U.K. OFFSHORE OPERATORS ASSOCIATION
(SURVEYING AND POSITIONING COMMITTEE)

GUIDANCE NOTES ON THE USE OF
CO-ORDINATE SYSTEMS
IN
DATA MANAGEMENT
ON THE UKCS

(DECEMBER 1999)

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1. INTRODUCTION AND BACKGROUND

1.1 Introduction

This guidance note concerns the management of spatial data for UK Continental Shelf (UKCS) petroleum operations. In December 1999, the oil and gas licensing division of the Department of Trade and Industry (DTI) published a notice in both the London Gazette and the Edinburgh Gazette, which clarified the co-ordinate systems to which licence boundaries on the UKCS were referred.

The UKOOA Surveying and Positioning (S&P) Committee recognises that some data management issues may arise out of the Gazette notice. This document has been produced to provide some guidance in handling co-ordinate integrity issues that may be encountered.

In writing such "Best Practice" guidance, it is impossible to strike the correct tone for every audience. Comments and suggestions have had to assume limited knowledge in the area of geodesy on the part of the user. Therefore, within this document, there is both a glossary of terms (see annex G) and a guide to co-ordinate geodesy (see annex F) that may assist with the technical nature of some of the comments.

We cannot cover all of the possible issues and thereby give explicit recommendations to everyone and so we have decided to split the issues into broad groupings. It should be noted that many of the individual comments might be relevant in other areas also. It is therefore recommended that the document be studied in its entirety. In addition, for completeness of the document, there is an element of repetition of information.

1.2 Background

Increasing UKCS activity to the west of Britain has led the UKOOA Surveying and Positioning Committee and the UK Government geodetic advisors (Hydrographic Office and Ordnance Survey) to express concern that the current definition of a geographic co-ordinate system for offshore concession boundaries, based on “European Datum”, is imprecise. Although adequate for describing position in the North Sea, in areas to the west of Britain it has the potential to lead to serious difficulties in inter company and possibly international unitisation of cross border oil and gas fields.

With DTI's backing, a working group was formed to recommend a technically acceptable definition and procedures for removing the ambiguity. The working group consulted widely on this issue, seeking and obtained support from Oil Companies, both operators and non-operators, seismic and positioning contractors, the Legal, Exploration and S&P Committees of UKOOA as well as the UKOOA Management Group. The working group's recommendations were submitted to the DTI Licensing Division, and the instrument chosen for their introduction was by publication of their content in both the London Gazette and the Edinburgh Gazette.

Two workshops were run jointly with the DTI to examine the data management issues that may result from the Gazettal notice and provide a basis for these guidance notes. Data managers from both Oil and Service companies were represented, as were seismic data acquisition companies, consulting companies, data vendors and software vendors.

The Gazette notice, as issued by the DTI early December 1999, is printed in full in annex A.

2. WHAT HAS HAPPENED AND WHY

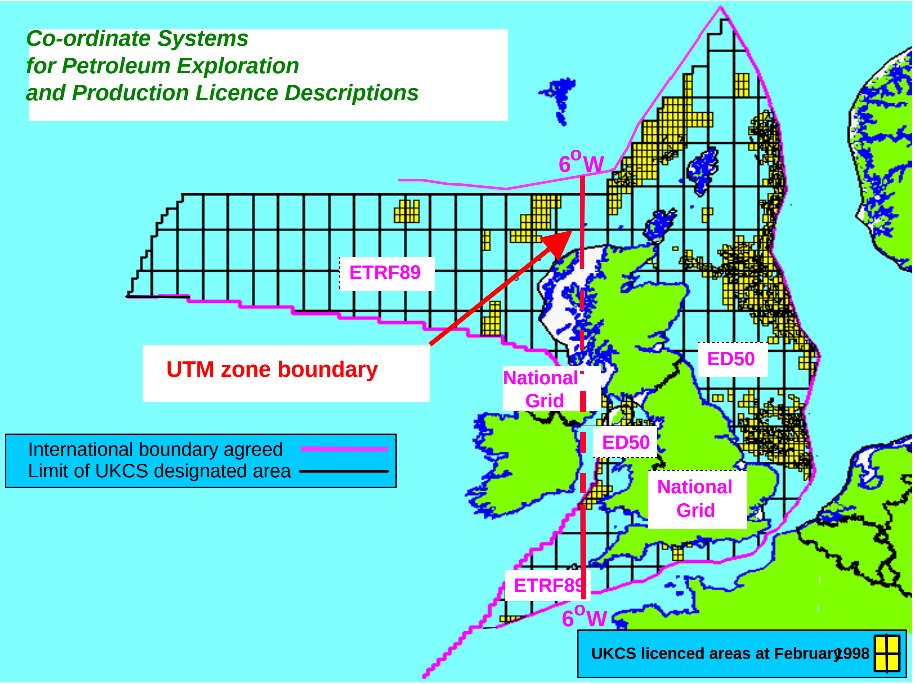
Co-ordinates describing a position on the earth are only unambiguous if the co-ordinate system to which they are referenced is identified. Geographical co-ordinate system components are geodetic datum and ellipsoid. Projected co-ordinate systems are Geographical Co-ordinate Systems with a projection transformation applied. See annex F for an overview of co-ordinate systems and annex G for a glossary of terms.

Petroleum licence boundary co-ordinates have previously been referenced to "European Datum". This term is not a precise one. Several versions of European Datum (ED) exist. Generally, in UKCS petroleum operations ED has been assumed to be the first (1950) iteration of European Datum (ED50). This was originally published to unify the co-ordinate systems used in mainland Western Europe and its extrapolation offshore becomes increasingly ambiguous as distance from the reference points used in its calculation increases. In the North Sea these ambiguities are of scientific curiosity only and not significant to petroleum operations. However, to the West of Shetland and even further west, differences arising from different technical assumptions quickly become very large. Potentially, tens or even hundreds of metres could be in dispute and could be legitimately argued by opposing sides in a unitisation case. For a discovery of oil & gas, such a variance could have severe economic impact.

It is this ambiguity and uncertainty in position that the DTI has removed in the Gazette notice by defining explicitly what it means by the term "European Datum".

2.1 *Longitude 6°W (ED50) - the Thunderer Line*

The DTI has chosen to be pragmatic in its implementation of these clarifications. Where the ambiguity in the term European Datum is small, which happily coincides with areas of mature UKCS petroleum activity, the co-ordinate system in use by the majority of the industry has been adopted. Where the differences in the interpretation of European Datum are potentially significant, a system has been adopted that can be considered to be coincident with the co-ordinate system used by satellite navigation GPS (Global Positioning System). A dividing line has been chosen (Longitude 6°W in ED50 terms) which is coincident with a UTM zone boundary. This dividing line has been dubbed "the Thunderer Line".



- East of the Thunderer line lies the majority of the more mature Exploration and Production activity on the UKCS. At the level of positional uncertainty here, there is no business justification for disrupting current practices for the majority of the industry. To the east of this line, the meaning of “European datum” is clarified as ED50. For UKCS petroleum purposes, ED50 is defined relative to ETRF89 (European Terrestrial Frame 1989) and GPS’s WGS 84 (World Geodetic System 1984) using accepted industry transformation methods and transformation parameter values, consistency being preferred to absolute accuracy.

- West of the Thunderer Line there is little data existing and, as yet, no Oil & Gas production. Hence, adoption of a technically preferred system is acceptable and encouraged. Here "European Datum" is clarified as ETRF89. The safety risk is reduced through adopting a system which for all practical purposes is that used by GPS. The geodetic datum adopted is also consistent with the UK international boundary definitions to the west of Britain.

- The Thunderer Line was chosen to be coincident with a UTM zone boundary, where there is normally a discontinuity of projected co-ordinates. Therefore there is no change in the number of projected co-ordinate systems in use on the UKCS.

- For landward areas of Scotland, England and Wales there is no change in the use of the Ordnance Survey ® GB National Grid and its geodetic datum OSGB 1936.

- For landward areas of Northern Ireland there is no change in the use of the Irish National Grid and its geodetic datum TM65.

Besides declaring which geographic co-ordinate systems should be used, the Gazette notice also declares the transformations applicable for petroleum purposes between ED50, ETRF89, OSGB36 and the GPS satellite navigation system’s co-ordinate frame WGS 84. This is a significant step forward in ensuring consistency of use across industry over the whole UKCS.

An example of how the UKCS licence boundary descriptions will appear, post-Gazettal, is given in annex B.

3. GUIDANCE FOR DATA USERS

Whilst the Gazette note refers explicitly to petroleum licence boundary co-ordinate descriptions, it is almost universal practise when communicating with the Petroleum Legislative body, to adopt the geographic co-ordinate system in which the legislation/licences are defined. The content of the Gazette notice should therefore be considered as standard for associated UK petroleum data management and mapping purposes. The DTI have stated that all data supplied to them should explicitly refer to the co-ordinate system to which it relates. All data acquired after 1st January 2000 should comply with the content of the Gazette notice.

Significant issues requiring guidance have been identified as being:

i. providing a simplified overview of co-ordinate systems and co-ordinate system transformations

ii. ensuring all software complies with these defined methods of transformation

iii. that all users of spatial data on the UKCS observe the correct utilisation of these parameters

The following sections of this guide give advice to data users and data managers, to applications vendors, and to data vendors.

A general rule applies to all:

> In the event of uncertainty, you are encouraged to call for specialist support. This may be from a Geomatics specialist (internally or externally) or help from your software supplier. You should recognise the fact that the incorrect specification of co-ordinate system can disturb the spatial integrity of your data in excess of hundreds of metres. Equally, if the identification of the co-ordinate system is missing the position described by co-ordinates will be uncertain by these distances.

