Is Geodesy Important In Our Industry?

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YES!

Topside under way with Navigation/positioning on the widely used local datum. Site and route survey undertaken to be sure of sufficient water clearance

The route survey was done on WGS84…….

Other Examples Include

- The draining of Lake Peigneur

- Seismic surveys shot in the wrong place

- Mis-match of seismic and well data

- Boundary errors leading to expensive disputes

All very expensive errors, avoidable by up-front attention to geodesy/ geomatics

However

With the advent of GPS, over the last 10-15 years:

- Operators reduced or eliminated Survey Departments

- Contractors have also reduced office-based expertise

- “Black Box” systems have reduced field expertise

- “GPS is here…our problems are solved”

Actually, they are only just beginning!

Problems not "solved"

They HAVE however, become less obvious and more difficult to locate

They often will not be noticed until a critical point of the project is reached and rectification becomes very expensive

Historical Overview: Past

In the past, problems tended to occur at the "upstream" end of the operation. eg:

- Incorrect base station coordinates/ geodesy

- Base stations now DGPS: Well-controlled

- Incompatible geodesy with field recording

- Now controlled by example transformations

- Incorrect mapping (UTM/TM) parameters

- Still see potential problems here

Overview: Present

Acquisition problems with geodesy or geomatics are now largely eliminated. Test points and use of OGP (EPSG) transformation database has helped standardisation. Data is mainly acquired where it was planned to be acquired!

