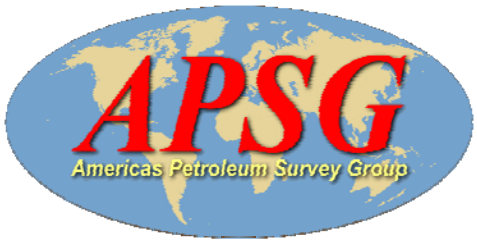
Guidelines for NAD27 Geodetic Transformations for use in the Gulf of Mexico



Revision history:

Version	Release Date	Amendments
1.0	8 March 2006	Initial Release
2.0	15 November 2006	Add JECA Campeche transformations; add accuracy assessments to early transformations
3.0	14 June 2007	Corrected sign errors in tertiary transformations and modified transformation presentation format to reduce transformation direction confusion.

Contents:

Introduction

1. This guideline is intended to document current "General Purpose" geodetic transformations ("datum shifts") used to perform transformations between Geographic Coordinate Reference Systems within the Gulf of Mexico.
2. The geodetic transformation parameters provided have been deemed acceptable for oil and gas exploration usage.
3. Transformations are listed in what is considered the preferred order of usage. PRIMARY RECOMMENDATION: The latest version of NADCON transformation software available from the US NGS should generally be used for transformations between WGS 84 and NAD27 in the Gulf of Mexico, unless there is a specific need to match legacy data using other transformations.
4. Where noted, geocentric translations have been included for historical purposes, but are considered obsolete for current usage and as such have been superseded.

5. It is understood that proprietary transformations and specific "NADCON-derived" transformations have been and may be used by specific companies in specific applications. Documentation of these is beyond the scope of this guideline. Should any such transformations be in common usage by more than one company, users are encouraged to submit these for consideration as additions to the EPSG geodetic dataset (via the user input form on www.epsg.org.)
6. In all cases, the APSG recommends that suitable documentation of both the transformation method and the defining parameters accompany all data. Appropriate metadata is crucial.
7. The APSG considers NAD27 to be the operational datum for the Gulf of Mexico.

Underlying Assumptions for applicability to the Oil and Gas Industry

The NADCON transformation files provided by NGS are strictly between NAD27 and NAD83 or between NAD83 and NAD83(HARN). For reference only, the "official" US NGS way to transform **onshore** from WGS 84 to NAD27 is via concatenation of the following three transformations, in reverse order and direction:

1. EPSG # 1241 NAD27 to NAD83 (1) NADCON using CONUS.las and .los files
2. EPSG # NNNN NAD27 to NAD83 (nn) NADCON 2nd pass using the appropriate state HPGN.las and .los files (which determines variant 'nn'). NNNN is the EPSG code number for the specific transformation. For onshore Louisiana this step is EPSG # 1484 NAD83 to NAD83(HARN) (11)
3. EPSG # 1901 NAD83(HARN) to WGS 84 (3) Coordinate Frame Rotation

The last two steps only add incremental adjustments at the 1 to 3 meter level and are not deemed necessary (or even appropriate) for support of marine oil and gas operations or offshore construction in the Gulf of Mexico.

The APSG recommends the use of NADCON with the general Contiguous US (CONUS) grid files for general offshore exploration and construction use in the Gulf of Mexico. This transformation is between NAD27 and the original (1986) realization of NAD83, which is coincident with WGS 84 at the 1-2 meter level; i.e., WGS 84 coordinates can be treated as NAD83 coordinates as input/output for NADCON to the level of accuracy consistent with the transformation offshore in the GOM.

The more accurate NAD83 High Precision Regional Networks (HARN or HPGN) have been developed for onshore applications in each of the GOM coastal states, with separate regional networks for eastern Texas, Louisiana, Alabama, Mississippi and Florida. Since these HARN networks themselves did not extend offshore, use of the associated second pass NADCON transformations from NAD83(1986) to NAD83(HARN) for those states is not applicable offshore except very near shore for the particular state HARN networks.

For purposes of this guideline, the oil and gas industry accept that NAD83 and WGS 84 are "operationally" the same within the accuracy needed for offshore applications. As such, transformations using NADCON in the Gulf of Mexico (GOM) allow for WGS 84 coordinates to be substituted for NAD83 as long as the substitution has been documented and such documentation accompanies the transformation data.