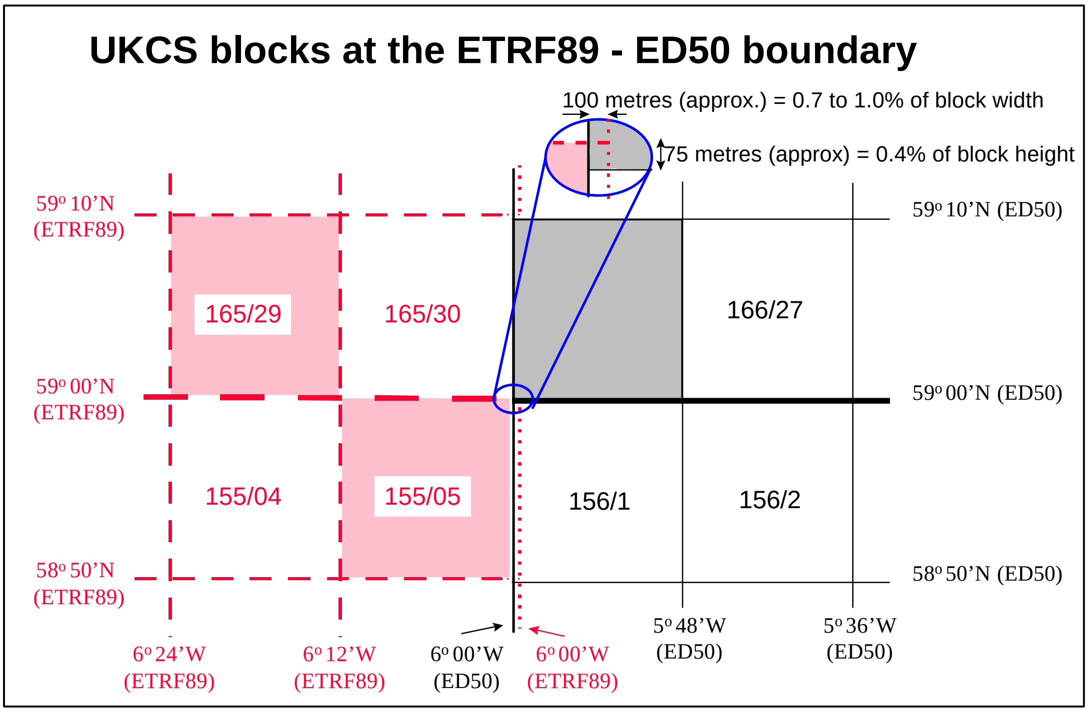
3.1 How will we map the UKCS?

There will be no change from the current practice of using the British and Irish National Grids as the co-ordinate systems for petroleum exploration and production in landward areas. In seaward areas the previously ambiguous position has been clarified.

UKCS licence boundaries to the east of the Thunderer Line follow a latitude and longitude graticule based on the ED50 co-ordinate system. UKCS licence boundaries to the west of the Thunderer Line follow a latitude and longitude graticule based on the ETRF89 co-ordinate system, except for licences abutting the Thunderer Line on their eastern side, where special provision is required to ensure exact adjacency to licences to the east based on ED50 (see figure overleaf).

The ETRF89 graticule is offset from the ED50 graticule by approximately 75 metres north south and 100 metres east west (these offsets change slowly with change of position). There will therefore be a discontinuity in the quadrant and block system along the Thunderer Line - see the diagram below. Co-ordinate conversion of one graticule to another is not a problem as long as the transformation details are clearly identified (as they are within the Gazette notice - see annex A), and if applications can properly apply these transformations.

A list of the north east and south east corners of the tier of blocks adjacent and west of the Thunderer line is given in annex C.



UKCS blocks at the Thunderer Line

The number of projected co-ordinate systems has not changed. There are still only five projected co-ordinate systems on the UKCS recognised by the DTI for offshore mapping.

Before
ED/UTM31, ED/UTM30, ED/UTM29, ED/UTM28 and ED/UTM27 (ED = "European Datum")

Now
ED50/UTM31, ED50/UTM30, ETRF89/UTM29, ETRF89/UTM28 and ETRF89/UTM27

Where the user's area of interest is confined to a single co-ordinate system, that system should be adopted. Where the area of interest crosses a co-ordinate system boundary what you do will depend upon the capabilities of your applications. It will generally be necessary to work in one preferred co-ordinate system.

- For areas east of the Thunderer line, most users will have assumed that the geographic co-ordinate system should be ED50. In these circumstances there is no change to current mapping practice of using a projected co-ordinate system based on this.

- For areas west of the Thunderer line, few users will have assumed that the geographic co-ordinate system should be ETRF89. This is the recommended geographic co-ordinate system in these areas, and projected co-ordinate systems should be based upon it. Guidance on changing to this is given below.

- If the area of interest crosses the Thunderer line, it is suggested that the same pragmatic approach is adopted as you would adopt ordinarily with data that straddles a UTM zone boundary i.e. if the majority of the data lies to one side, then you will work within that co-ordinate system. The caveat that applies here is that should this data be used for future presentation to the DTI, the DTI will require any submission to them to be in terms of ETRF89 for licences west of the Thunderer line and ED50 for licences east of the Thunderer line.

i. On the UKCS east of the Thunderer Line, the ED50 co-ordinate system encompasses the ED50 geodetic datum and the International 1924 ellipsoid. If projected, this is normally through either UTM zone 30 or zone 31 or a user-defined Transverse Mercator projection system.

ii. On the British mainland the Ordnance Survey® Great Britain National Grid co-ordinate system encompasses the OSGB 1936 geodetic datum and the Airy 1830 ellipsoid. If projected, this is only through the British National Grid, which uses a Transverse Mercator projection.

iii. On the UKCS west of the Thunderer Line, the ETRF89 co-ordinate system encompasses the ETRF89 geodetic datum and the GRS80 ellipsoid. If projected, this is normally through either UTM zone 27, zone 28 or zone 29 or a user-defined Transverse Mercator projection system.

iv. The WGS 84 co-ordinate system for GPS satellite navigation encompasses the WGS 84 datum and the WGS84 ellipsoid. In the UKCS it is not normally projected.

v. If you cannot find the geodetic datum ETRF89 in the geodetic datum list of your software, it may be that your software package does not yet recognise this geodetic datum. If this should be the case, it is recommended that a new geodetic datum be created bearing the name ETRF89, with GRS80 as its associated ellipsoid. Your software vendor should be able to assist with this procedure and it is recommended that they be contacted for updates to meet the UKCS co-ordinate system definitions post-Gazettal.

It should be noted that some software packages might not allow users to create a new datum, requiring the user to choose an existing, but non-relevant datum and re-name it. If this is the case, it is recommended that the software vendor be contacted, as above, to ensure this is done correctly.

Although it is not strictly appropriate, some applications require a relationship to a standard system (often WGS 84) as part of a geodetic datum or geographic co-ordinate system definition. For such packages:

- for ED50, enter the Common Offshore transformation, taking care to convert the units if your application does not accept those given in the Gazettal notice.
- for ETRF89, set all of the parameter values to zero.

vi. It is very important to ensure that the signs of the parameters used in the datum shifts are correct in respect of the transformation being executed. Preferably one should always express geodetic transformations in terms of "From".........."To"........... thus avoiding the confusion that may result from interpreting a dash as a minus sign or vice versa. Within the Gazette notice (annex A) representative test co-ordinate values are included as a confidence check that the parameters have been correctly set. Take particular care with matching the sign of the three-rotation parameters rotX, rotY and rotZ with the rotation convention used by the algorithm in your application. Different algorithms, both using seven-parameters, co-exist. If in doubt contact the application vendor. After loading the transformation information, run a test using the data in the Gazettal notice.

3.2 Mappers and Interpreters

i. Any map produced <u>must</u> have a co-ordinate system identification in the legend. Guidelines for correctly setting up map layout can be found on the EPSG website. Guidance Note No. 6 specifically refers to Map Content.

ii. If the "project" has already been set up for you as a user, verify the checklist supplied to you by the data loader to ensure the correct co-ordinate system has been adopted for the area covered by the data.

iii. Having set up the interpretation or mapping software for the correct co-ordinate system, the next thing is to enter the data. Here, the user will have to look at the type of data he is trying to map.

- Legacy licence boundary data files need to be edited to show the correct geodetic datum. Unless you require to map these values in a co-ordinate system using a different geodetic datum to that in which they are now defined, you will NOT need to change their values. The exception here is for blocks west of but adjacent to the Thunder Line whose eastern co-ordinates follow the ED50 graticule. Co-ordinate transformation will be required for consistency with ED50 values east of the Thunderer line. A listing of these co-ordinates may be found in annex C.

- Measured data (2D/3D seismic, well surface locations, well bore locations, surface facilities etc.), will, as always, need to be transformed if it is required to view, map or integrate with other data in a different co-ordinate system to that in which it is acquired/stored.

iv. *How will UKCS licence graticules be plotted in the future when their turning points are described in different systems?* This will depend on your application. Some can handle only one co-ordinate system. If so, a pragmatic solution to this would be that if you have separate plot files stored for the licence overlays, you will need to have one set with everything converted to ED50, or a projected co-ordinate system based thereon, and another with everything converted to ETRF89, or a projected co-ordinate system based thereon. To assist, annex C contains a list of the ETRF values of turning points applicable to the blocks adjacent to and immediately west of the Thunder Line.

v. Where the data and/or prospect occurs wholly to the west of the Thunderer line, then ETRF89, or a projected co-ordinate system based thereon, should be adopted as the co-ordinate system of choice to work within. If your data is currently referred to ED50 then you should transform it to ETRF89 before entering it into your project. It is important that this should be done correctly, and within software that is capable of conducting such a transformation. If in doubt, you should consult specialist support, from a Geomatics specialist (internally or externally). In the event of any uncertainty concerning a particular software package, you should consult the software vendor. The incorrect choice of co-ordinate reference system, or an incorrectly performed datum transformation can disturb the spatial integrity of your data up to hundreds of metres.

3.3 Data Management

East of the Thunderer Line

East of the Thunderer line the co-ordinate system for licence boundary description, ED50, is the de facto system in use by most UKCS practitioners. **Then no change to current practice is required**. Existing data can be left as it is. Data managers should however check whether their applications are set to use the geodetic transformation method and parameters recommended by the DTI on the UKCS.

If transformation method and/or parameters are set differently, the difference between the current method and/or parameters and the recommended method and/or parameters should be evaluated. If this difference is not significant, the recommended transformation method and/or parameters should be adopted in place of those in use.

If the transformation method and/or parameters are different and the difference is significant then consideration should be given to unloading the data, applying the old transformation method and/or parameters to WGS 84, transforming the data back to ED50 using the method and Common Offshore transformation parameters detailed in the Gazettal notice (annex A), and then reloading.

This note cannot determine what differences might be considered significant by different users or for different purposes. However you should note that before 1980 positioning techniques in use in the North Sea gave absolute positions no better than 15 metres accuracy, and only since the early 1990s have accuracies of better than 5 metres been achievable.

Note should be taken of the caveat within the Gazette notice that states: *"In certain cases involving existing unitisation across licence boundaries it will be necessary to retain the use of the transformation adopted by the unit operator to ensure that there is no change in equity attributable to revised co-ordinate system practices."* Do not apply the clarified co-ordinate systems to spatial data that are covered under special unitisation arrangements.

