International Association of Oil & Gas Producers

REPORT 430-1

NOVEMBER 2021

Geospatial Integrity of Geoscience Software (GIGS) Guidance Note

Acknowledgements

This report was authored by the IOGP GIGS Task Force in collaboration with the IOGP Geodesy Subcommittee, Geophysical Operations Subcommittee, and P7 Task Force, all under the auspices of the IOGP Geomatics Committee. The authors wish to thank all involved for their contributions.

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About

GIGS is an open-source digital testing framework designed to evaluate the capability of software in establishing and maintaining the integrity of geospatial data. It is primarily aimed at geoscience applications, but elements can be readily applied to any software that handles spatial data. The testing framework comprises a series of qualitative evaluations that assess software functionality and configuration, coupled with data-driven tests that quantify the accuracy and robustness of geodetic engines and libraries, in executing coordinate operations. The test package is supported by two documents, a general Guidance Note on the theory of geospatial integrity and GIGS testing (IOGP Report 430-1, this document), as well as a comprehensive User Guide providing technical procedures for executing the GIGS tests (IOGP Report 430-2).

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Revision history

VERSION	DATE	AMENDMENTS
2.0	November 2021	Major revision
1.0	September 2011	First release

Contents

Introduction

Background

The energy industry makes extensive use of geoscience software that handles spatial data, in support of safely and efficiently exploring for, producing, and storing sources of energy. The number of applications that handle spatial data has grown exponentially in the past decade as widespread digitalization has resulted in a significant increase in the volume, variety and veracity of spatial data being generated and exchanged.

A diverse range of geophysical, wellbore and cultural data are brought into such applications, where they are visualised, processed and exported to other software, shared with other users, and interpreted to form the basis of major operational and business decisions. Such datasets, referred to hereafter as 'geoscience data', are referenced to a location in 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.

There are thousands of different software packages available for use in the energy industry, as well as dozens of different geodetic engines and libraries. It has been estimated that a typical project will involve over a hundred transactions where data is 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 is complete, consistent, correct, and verifiable, and remains so during any 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 also be compromised.

Failure of the geospatial integrity of geoscience data sometimes can be attributed to a lack of understanding or knowledge of the user managing the data, but in other cases it can be traced to deficiencies or failings in the implementation, configuration or operation of the software.

In 2009, a joint industry project (JIP) sponsored by IOGP, was formed in response to significant concern and documented evidence of safety-critical geospatial data integrity failures in geoscience applications. In 2011, the first version of the Geospatial Integrity of Geoscience Software (GIGS) framework was released comprising technical recommendations, a series of software evaluation tests and a supporting set of standard test data. The entire testing package was subsequently revised, updated and re-released as open source in 2021, with enhancements intended to make the GIGS testing process simpler, more flexible, and easier to integrate programmatically.

Purpose

This document provides foundational information on geospatial data integrity and an overview of the GIGS process, with guidelines on how to plan and complete a GIGS evaluation.

The purpose of this Guidance Note is to provide geoscience software developers and users with recommended industry best practice to evaluate the capabilities of software with respect to establishing and maintaining geospatial data integrity. The Guidance Note aims to support the identification of geospatial integrity failures, via execution of the GIGS process, thereby reducing or eliminating incorrect results, inconsistent understanding and misleading information in the user community.

To fulfil this purpose, GIGS comprises a number of elements which can be which can be accessed via the GIGS main site (https://gigs.iogp.org):

- GIGS Guidance Note (IOGP Report 430-1, this document), describing the GIGS process
- GIGS User Guide (IOGP Report 430-2), providing specific procedural information on the GIGS Test Series and GIGS Test Dataset[1]
- GIGS Test Series package[2], containing the framework of tests in a checklist structure to undertake the evaluation, delivered by web portal or spreadsheet format
- GIGS Test Dataset package[3], comprising a compiled set of data files used for testing algorithms and data exchange capabilities
- GIGS Media Pack, made up of presentation material and engagement content

Scope

This Guidance Note is intended for wide use by anyone that manages or utilizes geospatial data, with a focus on energy industry users. It specifically addresses the developers, vendors, and users of geoscience software.

In this Guidance Note the term 'software' includes any executable code and underlying database (either cloud based or on-premise) used in spatial data manipulation, including applications, processing packages and their user interfaces. It also includes software components, such as geodetic computation engines, extensions, and libraries.

This Guidance Note applies especially to the software functions that address spatial data import, creation, manipulation, merging, processing, coordinate operations (including transformations and conversions), visualization, mapping, and export. It is, however, 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) 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 reference integrity and maintaining the geospatial quality inherent in the original data set.

[1] Previously GIGS comprised 3 Guidance Notes (430-1, 430-2 and 430-3), however due to the creation of the web platform, 430-2 and 430-3 have been consolidated and merged.

[2] Previously this was released as "430-2a", but due to the now web-based delivery the numbering has been dropped.

[3] Previously this was released as "430-3a", but due to the now web-based delivery the numbering has been dropped.

1. Geospatial Integrity Technical Background

1.1 Definition

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

Table 1: Defining principles of geospatial integrity.

Completeness	Geospatial data must be associated with an appropriate coordinate reference system (CRS), which should be fully defined. 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[4]	The defining parameters of CRSs and coordinate operations must be free from numerical and terminological errors, as well as being up to date in their definitions. Applications must honour the precision of the coordinates, insofar as no apparent precision may be suggested by the addition of decimal places, and coordinate operations must be executed commensurate with the precision of coordinates and the accuracy of the algorithm.
Consistency	Data model, terminology and algorithms must be applied consistently through the software.
Verifiability	The user must be able to ascertain that completeness, correctness and consistency have been achieved and maintained.

In some instances in industry and literature the term 'geodetic integrity' may also be used to describe such concepts. However in IOGP documentation the term 'geospatial integrity' is preferred as it refers to other elements of the data, i.e., more than just the geodetic algorithms and formulae.

1.2 Geospatial Data

Figure 1 below shows a conceptual model describing the relationship between the geospatial and non-geospatial elements of geoscience data.

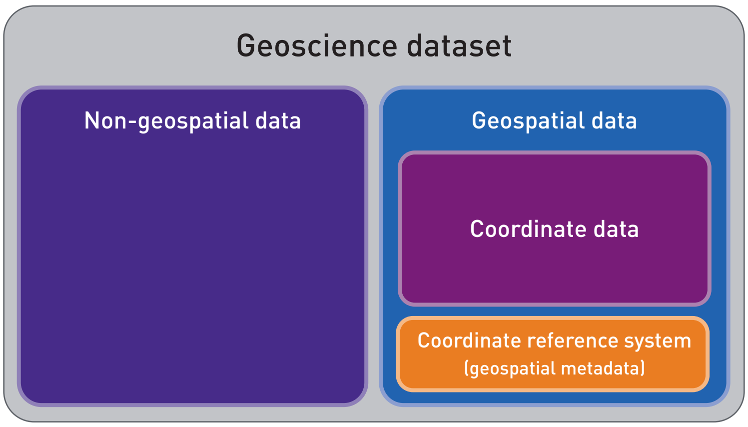

Figure 1: Conceptual model of geospatial data.

[4] In some data quality assessments, Currency is considered the "fourth C", in this case the assessment of Correctness incorporates the requirement to ensure data is current in its definition.

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 data
- 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. Where both the coordinate data 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 1.1 above are not met, geospatial integrity has failed 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 verified has a direct impact on the quality of a geoscience dataset, its fitness for a defined purpose and impact on the overall 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, manipulate, merge, correlate, visualise, map, and transfer that data.