If an operator so desires, it is certainly acceptable for a precise multi-step transformation to be performed as described earlier in this section:

- Using above Steps 1 and 2 reversed to go from NAD83(HARN) to NAD83 and then from NAD 83 to NAD27 or;
- by Steps 1, 2 and 3 reversed to go from WGS 84 (ITRF) to NAD83(HARN), then NAD83(HARN) to NAD83, then NAD83 to NAD27.

Although this nominal gain in accuracy is considered by the APSG to be meaningless since NAD27 was never established offshore to this level of accuracy. The accuracy of the basic NADCON transformation at the 67% confidence level is considered to be 0.15m onshore, 5m near shore and undetermined farther offshore.

The WGS 84 ellipsoid differs slightly in flattening from the GRS 80 ellipsoid. However, this difference only causes a positional variance at the few millimeter level.

Again, the APSG considers WGS 84 and all flavors of NAD83 as "operationally" interchangeable within the accuracy needed for offshore applications.

Methods and Parameters – Definitions and Terminology

The definitions of basic geodetic and cartographic objects should follow the EPSG database, www.epsg.org. The EPSG integer identifiers for the following objects should be utilized. These integer identifiers are unique within an object type:

a. Ellipsoids
b. Prime Meridians (Greenwich for all systems used in the GoM)
c. Geodetic Datums
d. Geographic Coordinate Reference Systems (GeogCRS)
e. Geodetic Coordinate Transformation Methods
f. Geodetic Coordinate Transformation Instances (Methods and Parameters), including both direct and concatenated transformations.
g. Map Projection Methods
h. Map Projection Instances (Methods and Parameters)
i. Units (Linear and Angular)

Transformation Methods Utilized and their Recommended Hierarchy

The following methods of transformation should be supported to comply with this guideline:

NADCON[1,2]

The NADCON transformation uses bi-linear interpolation of grids that were derived by NGS from derived minimum curvature surfaces based on the individual observed differences between the two CRS (i.e., NAD27 and NAD83). The latest version available at the time of release of this Guidance Note is NADCON version 2.1, available from www.ngs.noaa.gov.

Note that NADCON expects longitudes positive west; whereas the EPSG GeogCRS NAD27 (code 4267) and NAD83 (code 4269) both have longitudes positive east, in keeping with general geodetic practice worldwide.

Many companies use NADCON offline at single points or multiple point averages for a specific work area to determine 3-parameter Geocentric Translation values. This has often been done when navigation software would not or will not support full NADCON implementation. Although derived from NADCON, these are beyond the scope of this Guidance Note except that the APSG strongly recommends that the metadata associated with any such transformations clearly stipulate exactly how they were derived. Such metadata should remain with the datum transformation and associated data for audit purposes.

Recommendation: To convert from WGS 84 to NAD27 via NADCON, enter the WGS 84 coordinates as if they were NAD83 coordinates (if the software so requires), using the NADCON files CONUS.LAS and CONUS.LOS.

Geocentric Translations[3,4,5] or Molodensky 3 parameter shifts

These are simple linear shifts along the earth-centered X, Y and Z Cartesian axes. This document shows transformation sign conventions both from WGS 84 to NAD27 and from NAD27 to WGS 84.

Coordinate Frame Rotation 7 parameter transformation

This is “Step 3” in the rigorous NGS example mentioned above. Its use is not recommended for oil and gas operations in the Gulf of Mexico. Thus, parameters for the transformation are not given here. See EPSG transformation 1901 for this transformation, given from NAD83 to NAD83(HARN) in that document. The new NAD83(NSRS2007) differs from NAD83(HARN) by only a few centimeters and, like HARN, is not considered valid for offshore usage.

This Coordinate Frame Rotation transformation is given by NGS from NAD83(HARN) to target ITRF [specifically to the ITRF96(1997.0) adjustment and epoch]. This ITRF CRS is equivalent to WGS 84 at the sub-meter level (and has been since WGS 84 was adjusted to ITRF in 1994.)

Note 1: – NADCON has been used to derive "applied" area specific geocentric translations. Such are acceptable for GOM operations as long as the bounding coordinates used to derive such shifts are well documented and accompany the data.

Note 2: – In order to facilitate archival information, especially in existing exchange formats such as UKOOA, SEG and SPS, APSG recommend that additional header records be included, which provide the summary information and define the NADCON LAS and LOS files utilized.

Note 3: – The 3-parameter shifts as derived by John E. Chance and Associates (now Fugro) cover the Eastern, Central and Western areas of the Gulf of Mexico as well as the Tampico and Bay of Campeche (North and South) areas of Mexico.