West of the Thunderer Line

The recommended co-ordinate system west of the Thunderer line is ETRF89, or a projected co-ordinate system based thereon. It is probable that alternative assumptions have historically been made. These assumptions need to be understood (they may vary between data sets) and consideration given to correcting the data. As there is very little data existing to the west of the Thunderer line, management of legacy data should be achievable with care.

i. Ensure an audit trail exists for all changes made.

ii. Data managers need to ensure that ALL their spatial data is effectively flagged with the datum correctly associated with it. If this data is from west of 6°W do not flag it as ETRF89 unless it has first been transformed to ETRF89 from ED using the reverse of whatever transformation was applied to get it to “ED50” (this may not have been the Common Offshore transformation). The exception to this is licence block boundary data, for which the geographic co-ordinate values will be correct and do not require changing, but the co-ordinate system label incorrect and needing to be changed to ETRF89. (Note that grid co-ordinates derived from the same latitude and longitude differ between ED50 and ETRF89, so ED based projected co-ordinate system co-ordinates of licence block corners will need converting. No datum transformation should be applied in this conversion; it is safest to take the 10’ x 12’ geographical values and convert these to projected co-ordinates).

iii. Legacy projects do not require to be transformed unless they are or in the future become active projects. Ensure an audit trail exists for any changes made or not made!

iv. It is recommended that all existing stocks of legacy maps, plans, transparencies and reports that may contain data that could be considered affected should be stamped with the following warning:

   "The graticule or geographic co-ordinates shown on the UKCS portion of this map west of longitude 6degW (the Thunderer Line) are no longer current. If shown, Petroleum licence block boundaries and other data may be incorrectly depicted in this area. The datum used to control this portion of the map should be the European Terrestrial Reference Frame 1989 (ETRF89)." If applicable, this should be supplemented with the additional statement indicating a contact point, “For further information contact....".

v. If your database system stores all UKCS spatial data on a unified datum, and that datum is ED50, future data acquired on ETRF89 will require transformation to ED50 before storage. If this is done, "Best Practice" requires the original co-ordinate information to be also stored, together with its reference co-ordinate system and associated transformation parameters to ensure a correct data management audit trail is maintained.

Data crossing the Thunderer Line

If your database system currently stores all UKCS spatial data on a unified co-ordinate system, the licence boundary data west of the Thunderer Line will now be incorrect. If relevant, this boundary data will need to be unloaded and re-loaded after the Common Offshore transformation from ED50 to ETRF89 has been applied.

3.4 Data Loaders

This section should be read in combination with the following section 3.5 for application users.

i. Provide/accept only correct and full information about the data. All of the co-ordinate system identification fields, and particularly the geodetic datum field need to be completed intelligently. Data should be returned or at the very least queried if header information is missing or suspect. If uncertain, seek specialist advice, as many software packages do not allow this field to be edited after data has been loaded.

ii. Do not accept the defaults unless you know them to be correct.

iii. Do not assume the "geodetic datum". If it is genuinely unknown, then the datum should be expressed or input. It is better to know that you have uncertain information than to be misled into believing you have good information. A blank field should not be accepted. However, if it is possible to find out the correct information, then "unknown" should not be adopted as a panacea.

    To define a co-ordinate system, it is not necessary to make reference to its relationship with any other co-ordinate system. However, some software packages imbed the geodetic transformation parameters between different co-ordinate systems within the co-ordinate system definitions. If this is the case with the software package you are currently using, and that software allows an “unknown” choice for geodetic datum, ask your software vendor what effect this will have concerning future co-ordinate system transformations. Make users aware what effect this will have.

iv. More use should be made of checklists to enable a full data management audit trail to be developed.

3.5 Applications usage

i. Section 4 deals with guidance notes for Software Vendors. The answers to several of the questions raised in that section are also of direct relevance on you, the software user.

    Q *- Does your software utilise a Geographical or Projected Co-ordinate System?*

    If the answer is NO, and no reference is made within the software to the Geodetic Software, the user should consult their data manager to ensure that any data entered to the software has been correctly transformed to a unified co-ordinate system. Any output from that software package must be correctly labelled with the associated co-ordinate system and a spatial data audit trail maintained.

    If your software does not enable you to transform co-ordinate data between different geographical co-ordinate systems, users must use an external package to conduct any necessary transformations before re-input of the transformed data to the software package. Position errors of hundreds of metres can result through incorrect transformations, or mixture of data relating to different co-ordinate systems.

    Q *- Does your software allow for geodetic transformation of geographical co-ordinates through a method using seven-parameters?*

If the software you are using does allow a seven-parameter shift one should be aware that there are two opposing sign conventions for the three rotation parameters. These are considered to be two different transformation methods, either a Position Vector transformation or a Co-ordinate Frame Transformation**.** The convention used within the Gazette notice is that of the Position Vector transformation (elsewhere called the Bursa-Wolf Transformation). It is crucial that the signs and interpretation of the transformation parameters are consistent with the convention being applied by the algorithm within your application. Ask your vendor to clarify his application algorithm, and use a given test point, such as provided in the Gazette notice, to confirm.

If the software you are using does not allow a seven-parameter shift, it may be that it uses a three-parameter Molodenski transformation method. If this is the case one will NOT be able to use the seven parameter values given in the DTI Gazette notice. It is recommended that an alternative software package be used until the user's preferred application has the necessary capability.

ii. The Gazette notice provides defines transformation parameters between the geographic co-ordinate systems recognised for use on/around the UKCS. Applications including geodetic transformation data may be delivered with transformations that are inconsistent with those recommended for UKCS. Check and change if necessary. If you have already used the preset transformations and their parameters are different, consideration should be given to applying the old transformation to WGS 84, and transforming the data once more using the transformations detailed in the Gazettal notice (annex A).

iii. To define a co-ordinate system, it is not necessary to make reference to its relationship with any other co-ordinate system. However, some software packages imbed the geodetic transformation parameters between different co-ordinate systems within the co-ordinate system definitions. For such applications, the co-ordinate system definitions also need to be checked and if necessary changed.

If the geodetic co-ordinate system reference ETRF89 is not yet established within your software it is recommended that a new one is set-up using the parameters for ellipsoid as quoted in annex G. Its datum relationship with WGS 84 should be set with zero values. The software vendor should be approached for assistance if this is found not to be possible.

iv. If asked by a software vendor to use WGS 84 for the interim period until a new release of the software is given, be aware of the potential for "project amendment problems" when the future release arrives including ETRF89 as a separate geodetic datum.

Related to this is the potential for error in automated data exchange packages/links when merging data files with different naming conventions for the co-ordinate systems.

4. GUIDANCE FOR SOFTWARE VENDORS

Users working in several areas of the UKCS will encounter data related to several geographic and projected co-ordinate systems. Most software vendors dealing with a global market will have products able to handle different geographical and projected co-ordinate systems and transformations between them, but many of the UKCS users will only have experience with data handling in one geodetic datum (European Datum, which they may have assumed to be ED50).

Software vendors are encouraged to help and assist users of their software by preparing their own guidance notes on implementation of the clarified UKCS co-ordinate system relationships within their software.

4.1 Data Storage

Because UKCS users expect to deal with co-ordinates in several co-ordinate systems, database applications must either

a) be able to store co-ordinates in any of these systems, with all data associated with the appropriate co-ordinate system identifier.

or

b) if they use only a single co-ordinate system they should be able to retain the identification of the original co-ordinate system together with an audit trail of transformations applied to the data. Applications using this data should be able to reconstitute the original co-ordinates through reverse application of the transformations.

4.2 Co-ordinate System Definitions

i. Co-ordinates are unambiguous only when adequate co-ordinate system identification is made. Because a variety of co-ordinate systems may be encountered it is critical that these can be identified. All co-ordinate data should be tagged with its correct co-ordinate system identifier. Recommended practice in co-ordinate system definition can be found in the EPSG Guidance Note Number 5 (see the reference section at annex D of these guidance notes).

   In summary, a geographic co-ordinate system's components are geodetic datum and ellipsoid. A projected co-ordinate system's components are as a geographic co-ordinate system with a projection transformation (method and appropriate parameter values) applied.

   Does your software utilise a Geographical or Projected Co-ordinate System (as defined by POSC)? Software vendors should check if their application is consistent with this advice, and if not put in place a plan to work towards having this functionality.

ii. The geographic co-ordinate systems required for the UK petroleum purposes are ED50, ETRF89, OSGB36 and TM65. The projected co-ordinate systems required are:

   ED50 / UTM zone 31N,

   ED50 / UTM zone 30N,

   ETRF89 / UTM zone 29N,

   ETRF89 / UTM zone 28N,

   ETRF89 / UTM zone 27N,

OSGB 1936 / British National Grid, and

TM65 / Irish National Grid.

Co-ordinate system defining parameters and details are given in the EPSG database (see the reference section in annex D of these guidance notes).

If your software is delivered with co-ordinate system defining parameters, does it include the systems required for the UKCS? If not, they should be included in your next release. You should provide your users with guidance on what to do in the mean time.

iii. Oil companies and users may also wish to supplement these systems with their own, using the definition requirements given above. *Does your application allow user-defined co-ordinate systems following the POSC/EPSG guidelines for co-ordinate system definition?* If not, then you should;

a) provide advice to users on how they may add their own co-ordinate systems.

b) put in place a plan to work towards this functionality.

4.2 Co-ordinate System Transformations

Because a variety of co-ordinate systems may be encountered users may wish to transform co-ordinates between the systems.

i. Geodetic transformations consist of a method and a set of parameter values consistent with the method. It is recommended to all software vendors that they take note of the most recent POSC literature pertaining to Geographic and Projected Co-ordinate System Transformations. This information was compiled by EPSG members for the Petrotechnical Open Software Corporation (POSC). It can be found in the form of EPSG Guideline No.7 reproduced on the EPSG website with the permission of POSC. In particular your attention is drawn to the section titled Helmert Transformation.

ii. *Does your software allow for geodetic transformation of geographical co-ordinates through a method using seven-parameters?* If no, then it should be implemented. If yes, have you checked which geocentric method is used? Does your user documentation clearly state the method used?

iii. The DTI Gazettal notice (annex A) adopts the geocentric co-ordinate Position Vector transformation for the UKCS transformations. This is one of several methods that utilise seven-parameters and is the method favoured in the European E&P Industry. The parameter values given in the Gazettal notice can only be used with the position vector transformation. They need to be modified for use with other geocentric methods. Specifically, if the Co-ordinate Frame convention is utilised in your application then the signs of the values three-rotation parameters given in annex A need to be changed.

iv. The Molodenski three-parameter method is <u>not</u> recommended, as it assumes that the axes of the source and target systems are parallel to each other and have no scale difference. On the UKCS, this assumption is not true and consequently this transformation method will result in only moderate accuracy, especially if applied over large areas.

v. To define a co-ordinate system, it is not necessary to make reference to its relationship with any other co-ordinate system. However, several software packages imbed the datum transformation parameters to WGS 84 within the co-ordinate system definition. For the UKCS this can mean that ED50, and/or OSGB36, may have a set of transformation parameters relating it to WGS 84 already set within the software.

Your software should be checked to ensure the correct geodetic transformation method parameters, as defined within the Gazette notice (see annex A), are available for use. The transformations required for UKCS petroleum purposes are

- the Common Offshore transformation between ED50 and WGS 84, which can also be used between ED50 and ETRF89 (which can also be used between OSGB 1936 and WGS 84).
- the OSGB Petroleum transformation for transformations between OSGB 1936 and ETRF89.
- the UKOOA landward/seaward transformation between OSGB36 and ED50.

