OGP Joint Industry Project 24

To Review

Geospatial Integrity of Geosciences Software

Project GIGS

OGP JIP MEMBERS

devon

ExxonMobil

Anadarko Petroleum Corporation

bp

bhpbilliton resourcing the future

Chesapeake ENERGY

PERENCO

TOTAL

PETRONAS

StatoilHydro

MARATHON

PROJECT CUSTODIANS

OGP International Association of Oil & Gas Producers

PROJECT MANAGERS

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GIGS Rationale to Strengthen the Business Case

Purpose

The prime purpose of this document is to strengthen the business case for internal validation of current and prospective E&P Members. This document was complied on behalf of OGP Joint Industry Project 24 “Project GIGS”. It is not intended for software vendor distribution or discussion.

References

Material is drawn from GIGS evaluations, first and second-hand knowledge of the authors and reliable verbal reports. Each case is related to a specific software package, however identity and certain details have been concealed to maintain confidentiality.

Further public material is available in the latest GIGS Brochure (at time of writing No. 21 dated September 2009)

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Background

Since the JIP is primarily a strategic one, the overall investment return is hard to quantify. The following discussion points have been the drivers that have led current member companies to reach the conclusion that this JIP is not only worth supporting but offers members and industry the opportunity to reap significant gains through:

- Increasing exploration and development opportunities within existing investments
- Reducing risk of failure through mapping errors
- Increasing operational and staff efficiencies through decreased uncertainty about mapping issues
- Increasing revenue and profit per given dollar invested (ROI)

Discussion points

- In E&P, there are some 500 Geoscience applications being used that acquire, manipulate, interpret, and report co-ordinate based data sets. The spatial data handling performance of applications varies substantially. Industry lacks standards, guidelines, and robust, comprehensive test data set(s) for these applications to ensure that the spatial component of such applications is designed and built to meet the challenges of today's E&P goals and objectives.
- Any E&P geoscience project will be handled 90-160 different times by professional and technical staff using multiple different G&G applications, before its full life cycle is complete. Every data transaction, transfer, integration or analysis is an opportunity for blunders or other errors; any one of which may negate all the good work in the combined other stages.
- Large amounts of legacy data (boundaries, seismic, wells) carry inadequate geospatial metadata, are mostly spatially unverified and lack any quality indicators. This leaves often geospatially untrained users (technicians and professionals) the choice between operational necessity and the delays associated with investigating the provenance and references. In general, operational necessity wins and the resultant mapping is often degraded.
- In G&G software applications, users are often faced with ambiguous instructions and poorly designed user interfaces and 'on-screen' menus. This leads to confusion and guessing, especially in companies where there is little or no in-house expertise in the mapping sciences (geodesy and cartography).
- Proposed well locations are often not evaluated spatially against the supporting seismic data, to ensure that some geospatial operation in an

application did not malfunction in such a way as to create a misplacement from the true target.

- Return on investment (ROI) is difficult to cleanly quantify for this JIP, except that members are individually paying only a few cents on the dollar for tangible deliverables. For example, the three product evaluations cost more than $600,000. Millions of dollars are spent by the combined membership each year on applications, and this JIP can be seen as a strategic 'annuity' where a small investment today will reap a significantly greater and ongoing return as the industry learns to adapt and conform to well designed standards and guidelines for these applications

Overview

Of concern to industry is the variance of software in three key areas: Compliance, Security and Communication.

- Compliance with respect to naming conventions and nomenclature used in reference to geo-spatial parameters in comparison to international standards documented by the EPSG or ISO. This covered pre-defined geodetic systems, user-defined geodetic systems and axes definitions and units respectively.

- Security with respect to privileges afforded to different users. In some applications, the creation, deletion and editing of parameters is open to many classes of users. This makes an application extremely hard to administer to ensure that the integrity of the system is not compromised. Access to the geodetic database should be subjected to tighter security than is usually the case.

