Surveying the Gulf of Mexico

Surveying and mapping for the offshore petroleum industry in the Gulf of Mexico (GOM) has been a source of confusion and wonder, especially to non-US nationals working there for the first time. This article aims to clarify some of the more confusing aspects of the system of area/blocks, coordinates and government-agency regulations associated with this working environment.

The Mineral Management Service is the primary federal government regulatory agency involved in offshore construction and lease permits for pipelines and structures. Other government agencies may be involved, such as the Department of Transportation, depending on the circumstances. This article mainly refers to MMS involvement in the construction of offshore pipelines in the GOM.

Boundaries

The states bordering the GOM are Texas, Louisiana, Mississippi, Alabama, and Florida. The boundaries for state and federal waters lie three geographical miles from the coast (mean high-water line), except for Texas and the West Coast of Florida, which lie three marine leagues out. The East Coast of Florida has the state/federal boundary at three geographical miles.

Waters within state boundaries generally fall under state jurisdiction and regulation. As such, revenues received for natural resources also go to the state. There have been several disputes in determining state/federal boundaries that have resulted in extended court cases, since this is a matter that may have a significant impact on the amount of revenues a state receives.

The federal and state waters along the GOM are broken down for leasing purposes into areas and blocks. Offshore Leasing Areas are irregularly shaped and do not cut across state and federal boundaries. These lease areas are typically named after a geological structure within the area; for example, the High Island Area is named after the High Island salt dome and the Mississippi Canyon Area after the offshore canyon formed by the Mississippi River. Each lease area has a two-digit designation (ID) to make writing the description easier and more compact.

The lease areas are further broken down into numbered square blocks. Irregularly shaped blocks are used to fill in the edges of the lease areas. These are typically numbered starting at 1 in a north corner of an area, block numbers then being filled in sequentially in east-west rows, with a move to the next row to the south to continue the numbering. In describing a particular location the area and block can be used instead of a coord–inate: Ship Shoal Area, Block 89 (or SS89). Figure 1 shows the GOM areas and Table 1 their two-digit abbrevi–ation identification tags. Figure 2 shows the areas and blocks south of Galveston, pipelines, and the state-federal boundaries.

All blocks are not of the same size; the majority are three statutory miles square. Figure 3 shows some irregularities in block areas. Table 2 demonstrates some differences in block size; note how ST247 and ST252 differ in size though they are in the same area.

Differing Datums

One of the more confusing aspects of working in the GOM petroleum industry is that the coordinate datum used is the North American Datum of 1927 (NAD27), which uses the Clarke 1866 ellipsoid. The NAD27 datum is still used today because block boundaries and descriptions of the pipelines and other structures are historically referenced to the NAD27 datum. Another, possibly more persuasive, reason for not switching to a modern datum is the fear that some lease boundaries would change and some lease holders end up with less land and thus fewer petroleum reserves/revenues.Modern surveying positioning is typ-ically determined using GPS, which is referenced to the World Geodetic System of 1984 (WGS84). This is currently more of an ellipsoid reference; datums such as the International Terrestrial Reference Frame (ITRF) are available that represent specific adjustments to geodetic control networks similar to WGS84. The ITRF is actually referred to as a “reference frame” as opposed to a datum. The United States uses the North American Datum of 1983 (NAD83), which employs the Geodetic Reference System of 1980 (GRS80) ellipsoid. For all practical purposes the WGS84 and GRS80 ellipsoids are the same.

The ITRF and NAD83 datums have made adjustments to specific geodetic control, usually done every two to five years. For example, the ITRF 96 was adjusted in 1996, as was NAD83 (1996). ITRF adjustments are global. The GRS80 is a world spheroid model but NAD83 adjustments are based on geodetic control stations covering North America and US territories. More localised adjustments of the NAD83 are also conducted at state level.

The United States network of geodetic control is referred to as the National Spatial Reference System (NSRS) and contains all the different types of control: triangulation network, level networks, GPS control, etc. One of the largest contributors to the increased accur–acy of the NSRS is the addition of High Accuracy Reference Networks (HARN) and Continuously Operating Reference Station (CORS) networks. Most HARN and CORS networks started out at state level. Every state within the United States currently has at least one HARN and/or CORS network.

Three of the more notable adjustments to the NAD83, covering entire North America, are NAD83 (1986), NAD83 (CORS96), and NAD83 (NSRS 2007). The NAD83 (1986) was the original NAD83 North American adjustment. The NAD83 (NSRS 2007) will be the most recent adjustment to the NAD83. The differences between adjustments account for the addition of geodetic control (mainly GPS), the movement of the Earth’s surface (due to continental drift, subsidence, isostatic rebound, etc) and sometimes a change in location of the centre of the ellipsoid. There can be a difference of up to 1m between the NAD83 and ITRF datums. For that matter, there can be up to 1m difference between NAD83 (1986) adjustment and the more recent NAD83 adjustments. There is less difference between ITRF datums adjustments.