As shown in Figure 2 below, coordinate data 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. Such coordinates may also contain a third (elevation) or fourth (time) dimension.

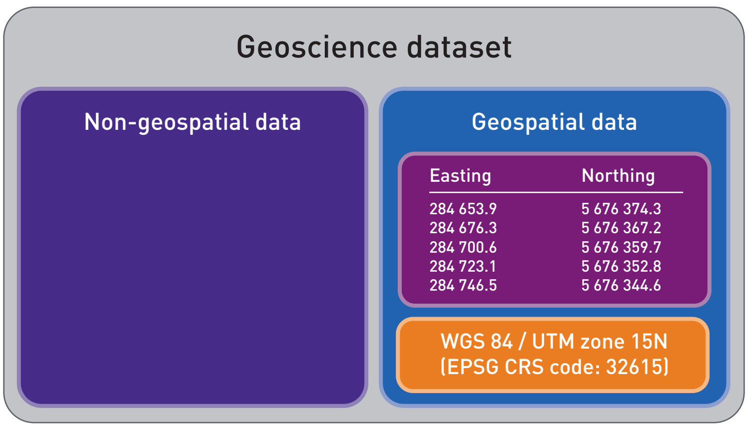

Figure 2: Example of coordinate tuples with their coordinate reference system[5]

[5] Note - this diagram considers only static CRS and does not represent the construct of dynamic entities.

Coordinates (or coordinate tuple) are only considered complete and unambiguous when they are 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. A fundamental 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, axis order, and unit(s) of measure, constitutes the concept coordinate system. For projected (map grid) coordinates the conversion definitions (including the projection method) are required. All these concepts are defined in International Standard ISO 19111[6]. Well-known text (WKT2) is a text markup language that can be used to represent defining geodetic parameters in a standard way, according to ISO 19162[7].

IOGP Report 373-05 *Geomatics Guidance Note 5: Coordinate reference system definition – recommended practice*[8] contains further background on the CRS basic concept, and examples of typical CRSs in the energy industry.

1.3 Key Geodesy Concepts

To fully understand geospatial integrity, and the solutions offered by GIGS, it is necessary to understand the conceptual background of geodetic referencing. The subject is too large to be treated completely in this document and is addressed elsewhere in large part by IOGP. Software developers and users are strongly urged to consult IOGP Report 373-01 *Geomatics Guidance Note 1: Geodetic awareness*[9] and 373-25 *Geomatics Guidance Note 25: Dynamic CRS versus static CRSs*[10], which provide more detail and develop the following key concepts:

- Coordinates are ambiguous unless the coordinate reference system (CRS) to which they are referenced is fully identified and kept[11] with the coordinates
- Latitude and longitude (or 'geographical coordinates') are typically used to define points on a curved representation of the surface of the earth (an ellipsoid); however a latitude and longitude graticule can be plotted on a two-dimensional map.
- The reference ellipsoid on its own does not define a geodetic datum; a specific ellipsoid (e.g. 'Clarke 1866') can be the basis for many geodetic datums. As well as an ellipsoid, a geodetic datum defines the scale, orientation and origin of the ellipsoid.
- A geodetic datum can have only one reference ellipsoid; identifying a specific datum implies that ellipsoid and no other.
- Easting and northing coordinates are used to define points on a projected plane. The use of "x" and "y" can confuse as their orientation can vary with respect to the associated CRS.
- Conversion (map projection) formulae distort the true curved surface of the earth in a number of ways - area, shape, orientation or scale, by representing it on a two-dimensional flat map surface. Different projection types distort different elements and in different ways, and the magnitude of distortion varies across the mapped area.

[6] ISO 19111:2019 Geographic information — Referencing by coordinates
[7] ISO 19162:2019 Geographic information — Well-known text representation of coordinate reference systems
[8] https://www.iogp.org/bookstore/product/crs-definition-rp/
[9] https://www.iogp.org/bookstore/product/geodetic-awareness-guidance-note/
[10] https://www.iogp.org/bookstore/product/geomatics-guidance-note-25-dynamic-versus-static-crss-and-use-of-the-itrf/
[11] "Kept" refers to some mechanism of storing coordinate data with associated geodetic parameters, such as a companion file or embedded metadata – it does not necessarily refer to early vs late bound CRS

- Map (grid) coordinates are not unique unless qualified with all parameters of the projected CRS (including specification of its base geographic CRS, its conversion [map projection] and its coordinate system).
- Heights are not unique unless the vertical CRS to which they are referenced, including the vertical datum, is identified.
- Azimuths and bearings are not unique unless qualified with a heading reference (e.g. True, Grid, Magnetic), and where relevant, the map projection details (for Grid), or date/time/location of the observations (for Magnetic).
- Length and angular parameter values are not unique unless qualified with a unit identification.
- A static CRS is a CRS in which tectonic deformation is ignored and the coordinates of a physical point feature do not change over time. A dynamic CRS is a CRS in which the coordinates on or near the surface of the Earth change with time. Coordinates referenced to a dynamic CRS are only unique when the coordinate epoch ('time stamp' of the coordinates) is referenced.

1.4 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.

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.

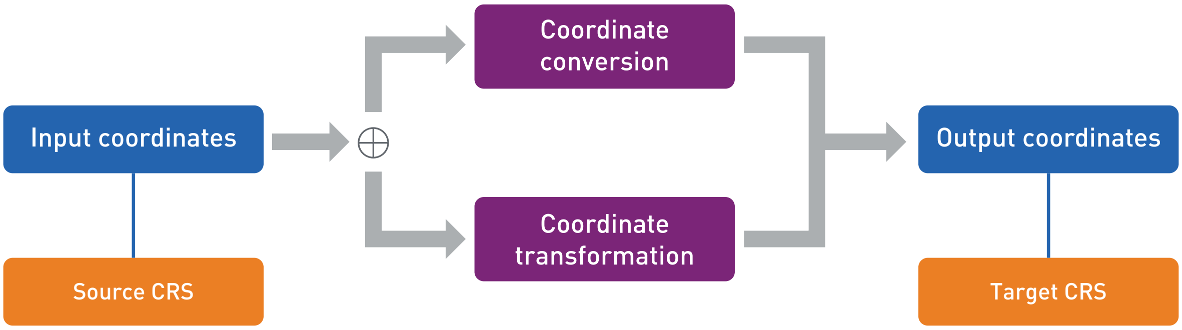

Figure 3: Diagram showing change of CRS through a coordinate operation.

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

- Concatenated coordinate operations 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 geographic 2D CRS' SAD69 to WGS 84 (using a certain transformation variant), and then the second, concatenated, step is to convert from WGS 84 to Aratu geographic coordinates using a certain variant of coordinate transformation between WGS 84 and Aratu geographic CRSs.

As of GIGS version 2.0, the GIGS framework only includes static CRS (tectonic deformation is ignored, and the coordinates of physical point features do not change over time because they are anchored to a particular plate to which validity is constrained). Dynamic CRSs on the other hand, are anchored to the Earth as a whole, that is, coordinates on or near the surface of the Earth change with time. Movement of tectonic plates within the dynamic CRS causes coordinates of any point on the surface of the Earth to change continually. The relationship of such 'global CRSs' to the Earth is described through the coordinates and velocities of a network of control points on the surface of the Earth. See the IOGP Report 373-25 *Geomatics Guidance Note 25: Dynamic versus static CRSs and use of the ITRF*[12] for further details.