The transformation method and parameters for relating TM65 and the Irish National Grid to the other systems is outwith the scope of the DTI Gazettal notice.

iv. The Gazette notice includes test data against which your software can be run. If the user is required to input the transformation parameter values, they should be instructed how to input them into your software with the correct regard to whether a Position - Vector (sometimes called "Bursa-Wolf") or Co-ordinate Frame Rotation transformation sign convention should be used.

v. For applications that are unable to transform directly between two co-ordinate systems but do so indirectly through a standard system (such as WGS 84) the UKOOA landward/seaward transformation may be effected through the concatenation of the Common Offshore and OSGB Petroleum transformations.

vi. Whilst the OSGB Petroleum transformation is adequate for offshore petroleum industry purposes, users working in landward areas may have a requirement for a more accurate transformation between WGS 84/ETRF89 and OSGB36. This is available through the Ordnance Survey National Grid Transformation OSTN97 for 2-dimensional transformations, or OSTN97 together with the OSGM91 geoid model for 3-dimensional transformations. Details of these transformations are available from the Ordnance Survey (see the reference section in annex D).

4.4 Mapping

Most mapping and GIS software will enable their users to represent their data in 2D hardcopy form. Users have to minimise the risk of incorporating legacy ED50 data (that has not been transformed), with data that may be ETRF89 based.

The following represent some of the ways Mapping software vendors can assist.

i. Every map, or screen from which hardcopy may be taken, should include the projected co-ordinate reference system as normal practice. Software vendors are encouraged to guide their users in best practice with regards to this principle.

The EPSG have produced a guidance note No. 6 concerning Map Content targeted specifically at petroleum exploration mapping (see the reference section in annex D of these guidance notes).

ii. The user should be advised if he is able to mix data relating to different co-ordinate system origin within the same map. This is an acceptable practice, but only if the necessary transformations to the map co-ordinate system have been applied. This of course requires correct identification of the co-ordinate system on which each element of data is based. Introduction of simple co-ordinate system integrity checks will assist here.

iii. Software vendors are encouraged to utilise the header records of internationally accepted standard data formats wherever possible for both loading and export of data. This may appear an obvious statement, but there are new format descriptions recently released, updated, or in the process of being released from many bodies, i.e. UKOOA, SEG, EPSG, POSC, OpenSpirit, PPDM etc. All of these bodies have embraced the principal of spatial data integrity and allow for both projected and geographical co-ordinate system components and transformations to be listed within their standard format header records. More information on these standards can be found in annex D.

4.5 Reporting

Because UKCS users expect to deal with co-ordinates in several co-ordinate systems, any reports that include co-ordinate information must include the name and parameters required for an unambiguous description of the co-ordinate system to which those co-ordinates are related.

5. GUIDANCE FOR DATA VENDORS

Data purchasers will be increasingly aware that if they are to manage the working in multiple co-ordinate systems on the UKCS effectively, they have to be sure of the co-ordinate integrity of their spatial data. Data vendors must ensure that all co-ordinate data is accompanied by an adequate identification of the co-ordinate system. Vendors should expect their clients to be increasingly intolerant of incomplete data information. Guidance on the description of co-ordinate systems is given in EPSG guidance note No. 5 (see the reference section in annex D).

i. It is recommended that supporting information be captured and supplied in an unchangeable format and be available on-line (i.e. PDF).

ii. Increasingly, Data Exchange Standards are being introduced that allow for a complete co-ordinate data history (audit trail) to be recorded. These should be rigidly followed and, in particular, the co-ordinate system identification field(s) must be intelligently populated. Some of these standards are listed in the reference section in annex D of these guidance notes.

iii. Virtually all data acquisition (i.e. offshore surveying and positioning) is now performed using the Global Positioning System (GPS). To date, transformation to/from the ED50 geographical co-ordinate system has been required to relate to the petroleum licence co-ordinate system concerned. If data has undergone transformation from the time of its original acquisition an audit trail should be supplied with the data detailing the transformations applied and the parameters used to affect them.

iv. From the 1st January 2000, the UKCS petroleum licence boundary co-ordinates supplied and used will have to reflect the clarifications contained in the Gazette notice. This type of spatial data (as explained further in 6.2 below) can be classified as defined data.

Other data types, seismic, wells etc. tend to fall under the "measured data" category, and here a decision has to be made "do we transform or not". Whatever the decision, the data has to be accompanied by a clear statement (digital or otherwise) to clarify what co-ordinate reference system the data is described within. Failure to do this may degrade its positional integrity by several hundreds of metres.

5.1 Future Data

For new data, if east of the Thunderer line, co-ordinates should be supplied in ED50 terms. If west of the Thunderer line, co-ordinates should be supplied in ETRF89 terms. If straddling the Thunderer line co-ordinates may be supplied in either wholly ED50 or wholly ETRF89 terms, usually in the system that the majority of the data is from.

For petroleum exploration and production purposes the co-ordinate transformations applicable are covered within the Gazette notice within annex A.

5.2 Legacy Data

For legacy data, the issue of whether to supply data in the legacy co-ordinate system or to convert to the recommended co-ordinate system should be addressed. If the legacy co-ordinate system is retained, it and any transformations applied to it during the acquisition process, must be adequately described. A distinction has to be made concerning whether one is dealing with "defined" or "measured" data.

Defined data

From the 1st January 2000, the UKCS petroleum licence boundary co-ordinates supplied either as numbers or in map form will have to reflect the clarifications contained in the Gazette notice. This type of spatial data can be classified as defined data. Except for the co-ordinates of licences in the tier immediately west of the Thunderer line (see annex C), blocks and quadrants retain the corner co-ordinates that they have always had. Licence boundary co-ordinates for licences to the east the Thunderer line are in ED50 terms, whilst those for licences to the west of the line are in ETRF89 terms.

Measured data

East of the Thunderer line

i. The recommended relationship between ED50 and WGS 84 or ETRF89 for petroleum exploration purposes has now been defined as the "Common Offshore" transformation detailed in the Gazette notice. However, it is recognised that slightly different transformations have been used historically. In general, for oil exploration and production purposes the results of these transformations are not significantly different and can be ignored, but if known, they should be documented.

ii. In certain cases involving existing unitisation across licence boundaries it will be necessary to retain the use of the transformation adopted by the unit operator to ensure that there is no change in equity attributable to revised co-ordinate system practices.

West of the Thunderer Line

i. Whether the decision is made to "transform or not", it is important to always supply full reference, digitally and/or in hard copy concerning the co-ordinate system to which the spatial data refers. Existing measured data must be fully documented.

ii. Existing data (seismic, well) positioned using GPS may have had an inappropriate datum transformation applied. If so the datum transformation should be reversed.

iii. Existing data positioned by Transit may have had an inappropriate datum transformation applied. This should be reversed and if a positioning accuracy of better than 15m is required the DMA WGS72 Broadcast Ephemeris to WGS 84 transformation applied.

iv. Existing data positioned by radio-navigation (e.g. Pulse/8) may not have had an appropriate datum transformation applied. If a positioning accuracy of better than 150m is required the so-called ED50 position (whatever that means) should be converted to ETRF89 by applying the Common Offshore transformation in reverse.

Generally

It is recommended that all existing stocks of published maps, plans, transparencies and reports that may contain legacy data that could be considered affected should be stamped with the following warning:

> "The graticule or geographic co-ordinates shown on the UKCS portion of this map west of longitude 6degW (the Thunderer Line) are no longer current. If shown, Petroleum licence block boundaries and other data may be incorrectly depicted in this area. The datum used to control this portion of the map should be the European Terrestrial Reference Frame 1989 (ETRF89)." If applicable, this should be supplemented with the additional statement indicating a contact point, "For further information contact....".

ANNEXES

Annex A - DTI Gazette Notice (in full)

Co-ordinate Systems for UKCS Petroleum Exploration and Production Licences

It has been drawn to the Department's attention that there may be some uncertainty as to petroleum licence boundary co-ordinate description across the UKCS. This Notice sets out the Department's interpretation of licence boundary co-ordinates in existing licences and confirms the position, until further notice, as to the co-ordinate systems that will apply in the case of future awards of licences. These are to be determined in accordance with the principles set out below.

Specific geographical co-ordinate systems are identified for use in various areas. Transformations between the relevant co-ordinate systems are defined. Through a combination of the declared co-ordinate systems and declared transformations, petroleum industry users can unambiguously merge positional data throughout the UK and its continental shelf. The recommendations are made explicitly for petroleum licence boundary co-ordinate description but are also suitable for use for petroleum data management purposes.

The Oil and Gas Directorate of the Department of Trade and Industry advise that:

1. To the east of 6 degrees West longitude, "European Datum" means the first adjustment dated 1950, usually referred to as ED50. For UKCS petroleum exploration and production purposes ED50 is equivalent to ETRF89 with the "Common Offshore" transformation applied.

2. To the west of 6 degrees West longitude, the co-ordinate system for UKCS petroleum exploration is ETRF89. UKCS licence boundaries to the west of 6 degrees West longitude follow a latitude and longitude graticule based on the ETRF89 system, except for licences abutting 6 degrees West longitude on their eastern side where special provision is required to ensure exact adjacency to licences to the east based on ED50.

3. The current practice of using the Ordnance Survey (R) GB National Grid as the co-ordinate systems for petroleum exploration and production in landward areas of Great Britain is maintained.

4. The following geodetic transformations are recognised as defining the relationships between the various co-ordinate systems required for UKCS petroleum exploration and production purposes:

   4.1 the difference between the WGS 84 and ETRF89 co-ordinate systems is not significant and WGS 84 co-ordinate values can be assumed to be equivalent to ETRF89. This is equivalent to the transformation between WGS 84 and ETRF89 being taken to be zero.

   4.2 the recommended relationship between ED50 and WGS 84 or ETRF89 is the "Common Offshore" transformation. The Common Offshore transformation is an operation using the position vector transformation method and the following specified set of Helmert transformation parameters for changing co-ordinates between the WGS 84 and ED50 co-ordinate systems on the UKCS. For petroleum exploration and production purposes the transformation can also be used between the ETRF89 and ED50 co-ordinate systems.

"Common Offshore" transformation parameters from ETRF89 (WGS 84) to ED50						
dX(m)	dY(m)	dZ(m)	RotX"	RotY"	RotZ"	Scale(ppm)
+89.5	+93.8	+123.1	0	0	+0.156	-1.200

Test Point using Common Offshore transformation parameters :

	Latitude	Longitude	Ellipsoid Height
ETRF89 (WGS 84)	53° 00' 00.000" N	01° 00' 00.000" E	50.00 m
ED50	53° 00' 02.887" N	01° 00' 05.101" E	2.72 m

4.3 the relationship between OSGB36 (OSGB National Grid) and ETRF89 is the OSGB petroleum transformation. The OSGB petroleum transformation is an operation using the position vector transformation method and the following specified set of Helmert transformation parameters for changing co-ordinates between OSGB36 and ETRF89 or WGS 84 co-ordinate systems. The transformation has an accuracy of typically 2 metres and is no worse than approximately 4 metres throughout Britain. A more accurate transformation is available from the Ordnance Survey.