Note 4: – The general EnSoCo derived GOM 3-parameter shift is included for historical information and is no longer recommended for use.

Note 5: – The general DMA /NIMA / NGA derived geocentric transformations given were derived for large areas of the USA and/or Mexico and are in no way specific to the Gulf of Mexico. They are considered completely superseded by the various transformations given prior to them in this guidance note.

Note 6: EPSG transformations involving WGS 84 are always given from the Local GeogCRS (e.g., NAD27) to WGS 84. All transformations given here are reversible and the parameters must be reversed from the signs given in the EPSG database if going from WGS 84 to NAD27.

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1. Primary Transformation used for the Gulf of Mexico

The latest version of NADCON transformation available from the US NGS should generally be used for transformations between WGS 84 and NAD27 in the Gulf of Mexico, unless there is a specific need to match legacy data using other transformations.

Transformation Files: CONUS.las and CONUS.los

EPSG transformation code – 15851 given as NAD27 to WGS 84 (79),
EPSG Transformation Version: OGP-Usa Conus

Note 7: NADCON software is bi-directional, allowing transformation from WGS 84 to NAD27 or from NAD27 to WGS 84.

Note 8: NADCON expects (requires) longitude positive west.

Note 9: To use transformation 15851 in NADCON requires the user to enter the WGS 84 coordinates as if they were NAD83 coordinates (whether as input or output).

2. Secondary Geocentric Translations used for the Gulf of Mexico

a. Eastern Gulf (Defined for areas from Miami to Pensacola).

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 3 m	DX = – 3 m
DY = – 154 m	DY = + 154 m
DZ = – 177 m	DZ = + 177 m

Source: Developed by John E. Chance & Associates (now Fugro Chance)
Horizontal transformation accuracy (1 sigma) is considered to be at the +/- 5 meter level, which is consistent with the other early Geocentric Translation transformations given herein.
* EPSG transformation code is 15852 given as NAD27 to WGS 84 (80)
EPSG transformation Version: JECA-Usa GoM E

b. EPSG transformation Central Gulf (Defined for areas from Pensacola to Galveston).

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 7 m	DX = – 7 m
DY = – 151 m	DY = + 151 m
DZ = – 175 m	DZ = + 175 m

Source: Developed by John E. Chance & Associates (now Fugro Chance)
Horizontal transformation accuracy (1 sigma) is considered to be at the +/- 5 meter level, which is consistent with the other early Geocentric Translation transformations given herein..
* EPSG transformation code is 15853 given as NAD27 to WGS 84 (81).
EPSG transformation Version: JECA-Usa GoM C

c. Western Gulf (Defined for areas from Galveston to Mexico).

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 7 m	DX = – 7 m
DY = – 151 m	DY = + 151 m
DZ = – 178 m	DZ = + 178 m

Source: Developed by John E. Chance & Associates (now Fugro Chance)
Horizontal transformation accuracy (1 sigma) is considered to be at the +/- 5 meter level, which is consistent with the other early Geocentric Translation transformations given herein.
* EPSG transformation code is 15854 given as NAD27 to WGS 84 (82.
EPSG transformation Version: JECA-Usa GoM W

d. Tampico area of Mexico
Defined at NAD27 Latitude, Longitude of 21º 55' 00.00" N, 97 º 20' 00.00" W.

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 8 m	DX = – 8 m
DY = – 125 m	DY = + 125 m
DZ = – 190 m	DZ = + 190 m

WGS 84 ellipsoidal height of water = minus 17m
Source: Developed by John E. Chance & Associates (now Fugro Chance)
Horizontal transformation accuracy (1 sigma) is considered to be at the
+/- 5 meter level, consistent with other early Geocentric Translations/
* EPSG transformation code is 15855 given as NAD27 to WGS 84 (83).
EPSG transformation Version: JECA-Mex GoM Tam

e. Bay of Campeche (North) area of Mexico
Defined at: NAD27 Latitude, Longitude of 21º 33' 00.00" N, 92 º 33' 00.00" W.

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 0 m	DX = – 0 m
DY = – 125 m	DY = + 125 m
DZ = – 196 m	DZ = + 196 m

WGS 84 ellipsoidal height of water = minus 16.699m
Source: Developed by John E. Chance & Associates (now Fugro Chance)
Horizontal transformation accuracy (1 sigma) is considered to be at the
+/- 5 meter level, consistent with other early Geocentric Translations.
* EPSG transformation code is 15913 given as NAD27 to WGS 84 (86).
EPSG transformation Version: JECA-Mex GoM CamN

f. Bay of Campeche (South) area of Mexico
Defined at NAD27 Latitude, Longitude of 19º 44' 00.00" N, 92 º 21' 00.00" W.