1.5 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, their type (geographic, projected, etc.) and their component elements (datums, ellipsoids, units etc).
- Coordinate transformations and conversions, including the associated parameter values and the description of the algorithm (method) associated with each coordinate operation.

[12] https://www.iogp.org/bookstore/product/geomatics-guidance-note-25-dynamic-versus-static-crss-and-use-of-the-itrf/

The EPSG Dataset is based on a profile[13] of the ISO 19111 data model. All EPSG geodetic data objects (coordinate reference systems, their associated datum and projection components, units of measure, coordinate transformations and their components etc.) have been allocated an EPSG code for reference purposes. The EPSG code is a unique identifier for CRSs and coordinate transformations and 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 component entities. The EPSG Dataset is available as a free online registry at: epsg.org. IOGP Report 373-07-01 - *Surveying and Positioning Guidance Note Number 7, part 1 - Using the EPSG Geodetic Parameter Dataset* may also be referenced.

Although the EPSG Dataset is the global standard for geodetic parameters used within the energy industry, a vendor or operator may establish its own proprietary CRSs or transformations 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 "authority codes", which are extensions of the EPSG codes.

1.5.1 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, or updates have been made (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 legacy data that utilised these erroneous or outdated records in the past and possibly correct/update such data.

It is important to note that EPSG codes can only be deprecated by IOGP. 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 transcription error or other mistake is made, then the software vendor will face the dilemma of either having to deal with deprecating a code number which is not deprecated by IOGP and is still in use, or correcting the error without leaving an audit trail.

Further details on Rules for Deprecation in the EPSG Dataset can be found in in IOGP Report 373-07-01 - *Surveying and Positioning Guidance Note Number 7, part 1 - Using the EPSG Geodetic Parameter Dataset*.

[13] A 'profile' in this context is an internally consistent sub-model.

2. GIGS Evaluation

2.1 Overview

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

- a qualitative evaluation of the application's geospatial capability by means of a series of checklists (using the GIGS Test Series package)
- a quantitative evaluation of the application's geospatial capabilities by means of test data (using the GIGS Test Dataset package)

Developers, vendors, and users are encouraged to undertake GIGS evaluations and will benefit from the results. For geoscience software vendors it provides a means of self-certification or self-validation of the geospatial capabilities of the software. It enables the application to be promoted more effectively by easily communicating the geospatial capability/functionality, as well as helping the vendor to identify development needs and to prioritise improvements in the software. Furthermore, a GIGS evaluation provides an opportunity for education in this geodetic niche discipline and offers structure and standard terminology in communications with users. The GIGS evaluation process is designed to be run at the release of new application versions, so should be embedded in the development pipeline where possible, alongside other unit and integration tests.

Users of geoscience software may conduct GIGS evaluations in their own organization. The process may assist in establishing whether the software meets business and technical requirements. GIGS evaluation is a key tool in the establishment and maintenance of geospatial data integrity in the business by optimising workflows, identifying both the strong and the weak points of geospatial data handling of relevant software.

Developers, vendors and users are encouraged to share the results of any GIGS evaluations conducted with others in the industry, in order to promote the open-source nature of the framework.

2.2 GIGS Evaluation Process

The evaluation process is split into a number of themes, for each of which, a series of unit and integration tests are defined:

- 0000 – Coordinate Reference Systems
- 1000 – General User Documentation
- 2000 – Predefined Geodetic Entities
- 3000 – User-defined Geodetic Entities
- 4000 – User Interface
- 5000 – Data Operations
- 6000 – Audit Trail
- 7000 – Deprecation

Three of the six themes are further subdivided. The Predefined theme is further divided into Test Series 2100 and 2200, the User-defined theme into 3100 and 3200, and Data Operations has subdivisions for Test Series 5100, 5200, 5300, 5400 and 5500.

The individual tests are numbered for the purpose of reporting and are described in further detail in the companion to this document, the GIGS User Guide (IOGP Report 430-2). The Test Series numbering is designed to be extensible and flexible[14], hence each ID number is defined in thousands, to allow for further subdivision at the "hundreds level". Within each Test Series the individual tests are numbered sequentially, referenced to the parent theme, and each test dataset procedure is further numbered accordingly. This means that it is easy to determine the context of each test from its number, for example Test 5100_1.1 is in the 5100 Conversions Test Series, which is part of the 5000 Data Operations series.

The Test Dataset procedures follow a similar numbering system and is designed to be executed either alongside or in advance of completing each Test Series, a detailed User Guide on the particulars of each Test Procedure can be found in IOGP Report 430-2.

The Test Series are intended to be undertaken sequentially but can be executed in any order. However, the set of Conditional tests should be addressed at the start of any evaluation, as these are used to determine which specific tests should be completed for any given application – with any irrelevant tests being excluded from the evaluation. Each Test Series is assigned a standalone score so in theory can be executed in isolation from others.

[14] Note that previous versions of GIGS had a standalone series, 8000, for Error Trapping. In recently released versions these tests have been embedded in the respective series they refer to.

GIGS Test Series #	GIGS Test Series Name	This series examines
0000	Coordinate Reference Systems	The association of geodetic metadata to coordinates, and general aspects of geodetic integrity of the application
1000	General User Documentation	Overview documentation, release notes and knowledge bases relating to the geospatial aspect of the application
2100	Predefined Geodetic Parameter Library	The configuration and functionality of the reference library within the geodetic engine of the application
2200	Predefined Geodetic Data Objects	The range and accuracy of the reference geodetic data objects supported within the geodetic engine of the application
3100	User-defined Geodetic Parameter Library	The configuration and functionality of the user-defined library within the geodetic engine of the application
3200	User-defined Geodetic Data Objects	The range and accuracy of the user-defined geodetic data objects supported within the geodetic engine of the application
4000	User Interface	The nomenclature, user-oriented nature and accuracy of information of the UI for geospatial aspects of the application
5100	Data Operations (Conversions)	The range and accuracy of coordinate operations, specifically map projections, supported within the application
5200	Data Operations (Coordinate Transformations)	The range and accuracy of coordinate operations, specifically coordinate transformations, supported within the application
5300	Data Operations (2D Seismic Position Data)	The range and accuracy of coordinate operations and data manipulations pertaining to 2D seismic position data supported within the application
5400	Data Operations (3D Seismic Position Data)	The range and accuracy of coordinate operations and data manipulations pertaining to 3D seismic position data supported within the application
5500	Data Operations (Surface and Wellbore Deviation Data)	The range and accuracy of coordinate operations and data manipulations pertaining to wellbore data supported within the application
6000	Audit Trail	The audit trail for coordinate and data operations carried out within the geodetic engine of the application
7000	Deprecation	The deprecation of algorithms and files within the geodetic engine of the application

Figure 4: GIGS Test Series structure

2.3 GIGS Results

The interpretation of the GIGS evaluation results will depend on the scope of the software and its intended purpose. The value of the GIGS evaluation generally is in the identification of specific "good" and "bad" aspects of the software functionality, however, to make a meaningful comparison possible, the GIGS results can be assigned four levels of capability. These levels are identified by the following terms and indicate that the software satisfies minimum requirements for the category of software[15]:

- No GIGS score – software that directly compromises geospatial integrity.
- Elementary - software without the capability to perform coordinate operations, but maintains geospatial integrity
- Basic - software with a limited capability to perform coordinate operations, establishes and maintains geospatial integrity
- Intermediate - software with an extensive capability to perform coordinate operations; establishes and maintains geospatial integrity to a fully satisfactory degree, based on industry best practices.
- Advanced - software with a complete capability to perform coordinate operations; incorporating additional features that expand the range of applicability and/or reduce the possibility of compromising geospatial integrity

The Basic, Intermediate and Advanced conformance levels are progressively inclusive, in the sense that the Intermediate level implies conformance to the Basic level, and Advanced implies that the Intermediate level is also achieved. This means that the overall level assigned to each series will be the lowest level achieved in any of the tests.