OSGB petroleum transformation parameters from ETRF89 (WGS 84) to OSGB36						
dX(m)	dY(m)	dZ(m)	RotX"	RotY"	RotZ"	Scale(ppm)
-446.448	+125.157	-542.060	-0.150	-0.247	-0.842	+20.4894

Test Point using OSGB petroleum transformation parameters :

	Latitude	Longitude	Ellipsoid Height
ETRF89 (WGS 84)	53° 00' 00.000" N	01° 00' 00.000" E	50.00 m
OSGB36	52° 59' 58.719" N	01° 00' 06.490" E	3.99 m

4.4 the relationship between OSGB36 and ED50 is the concatenation of the OSGB36 to ETRF89 and ETRF89 to ED50 transformations in recommendations 4.2 and 4.3 above, known as the UKOOA landward/seaward transformation.

UKOOA landward/seaward transformation parameters from OSGB36 to ED50						
dX(m)	dY(m)	dZ(m)	RotX"	RotY"	RotZ"	Scale(ppm)
+535.948	-31.357	+665.160	0.150	0.247	0.998	-21.689

Test Point using UKOOA landward/seaward transformation parameters :

	Latitude	Longitude	Ellipsoid Height
OSGB36	52° 59' 58.719" N	01° 00' 06.490" E	3.99 m
ED50	53° 00' 02.887" N	01° 00' 05.101" E	2.72 m

It is recognised that slightly different transformations have been used historically. In general, for oil exploration and production purposes these transformations are not significantly different. In certain cases involving existing unitisation across licence boundaries it will be necessary to retain the use of the transformation adopted by the unit operator to ensure that there is no change in equity attributable to revised co-ordinate system practices.

Further details and guidelines are published on the DTI and UKOOA websites (www.og.dti.gov.uk, www.ukooa.co.uk)

Annex B - Post Gazette description of UKCS licence areas

B1. For licences east of 6 degrees west.

The area bounded by parallels of latitude and meridians of longitude joining the following European Datum 1950 (ED50) geographical co-ordinate system co-ordinates:

56° 20’ N, 0° 24’ E
56° 20’ N, 0° 36’ E
56° 10’ N, 0° 36’ E
56° 10’ N, 0° 24’ E

Equivalent turning point co-ordinates in ETRF89 geographical co-ordinate system terms, derived through the Common Offshore transformation, are:

56° 19’ 57.489” N, 0° 23’ 54.421” E
56° 19’ 57.498” N, 0° 35’ 54.440” E
56° 09’ 57.477” N, 0° 35’ 54.463” E
56° 09’ 57.468” N, 0° 23’ 54.445” E

B2. For licences west of and adjacent to 6 degrees west.

The area bounded by parallels of latitude and a meridian of longitude joining the following ETRF89 geographic co-ordinate system co-ordinates:

from in the south east:	58° 50’ 00.000” N,	6° 00’ 06.554” W
to in the south west:	58° 50’ 00.000” N,	6° 12’ 00.000” W
to in the north west:	59° 00’ 00.000” N,	6° 12’ 00.000” W
to in the north east:	59° 00’ 00.000” N,	6° 00’ 06.585” W

and between the north east and south east turning points by the meridian of 6° West longitude constructed on the European Datum 1950 (ED50) geographic co-ordinate system.

Equivalent turning point co-ordinates in European Datum 1950 (ED50) geographic co-ordinate system terms, derived through the Common Offshore transformation, are:

in the south east:	58° 50’ 02.489” N,	6° 00’ 00.000” W
in the south west:	58° 50’ 02.498” N,	6° 11’ 53.429” W
in the north west:	59° 00’ 02.477” N,	6° 11’ 53.398” W
in the north east:	59° 00’ 02.467” N,	6° 00’ 00.000” W

B3. For licences further west than 6 degrees west.

The area bounded by parallels of latitude and meridians of longitude joining the following ETRF89 geographical co-ordinate system co-ordinates:

58° 40’ N, 6° 24’ W
58° 40’ N, 6° 12’ W
58° 20’ N, 6° 12’ W
58° 20’ N, 6° 24’ W

Annex C - Co-ordinates of Blocks immediately West and adjacent to the Thunderer Line

	ETRF89 Latitude Longitude	ED50 Latitude Longitude	OSGB36 British National Grid Easting Northing
UK-Faeroes boundary (???/25) NE corner	60°15'29.611"N 6°00'06.830"W	60°15'31.910"N 6°00'00.000"W	
(???/30) NE corner	60°10'00.000"N 6°00'06.811"W	60°10'02.312"N 6°00'00.000"W	
(165/05) NE corner	60°00'00.000"N 6°00'06.778"W	60°00'02.334"N 6°00'00.000"W	
165/10 NE corner	59°50'00.000"N 6°00'06.745"W	59°50'02.356"N 6°00'00.000"W	
165/15 NE corner	59°40'00.000"N 6°00'06.712"W	59°40'02.379"N 6°00'00.000"W	
165/20 NE corner	59°30'00.000"N 6°00'06.680"W	59°30'02.401"N 6°00'00.000"W	
165/25 NE corner	59°20'00.000"N 6°00'06.648"W	59°20'02.423"N 6°00'00.000"W	
165/30 NE corner	59°10'00.000"N 6°00'06.616"W	59°10'02.445"N 6°00'00.000"W	
155/05 NE corner	59°00'00.000"N 6°00'06.585"W	59°00'02.467"N 6°00'00.000"W	
155/10 NE corner	58°50'00.000"N 6°00'06.554"W	58°50'02.489"N 6°00'00.000"W	
155/15 NE corner	58°40'00.000"N 6°00'06.524"W	58°40'02.510"N 6°00'00.000"W	
Cape Wrath to Butt of Lewis landward/seaward limit	58°32'32.900"N 6°00'06.501"W	58°32'35.426"N 6°00'00.000"W	167 223 968 540
Mull of Oa to Mull of Kintyre landward/seaward limit	55°24'31.256"N 6°00'05.990"W	55°24'34.173"N 6°00'00.000"W	146 792 620 038
(125/20) NE corner	55°20'00.000"N 6°00'05.978"W	55°20'02.926"N 6°00'00.000"W	
(125/25) NE corner	55°10'00.000"N 6°00'05.954"W	55°10'02.946"N 6°00'00.000"W	
Ulster coast		6°00'00.000"W	

	ETRF89 Latitude Longitude	ED50 Latitude Longitude	OSGB36 British National Grid Easting Northing
UK-Ireland boundary 102/10 NE corner	51°50'00.00"N 6°00'05.52"W	51°50'03.32"N 6°00'00.00"W	
102/15 NE corner	51°40'00.000"N 6°00'05.497"W	51°40'03.340"N 6°00'00.000"W	
102/20 NE corner	51°30'00.000"N 6°00'05.477"W	51°30'03.357"N 6°00'00.000"W	
102/25 NE corner	51°20'00.000"N 6°00'05.458"W	51°20'03.375"N 6°00'00.000"W	
102/30 NE corner	51°10'00.000"N 6°00'05.439"W	51°10'03.392"N 6°00'00.000"W	
93/05 NE corner	51°00'00.000"N 6°00'05.420"W	51°00'03.410"N 6°00'00.000"W	
93/10 NE corner	50°50'00.000"N 6°00'05.401"W	50°50'03.427"N 6°00'00.000"W	
93/15 NE corner	50°40'00.000"N 6°00'05.382"W	50°40'03.444"N 6°00'00.000"W	
93/20 NE corner	50°30'00.000"N 6°00'05.364"W	50°30'03.461"N 6°00'00.000"W	
93/25 NE corner	50°20'00.000"N 6°00'05.346"W	50°20'03.478"N 6°00'00.000"W	
93/30 NE corner	50°10'00.000"N 6°00'05.328"W	50°10'03.495"N 6°00'00.000"W	
85/05 NE corner	50°00'00.000"N 6°00'05.310"W	50°00'03.512"N 6°00'00.000"W	
85/10 NE corner	49°50'00.000"N 6°00'05.292"W	49°50'03.529"N 6°00'00.000"W	
85/15 NE corner	49°40'00.000"N 6°00'05.275"W	49°40'03.545"N 6°00'00.000"W	
85/20 NE corner	49°30'00.000"N 6°00'05.257"W	49°30'03.562"N 6°00'00.000"W	
85/25 NE corner	49°20'00.000"N 6°00'05.240"W	49°20'03.578"N 6°00'00.000"W	
85/30 NE corner	49°10'00.000"N 6°00'05.223"W	49°10'03.594"N 6°00'00.000"W	
UK-France boundary	49°06'47.805"N 6°00'05.217"W	49°06'51.404"N 6°00'00.000"W	
Note: As at 1/12/99, blocks with names given in parentheses have yet to be created through a Continental Shelf Order.			

Annex D - Reference Information

Department of Trade and Industry (DTI)

The Department of Trade and Industry is responsible through its Oil and Gas Directorate for the regulation and sponsorship of the United Kingdom's oil and gas resources onshore and offshore, and for the associated environmental protection regime.

Responsibility for petroleum licensing policy and the administration of the licensing process lies with the Directorate's Exploration and Licensing Branch. Licences to explore for and extract petroleum are issued by this branch.

http://www.og.dti.gov.uk

EPSG

The European Petroleum Survey Group (EPSG) was formed in 1986. It comprises specialist surveyors, geodesists and cartographers from European oil companies. The EPSG aims to help member companies, and where relevant others, by the dissemination of information, which by generally improving oil industry survey practices and procedures, will contribute to increased efficiency, enhanced quality, improved safety of operations and the protection of the environment.

To encourage standardisation across the Exploration and Production segment of the oil industry the EPSG has compiled and is distributing a set of parameters defining various co-ordinate systems and transformations between systems. This EPSG Geodetic Dataset is distributed in an MS Access database and may be downloaded at no charge from the EPSG website (detailed below). The data has been included as reference data in the GeoTIFF raster data exchange specification, in Iris21 (Petroconsultants' data model) and in Epicentre (the POSC data model). It is also included with some applications.

http://www.petroconsultants.com/products/geodetic.html

OpenSpirit

OpenSpirit is the E&P application integration framework developed and marketed by PrismTech, which was launched at SEG 98. Based on distributed objects technology and open standards, it enables interoperability between multiple vendor software application components and proprietary in-house software developed by oil companies. It offers data access to and from a variety of exploration and production (E&P) databases. OpenSpirit will also be endorsing the EPSG Guideline No.7 within its data model and incorporate the EPSG geodetic parameter data set.

http://www.openspirit.com

Ordnance Survey(of Great Britain)

The national mapping agency for Scotland, England and Wales.

http://www.ordsvy.gov.uk

Ordnance Survey of Northern Ireland

The national mapping agency for Northern Ireland

http://www.osni.gov.uk

POSC

The most recent Petrotechnical Open Software Corporation (POSC) literature pertaining to Geographic and Projected Co-ordinate System Transformations was compiled by EPSG members for POSC. It can be found in the form of EPSG Guideline No.7 on the EPSG website as well as in the Epicentre documentation. Epicentre co-ordinate system standard references are taken from the EPSG compilation.

http://www.posc.com

PPDM

The Public Petroleum Data Model Association is an independent, not-for-profit association representing over 100 oil and gas companies, vendors, and regulatory agencies worldwide. PPDM delivers a vendor-independent standard petroleum data model that serves as the industry foundation for managing information as an essential asset in the global business of oil and gas exploration.

http://www.ppdm.org

SEG

The Society of Exploration Geophysicists seismic data exchange format SEG-Y Revision 1 will include provision in the tape header for co-ordinate system identification following the POSC/EPSG guidelines.