- Communication with respect to how a product
    - Generates and maintains audit trails, error and warning messages
    - How the documentation and user interface are presented
    - How one application transfers data to and/or from other applications without geospatial mistakes or misunderstandings

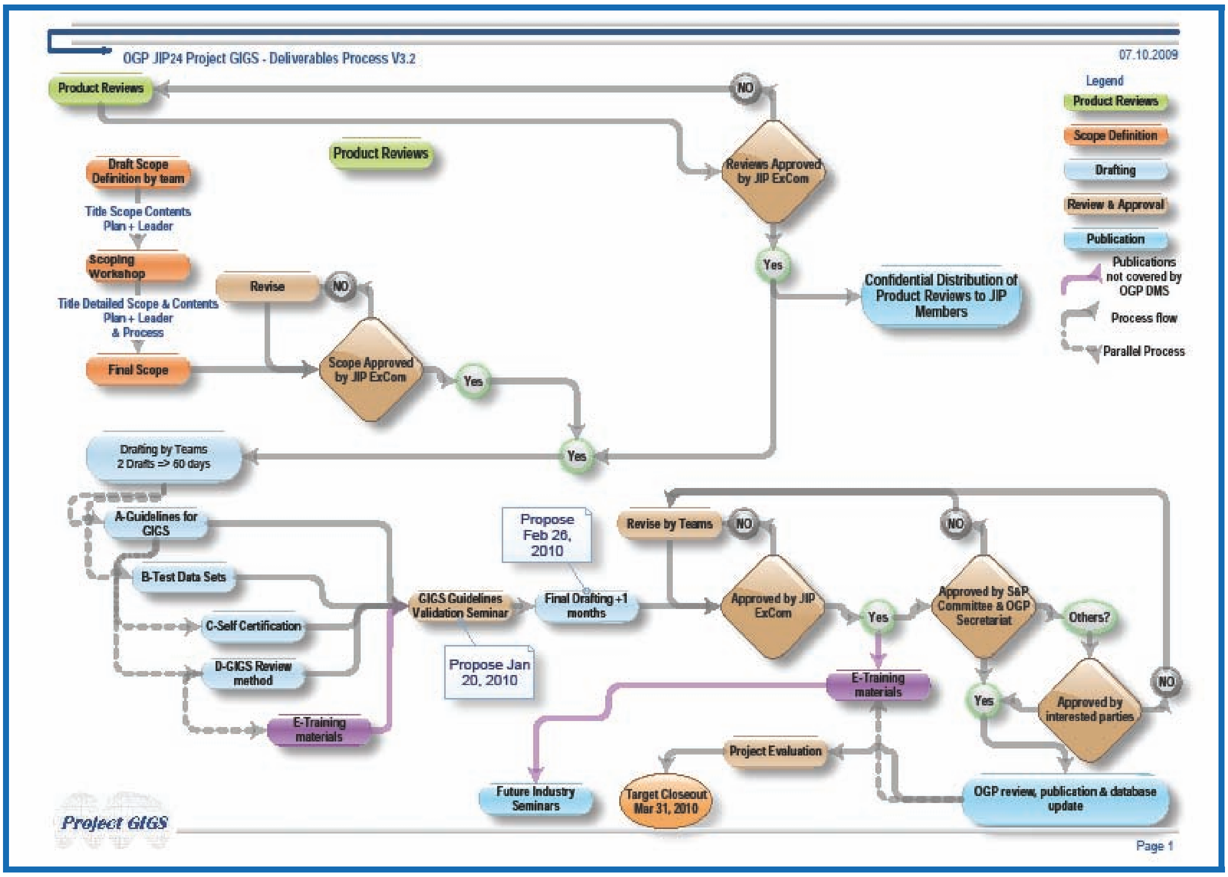
The Project Deliverables

The ultimate deliverables are stated at a high level as objectives in the accompanying GIGS Brochure. Project features and benefits are also highlighted in that brochure. Deliverables exclusive to JIP Members include:

- Members only
    - Detailed reports from each of the application reviews
    - Additional review reports contributed by members and pre-JIP reviews
    - Participation in the JIP Process, including associated workshops
- Published to Members and Industry
    - Guidelines for Geospatial Integrity of Geoscience Software (WP-A)

- Guidelines for Use of Test Data Set with Geoscience Software (WP-B) along with the associated Test Data Set
- Guidelines for Self-Certification by Geoscience Software Developers (WP-C)
- Guidelines for Review of Geoscience Software by E&P Companies (WP-D)
- GIGS Training Materials (WP-E)

The JIP Deliverables Activity and Timeline



The Geospatial Integrity Review Issues Defined

The GIGS project has identified eight sections for evaluation of geospatial integrity in Geoscience software.

1. Application Purpose

Is the stated purpose of the application accurate and clear to users? We face some confusion when presented with certain applications that claim to be fully geodetically enabled.