To attain a GIGS Score of Intermediate, all tests that have an Intermediate level criterion should be selected, and all tests that have a maximum of Basic level should have the Basic criteria selected. If even one test acquires only a Basic level where an Intermediate level is possible, then the overall score will revert to Basic. The GIGS Score for any given Test Series therefore shows the minimum level at which the software is rated. It is not possible to compensate shortcomings on one aspect of the software by superior results on other aspects.

The exception is the Elementary level which applies to software without coordinate operation capability, and is thus not used in scoring calculations for Basic/Intermediate/Advanced.

For each Series, a percentage score is also assigned, to give further indication of the subtleties of the software functionality. A weighted percentage score is assigned for each level, which indicates how the application has performed for that level. For example, a GIGS result of Intermediate (95%) is considered better quality than Intermediate (90%). The score also makes it easier to identify what improvements are required to reach the next level.

A GIGS score is assigned for each series, rather than calculating a single total score for the entire application[16], as the latter was deemed meaningless, and does not always recognise the idiosyncrasies or intricacies of an evaluation. However, if felt appropriate, an overall GIGS score can be determined by awarding the lowest common denominator level and aggregating the percentage scores.

[15] Previous versions of GIGS used a "medal system" of Bronze, Silver and Gold, which has been discontinued.

[16] Previous version of GIGS resulted in a single overall Score, which has been discontinued.

Additionally, a number of "Conditional" tests preclude the main Test Series. These Conditionals are designed to identify certain functionality in the software being evaluated, that in turn determine which subsequent tests are to be undertaken. Answering "No" to certain Conditionals results in specific tests or test series being disabled, and therefore excluded from the GIGS scoring calculations.

Table 2 contains further details on the specific capability/functionality expectations of each level, with respect to the geospatial integrity definitions (completeness, correctness, consistency and verifiability).

2.4 Early-Binding vs Late-Binding Applications

Geospatial metadata is defined in this Guidance Note as information about the coordinate reference system to which geospatial data is referenced, extended with the definition of any relevant coordinate operations. The extension becomes relevant when the current coordinates have been derived from coordinates defined in another CRS, by means of a coordinate transformation. In order to fully control geospatial integrity, this derivation also has to be defined in the metadata, because there may be multiple options for 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 then treated as part of the definition of the CRS. This technique is referred to as 'early-binding', as it binds a coordinate transformation to the CRS before it is associated with any geospatial data.

On the other hand, 'late-binding' software solutions only require the specification of a coordinate transformation when the coordinates are transformed (when source CRS, target CRS, epoch and area of interest are known), i.e., after the association of geospatial data and CRS has taken place.

The solution chosen for any given geoscience software package is fundamental to its behaviour with respect to geospatial integrity. Essentially, late-binding gives the user freedom to select any combination of CRS and transformation, whereas in early-binding, a "hub CRS" (usually WGS 84) is selected and all CRSs contain transformation parameters to that hub CRS, embedded in their definition.

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 disadvantages of this solution are resolved in the software.

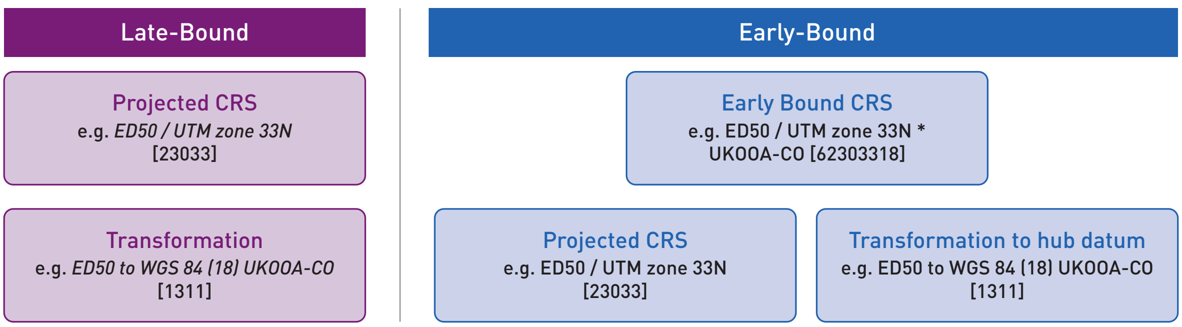

Figure 5: Diagram showing late-bound and early-bound entities, codes are examples only

Table 2: Criteria for geospatial integrity and corresponding GIGS Levels

Criteria for Geospatial Integrity		**Elementary**	**Basic**	**Intermediate**	**Advanced**
		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 limited scope of the application. Integration or interaction with other 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 software by adhering to a number of industry standards or best practices.	Software satisfies the requirements of the Intermediate 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	The defining parameters of CRSs and coordinate operations must be free from numerical and terminological errors. 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.	Merging and co-visualization 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 GIGS 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 synchronization with new releases of EPSG dataset.

Criteria for Geospatial Integrity		Elementary	Basic	Intermediate	Advanced
		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 limited scope of the application. Integration or interaction with other 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 software by adhering to a number of industry standards or best practices.	Software satisfies the requirements of the Intermediate level and has additional features regarding geospatial integrity.
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.

2.5 GIGS Evaluation Workflow

Key steps in the recommended GIGS evaluation process are:

- Define scope
- Prepare workplan
- Quantify time requirements
- Identify and obtain expertise and resources
- Execute evaluation
- Prepare report(s)
- Embed into development pipeline

2.5.1 Define scope

A full GIGS evaluation may not be required in every case. A new release version of an application that has been tested before may only require an update of the existing tests covering only the functionality that has changed. Additionally, GIGS evaluation may only be required on a single module/component of the software, rather than the entire suite. In these cases, the scope should be considerably limited. At the other end of the spectrum, a user may wish to fully test a complex piece of geoscience software in an integrated architecture, where geospatial integrity is influenced by interactions with other software packages and data stores.

The scope of a GIGS evaluation can be determined by completion of the Conditional tests and reference to the Usage Extent of relevant geodetic data objects. If any of the tests are deemed to be irrelevant to the application, then they can be excluded (although this should be reported). For example, software that has no functionality concerning wellbore data would not have to complete the 5500 Test Series. As each Test Series is assigned a standalone score, it is possible to undertake only a single, or set number of Series if required.

2.5.2 Prepare workplan

The level of effort and difficulty in planning and executing a GIGS evaluation depends on the complexity of the software to be reviewed and the scope of the evaluation. A full GIGS evaluation for complex integrated geoscience software may take over a hundred hours of combined effort, once software has been licensed and installed. However, smaller and simpler software, reduced scope, or focused evaluations may only take a matter of hours. GIGS test dataset implementation within a library that can be called into the development environment of an application easily can aid automation of many tests, and significantly reduce time commitments. On the other hand, resources reserved for the evaluation may require an element of training or familiarization with the software and process.