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 2 m	DX = – 2 m
DY = – 124.7 m	DY = + 124.7 m
DZ = – 196 m	DZ = + 196 m

WGS 84 ellipsoidal height of water = minus 13.342m
Source: Developed by John E. Chance & Associates (now Fugro Chance)
Horizontal transformation accuracy (1 sigma) is considered to be at the
+/- 5 meter level, consistent with other early Geocentric Translations.
* EPSG transformation code is 15699 given as NAD27 to WGS 84 (87).
EPSG transformation Version: JECA-Mex GoM CamS

3. Tertiary Geocentric Translations used for the Gulf of Mexico

a. EnSoCo mean shift developed for Gulf of Mexico operations historical only

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 7 m	DX = – 7 m
DY = – 158 m	DY = + 158 m
DZ = – 172 m	DZ = + 172 m

Source: Developed by EnSoCo
Horizontal transformation accuracy (1 sigma) is estimated at 8m (in the Central Gulf of Mexico)
* EPSG transformation code is 15856 given as NAD27 to WGS 84 (84).
EPSG transformation Version: ESC-Usa GoM

b. Mean shift for USA (CONUS)

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 8 m	DX = – 8 m
DY = – 160 m	DY = + 160 m
DZ = – 176 m	DZ = + 176 m

Source: Developed by US DMA / NIMA / NGA. Derived at 405 stations by the U.S. Defense Mapping Agency and published in TR8350.2 September 1987
USA onshore horizontal accuracy is quoted by NGA as 5m, 5m and 6m in X, Y and Z axes respectively (better than 10m horizontal), 1 sigma. Offshore horizontal accuracy is less but not known.
* EPSG transformation code is 1173 given as NAD27 to WGS 84 (4).
EPSG transformation Version: DMA-Usa Conus

c. Mean shift for USA (CONUS east of the Mississippi)

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 9 m	DX = – 9 m
DY = – 161 m	DY = + 161 m
DZ = – 179 m	DZ = + 179 m

Source: Developed by US DMA / NIMA / NGA (Derived at 129 stations by the U.S. Defense Mapping Agency and published in TR8350.2 September 1987
USA onshore accuracy is quoted by NGA as 5m, 5m and 8m in X, Y and Z axes respectively (better than 11m horizontal), 1 sigma.
Offshore accuracy is less but not known.
* EPSG transformation code is 1174 given as NAD27 to WGS 84 (5).
EPSG transformation Version: DMA-Usa ConusE

d. Mean shift for USA (CONUS west of the Mississippi)

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 8 m	DX = – 8 m
DY = – 159 m	DY = + 159 m
DZ = – 175 m	DZ = + 175 m

Source: Developed by US DMA / NIMA / NGA(Derived at 276 stations by the U.S. Defense Mapping Agency and published in TR8350.2 September 1987

USA onshore accuracy is quoted by NGA as 5m, 3m and 3m in X, Y and Z axes respectively (better than 7m horizontal), 1 sigma. Offshore accuracy is less but not known.

* EPSG transformation code is 1175 given as NAD27 to WGS 84 (6)

EPSG transformation Version: DMA-Usa ConusW

e. Mean shift developed for all of Mexico – onshore and offshore

WGS 84 TO NAD27	NAD27 TO WGS 84 *
DX = + 12 m	DX = – 12 m
DY = – 130 m	DY = + 130 m
DZ = – 190 m	DZ = + 190 m

Source: Developed by US DMA / NIMA / NGA(Derived at 22 stations by the U.S. Defense Mapping Agency and published in TR8350.2 September 1987

Onshore accuracy throughout Mexico is quoted by NGA as 8m, 6m and 6m in X, Y and Z axes respectively (better than 12m horizontal), 1 sigma. Offshore accuracy is less but not known.

* EPSG transformation code is 1187 given as NAD27 to WGS 84 (18).

EPSG transformation Version: DMA-Mex

There are additional transformations from WGS 84 to NAD 27 that are applicable for transformations within Cuban territorial waters, but these are not enumerated here. See the EPSG database for these transformations provided by NGA and by the Institut Cubano di Hidrografia (ICH)

Transformations were also derived from WGS 72, WGS 72BE and WGS 72 Precise Ephemeris to NAD27 based on NNSS Transit Doppler Satellite observations prior to the development of NAD83 and WGS 84. However, these transformations have all been superseded and are *not* covered within this Guidance Note.