Example 1: We know of at least one popular industry package that is so full of short term fixes and instability that a complete architecture review and geodetic rewrite is probably the only solution. Such a re-write, once a significant user base has been established, leaves both the developer/vendor and the client base with a no-win situation commercially. Switching to another application is disruptive, and operationally unacceptable. While such a situation cannot be resolved immediately, the JIP will offer a long-term strategic opportunity for change. It is anticipated that such a situation will generate motivation for developers to start new applications that conform to the standards provided and offer the real choice of geospatially well-designed alternatives.

2. Pre-defined geodetic parameters

The motivation for geo-referencing the heterogeneous datasets used in E&P is to ensure that when combined together in a map, there is agreement in both the relative locations and the absolute locations of the different objects or features represented. The four contexts, for a given application, are:

- Establishing within the application a basic geodetic and cartographic reference frame, with suitable geospatial metadata, for a project
- Setting the input dataset criteria so the application can efficiently and correctly transform the geodetics of incoming data to match the project defined coordinate reference system (CRS)
- Transforming of output datasets to clearly express the project's geodetic reference framework to the next functional stage of the project (personnel and application) without mistakes
- Handling of data storage in the application database with respect to location within the data model and specific context e.g. storage versus display project datums and projections and the handling of subsequent changes to the data model in later releases (backwards compatibility)

The references and metadata referred to are:

- Geodetic CRS (Latitude and Longitude)
- Projection CRS (Easting and Northing)
- Units (Meters, Feet, including variations such as US vs. International feet)
- North reference (True, Magnetic, Grid, CAD etc)
- Elevation/Height (Vertical Geodetic CRS, MSL, Ellipsoidal)
- Quality (Fit for purpose evaluation)
- Audit trail (Who, What, When, Where, Why, How)

Example 2: We are aware of two major G&G packages where the pre-defined unit parameters do not use EPSG or ISO 19111 values or nomenclature. A great many other applications default to a specific reference frame such as NAD27 and US survey feet, without any indication, to the installer or the user, of this default. Such 'hardwired' parameters have caused NAD27 to be used in areas of West Africa, the Middle East and other parts of the world, causing 200-500 meters of mismatching between datasets.

Example 3: An application read the database of a second application. They used an old data model, which had been updated, and read the project's display datum as the storage datum and misapplied it when transferring the data. The second application only referred to 'feet', which turned out to be 'International' feet, and was applied as US survey feet in the first application. Every time well locations were transferred, the location was shifted 20 ft.

3. User-defined geodetic parameters

Linked to the previous 'Pre-defined parameters', the user defined examinations are designed to evaluate how well an application the parameter library and allows the administrator and the user to implement specific geodetic parameters not contained in preset parameter library. The major issues in this are:

- Examination and review of values by knowledgeable specialists
- System security to prevent casual input of incorrect (even absurd) values and thus prevent use of the wrong geodetic parameters on a specific E&P project
- Tracking of the use of the user defined parameters and inclusion in exported metadata – i.e., the ability to expand continued use in other, subsequently used, applications. Provision of such an "audit trail" for the geospatial data handling is greatly increasing amongst applications vendors, partially due to visibility generated by the GIGS JIP.

Example 4: One application until recently had full and open access to the user defined parameter dataset file by any user. This resulted in the original input, whether correct or not, being changed by subsequent users, and then being applied by the original user assuming that it was correct. In fact, this issue was addressed by the application vendor due to input from some of the JIP members, making the next release of the application far more geospatially robust for all users.

Example 5: In many applications, including at least two of those being reviewed, both the pre-defined and user-defined geodetic parameters cannot be checked by the user. That is, users are typically unable to check that correct parameters are actually being used in project computations. Furthermore, in many applications, users parameters are entered on a project-specific basis and so there are multiple versions of the 'same' parameters in an amalgamated list, from which a usually un-initiated user has to select. In many cases the project parameters in these lists are named the same as or similarly to others in the list, even if the CRS are different. At a minimum this leads to confusion amongst the users and often leads to selection of wrong parameters for a project or for a new incoming or outgoing dataset.