2.5.3 Identify resource

Resources required for a typical GIGS evaluation can be divided into:

- Expertise
- Software provisions (licenses, source code, sandbox environment etc)
- Test data
- Capex

Contribution is typically required from several subject matter experts:

- IT/digital expertise related to the software architecture and systems development, network support, security privileges and licensing
- Geodetic and geospatial data management expertise (e.g. data loading)
- Domain and workflow expertise for the deployment of the software
- Developer support for implementation or investigation

A GIGS evaluation preferably should be done in the context of a user's typical operating environment, using a typical hardware platform or cloud environment. However, there can be advantages to an additional sandbox deployment, where specific corporate IT infrastructure or security issues do not influence the application's performance.

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

2.5.4 Execute evaluation

The evaluation is undertaken based upon the specific scope, in accordance with the GIGS Test Series package, and the result of the Conditionals responses. The scope of the test framework may be modified, either increased or decreased, depending on the purpose of the evaluation and type of application being tested.

Quantitative numerical testing of the application's functionality and calculation of results utilising the GIGS Test Dataset ideally should be completed before the qualitative evaluation. When executed in parallel or after the Test Series checklist, the test responses may have to be revisited to record the results, including any issues that have been identified during numerical testing. The Test Procedures should be executed with reference to the GIGS User Guide (see IOGP Report 430-2) which provides specific guidance for each individual test, including what input data/actions are required, what the expected result is and what issues may be encountered.

The GIGS Test Series can be accessed via an online portal (https://gigs.iogp.org) or downloaded as an offline spreadsheet-based checklist. The GIGS online portal contains more functionality in terms of managing and storing results, application details and Evaluator credentials, however the Test Series content is identical in both online and offline versions.

The GIGS Test Dataset can be accessed online or as offline files downloaded from the GIGS site.

2.5.5 Prepare reports

Summary Report

The result of a completed evaluation is the assignment of a GIGS Level and Score per Test Series for the application being tested, as well as a wealth of compiled evidence and information gathered from the tests undertaken.

A summary report can be extracted from the online and offline versions of the GIGS Test Series; the online portal allows for generation of an auto-populated report template containing all scores and supporting evidence. The summary report contains the scoring "dashboard", followed by a list of the response criteria selected for each test. This provides an overview of the capabilities of the application with respect to the GIGS geospatial integrity requirements.

The 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 and used to underpin an internal development programme.

Full Report, Conclusions and Recommendations

As well as a summary report, it is recommended that a full written report is also created to highlight any particular areas that require further investigation or action. The report should cover the following areas, depending on which party conducted the evaluation.

When the evaluation has been conducted by the developer/vendor:

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

When the evaluation has been conducted by the user:

- Which of the geospatial integrity requirements the software fully meets, partially meets, or does not meet at all – as well as an assessment of overall degree of geospatial integrity of the software and best practices observed.
- Requirements that are not met should be clearly delineated, with unresolved issues labelled with user warnings, and/or workarounds clearly defined. It is very important that key problems that might cause user errors are flagged and documented by the Evaluators for circulation throughout the company's user community. For example, incorrect or misleading nomenclature should be clearly communicated to users.

- Enhancements which may be proposed to the vendor for their consideration in future releases.
- Critical problems requiring 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.
- User guidance related to any of the above for further distribution within the company.
- Comparisons with other relevant geoscience software packages known to the Evaluators, as appropriate.

2.5.6 Embed into development pipeline

After a full GIGS evaluation has been completed it is recommended that the test framework is embedded into the standard development pipeline/cycle of the application. GIGS is a form of DDT (Data-driven testing) that can be readily deployed in TDD (test-driven development).

Specific guidance on how to fully utilize the GIGS testing process in TDD is not provided in this document, as it will largely depend on the specifics of the codebase of an application. Nonetheless, it is recommended that the ASCII base class GIGS Test Dataset routines are utilised in a "red, green, refactor" approach, whereby when a major or minor update is made to the geodetic engine/library, the appropriate test procedures are automatically run before changes are committed/compiled into a release candidate. This form of testing has become more pervasive in geoscience software in recent years as agile-based 'continuous build and delivery' methodologies are utilized, and there has been a marked increase in the number of applications that undertake geospatial operations and that are developed using agile processes.

3. Glossary

The following terms and acronyms are used throughout this publication and are defined here for clarity. The source of the definition is indicated in square brackets where relevant.

Term	Definition
Accuracy [ISO/TC211]	Closeness of agreement between a test result and the accepted reference value.
Affine operation [GIGS]	Coordinate operation on plane coordinates involving an origin shift and separate rotations and/or scale/unit changes affecting the two axes. *Note: 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, a character encoding standard for electronic communication.
Audit trail [GIGS]	The facility provided by an application 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 of geospatial data; in particular, data about all coordinate operations and CRS applied to the data over time, from its original CRS through to the final CRS used in each module.
Azimuth (Reference) [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.
Bin grid (Seismic) [IOGP 483-6]	3D seismic traces grouped into a regular pattern of cells, referenced to a point (bin node) on the Earth. *Note: technically seismic bin grids can either form of 'Engineering CRS', or inherit the geodetic datum of its base projected CRS (a 'derived CRS').*
Convergence (Grid) [IOGP 373-21]	The angle between the directions of true north and grid north. *Note: Grid convergence is used to convert an azimuth, which is related to true north and defined on the surface of the ellipsoid, to a bearing, which is defined in the map plane and is related to Grid north.*
Declination (Magnetic)	The angle between true north and magnetic north. *Note: Magnetic declination is always defined as the angle that needs to be added to magnetic bearing to yield the azimuth.*
Cartesian coordinate system [ISO/TC211]	Coordinate system which gives the position of points relative to n mutually perpendicular axes all having the same unit of measure.
Compliance [GIGS]	Agreement to a norm, either precisely or within an acceptable tolerance *Note: 'compliance' may refer to terminology as specified in standards such as 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.*

Term	Definition
Compound CRS [ISO/TC211]	Coordinate reference system using at least two independent coordinate reference systems. *Note 1: Coordinate reference systems are independent of each other if coordinate values in one cannot be converted or transformed into coordinate values in the other.* *Note 2: 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'.* *Note 3: in the context of wellbores, although considered 3D the wellbore local coordinates (n,e,d) may (and usually will) have separate horizontal and vertical origin points, the well WRP (well reference point) and ZDP (zero depth point) respectively. In the EPSG data model these local coordinates are referenced to a compound CRS consisting of a local horizontal CRS and a local vertical CRS. The local coordinates themselves are the output of a computation such as minimum curvature using the borehole survey observables measured depth, inclination and azimuth (MD, INC, AZ).*
Concatenated coordinate operation [ISO/TC211]	Coordinate operation consisting of sequential application of multiple coordinate operations.
Concatenated coordinate transformation [GIGS]	Concatenated coordinate operation consisting of sequential application of multiple coordinate transformations.
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 that changes coordinates in a source coordinate reference system to coordinates in a target coordinate reference system in which both coordinate reference systems are based on the same datum *Note: A coordinate conversion uses parameters which have specified values.* *Example 1: A mapping of ellipsoidal coordinates to Cartesian coordinates using a map projection.* *Example 2: Change of units such as from radians to degrees or from feet to metres.*
Coordinate data [GIGS]	*Note: See coordinate set*
Coordinate dataset [GIGS]	*Note: See coordinate set.*
Coordinate epoch (of a coordinate data set) [IOGP 373-25]	In a dynamic CRS coordinates of any point on the surface of the Earth continually change as a result of tectonic plate motion and/or crustal deformation. They always must be qualified with the epoch at which they are valid – the coordinate epoch. *Note: By convention, coordinate epoch is given in decimal years referenced to the Gregorian calendar. This is often expressed in the form "<CRS name> at epoch t" or "<CRS name>@t", for example: ITRF2014 at epoch 2017.53 or ITRF2014@2017.53.*
Coordinate metadata [GIGS]	Coordinate metadata is the identification of the coordinate reference system and, for dynamic CRSs, also the coordinate epoch for the dataset. *Note: see also geospatial metadata*
Coordinate operation [ISO/TC211]	Process using a mathematical model, based on a one-to-one relationship, that changes coordinates in a source coordinate reference system to coordinates in a target coordinate reference system, or that changes coordinates at a source coordinate epoch to coordinates at a target coordinate epoch within the same coordinate reference system *Note 1: Generalization of coordinate conversion, coordinate transformation and point motion operation."*
Coordinate operation parameter [IOGP]	A numeric variable used in a coordinate conversation or transformation.

