarta etc.*

Projected CRS *[ISO/TC211]*
CRS derived from a 2-dimensional *geodetic CRS* by applying a *map projection*.

> *Note: a projected CRS is sometimes referred to as a 'map grid'; 'coordinates' in a projected CRS are sometimes referred to as grid coordinates.*

Quality *[ISO/TC211]*
Totality of characteristics of a product that bear on its ability to satisfy stated and implied needs.

> *Note: quality is often expressed as 'fitness for purpose'.*

SEG
Society of Exploration Geophysicists. A not-for-profit organization that promotes the science of applied geophysics and the education of geophysicists.

> *Note: see* http://www.seg.org *link to Technical Standards.*

SEG-PI
Postplot location data exchange format 1983.

> *Note: the SEG-P1 format generally superseded by OGP P1/90 but is still important with legacy data. See* http://www.seg.org *link to Technical Standards.*

SEG-Y
Seismic data recording format, including position data.

> *Note: current version is Rev 1 2002. Earlier versions may be important with legacy data. See* http://www.seg.org *link to Technical Standards.*

Shape files
.shp format and associated files used for spatial data, to store non-topological geometry and attribute information for the spatial features in a data set. The geometry for a feature is stored as a shape comprising a set of vector coordinates. Used in conjunction with other essential files for data exchange. Developed and regulated by *ESRI*.

> *Note: current version July 1998. See* http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf.

Southing *[OGP]*
Distance in a *coordinate system*, southwards (positive) or northwards (negative) from an East-West reference line.

> *Note 1: southing is rarely encountered and is applicable only to south orientated coordinate systems and may be designated by e.g. S, y or x.*
>
> *Note 2: definition from 'OGP Guidance Note 7, Part 1: Using the EPSG Geodetic Parameter Dataset', with URL:* http://www.epsg.org/guides/docs/G7-1.pdf.

SPS
SPS format - SEG Technical Standards Committee on Ancillary Data Formats, Shell Processing Support Format for Land 3-D Surveys, 2006.

> *Note: current version is SPS rev 2.1. See* http://www.seg.org *link to Technical Standards.*

Transformation
See *coordinate transformation*.

True north
See *geographic north*.

Tuple *[ISO/TC211]*
Ordered list of values.

> *Note: see also 'coordinate tuple'.*

TVD
True Vertical Depth: the vertical distance from a point in the well (usually the current or final depth) to a point at the surface, usually the elevation of the rotary kelly bushing (RKB).

> *Note 1: see* http://www.glossary.oilfield.slb.com.
>
> *Note 2: the vertical 'CRS' of a TVD value is a 1D 'engineering CRS' of which the (positive) axis points down, its direction coinciding everywhere with the vector of gravity.*

TVDBML
TVD below Mud Line - for well data.

TVDSS
TVD sub-sea (below sea level) - for well data.

UKOOA
United Kingdom Offshore Oil and Gas Industry Association, trading as Oil & Gas UK, was originally known as the UK Offshore Operators' Association. It is the leading representative body for the UK offshore oil and gas industry.

> *Note 1: several of the data exchange formats referenced in this document were originally published by UKOOA. Responsibility for the maintenance of these formats passed to OGP in 2006.*
>
> *Note 2: see* http://www.oilandgasuk.co.uk.

Unit *[ISO/TC211]*
Defined quantity in which dimensioned parameters are expressed.

Note: also referred to as 'unit of measure'. In the EPSG Dataset three types of unit are distinguished: linear, angular and scale.

Vertical coordinate system *[ISO/TC211]*
1-dimensional *coordinate system* used for *gravity-related height* or *depth* measurements.

Vertical CRS *[ISO/TC211]*
1-dimensional *CRS* based on a vertical datum.

Vertical datum *[ISO/TC211]*
Datum describing the relation of *gravity-related heights* or *depths* to the Earth.

Vertical transformation *[GIGS]*
Coordinate transformation applied to heights or depths.

Note: this may apply to 'gravity-related heights' or 'depths' and to 1D 'engineering CRSs' with a vertical coordinate axis.

Wellbore survey data *[GIGS]*
The set of *Measured Depth (MD)*, azimuth and inclination *tuples* observed in points along a wellbore in a wellbore survey.

Well track *[GIGS]*
The set of *coordinates* of identified points along the wellbore, calculated from wellbore survey data for that wellbore.

Westing *[OGP]*
Distance in a *coordinate system*, westwards (positive) or eastwards (negative) from a North-South reference line.

Note: westing is rarely encountered and is only applicable to 'coordinate systems' that are positive westward and may be designated by e.g. W, x or y depending upon the 'coordinate system' in use with a specific 'CRS'.

Recommended reading

The following are listed here for their useful background.

Iliffe, J. and Lott, R. – Datums and Map Projections: for Remote Sensing, GIS and Surveying, Second Edition 2008 – ISBN 978-1-4200-7041-5 (USA only), ISBN 978-1-904445-47-0 (World except USA).

ISO Standards – contact: http://www.iso.org/iso/home.htm for details of ordering. Of particular relevance to GIGS are:

ISO 6709: Standard representation of geographic point location by coordinates

ISO 19111: Geographic information – Spatial referencing by coordinates

OGP S&P Guidance Notes - they can be downloaded from: http://www.epsg.org/guides. Of particular relevance to GIGS are:

OGP Guidance Note 7, part 1 - Using the EPSG Geodetic Parameter Dataset - OGP Publication 373-07-1

OGP Guidance Note 7, part 2 Coordinate Conversions and Transformations including Formulas - OGP Publication 373-07-2

OGP Guidance Note 1 Geodetic Awareness - OGP Publication 373-01

OGP Guidance Note 5 Coordinate reference system definition - OGP Publication 373-05

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