We still have to take care though

For example, in knowing which datums and spheroids to use in a particular area

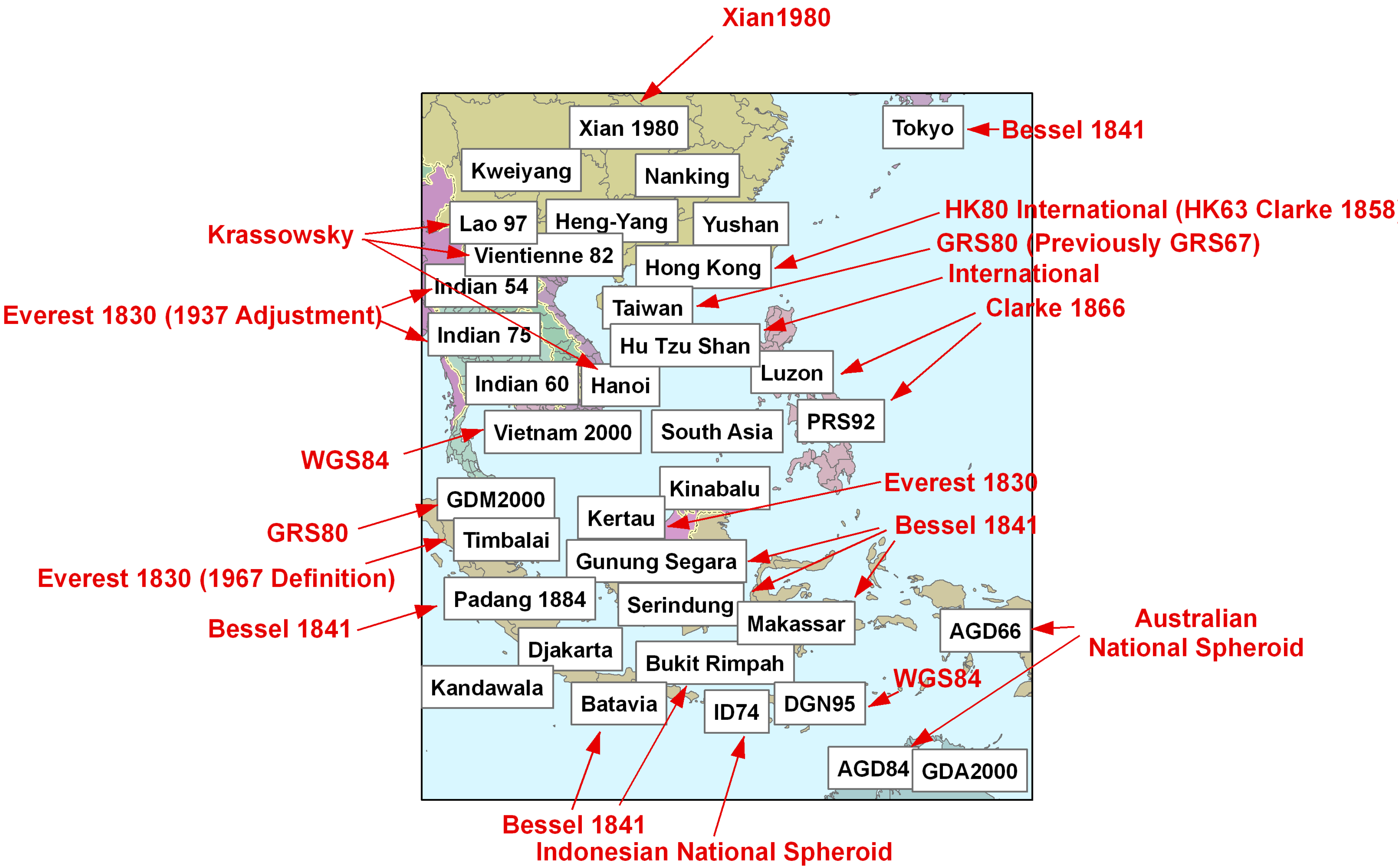
Overview: Present

Although GPS operates in an ECEF frame, WGS 84, a lot of data is still acquired or at least delivered in a local datum

Data may need to fit with legacy data, or local mapping systems

It can be problematic to ensure coherence of data in areas where many different datums are in use

Overview: Present



Overview: Present

Of the 4 commonly used datums in Brazil, 3 use the same spheroid

Aratu	**International**
Corregro Alegre	**International**
PSAD 56	**International**
SAD 69	**GRS 1967**

But the coordinates of a point in any one of them will differ from all the others, often very significantly (100s of metres)

Overview: Present

There are at present 431 Datums (current and legacy) documented in the OGP database.

The common spheroids used are:

International	29.5%	127 different datums!
"A" Clarke	23.7%	Next slide!
GRS80	12.1%	
Bessel	9.3%	
WGS84	4.6%	
Krassovsky	3.0%	

Overview: Present

This is not the whole story. Several spheroids have similar names, but different parameter values:

Clarke 1858	a = 6378293.637	f = 1/294.260680
Clarke 1866	a = 6378206.400	f = 1/294.978698
Clarke 1866 (Michigan)	a = 6378450.048	f = 1/294.978700
Clarke 1880	a = 6378249.136	f = 1/293.466307
Clarke 1880 (Arc)	a = 6378249.145	f = 1/293.466307
Clarke 1880 (Benoit)	a = 6378300.789	f = 1/293.466316
Clarke 1880 (IGN)	a = 6378249.200	f = 1/293.466020
Clarke 1880 (RGS)	a = 6378249.145	f = 1/293.465000

Overview: Present

We have a further complication, in that transformations between 2 datums are not necessarily unique. There are 2 types of difference:

- Different types of transformation. Eg 3 parameter vs 7 parameter shifts

- The same number of parameters, but different values, as determined by different agencies at different times

Examples

3 **Selection of DATUM SHIFTS from MINNA to WGS 84 used by Oil Operators**

- From MINNA – NIMA 1987 to WGS 84:

Delta X = minus 92)
Delta Y = minus 93) 3 translation parameters only
Delta Z = plus 122)

Datum shift derived by the US Defense Mapping Agency at 6 stations for military purposes

Nota: this datum shift is associated to the datum code: NGRA in the GEOFRAME V4.04 geodetic database. But the datum transformation made with GEOFRAME with the NGRA code do not use the above parameters, and is erratic for approximately 100 or 150 metres, depending of the offshore blocks.