Term	Definition
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 'derived 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; essentially the positional component of geospatial data that refers to a locates on or near the Earth's surface. *Note: identical to 'coordinate dataset' and 'coordinate data'*
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 and 3D, Cartesian 2D and 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 that changes coordinates in a source coordinate reference system to coordinates in a target coordinate reference system in which the source and target coordinate reference systems are based on different datums *Note 1: A coordinate transformation uses parameters which are derived empirically. Any error in those coordinates will be embedded in the coordinate transformation and when the coordinate transformation is applied the embedded errors are transmitted to output coordinates.* *Note 2: A coordinate transformation is colloquially sometimes referred to as a 'datum transformation'. This is erroneous. A coordinate transformation changes coordinate values. It does not change the definition of the datum. In this document coordinates are referenced to a coordinate reference system. A coordinate transformation operates between two coordinate reference systems, not between two datums.*
Coordinate tuple [ISO/TC211]	Tuple composed of a sequence of coordinates.
CRS	*See coordinate reference system.*
Data exchange format [IOGP]	Defined format for the exchange of digital data. *Note: see IOGP, SEG*
Data operation [GIGS]	Any action performed on geospatial 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 software package; it may be used for output, export or as input to another part of the same software. This is not to be confused with the GIGS Test Dataset*
Datum [ISO/TC211]	Parameter or set of parameters that define the position of the origin, scale, and 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.

Term	Definition
Depth	Distance of a point from a chosen vertical reference surface downward along a line that is perpendicular to that surface *Note 1: The line direction may be straight, or be dependent on the Earth's gravity field or other physical phenomena.* *Note 2: A depth above the vertical reference surface will have a negative value* *See gravity-related height (or depth).*
Dynamic CRS [IOGP 373-25]	Coordinate Reference System in which the coordinates of locations on or near the surface of the Earth change with time. Dynamic CRSs are anchored to the Earth as a whole. Movement of tectonic plates within the dynamic CRS causes coordinates of any point on the surface of the Earth to change continually. The relationship of the global CRS to the Earth is described through the coordinates and velocities of a network of control points on the surface of the Earth. *Note: Examples of global dynamic CRSs are ITRF2008 and ITRF2014, or any CRS used by a satellite navigation system, such as WGS 84.*
Early-binding [GIGS]	A priori association of a coordinate transformation with a geodetic CRS. *Note: the association is usually made at start-up of an application 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 typically by E, x or y; this is defined in the 'coordinate system' in use with the specific 'CRS'.*
Ellipsoid [ISO/TC211]	Geometric reference surface embedded in 3D Euclidean space formed by an ellipse that is rotated about a main axis *Note 1: For the Earth the ellipsoid is bi-axial with rotation about the polar axis. This results in an oblate ellipsoid with the midpoint of the foci located at the nominal centre of the Earth.*
Ellipsoidal coordinate system [ISO/TC211]	Coordinate system in which position is specified by geodetic latitude, geodetic longitude and (in the three-dimensional 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 Datum [ISO/TC211]	Datum describing the relationship of a coordinate system to a local reference. *Example: Reference points of engineering plant grids, well paths, etc.*
EPSG [IOGP]	Acronym of the European Petroleum Survey Group, formerly a forum of 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 IOGP Geomatics Committee. The acronym EPSG remains as a brand name of the EPSG Geodetic Parameter Dataset, a product of the original EPSG and now maintained by IOGP.
EPSG code [IOGP]	Numeric code allocated to geodetic data objects in the EPSG Dataset. *Note: Also see 'EPSG Geodetic Parameter Dataset'.*
EPSG data model [IOGP]	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*

Term	Definition
EPSG Geodetic Parameter Dataset [IOGP]	Dataset of geodetic data objects with worldwide coverage, published by IOGP. *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.*
EPSG Registry [IOGP]	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 browser at: https://epsg.org.*
Error Trapping [GIGS]	The prediction, finding and fixing of programming errors.
Evaluator [GIGS]	See GIGS Evaluator
False Easting/Northing [IOGP]	A linear value applied to the origin of coordinates, normally used to make all values are positive.
Geodetic data object [GIGS]	A component part of the geodetic data model implemented in the software or the EPSG data model. *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'.* *Example: Geodetic data objects may be CRS, coordinate transformation, datum, ellipsoid, map projection, coordinate system, etc.*
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 [IOGP]	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 'IOGP Guidance Note 7, Part 1: Using the EPSG Geodetic Parameter Dataset'.*
Geodetic CRS [ISO/TC211]	Coordinate reference system based on a geodetic datum. *Note: see '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 reference frame [IOGP]	A static reference frame or static datum has no time-dependent parameters in its definition. A dynamic reference frame includes in its definition time-dependent parameters, such as point velocities.
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* φ.
Geodetic parameter library [GIGS]	The collection of geodetic data objects available for use in an application, can be either predefined (i.e. shipped with the application), or user-defined.

Term	Definition
Geographic 2D CRS [IOGP]	A geodetic CRS using a 2D ellipsoidal coordinate system in which ellipsoidal height is not included. *Note 1: used when positions of features are described on the surface of the 'ellipsoid' through 'latitude' and 'longitude' coordinates.*
Geographic 3D CRS [IOGP]	A geodetic CRS using a 3D ellipsoidal coordinate system, in which ellipsoidal height is included. *Note 1: used when positions of features are described on, above or below the surface of the 'ellipsoid' through 'latitude' and 'longitude' and 'ellipsoidal height'.*
Geographic CRS [IOGP]	Collective term for 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 [IOGP]	The branch of science that deals with the acquisition, modelling, analysis and management of spatial data including aspects such as remote sensing, land surveying, and geospatial information management. *Note 1: Geomatics includes all forms of land and hydrographic surveying, positioning, mapping, and boundary determination, and is based on the scientific framework of geodesy, applying modern technologies such as GIS, photogrammetry, terrain modelling and cartography.*
Geomatics Committee [IOGP]	IOGP Geomatics Committee. One of eleven standing committees (at the time of writing) of IOGP, comprised of leading specialists in the areas of surveying, geodesy, cartography and spatial data management. *Note: the IOGP 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 organizations.* • *maintaining international positioning exchange formats and a geodetic parameter database (known as EPSG Geodetic Parameter Dataset).* • *liaising with industry associations. See: https://www.iogp.org.uk/geomatics/*
Geoscience [GIGS]	All scientific disciplines relating to studies of the subsurface, including Geology, Geophysics, Geodesy, Geomatics, Geotechnical studies, and others.
Geoscience dataset [GIGS]	Data related to geoscience activity, comprised of geospatial data and non-geospatial data.
Geoscience software [GIGS]	Geoscience software includes any executable code and underlying database (either cloud based or on-premise) used in geoscience activities, including applications, processing packages and their user interfaces. It also includes software components, such as geodetic computation engines, extensions and libraries.
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 application functionality which addresses data import, creation, merging, processing, 'coordinate operations' and 'map projections', visualization, and export. It is therefore more than a static property of geospatial data.*