The new Ancillary Data Standard metaformat, developed collectively between the IAGC, SEG and UKOOA. The ADS metaformat itself is co-ordinate neutral. However, the Trace Attribute sub-format uses a "P1/90" style geodetic definition for pre-defined co-ordinate attributes. It can be found on the SEG website.

http://www.seg.org

UKOOA

The UKOOA Surveying and Positioning Committee have been very active in producing format standards for data provision and exchange. To date they have included details within the Header records describing the spheroid (ellipsoid), geodetic datum and projection parameters associated both with acquisition and processed data. These have recently been supplemented with additional header information that includes reference to the EPSG database of geodetic parameters. The intention of this supplementary information is to facilitate improved machine readability and/or to enable integrity checking of co-ordinate system definitions in the UKOOA P1, P2, P5 and P6 formats. Reference to these additional header records can be found in Annex E and free downloads of the P formats themselves on the UKOOA web site.

http://www.ukooa.co.uk

Annex E - Incorporation of the EPSG Co-ordinate System Description in UKOOA Positioning (P) formats

For improved machine readability and/or to enable integrity checking of co-ordinate system definitions in UKOOA P1, P2, P5 and P6 formats, provision is made to describe co-ordinate system by reference to the European Petroleum Survey Group (EPSG) database of geodetic parameters. This allows an industry-standards name to be quoted where the geodetic co-ordinate system used is a common system. Defining parameters and units are then as given by EPSG and are not strictly required to be explicitly given in the P-format records. However, as an integrity check, it is considered good practice also to include the explicit definition .

The new records which can be used as extensions within the P1/90, P2/94, P5/96 and P6/98 formats are:

TYPE	***ITEM***	***FORMAT***
Col 1-6	***Col 7-32***	***Col 33-80***
H8000	**EPSG Geographic CS Name**	**A40**
H8001	**EPS Geographic CS Code**	**I5**
H8002	**EPSG Projected CS Name**	**A40**
H8003	**EPSG Projected CS Code**	**I5**
H8004	**EPSG Vertical CS Name**	**A40**
H8005	**EPSG Vertical CS Code**	**I5**
H8006	**EPSG Database Version**	**F4.1**

Geographic co-ordinate systems may be two- or three- dimensional. A vertical co-ordinate system is one-dimensional. Ellipsoid heights are part of a three-dimensional geographical co-ordinate system and never exist on their own as a vertical co-ordinate system. Vertical co-ordinate systems are used for gravity-related heights and depths which are often referenced to the geoid (approximately mean sea level).

For the P1, P2 and P5 formats:
(a) the H8002, H8003 and H8006 records are required when latitude, longitude, easting and northing but no height or depth are given;
(b) the H8002, H8003, H8004, H8005 and H8006 records are required when latitude, longitude, easting, northing and <u>gravity related height</u> or depth are given;
(c) the H8000, H8001, H8002, H8003 and H8006 records are required when latitude, longitude, easting, northing and <u>ellipsoidal height</u> or depth are given.

For the P6 format, the H8002, H8003 and H8006 records are required.

UKOOA Surveying and Positioning Committee.
September, 1999.

Annex F - A guide to co-ordinate system geodesy

Introduction

Co-ordinates describing a position on the earth are only unambiguous if the co-ordinate system they are referenced to is identified. Many geographical co-ordinate systems exist. In the UK and on the UKCS, three geographic co-ordinate systems are frequently encountered. OSGB36 is the basis for the onshore National Grid used for Ordnance Survey of Great Britain mapping, ED50 is used in the North Sea and WGS 84 for the GPS system which is now in regular use for navigation and surveying. The same co-ordinate values on these systems describe different positions on the Earth which may be several hundred metres apart. The corollary of this is that latitude and longitude are only unique when the co-ordinate system to which they belong is given.

Locations with same geographical values on three different Co-ordinate systems

X
51d 30m 45sN
0d 20m 20sW
(OSGB36)

X
51d 30m 45sN
0d 20m 20sW
(WGS84)

51d 30m 45sN
0d 20m 20sW
(ED50)
X

100 metres

Figure F-1 - relative disposition of locations with the same co-ordinate values.

In the case of a business park near London, three different office buildings have the same co-ordinate values on these three systems - see figure F-2.

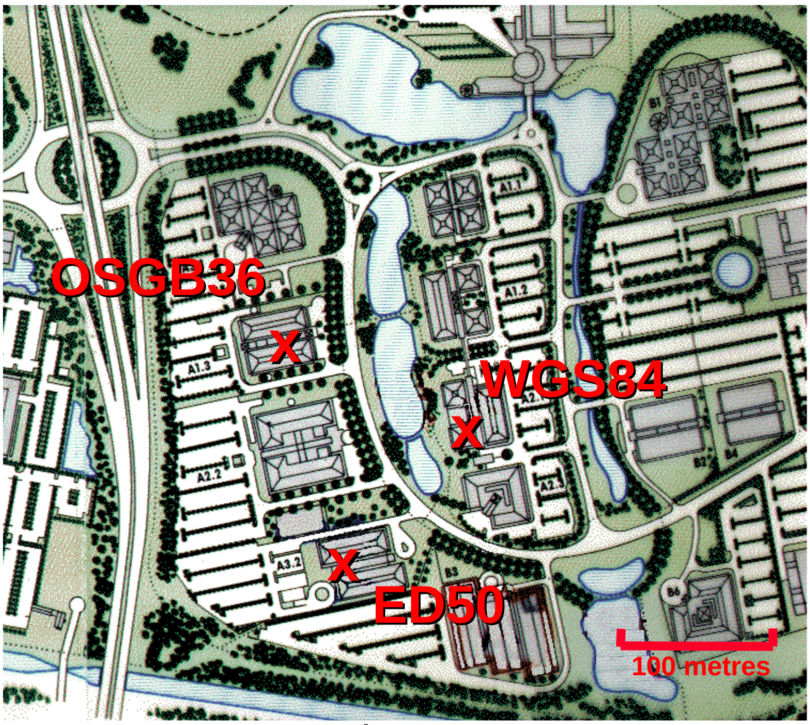


Figure F-2

Model of the Earth

The earth has a complex surface. A simpler surface is produced if the earth's topography is removed. The gravity surface approximating to mean sea level (the "geoid") is taken by geodesists to be the shape of the earth. But even when stripped of all of its topography, the earth's internal composition gives rise to local gravity anomalies which cause the geoid to be irregular. Because of these irregularities the geoid is a difficult surface on which to describe or relate locations. Geodesists therefore employ a model of the earth using a relatively simple mathematical figure to approximate the geoid. Classical navigators assumed the earth to be spherical. It is now known that an oblate ellipsoid (or spheroid) is a better approximation of the shape of the earth. See figure F-3.

<u>Model of the Earth</u>

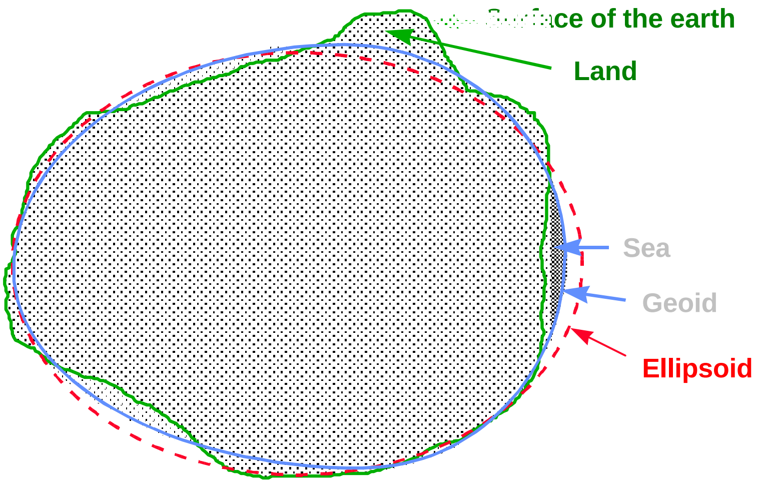


Figure F-3

Many determinations of the best-fitting ellipsoid have been made. Several hundred ellipsoids have been defined for scientific purposes and about 30 are in use today for mapping. Examples include Airy 1830, International 1924 and the Geodetic Reference Spheroid of 1980 (GRS80).

The size and shape of an oblate ellipsoid can be described through many parameters. Only two parameters are needed to describe both size and shape as long as at least one of these is linear to define dimension. In classical geodesy it was usual to define the ellipsoid though the semi-major axis (a) and semi-minor axis (b), or through the semi-major axis and the inverse flattening (1/f) (where f is a simple function of a and b). In modern geodesy it is practice to define the semi-major axis and several parameters describing the earth's gravitational field and rate of rotation, from which 1/f is derived.

Geodetic Datum

Defining an ellipsoid is in itself insufficient for co-ordinate values describing a point on the earth to become unique. It is also necessary to define the spatial relationship (position and orientation) between the chosen ellipsoid and the geoid. This is achieved through the definition of a "geodetic datum". In modern geodesy it is usual to define the position and orientation of the ellipsoid relative to the centre of the earth. Classically, an ellipsoid was chosen and fitted to a particular area of interest, for example a country, either at a single point or as the best fit between several points on the earth's surface. Such ellipsoids did not necessarily fit in other parts of the earth. See figure F-4.

