International Association of Oil & Gas Producers

Surveying & Positioning Guidance note 4

Use of the International Terrestrial Reference Frame (ITRF) as the reference geodetic system for surveying and real-time positioning

Revision history

Version	Date	Amendments
2.0	July 2002	Updated to ISO 19111 terminology.
1.0	April 1997	First release

Considering that:

- The use of Differential GPS (DGPS) technology for surveying & real time positioning requires that geographical coordinates of reference stations must be known on the WORLD GEODETIC SYSTEM 1984 (WGS84) , and that a geodetic transformation (sometimes called « datum shift ») between the WGS 84 and the local coordinate reference system must be available and valid on the whole survey area.
- The development of commercial Wide Area DGPS (WADGPS) has involved the use of permanent reference stations which are installed in many different countries, where coordinate reference systems are different.
- Various sets of published geodetic transformation parameter values are used by various survey contractors providing DGPS services. Accuracy of these parameter values is not always in agreement with the required accuracy for the DGPS positioning in the local coordinate reference system, because these parameters may have been derived from the results of old geodetic surveys performed in the former WGS 72 system associated with the TRANSIT satellites, and afterwards transformed into WGS 84 system within an absolute accuracy of 5 to 15 meters only.
- The International Earth Rotation Service (IERS) has defined a civil International Terrestrial Reference System (ITRS), in agreement with and more accurate than the U.S. military WGS 84 system. The ITRS was adopted by the International Union of Geodesy and Geophysics (IUGG) in 1991. The realization of the ITRS is a network of more than 200 sites throughout the world, called the "International Terrestrial Reference Frame" (ITRF). This network is constructed from the combination of sets of station coordinates and velocities derived from observations of space geodetic techniques such as very long baseline interferometry (VLBI), satellite laser ranging (SLR), lunar laser ranging (LLR), GPS and DORIS techniques. The coordinates of sites slowly change (by up to 10 centimeters per year) due to the motion of tectonic plates; ITRF coordinates are given in relation to the year (ITRFyy for the year 19yy or 20yy) and associated velocity is obtained by differencing combined coordinates at two epochs.
- A refined WGS 84 coordinate reference system, designated first "WGS 84 (G730)" in 1994 and then "WGS 84 (G873)" in 1996, has been implemented by the GPS Master Control Station and in NIMA's GPS orbit processing, and is now coincident with the ITRF to the decimeter level.
- An International GPS Service for Geodynamics (IGS), interfaced with IERS, has been created in 1992 and can be used by the civil community from January 1994. This service collects, archives, and distributes GPS observation data sets recorded on various ITRF stations, in order to satisfy the objectives of a wide range of applications. IGS products allow in particular to tie to the ITRF, within a few centimeters accuracy, the position of any geodetic marker on which GPS data have been recorded during 48 hours with a dual frequency GPS receiver.

The OGP Surverying & Positioning Committee recommends the following to Oil Operators:

1. To use only reference stations of commercial Wide Area DGPS system which have been tied to the ITRF at decimeter level or better accuracy. A detailed geodetic report concerning the accepted WADGPS shall be available from the positioning contractor, on client request.
2. To tie to the ITRF any local geodetic framework used in the past for offshore or onshore oil industry surveys, as soon as new surveys and positioning operations using DGPS technology are planned. The number of geodetic points to be tied to ITRF will depend on the following:
   - Size of the concession or working area.
   - Relative accuracy of the geodetic network in the local datum.
   - Availability of prime or second order points of the local framework.
3. To derive a geodetic transformation between the local geodetic system and the ITRF system; 3 or 7 transformation method parameter values will be calculated, depending on the internal accuracy of the local system and the size of the working area. This geodetic transformation shall allow for the transformation of coordinates to better than one meter accuracy throughout the working area.
4. To keep the old wording "from local coordinate reference system to WGS 84" only when the published transformation parameter values allow a coordinates transformation to an accuracy worse than one meter, and to use the new wording: "from local coordinate reference system to ITRFyy at epoch yyyy.y" for the publication of transformation parameter values at a sub-meter precision.
5. To make available to the Oil Industry community the results of connecting the local coordinate reference system to the ITRF, in order to avoid multiple geodetic surveys when various Oil Companies are operating in neighbouring concessions.

Example of Transformation Definition

Local geographic CRS:	Pulkovo 1942
Ellipsoïd:	Krassowsky 1940
	Semi major axis a = 6 378 245.000
	Inverse flattening $^1/_f$ = 298.3
GPS satellite CRS:	International Terrestrial Reference Frame (ITRF92 at epoch 1994.4)
Ellipsoïd:	WGS 84
	Semi major axis a = 6 378 137.000
	Inverse flattening $^1/_f$ = 298.257 223 6

Geodetic Transformation from Pulkovo 1942 to ITRF 92 at epoch 1994.4

(applicable only for the northern part of the Caspian Sea coast in Kazakhstan)

X-axis translation	= plus 43.8
Y-axis translation	= minus 108.8
Z-axis translation	= minus 119.6
X-axis rotation	= plus 1.455″
Y-axis rotation	= minus 0.761″
Z-axis rotation	= plus 0.737″
Scale difference	= plus 0.549 ppm

- *rotations are based on the «position vector» convention.*
- *survey from which transformation parameter values were derived by NeSA (RACAL SURVEY) in May 1994.*

Example of transformation (to be provided with the transformation parameter values)

Coordinate	Coordinate Reference System Pulkovo 1942	Coordinate Reference System ITRF92-Epoch 1994.4
Geocentric X	2 827 122.53	2 827 138.86
Geocentric Y	3 369 233.43	3 369 104.11
Geocentric Z	4 603 736.24	4 603 653.37
Geodetic Latitude	46° 30′ 00″.00 N	46° 30′ 00″.32 N
Geodetic Longitude	50° 00′ 00″.00 E	49° 59′ 55″.52 E
Ellipsoidal height	minus 35.0m	minus 46.7 m

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