Term	Definition
Geospatial metadata [GIGS]	The CRS to which the coordinate dataset is referenced, extended by the definition of any coordinate operations when relevant. *Note 1: For dynamic CRSs, it also includes the coordinate epoch for the dataset.* *Note 2: 'coordinate operation' information is relevant when the geospatial data was originally collected in a different 'CRS' to that which it is stored in. It is not relevant when the 'geospatial data' is not (going to be) merged with 'geospatial data' that is referenced to another 'CRS'.* *Note 3: see also coordinate metadata.*
GIGS [IOGP]	An open-source data-driven testing framework to evaluate application capability in establishing and maintaining geodetic integrity and data quality, managed by the IOGP Geomatics Committee
GIGS Documentation [IOGP]	Public-release products from the GIGS, published as IOGP Reports 430-1 and 430-2. *Note: see https://www.iogp.org/bookstore/*
GIGS Level [GIGS]	A classification of the level of conformance attained; levels are No GIGS Score, Elementary, Basic, Intermediate, Advanced. A level is assigned to each completed test series. An overall level for the entire GIGS Evaluation is not calculated.
GIGS Evaluation [GIGS]	The structured process of undertaking all applicable GIGS tests for an application, with a full report of findings and recommendations produced. *Note: may previously or alternatively referred to as a 'GIGS Review'*
GIGS Evaluator [GIGS]	The person or persons undertaking a GIGS Evaluation on a piece of software.
GIGS Score [GIGS]	A weighted percentage value calculated to indicate the level of compliance of an application within each GIGS level. A score is assigned to each completed test series. An overall score for the entire GIGS Evaluation is not calculated.
GIGS Test [GIGS]	The individual assessment of a specific function, condition or component of an application, the test is constructed of a number of test criteria. *Example: 1000_4 'Version Numbering' is a GIGS Test*
GIGS Test Criterion [GIGS]	A statement regarding the functionality of an application's condition or standard, corresponding to a respective GIGS level. Collectively referred to as GIGS Test Criteria. *Example: 1000_4_Basic 'Help documentation and release notes have consistent version numbers' s a GIGS Test Criterion*
GIGS Test Dataset [GIGS]	A dataset created to enable tests of coordinate operations; based on use of the EPSG Dataset, and using methods and formulae outlined in 'IOGP Guidance Note 7, Part 1: Coordinate Conversions and Transformations including Formulas'.
GIGS Test Procedure [GIGS]	A specific test routine utilising the GIGS Test Dataset
GIGS Test Series [GIGS]	Collection of GIGS Tests related to a common theme, there are 13 series in a full GIGS Evaluation *Example: 1000 'General User Documentation' is a GIGS Test Series*
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 [IOGP]	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	*Note: See gravity-related height and ellipsoidal height.*

Term	Definition
International Standard [ISO]	Standard published by the International Organization for Standardization. *Note: International Organization for Standardization is commonly abbreviated as ISO.*
ISO 19111 [ISO]	International Standard describing a data model for geospatial metadata. *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]	ISO Technical Committee 211. It's scope is defined as: "standardization in the field of digital geographic information". *Note 1: 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 2: see https://www.isotc211.org*
JIP [IOGP]	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	*Note: See geodetic latitude.*
Late-binding [GIGS]	Association at runtime 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 [IOGP]	Arbitrarily chosen reference direction for azimuths for local usage. *Note: use of local 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.*
Latitude of Natural Origin [IOGP]	Defines the origin of the y-coordinates; this parameter may not be located at the centre of the projection. In particular, Conic projections use this parameter to set the origin of the y-coordinates below the area of interest. In that instance, you do not need to set a false northing parameter to ensure that all y-coordinates are positive.
Longitude of Natural Origin [IOGP]	Defines the origin of the x-coordinates; the central meridian and longitude of origin parameters are synonymous.
Longitude	*Note: See geodetic longitude.*
Magnetic north [IOGP]	Direction of the projection of magnetic field lines to the horizontal plane, pointing approximately towards the Earth's magnetic north pole.
Map grid [IOGP]	The realization of a projected CRS.
Map projection [ISO/TC211]	Coordinate conversion from an ellipsoidal coordinate system to a plane. *Note: Also see coordinate conversion.*
MD [IOGP]	Measured Depth, in well log data.
Meridian [IOGP]	Intersection of an ellipsoid by a plane containing its shortest axis. *Note: see also 'prime meridian'*
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'.*

Term	Definition
Nomenclature [GIGS]	Names, definitions and terminology applied to given classes 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 typically by N, y or x depending upon the 'coordinate system' in use with the relevant 'CRS'.*
OGC [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 https://www.ogc.org/*
IOGP [IOGP]	The International Association of Oil & Gas Producers - encompasses most of the world's leading publicly traded, private and state-owned oil and gas companies, oil and gas associations and major upstream service companies. *Note: see https://www.iogp.org/*
P1/84 [IOGP]	Industry standard seismic post plot positioning data exchange format prepared by the Position Fixing Group Working Party for the UKOOA Exploration Committee. Its title may be abbreviated as UKOOA-PI/84. *Note 1: replaced in 1990 by the UKOOA-P1/90 but still important in supporting legacy data.* *Note 2: Custodianship transferred to IOGP in 2006. Available for download from the IOGP Geophysical Operations Subcommittee webpage at https://www.iogp.org/geomatics/*
P1/90 [IOGP]	Industry standard seismic post plot positioning data exchange format prepared by the UKOOA Surveying and Positioning Committee for the UKOOA Exploration Committee Its title may be abbreviated as UKOOA-PI/90. *Note 1: Custodianship transferred to IOGP in 2006. Available for download from the IOGP Geophysical Operations Subcommittee webpage at https://www.iogp.org/geomatics/* *Note 2: replaced in 2011 by the OGP – P1/11 but P1/90 version is still important with legacy data.* *Note 3: 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 [IOGP]	The P1/11 is a standard exchange format for seismic positional data, for adoption by all parties involved in acquiring, processing, loading and interpreting a seismic survey. This includes exchange of the pre-plot and the post-plot data. The data structure, while human-readable, will allow it to be directly interpreted by spreadsheet software and machine-read directly into seismic processing algorithms, data tables in seismic databases and interpretation workstations, removing the need for manual intervention. *Note 1: Available for download from the IOGP Geophysical Operations Subcommittee webpage at https://www.iogp.org/geomatics/* *Note 2: Current version 1.1 released April 2015.* *Note 3: P1/11 files are written in comma separated value (csv) ASCII format. This supports both the intention of making the files human (as well as machine) readable, and to enable easy extraction and tabulation of records using spreadsheet tools.*
P6/98 [IOGP]	The guidelines for the definition of 3D Seismic Binning Grids and the associated data exchange format – P6/98 was written by a working group established by the UKOOA Surveying and Positioning Committee. Last revision (3) in May 2000. *Note 1: Custodianship transferred to IOGP in 2006. Available for download from the IOGP Geophysical Operations Subcommittee webpage at https://www.iogp.org/geomatics/* *Note 2: replaced in 2011 by the OGP – P6/11 but P6/98 version is still important with legacy data.*