As already mentioned, all survey data within the GOM petroleum industry needs to be reported in NAD27 coordinates. There is approximately 30m difference in coord–inates between NAD27 and NAD83, depending on location. Until about ten years ago there was no specified method for transforming WGS84/NAD83 coordinates into NAD27. As a result, each survey company would use their own transformation parameters; often these were three parameter shifts (dX, dY, and dZ) that covered a particular region of the GOMor were associated with the DGPS reference station being used. Theresulting NAD27 coordinates could vary significantly.

NADCON

About a decade ago the MMS made it mandatory to transform WGS84/NAD83 to NAD27 coordinates using the NADCON transformation. NADCON was developed by the National Geodetic Survey (NGS, WEB REFERENCE 2) in 1990. It is free software that can be obtained from the NGS website. The transformation is based on geodetic control stations within the NSRS, using only first- and second-order stations that had coordinates in the NAD83 (1986) and NAD27. A transformation grid was developed from this in which two database files are used, one for latitude and one for longitude. For the conterminous United States (the mainland 48 states), the transformation files to use are CONUS.LAS and CONUS.LOS. Working in another region, such as Hawaii, Alaska, Puerto Rico, the Virgin Islands or Samoa, different transformation files would be used. Most navigation and geodetic computation software incorporates the NADCON routines as an option.

Examining the Readme file for NADCON, it specifies that NADCON is not designed for use offshore and that it is to be used with the NAD83 (1986) datum. The reason NADCON was not designed for offshore use is that during its creation the NSRS database did not contain any geodetic control station offshore with NAD83 (1986) and NAD27 coord–inates, so that NADCON would only be extrapolating the land database when extended offshore. Although the NADCON transformation is not a mathematically proper way to transform coordinates to NAD27 when used offshore, it remains a consistent method and anyone applying it will derive the same results when using the same source coordinates.

So NADCON converts between NAD83 (1986) and NAD27. NAD83 (1986) is used because it was the first national adjustment to NAD83 and was employed to create the database for NADCON. Other adjustments to NAD83 came much later. Most satellite-base DGPS corrections currently used are referenced to an ITRF datum, and the US Coast Guard HF DGPS reference stations are referenced to the NAD83 (CORS96) adjustment.

There are methods for converting to the NAD83 (1986) from the more recent NAD83 adjustments or one of the ITRF datums. However, this is not done for offshore use and the GPS-based coordinates are transformed to NAD27 without first converting to NAD83 (1986). The NGS has no plans to revise the NADCON programme to work directly with a more recent NAD83 datum. For the offshore industry it is generally felt that the discrepancy in coordinates of up to 1m is insignificant enough to make no difference.

Grid Coordinates

Onshore and near-shore surveying work within the United States typ-ically employs State Plane coordinate systems for grid coordinates. These are either Lambert or Transverse Mercator projection systems and are designed for use within the designated zone boundary of the states so as to show minimal distortion. Extending these projection systems outside their designated zone demands a larger scale factor and/or convergence angle to convert from grid values to geodetic values. Lambert projection systems can be extended in the east-west direction without significant distortion, and the Transverse Mercator projection system can be extended in a north-south direction without significant distortion.

The Universal Transverse Mercator (UTM) projection system is used in the deeper water areas of the GOM, at continental shelf areas and deeper. The UTM zones are the standard ones used worldwide, with the designed zone being 6 degrees in east-west width. The GOM uses UTM Zones 14, 15, 16, and 17.

All projection systems used in the GOM for the petroleum Industry are measured in NAD27 US survey feet. Not all State Plane coordinate systems in the United States use US survey feet, (some states use the international foot) but states all along the GOM use US survey feet.

One of the stranger situations arising from the use of grid coordinates in the GOM occurs offshore of the state of Louisiana. The Louisiana South projection zone is a land-based state plane projection zone for the southern portion of Louisiana. A Louisiana Offshore projection zone was developed in the early 1960s but was never accepted by the offshore industry. Instead, the Louisiana South zone is extended to the continental shelf area, where the UTM projection system is used. As a result, areas offshore Louisiana lying north of the continental shelf may have negative Northing coord–inate values, as much as -270,000 US survey feet.