4. Axes Definitions

A coordinate reference system (CRS) has two or three axes. This separate treatment of axes within the GIGS JIP software reviews was put in because axes and the associated units of measure are sometimes misunderstood or misrepresented in G&G applications. The axes examinations include:

- 3-dimensional Cartesian reference frame. The axes are referenced to the ellipsoid center. One axis is oriented in the equatorial plane from the ellipsoid center toward the prime meridian (typically Greenwich), one axis is oriented toward geographic north pole (approximate to the mean rotational axis of the earth) and the third axis is orthogonal to the other two, in a Cartesian right handed system.
- The projection grid or Projected Coordinate Reference System (ProjCRS) is 2-dimensional and these grids are typically generated by complex algorithms. There are projections that preserve “equal area” for acreage and reservoir determinations, conformal projections that are used in surveying and mapping and a myriad of other projections for special applications. A large majority of the projections used in E&P use Transverse Mercator or Lambert Conformal Conic projection methods. For these conformal surveying projections, the grid is referenced in the center of the projection to a ‘central meridian’, along which grid north and true north are oriented the same, and to the latitude of origin which specifies the North-South reference for the grid. In these projections, grid north varies from true north as one moves away from the ‘central meridian’, increasing in a non-linear fashion with distance east and west from the central meridian and north or south from the equator or the latitude of the origin. For other types of projections and grids encountered in E&P, the grid orientations and distortions are not so well behaved.
- Other axes are generally *a-geodetic* (i.e., they do not understand nor are they able to apply CRS coordinate), and are created by a local reference origin such as a well surface location and corner points on the public land survey system or local cadastral grid systems such as in Texas.
- CAD systems, unless specifically geodetically adapted (e.g. AutoCAD Map), are referenced to 0º in an ‘easterly’ direction and increasing anti-clockwise, as opposed to 0º in a northerly direction and increasing clockwise in a normal geodetic/cartographic system.

Many G&G applications are non-compliant with respect to coordinate axis order and coordinate labelling conventions. This has been the source of many user errors due, in part, to lack of training, but fundamentally because the application presents information poorly or not at all, and is not demanding the necessary information from the user or input file prior to operating on the data. In some cases, different modules in an application make a different decision about the meaning or the format of a certain set of coordinates.

There is a global convention (ISO 6709, adopted for the EPSG Geodetic Parameter Dataset) for the order of coordinates in a geographic CRS to be latitude, longitude (and in the 3D case) ellipsoidal height. When geographical coordinates are applied internally and/or presented at the user interface, this ordering convention is not always applied. The appropriate application behaviour is always to display associated projected grid and graticules. These must be in CRS-defined format and abbreviations. However, there could be with an option for the user to show coordinates in CRS-defined order or user-preferred order, clearly annotated as such.

Example 6: In UTM grids around the world and in the US State Plane systems easting and northing parameters are generally represented by ‘x’ and ‘y’ respectively. What is not commonly known by developers or users is that about half the globe is covered by Projected CRSs that defines Y as Eastings and X as Northings. The axes order is also reversed, exacerbating the confusion. Geopolitical areas that use these CRS include Argentina, China, Germany, and all Former Soviet Union (FSU) States. Thus, an application can ask for ‘x’ and ‘y’ and then mis-plot the data rotated 90º. One of the major applications reviewed by GIGS asks only for “x” and “y” without any explanation of the term, options or cautions to the user about this potential problem. One of the other reviewed applications asks users to input “Easting” and “Northing” thus avoiding such confusion. That type of input (and/or display) is encouraged by GIGS amongst other application vendors.

In ISO 6709 there is a recommendation that angles in degrees, particularly latitude and longitude, be depicted at the user interface in sexagesimal form (e.g., 123.456789 = 123º45'67.89"N). Few applications follow this recommendation and users have to remember the unique depiction for each application and sometimes for each module within an application. As examples, seismic data in UKOAA P1 format never use sexagesimal format – nor are there any plans or recommendations afoot that it should do so.

Example 7: Errors of hundreds of meter can be created by misinterpretation of Latitude / Longitude formats. Tabulated below is the same well location expressed in four formats that software developers use in G&G applications. All four are consistent in their precision to centimeter level, and when properly labeled and applied, represent the same location within a given datum. However, unless clearly labeled, the location presented on a map can be misplaced by hundreds of meters and in some cases tens of kilometers. In the table below, confusing the last two formats (i.e., using the decimal degree format as DMS in decimal format or vice versa) will create a blunder of 20 kilometers. It is important that the format be appropriately labeled to the user of the application to avoid such a blunder.