Term	Definition
P6/11 [IOGP]	The P6/11 format is designed for the exchange of seismic bin grid definitions and data. It replaces both the legacy P6/98 bin grid data exchange format and the UKOOA P1/90 data exchange format (when used as a bin centre data exchange format). This typically originates from the planning and execution of seismic data acquisition operations. P6/11 files also result from seismic data processing, loading and interpretation steps, where the resulting deliverable is intended to be exchanged for further use, or visualised, such as: • Data processing • Data management (reprocessing, loading, merging surveys, etc.) • Interpretation *Note 1: Available for download from the IOGP Geophysical Operations Subcommittee webpage at https://www.iogp.org/geomatics/* *Note 2: Current version 1.1 released June 2017.* *Note 3: P6/11 files are written in comma separated value (csv) ASCII format. This supports both the intention of making the files human (as well as machine) readable, and to enable easy extraction and tabulation of records using spreadsheet tools.*
P7/2000 [IOGP]	The data exchange format for well deviation data (P7/2000) prepared by a working group established by the UKOOA Surveying and Positioning Committee, with input from the Common Data Access (CDA) Well Data Advisory Group and feedback from a wide range of interested parties in the oil & gas industry, both in the UK and Overseas. *Note 1: contains description of well curve data, through wellbore survey measurement data (measured depth, inclination and azimuth) or calculated positions.* *Note 2: Custodianship transferred to IOGP in 2006. Available for download from the IOGP Surveying and Positioning Subcommittee webpage at https://www.iogp.org/geomatics/* *Note 3: replaced in 2021 by the OGP P7/17 but UKOOA P7/2000 Rev 5 is still important with legacy data.*
P7/17 [IOGP]	The P7/17 format for the reporting, storage and exchange of wellbore positioning data is recommended by the International Association of Oil & Gas Producers (IOGP) Geomatics Committee for general use in the oil and gas industry. It supersedes the earlier UKOOA P7/2000 format. The format update was developed in response to a need to extend the functionality of the older P7/2000 format, particularly to enable storing raw sensor measurement data, tool error models and uncertainties. *Note 1: Available for download from the IOGP Geomatics Committee webpage at https://www.iogp.org/geomatics/* *Note 2: Current version 2.1 released January 2021*
Parameter value [IOGP]	Value allocated to one specific instance of a 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 'GRS 1980' 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. does occur, particularly in legacy datasets.*
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.*

Term	Definition
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'.*
Scale Factor [IOGP]	Precise definition of the amount of distortion on a plane projected from the ellipsoid.
SEG [SEG]	Society of Exploration Geophysicists. A not-for-profit organization that promotes the science of applied geophysics and the education of geophysicists. *Note: see https://www.seg.org*
SEG Positioning Standards [SEG]	In 2009, SEG transferred custodianship of positioning standards to the International Association of Oil and Gas Producers (OGP). These standards have been superseded by the introduction of the latest IOGP P-formats P1/11 and P6/11. Still important for interpretation of legacy positioning data.
SEG-Y [SEG]	Seismic data recording format, including position data. *Note1: current version is Rev 1 2002. Earlier versions may be important with legacy data. See https://www.seg.org link to Technical Standards.* *Note 2: In 2017 the Society of Exploration Geophysicists released a major update SEG-Y_r2.0 seismic data exchange standard.* *Note 3: SEG-Y_r2.0 provides highly enhanced flexibility while maintaining a high degree of backward compatibility. It includes the latest IOGP general positioning header allowing incorporation of higher-precision coordinates, depths, and elevation and more options for coordinate reference system specification.*
Standard Parallel [GIGS]	A parallel of latitude along which scale is preserved on a map projection.
Static CRS [IOGP]	CRS in which tectonic deformation is ignored and the coordinates of a physical point feature do not change over time. A static CRS is usually anchored to a particular tectonic plate and its validity is constrained to an area on that plate. If such a CRS straddles two or more plates, any deformations of the geodetic infrastructure as a result of differential plate motion are handled by localized corrections to the coordinates of control points. *Examples: ED50 and NAD27.*
Southing [IOGP]	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 typically S, y or x.* *Note 2: definition from 'IOGP Guidance Note 7, Part 1: Using the EPSG Geodetic Parameter Dataset'*
SPS [SEG]	Shell Processing Support (SPS) data format was initially defined and used by Shell Internationale Petroleum for transferring of positioning and geophysical support data from 3D field crews to seismic processing centres. In 1993 SEG Technical standards committee on ancillary data formats adopted SPS as the standard format for exchanging Geophysical positioning data. *Note 1: current version is SPS rev 2.1. See http://www.seg.org link to Technical Standards.* *Note 2: The OGP P1/11 and P6/11 together have largely subsumed the full capabilities of SPS.*
Transformation	*Note: See coordinate transformation.*
True north	*Note: See geographic north.*
Tuple [ISO/TC211]	Ordered list of values. *Note: see also 'coordinate tuple'.*

Term	Definition
TVD [IOGP]	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), or the Zero-depth Point. Ambiguous term which in general means the same as local depth (i.e., the vertical distance below the ZDP) but can also mean depth below MSL. *Note 1: see P7-17 User Guide* *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.* *Note 3: Local depth (d) is often referred to as TVD. It is given as linear distance in a 1D vertical CRS.* *Note 4: Not used in P7/17, except in reference to LMP method.*
TVDBML [IOGP]	TVD below Mud Line - for well data. *Note: Term not used in P7/17.*
TVDSS [IOGP]	TVD sub-sea (below sea level) - for well data. *Note: Term not used in P7/17.*
Usage Extent [IOGP]	Describes the region(s) to which a geodetic data object, for example a coordinate reference system, may be apply. Typically, corresponds to the horizontal component of ISO 19115's "Extent".
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 Known Text (WKT)	This Standard defines the structure and content of well-known text strings describing coordinate reference systems (CRSs) and coordinate operations between coordinate reference systems. *Note 1: The format was originally defined by the Open Geospatial Consortium (OGC) and described in their Simple Feature Access. The current standard definition is in the ISO 19162 standard - Geographic information — Well-known text representation of coordinate reference systems. Commonly referred to as WKT2. Published August 2019.* *Note 2: Can be downloaded from http://docs.opengeospatial.org/is/18-010r7/18-010r7.html or https://www.ogc.org/standards/wkt-crs*
Well Path [IOGP 483-7u]	Computed trajectory in 3D geodetic space (i.e., the Northing, Easting and Depth coordinates of the wellbore at specific stations), calculated from wellbore survey data for that wellbore.
Westing [IOGP]	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 typically by W, x or y depending upon the 'coordinate system' in use with a specific 'CRS'.*

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GIGS is an open-source digital testing framework designed to evaluate the capability of software in establishing and maintaining the integrity of geospatial data. It is primarily aimed at geoscience applications, but elements can be readily applied to any software that handles spatial data. The testing framework comprises a series of qualitative evaluations that assess software functionality and configuration, coupled with data-driven tests that quantify the accuracy and robustness of geodetic engines and libraries, in executing coordinate operations. The test package is supported by two documents, a general Guidance Note on the theory of geospatial integrity and GIGS testing (IOGP Report 430-1, this document), as well as a comprehensive User Guide providing technical procedures for executing the GIGS tests (IOGP Report 430-2).