<u>**Different Models of the Earth**</u>

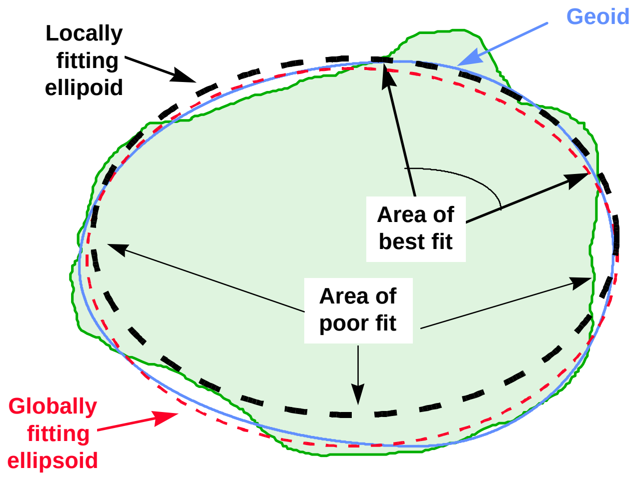


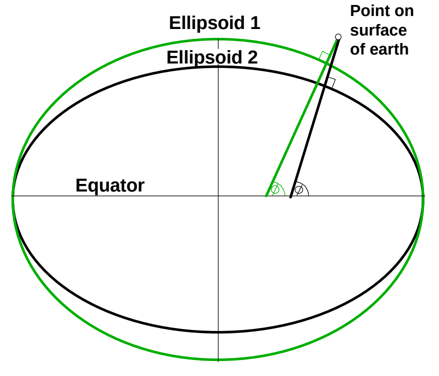
Figure F-4

Latitude and Longitude

Geographic co-ordinate systems use axes of latitude and longitude. Latitude of a point is defined as the angle subtended between the ellipsoid's equatorial plane and a line from the point drawn perpendicular to the ellipsoid surface. (Strictly, this is the geodetic latitude. Other types of latitude exist. These are important in geodesy but for practical geographic information processing purposes it is generally not necessary to consider them. They are therefore not discussed further in this document). By convention, latitude is positive if north of the equator, negative if south. If the spatial relationship between the ellipsoid and the geoid is changed, or if the size or shape of an ellipsoid is changed, the latitude of a point will change. See figure F-5.

<u>**Latitude Definition**</u>

Latitude = the angle at the equator subtended by the normal to the ellipsoid



Angle at the equator is changed when ellipsoid is changed

Figure F-5

Longitude is defined to be the angle measured about the minor (polar) axis of the ellipsoid from an origin or prime meridian plane to the plane of the meridian through the point, positive if east of the prime meridian and negative if west. Unlike latitude for which there is a natural origin in the equator, there is no feature on the ellipsoid which forms a natural origin for the measurement of longitude. The zero longitude can be defined to be any meridian. Historically, nations have used the meridian through their national astronomic observatory, giving rise to several prime meridians. By a 19th century international convention the meridian through Greenwich, England, is the standard prime meridian. However prime meridians other than Greenwich are still found in use around the world. To be integrated with other geographical co-ordinates, the relationship between the local prime meridian and Greenwich meridian must be known.

Height

Latitude and longitude form a two-dimensional co-ordinate system on the surface of the ellipsoid. To fully define the spatial location of an object it is necessary to add a vertical ordinate. This is measured outwards from the ellipsoidal surface along a perpendicular to the surface and is known as *ellipsoidal height*. Latitude, longitude and ellipsoidal height form a three-dimensional co-ordinate system.

But most heights encountered in geographic information processing are not ellipsoidal. They are measured from the geoid (or an estimation of the geoid), and measured along the direction of the gravity field of the earth. These we will call *gravity-related heights*. Geodesists recognise several types of gravity related height, with names such as orthometric height and normal height, differentiated by the assumptions made about the gravity field. These issues are beyond the scope of this note. For geographic information processing the differences between various types of gravity-related height are usually insignificant and can be ignored.

Geodetic Heights

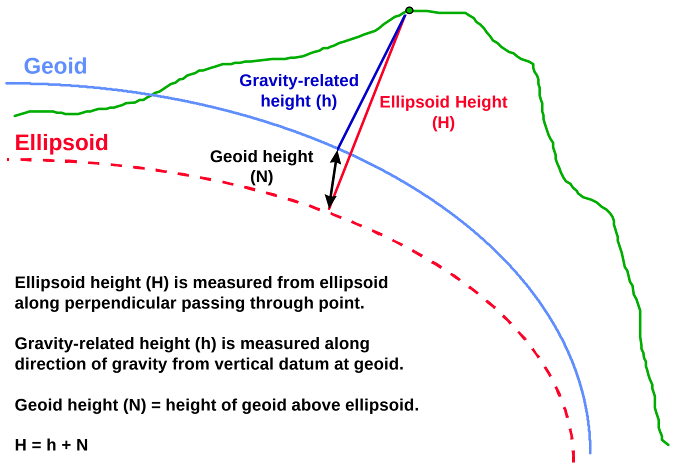


Figure F-6

The separation in the vertical plane between the ellipsoid and the geoid is known as the *geoid height* or "geoidal undulation". At any point there is a geoid height for every geodetic datum relevant to that point. For a particular geodetic datum, the geoid height value changes continuously with change in horizontal position. An exact value for geoid heights relative to the ellipsoidal surface for a geodetic datum is not usually known. However, for some geodetic datums a model of the geoid heights has been built and approximate geoid heights can be interpolated across the model. With a locally well-fitting and well-positioned ellipsoid, the values of geoid height will be close to zero. For global geodetic datums such as WGS 84, geoid height values range between +50 to -50 metres. For non-global geodetic datums covering extensive areas, especially if near mountains or if using an old ellipsoid adopted from measurements elsewhere in the world, the absolute values of geoid height can exceed 200 metres in extreme cases.

Gravity-related vertical co-ordinate systems are measured relative to a vertical datum. The vertical datum will be taken to be the geoid, and will usually be mean sea level at a particular location or series of locations over a particular period of time. As with geodetic datums, the parameters required to define a vertical datum can vary and can be complex, but for practical geographical information processing whilst the definition of the vertical datum may be useful it is not essential. However it is critical that the vertical datum is identified. This is because if the datum surface is changed, the values of heights measured from that surface will change.

Geocentric Co-ordinates

Latitude, longitude and ellipsoidal height can be easily transformed into a three-dimensional cartesian co-ordinate frame where the cartesian origin is coincident with the centre of the ellipsoid. Such a system is known as a **geocentric** co-ordinate system. Indeed in modern geodesy this is the starting point for a reference system definition, with geographical and then projected co-ordinates being derived from the geocentric system.

Relationship between geocentric and ellipsoidal co-ordinate systems

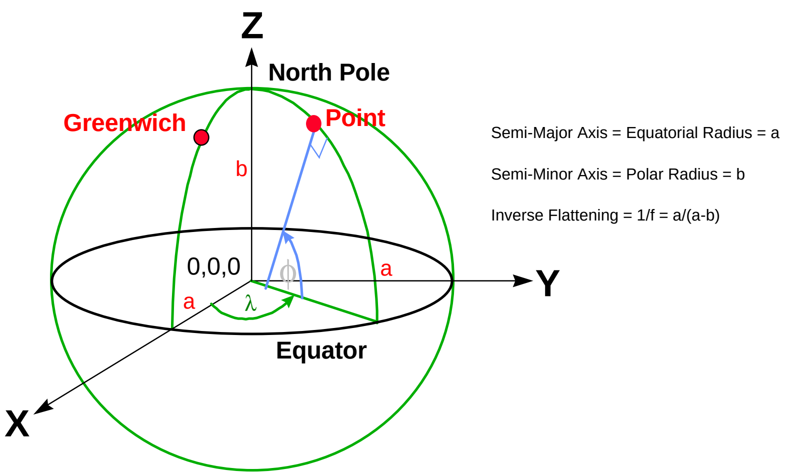


Figure F-7

Equations for changing latitude, longitude and ellipsoidal height to and from geocentric co-ordinates (using the same geodetic datum) can be found in standard geodetic texts. The only parameters required are for the size and shape of the ellipsoid.

Geodetic Transformations

Geographic 3D and geocentric co-ordinates in one co-ordinate system can be transformed to another geodetic co-ordinate system if the relative positions of the two systems can be described. This is frequently achieved through a simple three-dimensional transformation between geocentric co-ordinate systems. For geographic 3D co-ordinates, the relationship between ellipsoidal and geocentric co-ordinates is straightforward and can be included in the transformation process.

The same procedures can be used to transform geographic 2D co-ordinates, but exactly only if an orthometric height is known or assumed and can first be transformed to an ellipsoidal height through the application of the geoid height. In practice, for geographical information processing, the method can sometimes be used within the general accuracy requirements of the user without knowledge of the geoid height. Alternative methods which transform directly between geographic 2D co-ordinate systems are also available.

The 3-translation model assumes that the axes of the geocentric co-ordinate systems are parallel, and that the scales of the co-ordinate systems are identical. Both of these assumptions in general are not true. The 3-translation model is therefore an approximation. The approximation can be improved if a 7-parameter Helmert transformation is used. This adds three rotations and a scaling to the three translations. A difficulty with practical implementation of this is that there are two opposite conventions in use for the sign of the rotations. For the transformation to be correctly implemented it is essential that the mathematical formulation is known and that parameter values are consistent with this formulation.

But even the 7-parameter transformations do not model distortions inherent in the realisation of the geodetic datum. This results in different sets of transformation parameter values being available between any two co-ordinate systems, with the sets having applicability to different (possibly overlapping) geographical areas. Alternatively, different translations may co-exist for a particular area, each being used for specific applications. It cannot be assumed that publicly available geodetic transformation data for an area can be used for all purposes. It is the fact that geodetic transformation parameters are measured and therefore not exact that distinguishes transformations from projections or unit conversions.

Some national authorities suggest a two-step transformation between co-ordinate systems with the co-ordinates related to the source co-ordinate system being transformed to the target co-ordinate system via an intermediate co-ordinate system.

Map Projections

The lattice of geographical co-ordinates on the ellipsoid is not an especially convenient surface for spatial manipulation. Far simpler is a plane. A map projection converts geographic 2D co-ordinates (latitude/longitude) into plane or **projected** co-ordinates (easting/northing). The resulting projected co-ordinates remain geolocated. They are, however, dependent upon the source geographic co-ordinate system. "Northing" and "easting" are terms used to describe the direction of the axes of a projected co-ordinate system. The axes may be given alternative names and/or be given in a user-defined order.

The ellipsoid is not a developable surface, that is it cannot be transformed onto a plane without distortion. Mathematical cartographers have studied the distortions and produced projection types (conversion formulae) in which the behaviour of the distortions is controlled. Projection methods in common use have names such as "Albers Equal Area" (which controls distortion of area), "Lambert Conformal" (which controls angular distortion), etc. Many of these methods were first developed for the sphere and then adapted for the ellipsoid. The complexities of the ellipsoidal adaptation have often led to several solutions. Some of these may differ only very slightly in their result and for practical purposes within geographic information processing be considered identical. For example, the "Gauss-Kruger" and "Gauss-Boaga" ellipsoidal forms of the "Transverse Mercator" method are for all practical purposes identical. Others, sometimes unfortunately with the same name, may produce differences which are of an unacceptable magnitude. For example the ellipsoidal formulas for the "Oblique Stereographic" method commonly used in the USA are not the same as those encountered in Europe. Errorless co-ordinate conversion requires that the projection method, its projection parameters, and the projection parameter values are all clearly defined and mutually compatible.