Degrees Minutes Seconds (DD MM SS.sss)	34° 27' 17.453" N	118° 31' 32.684" E
Degrees Decimal Minutes (DD MM.mmmmm)	34° 27. 29088' N	118° 31. 54473' E
Decimal Degrees * (DD.ddddddd)	34.2881814° N	118.5257456° E
DMS in “decimal” format (DD.MMSSssss)	34.2717453° N	118.3132684° E

Example 8: One application with many modules defaults to true north in one part of the program but grid north in another part and failed to apply the correction when data are passed from one module to the other. Depending on the offset distance, this can create many hundreds of feet error at the ‘other’ end of a measured length, such as a seismic streamer or a deviated well – if the type of north used in each module is not properly managed. Obviously, this data management is much easier to

do correctly if the application provides users with visible displays of the North Reference being used by each software module.

Example 9: Many applications assume true or grid north as a default for incoming data and either apply or do not apply convergence irrespective of the incoming data reference setting metadata. For deviated well computations, one major G&G application reviewed under the GIGS JIP applies grid convergence at the well's surface location only and does not recompute the variable grid convergence as the well moves along its downhole deviated path. This misapplication of grid convergence definitely has caused significant errors in bottom hole location. This has become very important with our current propensity for drilling deviated wells with large horizontal offsets from surface location.

Example 10: One volumetric application allows for grid-to-grid conversion of projection coordinates of the well surface location, by asking for a 'dx', 'dy' and 'dz'. There is no explanation of what is required here. For instance these algebraic symbols could (true) refer to delta easting, delta northing and delta elevation, or they could refer to the ellipsoid centre offset for a datum transformation (false). In addition when entering the values, the program applies them, but fails to clear the buffer, the new values are added to the original values and applied again! The same application fails to understand that the new projection has a different grid north and therefore all surface location offset values need to change to present the wellbore in the same location in the new projection.

Example 11: A failure, to define if the grid axes are geodetic or CAD, can cause untold confusion when incorporating engineering design drawings (e.g., for pipelines or platforms) into site survey maps for the placement of such data. Geospatial metadata should contain a component that describes which type of axes are being used for the map and their order, so the application can make the necessary adaptation to the data before combining it with the geodetically referenced map.

Proper understanding of axes and their manipulation and conversion requires careful inspection of the corrections to be applied and careful checking of the results to ensure correctness. In general, developers and users are advised to obtain appropriate specialist help when undertaking these operations for unfamiliar or new systems and/or project applications and tasks.

5. Data Operations

This section of the GIGS software examination examines the actual operations performed within the application on data sets imported to and exported from the projects created within G&G applications. The tasks were divided into five sections, namely:

- 5.1. Coordinate Conversions
- 5.2. Datum Transformations
- 5.3. 2D Seismic Data
- 5.4. 3D Seismic Data
- 5.5. Well Data

These data operations require extensive testing as part of the GIGS evaluation of software applications. Accuracy and reliability are being tested in a maze of G&G project scenarios. Results determine the geodetic correctness of the product and use these results to obtain “lessons learned” about each application. Creation of best practices and workflows evolve from these tests. Beyond the mathematics, there are many examples in this subject area of data operations.

Example 12: The application has no recognition of the UKOOA P7/2000 Rev 5 format for handling well data. In fact, the application had no recognition of the UKOOA P7/2000 Rev 1 format or of any other industry standard well-data format. The vendor’s response was to state that well formats were so varied that they did not cater for any specific formats. This issue is left up to the user to create (using the Vendor interface editor) individual formats for different file types encountered. The same is true of the export functionality within the application. It is not possible to import or export well header data or down-hole data to or from the application in a P7 format. A major difficulty created by this is that data cannot be exchanged without a specific format ‘translator’ with each and every well, and receivers of the data have to be able to manage whatever variation on the format is presented. Another major difficulty is that often fields in locally custom-made formats may differ slightly from one another, creating columnar offsets in imported data that can change a well name or coordinate by a single digit. Thus a new well or location are created. In one application, this can lead to several ‘extra’ and useless wells in multiple projects. These can confuse the user and lead to misinterpretations.

Example 13: Most interpretation systems cannot import a non-orthogonal grid for a 3D survey correctly. One in particular loads the dataset but makes huge adjustments to one or two corners in order to make the project orthogonal. The message that appears before doing this simply says: “This action will adjust the corners”! There is no request to the user to cancel the action if it is not acceptable. Corners can be moved fairly large distances when certain re-projections are required.

Example 14: Many applications are *a-geodetic* or ‘non-geodetic’. That is they do not understand nor are they able to apply CRS coordinate conversions or transformations between different CRS. This requires that the user must know what EVERY dataset in the system is referenced to and convert all the new incoming data to the correct reference before loading. Such applications at this time include relatively ‘new and powerful’ interpretive applications.