Glossary of Terms

APSG	Americas Petroleum Survey Group. See www.apsg.info
CONUS	Contiguous (or Continental) United States, i.e., the "lower 48 states" excluding Alaska and Hawaii.
CORS	See NAD83(HARN).
CRS	Coordinate Reference System (may be either Geographic 3D, Geographic 2D, Geocentric, Projected, Vertical, Compound or Engineering/Local). Traditionally known as "Coordinate System"
DMA / NIMA / NGA	The former US Defense Mapping Agency (DMA) was renamed to the US National Imagery and Mapping Agency (NIMA) and then later renamed again to the US National Geospatial Intelligence Agency (NGA)
Ellipsoid Height or Ellipsoidal Height	Distance from the reference ellipsoid to the earth's surface, measured along the normal to the ellipsoid
EPSG	Formerly "European Petroleum Survey Group", now the identifier for the geodetic parameters database and associated dataset developed by that group and maintained by the OGP Surveying and Positioning Committee. See www.epsg.org
Geoid Height or Geoidal Height	Distance from the ellipsoid to the geoid along the ellipsoid normal
GeogCRS	Geographic Coordinate Reference System (often called a "datum" in industry usage)
GOM or GoM	Gulf of Mexico
GRS 80	Global Reference System 1980, ellipsoid used for NAD83, ITRF realizations and most other modern earth centered, earth fixed CRS except for WGS 84
HARN or HPGN	High Accuracy Regional Network or High Precision Geodetic Network. See NAD83(HARN).
ITRF	International Terrestrial Reference Frame, a very precise earth-centered CRS that is actually a series of global adjustments, with earth plate velocities also computed. Hence each ITRF solution has both an adjustment date and an epoch in time for its validity. E.g., ITRF96(1997.0) represents the 1996 ITRF adjustment with plate motions moved forward to January 1997
JECA	(formerly) John E. Chance & Associates (now Fugro Chance)
LAS and LOS	File extensions for NADCON input files: Latitude Difference Files = *.LAS and Longitude Difference Files = *.LOS
NADCON	North American Datum CONversion program from US NGS.
NAD27	North American Datum of 1927 (both a horizontal geodetic datum and a Geographic CRS
NAD83	North American Datum of 1983 (both a horizontal geodetic datum and a Geographic CRS. This usually means the original 1986 release from NGS, but can upon occasion be used to represent all generalizations of NAD83

NAD83(HARN)	Precise High Accuracy Regional Network adjustments of the North American Datum of 1983. These are matched at the HARN regional borders by NGS and are collectively called a unified horizontal geodetic datum and Geographic CRS. Synonyms used for HARN include "High Precision Geodetic Network" and "Continuing Operation Reference System", so users may also encounter NAD83(HPGN) or NAD83(CORS), all synonymous with NAD83(HARN).
NGS (or US NGS)	The US National Geodetic Survey, division of the US National Ocean and Atmospheric Agency (NOAA), responsible for maintenance of mapping systems and monuments within the USA.
NNSS	Naval Navigation Satellite System that preceded WGS 84, commonly known as the "Transit" Satellite System.
OGP	International Association of Oil and Gas Producers. See www.ogp.org.uk
Orthometric Height	Distance from the earth's geoid to the earth's surface, measured along a plumb line (i.e., normal to the geoidal surface)
S&P Committee	The Surveying and Positioning Committee of the OGP. This committee was formerly known as the European Petroleum Survey Group (EPSG). See www.egps.org
SEG	Society of Exploration Geophysicists. See www.seg.org
Sigma	Mathematical definition to be inserted
SPS	Shell Processing Support format for land 3D seismic surveys. See http://www.seg.org/publications/tech-stand/seg_sps_rev0.doc
UKOOA	United Kingdom Offshore Operators Association. See www.ukooa.org
WGS 72	World Geodetic System 1972 (uses WGS 72 ellipsoid)
WGS 72BE	World Geodetic System 1972 Transit Broadcast Ephemeris (uses WGS 72 ellipsoid)
WGS 72 Precise Ephemeris	World Geodetic System 1972 Transit Precise Ephemeris (uses NWL 9D ellipsoid, also called NSWC9Z2 and WGS 66)
WGS 84	World Geodetic System 1984 (uses WGS 84 ellipsoid)