The MMS

The US petroleum industry began expanding offshore in the GOM in the late 1940s. In 1953 the US government passed the Outer Continental Shelf Lands Act (OCSLA) and the US Submerged Land Act. These gave the US government ownership and jurisdiction over US submerged lands outside its state coastal waters. The OCSLA made the Secretary of Inter–ior responsible for administering the mineral exploration and development of the Outer Continental Shelf (OCS). After the Santa Barbara Oil Spill in 1969 several government acts were passed to help prevent various types of pollution and to empower government to penalise and fine individual companies.

In 1982 the US congress passed the Federal Oil and Gas Royalty Act, which facilitated protection of the environment and conservation of federal lands in the process of their developing oil & gas capabilities. As part of this act the MMS was formed as a branch of the Department of Interior for the purpose of regulating and leasing lands from the OCS, as well as American Indian Lands.

Today the MMS has numerous functions. For the purpose of offshore construction in the petroleum industry it has charge of permitting pipeline right-of-ways (ROW) and leasing blocks, and regulating construction and maintenance specifications to ensure safe exploration, development, production and transportation of natural resources within the OCS. In addition, the MMS maintains an OCS database of all block-area-lease information, pipelines and umbilicals, wells, platforms, production facilities, etc. This database contains a considerable amount of information, and a reference sheet is typically required to determine what is represented by its various codes. Information from the database can be obtained in various formats from the MMS website.

The US government issues regulation in the form of a Code of Federal Regulation (CFR) for the various government agencies, including the MMS. In addition to CFRs the MMS issues “Notice to Lessees and Operators” (NTL) that outline MMS policy changes and clarify violations for review by the MMS. MMS regulation 30 CFR 250 refers specifically to oil & gas and sulphur operations in the OCS, outlining procedures for granting permission for, constructing, testing, commissioning and reporting various construction-related activities, and the fees involved. Subsection J of 30 CFR 250 applies specifically to pipelines and pipeline right-of-way.

Several commercial companies specialise in obtaining MMS permits for construction activities. To obtain a permit for a proposed pipeline ROW the steps outlined in 30 CFR 250 subsection J are followed. Part of the ROW permit-application process includes a proposed ROW plat and additional schematic drawings and reports to ensure that the pipeline engineering design meets the specifications outlined and that the required safety equipment is included. The ROW plat needs to adequately describe the proposed ROW and show any pertinent features, such as area, block, lease, water depth, extension in federal waters, connecting facilities, burial depth, direction of flow and pipeline crossings. The engin–eer making the plat must certify it. The permit application must include a shallow-hazard survey report covering the entire length of the proposed pipeline route.

Within ninety days of completion of the pipeline the ROW holder submits a report to MMS. The reports must cover as-built location plat drawn to scale and featuring pipeline location, length in federal waters, X-Y coord–inates of key points, completion date, proposed data of first operations, and the date of the Hydrostatic Pressure Test. The pipeline ROW as-built plat is certified by a registered engineer or land surveyor and shows the bound–aries of the ROW as granted. If there are any substantial deviations of the pipeline outside the granted ROW the report must include a description of the reasons for these.

Just described is a simplified version of the actual process. There are pages of rules and regulations in 30 CFR 250 subsection J, and additional regulations in the form of NTLs. For example, supplementary to subsection J is NTL No. 98-09, further stipulating that NADCON software, version 2.0 or better, will be used to convert NAD83 coordinates to NAD27 coordinates. It further states that the pipeline as-built position will be additionally reported in a specified digital format and submitted to the MMS on a 3_” diskette. The digital format specifies data fields for MMS segment number, fix number, position in decimal latitude and longitude, and point description code and comments. Digital data is required so that the MMS can easily add as-built information to the overall MMS database.

It should be pointed out that companies planning to perform construction work in the GOM OCS need to initiate many MMS-related activities well in advance. For certification of the final pipeline as-built ROW plat, the registered engineer or land surveyor needs to be involved in the project from the start and for its duration. A registered engineer or land surveyor from any US state can certify the plat for federal waters. If boundaries are involved certification usually needs to be by a registered land surveyor. Each state in the US has different rules and regulations for registered engineers and land surveyors, although some standards and tests are set nationally.

Concluding Remarks

Survey work in the GOM can be extremely confusing, with differing coordinate system, lease areas and blocks and the MMS regulations. Companies have often performed construction work only to find later that the proper permission and/or other procedures, or reporting have not been followed. It is advisable to carry out appropriate advance research and to consult professionals familiar with the requirements.

The MMS is a necessary government organisation that provides a valuable service. Without it and other government agencies, companies could freely exploit the natural resources of the OCS and pollute the environment. The MMS also provides a useful database of pipelines, structures and hazards that the majority of GOM service-providers depend on for their everyday work. The MMS collected more than US$143 billion in fees and fines between its inception in 1982 and 2004, and disburses a large portion of these revenues to various special funds, such as the Land and Water Conservation Fund.