The mathematical conversion of geographic co-ordinates to plane requires the dimensions of the ellipsoid and values for a set of parameters specific to the projection type. Geodetic datum parameters are not a necessary part of the mathematical manipulation. But note that if the input geographical co-ordinates are not related to a geodetic datum then the output plane co-ordinates will also be ambiguous. The ambiguity will not be significant if the geographical processing requires an accuracy of no better than about 1 km (mapping at scales smaller than 1:1,000,000), but for detailed analyses properly geolocated co-ordinates will be required. In a purely mathematical sense, any one projection could be applied to many geographic co-ordinate systems. Thus the UTM zone 30N grid may be found related to ED50 and to WGS 84. The same point on the earth will have different UTM grid values. For example, the ED50 co-ordinates in figure F-1 can be converted to UTM zone 30N values of 684658 metres East, 5710295 m N. The equivalent WGS 84 / UTM zone 30N values are 684556E, 5710077N. “UTM” co-ordinates without reference to the underlying geodetic datum are ambiguous.

Annex G - Glossary

7-parameter transformation: See **Helmert transformation**

British National Grid: see **National Grid**.

Common Offshore transformation: An operation using the **position vector transformation method** and a specified set of Helmert transformation parameters for changing co-ordinates between the **WGS 84** and **ED50 co-ordinate systems** in the UKCS North Sea, English Channel, and Irish Sea. For petroleum exploration and production purposes the transformation can also be used between the **ETRF89** and ED50 co-ordinate systems.

"Common Offshore" transformation parameters from ETRF89 (WGS 84) to ED50						
dX(m)	dY(m)	dZ(m)	RotX"	RotY"	RotZ"	Scale(ppm)
+89.5	+93.8	+123.1	0	0	+0.156	-1.200

Test Point using Common Offshore transformation parameters :

	Latitude	Longitude	Ellipsoid Height
ETRF89 (WGS 84)	53° 00' 00.000" N	01° 00' 00.000" E	50.00 m
ED50	53° 00' 02.887" N	01° 00' 05.101" E	2.72 m

co-ordinate system: A general term for the geometric framework with respect to which places can be given unique co-ordinates. These co-ordinates might be latitude and longitude, or X, Y and Z cartesian co-ordinates. A **co-ordinate system** must be realised by surveying to be useful, and is therefore subject to error. Co-ordinates given for a point are valid only within the extent and accuracy of the stated co-ordinate system. Because co-ordinate systems are realised by different survey methods, their region of application and accuracy varies widely. The relevant co-ordinate systems here are **ED50**, **ETRF89**, **British National Grid**, **Irish National Grid** and **WGS 84**.

datum: a reference surface for a **co-ordinate system**. See **geodetic datum**.

ED50: European Datum of 1950, a co-ordinate system based on a **geodetic datum** of the same name covering mainland western Europe, derived from traditional theodolite triangulation networks. ED50 is the unambiguous term for the original co-ordinate set of the European Datum. Because of distortions in the ED50 system, accurate extrapolation offshore is impossible. Inaccuracies increase with distance from mainland western Europe. Uncertainty in establishing ED50 offshore varies from 2 metres in the southern North Sea to several hundred metres in the Atlantic margins. The uncertainties of establishing European Datum in the Atlantic margins would be unacceptable where petroleum reserves straddle licence boundaries.

ellipsoid: The simple geometric shape used as a model of the shape of the earth. Many ellipsoids exist to suit different regions of the earth. Those encountered on the UKCS include the **Airy 1830** ellipsoid which is used by the **British National Grid** and has a semi-major axis of 6377563.396 metres and inverse flattening of 1/299.32496; the **Airy modified 1849** ellipsoid which is used by the **Irish National Grid** and has a semi-major axis of 6377340.189 metres and inverse flattening of 1/299.32496; the **International 1924** ellipsoid which is used by the **ED50** co-ordinate system and has a semi-major axis of 6378388.0 metres and inverse flattening of 1/297.0; the **GRS80** ellipsoid which is used by the **ETRF89** co-ordinate system and has a semi-major axis of 6378137.0 metres and inverse flattening of 1/298.25722; and the **WGS84 ellipsoid** which is used by the **WGS 84** co-ordinate system and like GRS80 has a semi-major axis of 6378137.0 metres and inverse flattening of 1/298.25722.

ETRF89: European Terrestrial Reference System 1989, the accepted Europe-fixed realisation of the **WGS 84** co-ordinate system. Due to tectonic motion, ETRF89 is not identical to global realisations of WGS 84. The discrepancy between ETRF89 and WGS 84 in Europe is about 20cm (in 1998) and growing at 2-3cm per year. ETRF89 is based on the GRS80 **ellipsoid**.

European Datum: A **co-ordinate system** covering most of mainland Europe. There are three co-ordinate sets - the original **ED50**, a provisional ED79 estimation and the later ED87 re-estimation. The reference systems on which ED50, ED79 and ED87 are based use the **International 1924 ellipsoid**.

geodetic datum: A set of geodetic parameters which define the relationship in position and orientation of the ellipsoid and the earth. The latitude and longitude of a point are only defined uniquely when qualified with respect to a stated geodetic datum.

graticule: The lattice created by intersecting lines of latitude and lines of longitude, usually drawn as a series of lines with constant angular separation to create a lattice of four-sided figures which vary in size and shape. Regular UKCS ‘blocks’ are an example of these.

Helmert transformation: The most commonly encountered simple geodetic transformation method. Two co-ordinate systems are related by estimating seven parameters in 3D cartesian co-ordinates: 3 parameters of translation parallel to each of the 3 axes, 3 parameters of rotation about each axis, and a single scale parameter. There are various ways of implementing the Helmert transformation using different parameter sign conventions and mathematical approaches: some of these have special names (e.g. **position vector** method). Three particular transformations using this method are of concern to the UKCS:

i) the **Common Offshore transformation** for changing co-ordinates between **ETRF89** (or **WGS 84**) and **ED50**.
ii) the **Ordnance Survey petroleum transformation** for changing co-ordinates between **OSGB36** (British National Grid) and **ETRF89** (or **WGS 84**).
iii) the **UKOOA landward/seaward transformation** for changing co-ordinates between **OSGB36** (British National Grid) and **ED50**.

Irish National Grid: see **National Grid**.

landward areas: The onshore and nearshore areas to a boundary as defined in the Petroleum Production Regulations. This boundary approximates to the baselines for UK territorial waters.

National Grid: The projected **co-ordinate system** used for land mapping in the UK. In Britain it is based on the Airy 1830 ellipsoid, OSGB36 datum and a Transverse Mercator projection grid. A similar system based on the Airy Modified 1849 ellipsoid, TM65 datum and a different Transverse Mercator projection grid is used in Ireland.

OSGB petroleum transformation: An operation using the **position vector transformation method** and a specified set of Helmert transformation parameters for changing co-ordinates between **OSGB36** (British National Grid) and **ETRF89** or **WGS 84 co-ordinate systems**. The transformation has an accuracy of typically 2 metres and is no worse than approximately 4 metres throughout Britain. For a more accurate transformation contact the Ordnance Survey.

OSGB petroleum transformation parameters from ETRF89 (WGS 84) to OSGB36						
dX(m)	dY(m)	dZ(m)	RotX"	RotY"	RotZ"	Scale(ppm)
-446.448	+125.157	-542.060	-0.150	-0.247	-0.842	+20.4894

Test Point using OSGB petroleum transformation parameters :

	Latitude	Longitude	Ellipsoid Height
ETRF89 (WGS 84)	53° 00' 00.000" N	01° 00' 00.000" E	50.00 m
OSGB36	52° 59' 58.719" N	01° 00' 06.490" E	3.99 m

OSGB36: The triangulation station co-ordinate set used to define **National Grid** on the ground in Britain.

position vector method**.** A type of **Helmert transformation** expressed in matrix form with 7 parameters, in what is sometimes known as the "Bursa-Wolf" formula:

$$\begin{pmatrix} X' \\ Y' \\ Z' \end{pmatrix} = M * \begin{pmatrix} 1 & -Rz & +Ry \\ +Rz & 1 & -Rx \\ -Ry & +Rx & 1 \end{pmatrix} * \begin{pmatrix} X \\ Y \\ Z \end{pmatrix} + \begin{pmatrix} dX \\ dY \\ dZ \end{pmatrix}$$

The parameters are commonly referred to defining the datum transformation "from Datum 'A' to Datum 'B'", whereby (X, Y, Z) are the geocentric co-ordinates of the point on Datum 'A' and (X', Y', Z') are the geocentric co-ordinates of the point on Datum 'B'. However, that does not define the parameters uniquely; neither is the definition of the parameters implied in the formula, as is often believed. However, the following definition, which is consistent with the "Position Vector Transformation" convention, is common E&P survey practice:

(dX, dY, dZ): Translation vector, to be added to the point's position vector in co-ordinate system 'A' in order to transform from system 'A' to system 'B'; also: the co-ordinates of the origin of system 'A' in the 'B' frame.

(Rx, Ry, Rz): Rotations to be applied to the point's vector. The sign convention is such that a positive rotation about an axis is defined as a clockwise rotation of the position vector when viewed from the origin of the Cartesian co-ordinate system in the positive direction of that axis. E.g. a positive rotation about the Z-axis only from system 'A' to system 'B' will result in a larger longitude value for the point in system 'B'.

M: The scale correction to be made to the position vector in co-ordinate system 'A' in order to obtain the correct scale of co-ordinate system 'B'. $M = (1+S*10^{6})$, whereby S is the scale correction expressed in parts per million.

Thunderer Line: Is the dividing line between ED50 and ETRF89 licence descriptions on the UKCS. It is co-incident with Longitude 6°W (ED50).

UKCS: United Kingdom Continental Shelf.

UKOOA: UK Offshore Operators' Association.

UKOOA landward/seaward transformation: An operation for changing co-ordinates between the **OSGB36** (British National Grid) and **ED50 co-ordinate systems** at the UKCS landward/seaward boundary for petroleum exploration and production purposes using the position vector transformation method and a specified set of Helmert transformation parameters. The transformation parameters are a concatenation of those from the **OSGB petroleum transformation** and the **Common Offshore transformation**.

UKOOA landward/seaward transformation parameters from OSGB36 to ED50						
dX(m)	dY(m)	dZ(m)	RotX"	RotY"	RotZ"	Scale(ppm)
+535.948	-31.357	+665.160	0.150	0.247	0.998	-21.689

Test Point using UKOOA landward/seaward transformation parameters :

	Latitude	Longitude	Ellipsoid Height
OSGB36	52° 59' 58.719" N	01° 00' 06.490" E	3.99 m
ED50	53° 00' 02.887" N	01° 00' 05.101" E	2.72 m

WGS 84: World Geodetic System 1984. The most popular global **co-ordinate system**, used by the GPS navigation system. WGS 84 includes an **ellipsoid** of the same name (WGS84) which for all practical purposes is the same as the GRS80 ellipsoid.