Example 15: When developers first decide to add geodetic capability to their applications, they invariably fail to apply the changes across all modules and every possible CRS selection. One such application allowed that the user could request a datum transformation, relabeled the apparently ‘newly transformed dataset’ but in fact did not change the coordinates at all.

Example 16: One application for loading wellbore survey locations succeeded in loading the bottom hole as the surface location and the surface location as the bottom hole.

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Example 17: One application has absolutely no discernment about user request for changes. They deliver changes at the rate of 2-3 a month, doing anything the users request whether it is appropriate to the geospatial data management or not. This means that the application has become essentially dysfunctional where several of the modules do different things to the data.

Example 18: Managing datum transformations where neither datum is WGS84. The major parameter datasets available have generally related any given datum to WGS84. In some applications, they are unable to handle this transformation where neither dataset is WGS84. This is relatively easy to do being in most cases a simple arithmetic sum of the two datum shift transformations i.e. datum 'A' to WGS84 and WGS84 to Datum 'B'. There are slightly more complicated transformation methods, but in every case, easily encoded with a knowledgeable developer. If a user puts in a "local to local" transformation into one such application and then uses that "user defined" transformation to convert from the source geographic CRS, the application will "think" it is converting to WGS 84 but using the "local to local" transformation parameters. This can (and has) caused hundreds of meters of error in resultant project coordinates.

6. Audit Trail

An audit trail (in geodetic terms) is a means whereby a user's activities, in relation to any given dataset, is recorded for later forensic analysis in case of geospatial data problems. The importance of this for the spatial component of the data cannot be over-emphasized. A major problem for the industry today is that we have so much data that has been 'passed on' so many times, there is absolutely no consistency or confidence that the original locations represented are valid with respect to the real world.

This section examines whether an audit trail is created for any aspect of the work performed is within the application and tracked (and retained) in the dataset metadata. The test purpose is to verify whether software application has appropriate audit trails of the reference geodetic data. In addition, the test method includes discussion of audit trail facility and possibilities with the developer of the software application, record audit trail capability during the tests carried out in the Predefined Geospatial Parameter file, User Defined Geospatial Parameter file and Data Operations sections.

Example 19: Most current G&G software applications contain only a small audit trail facility or none at all. Most of those that do are perfunctory at best and make it difficult to find the information, which is formatted in a text manner so that reading through the data is very time consuming. Most audit trails capabilities are inadequate and do not provide or produce the users with any form of hardcopy printouts. That said, there is definitely movement in the industry to enhance the geodetic audit trail capability of G&G applications. The GIGS JIP is working with developers on this issue.

Example 20: One project examined showed multiple datasets, but so much disagreement spatially that the mismatch could be seen at a geophysical level (>150 meters). After review, it was necessary to go back to the seismic acquisition data to determine which of several datasets were referenced to what datums and geographic coordinate reference systems (CRS). This process took over 2 months. There was no tracking in the application to say who had done what and when – which would have saved a huge amount of forensic 'footslogging'!

7. Deprecation

Deprecation of old parameters and algorithmic methods is a way of retaining outdated or even incorrect methods and parameters that may have been used in the past, not by deleting them, but by retaining them in a deprecation context, so that they can at least be used to 'undo' incorrect operations from earlier times. Without this, it is hard or impossible to update an older incorrect dataset to match new correctly referenced or computed data. This section examines the way in which the application deals with deprecated CRSs and/or transformations and their methods of superseding older CRSs and/or transformations with updated or newer versions.

Example 21: updating a CRS can lead to the geo-referencing of a project being inadvertently changed. The methods of how an application handles this topic are critical to ensure no changes to the horizontal and vertical referencing of project data. There is no facility within a major application to deal with deprecated and / or superseded CRS'. To change and / or update the parameters associated with a projected or geographical CRS will involve either editing an existing system or creating a new system. If a new system is generated all project data associated with the old system will have to be reassigned to the new system. Neither method is trivial nor is acceptable since no internal procedure is available to track such changes.

Example 22: Years ago the Hungarian government published an "official" datum transformations from their national datum (HD72) to WGS 84. However they made an error and actually published the parameters for "WGS 84 to HD72" although they were (officially) labeled in the reverse sense. This was discovered in 2002, with the corrected transformation placed on the Hungarian geodetic website at that time. The EPSG had documented the original transformation and then "deprecated" it when the official error was discovered, replacing it with the corrected version. At least one major G&G application continues to carry the erroneous transformation and has not picked up the corrected one (at least in versions reviewed). The resultant positions generated are hundreds of meters in error from the correct position.

8. Error Messages and Warnings

This section deals with the manner in which the application provides error messages and warnings to users to prevent inappropriate actions being performed with respect to setting the parameters of projects. The issuing of such messages is an integral part of an application, can often prevent simple mistakes and illustrates that levels of sophistication have been integrated into the product. There are many examples of inadequacy in this topic

Example 23: Within the well data manager, well header panel, the CRS of the well is displayed under “Orig CRS Name”. This confirms the CRS of the coordinates of the well when it was imported into the project. The CRS reported here can be changed at will with no warning message being produced by the application. The changes were made and saved with also no warning being provided at this stage. Within the seismic data loader, a 2D seismic line can be loaded into the Survey / Project where that Survey / Project has a different CRS from the line being imported. No warning messages are provided to highlight that the options selected are correct. The CRS of the line being imported is selected from the main loader panel. Using the Seismic Data Export function a similar situation is encountered. The SDE has a simple UI to select the 2D Survey and the line(s) within the Survey. Of the other parameters, required one is the CRS name. The user can specify to which CRS the exported data will be referenced. The list of CRS’ provided is a replica of those shown within the Map Projection Editor. Any one of the list can be selected regardless of suitability. No warnings or errors appear to state that the CRS selection is appropriate. The user will not be informed for any potential problems.

Example 24: Use of interpolation methods of datum shifts. Some datum shifts in more geodetically developed areas use an interpolation grid for datum shift transformations. An example is NADCON (North American Datum Conversion) which allows for conversion of NAD83 to and from NAD27 in North America. When such a facility is available throughout the world on any given application seat, then it can be used by the uninitiated to convert data incorrectly, since it only applies in North America. A similar method (NTv2) is used in Canada, Australia, Germany, France and Spain). The application should (and many do) provide information that the point to be converted is “outside the grid” provided for the transformation when used in an inappropriate geographic region. That said, some major applications do not advise the user if point is “outside the grid”. This is relatively easy to do by examining the coordinates the user is proposing to convert and matching against anticipated validity for the given parameter and/or method. See also Example 26 which is related.

Example 25: A survey off the north coast of South America was set up in a shore office to use the Timbalai datum. This datum only has application in Borneo! It turns out the project was copied over from an older project, and as such, was not directly an application issue, but more of a user education issue. Nevertheless, a simple error trap similar to that described in the previous example would have immediately alerted the project manager that there was an improper datum being selected for the project. The potential error, which was caught by luck rather than by good judgment, was about 800 meters misplacement of the acquired data. Partially stimulated by GIGS, several applications vendors are coming out with products that at least allow users to limit their use to the established EPSG polygons of use validity.

Example 26: Some coordinate transformations require the use of gridded files to actually convert from one geographic CRS to another within an application. One application returns the input geographic coordinates as “transformed” output coordinates if the required file is missing, in a wrong directory or misnamed for some reason. There are no error messages generated and the application advises that the transformation was executed. Exactly the same message is sent to the user whether the grid file is found and the correct transformation is performed or the file is not found and garbage results are returned. This error of hundreds of meters is demonstrable for a major application used by essentially all significant E&P.

Conclusion

The reader should realize that while this is a small sample of some of the errors the authors have discovered over the years, for every story from one user and one application, there are several hundred if not thousands of users and seats that have not caught these problems. There is no operating company immune from the impact of geospatially poorly designed software. The systemic impact on the industry can reasonably be estimated in the many millions of dollars.

As professionals, we rely on hundreds of G&G software applications that have coordinate reference system functionality. Costly errors in coordinate data have been a direct result of software problems. These include, but are not limited to: improperly coded geodetic or cartographic algorithms, wrong values for embedded geodetic parameters, poor presentation of user input requirements by software applications, incorrect default settings used without reference to user, software processes not working as specified, confusing or imprecise terminology, lack of error trapping for user blunders, lack of audit trail for forensic analysis, inadequate metadata functionality and misguided users. The joint industry project (JIP) is underway to study these costly and industry-wide problems at a time when correct geospatial data is vital to successful technical and commercial decision making at all levels of E&P companies and throughout work flows.