- From MINNA - ELF Offshore to WGS 84: *TOTAL code: MIN*

Delta X = minus 88.98)
Delta Y = minus 83.23) 3 translation parameters only
Delta Z = plus 113.55)

Datum shift derived by Elf Petroleum Nigeria ltd (P. Balestrini) in 1994, from 1 onshore station M101 and 2 offshore Mobil platforms XSW06 & XSV39.
Used in OMLs 99-102 and OPLs 222-223

- From MINNA - CONOCO to WGS 84: *TOTAL code: MIC*

Delta X = minus 93.20)
Delta Y = minus 93.31) 3 translation parameters only
Delta Z = plus 121.16)

Datum shift derived by NORTECH at station L40 using NNPC 1989 GPS network tied to 4 ADOS stations.
Used by CONOCO in OPLs 219-220 and EXXONMOBIL in OPL 209

- From MINNA - SHELL to ITRF- WGS 84: *TOTAL code: MIS*

Delta X =	minus 111.92 m	Rot X =	plus 1.875 "
Delta Y =	minus 87.85 m	Rot Y =	plus 0.202"
Delta Z =	plus 114.50 m	Rot Z =	plus 0.219"
Delta scale =	plus 0.032 ppm		

Rotations are based on the BURSA WOLF formula (Position Vector Method)
Datum shift parameters used by SHELL PETROLEUM DEVELOPMENT COMPANY (SPDC) throughout southern Nigeria onshore, delta and shallow offshore from 1994. (1993 1994 GPS campain)
Used by TOTAL in offshore OPL 246.

Sample Transformations

4 EXAMPLE OF TRANSFORMATION

Datum *TOTAL code*	WGS 84 *W84*	MINNA- NIMA 1987	MINNA- ELF Offshore *MIN*	MINNA- CONOCO *MIC*	MINNA- SHELL *MIS*
Latitude	4° 00' 00" N	3° 59' 57.3864"	3° 59' 57.6700"	3° 59' 57.4109"	3° 59' 57.5914"
Longitude	6° 00' 00" E	6° 00' 02.6865"	6° 00' 02.3818"	6° 00' 02.6925"	6° 00' 02.3650"

Projection : Transverse Mercator Central Meridian 6 deg East

Easting	500 000.00				
Northing	442 127.39				

Projection : UTM zone 32 North

Easting	166 831.07	166 907.76	166 898.38	166 907.95	166 897.86
Northing	442 736.25	442 614.92	442 623.68	442 615.68	442 621.26

Projection: Nigerian Transverse Mercator, zone Mid Belt

Easting	392 910.22	392 987.94	392 978.56	392 988.12	392 978.03
Northing	422.74	342.16	350.91	342.91	348.49

Summary

We have seen so far that several pitfalls exist in dealing with datums:

- Multiple datums in same area using same spheroid

- Many different spheroids with same or similar name

- Different types of transformation (3 or 7 parameter, eg)

- Same transformation types but different actual values

Overview: Present

There are 2 other pitfalls not specifically noted:

- **The sign of the transformation values when going FROM datum A TO datum B and vice versa. Not highlighted because awareness is high**

- **The convention of the transformation in a 7-parameter shift**

-Less awareness and causes significant problems

Overview: Present

2 conventions operating:

Position Vector and Coordinate Frame

Bursa-Wolf method usually uses the Position Vector, where the rotations are defined as being clockwise around the cartesian axes

Other methods use Coordinate Frame, where the rotations are described as counter-clockwise around the coordinate axes

Effect is that signs of rotation parameters are reversed

Overview: Present

Bursa-Wolf transformation:

$$\begin{pmatrix} X' \\ Y' \\ Z' \end{pmatrix} = M * \begin{pmatrix} 1 & -R_Z & +R_Y \\ +R_Z & 1 & -R_X \\ -R_Y & +R_X & 1 \end{pmatrix} * \begin{pmatrix} X \\ Y \\ Z \end{pmatrix} + \begin{pmatrix} dX \\ dY \\ dZ \end{pmatrix}$$

Using Position Vector convention

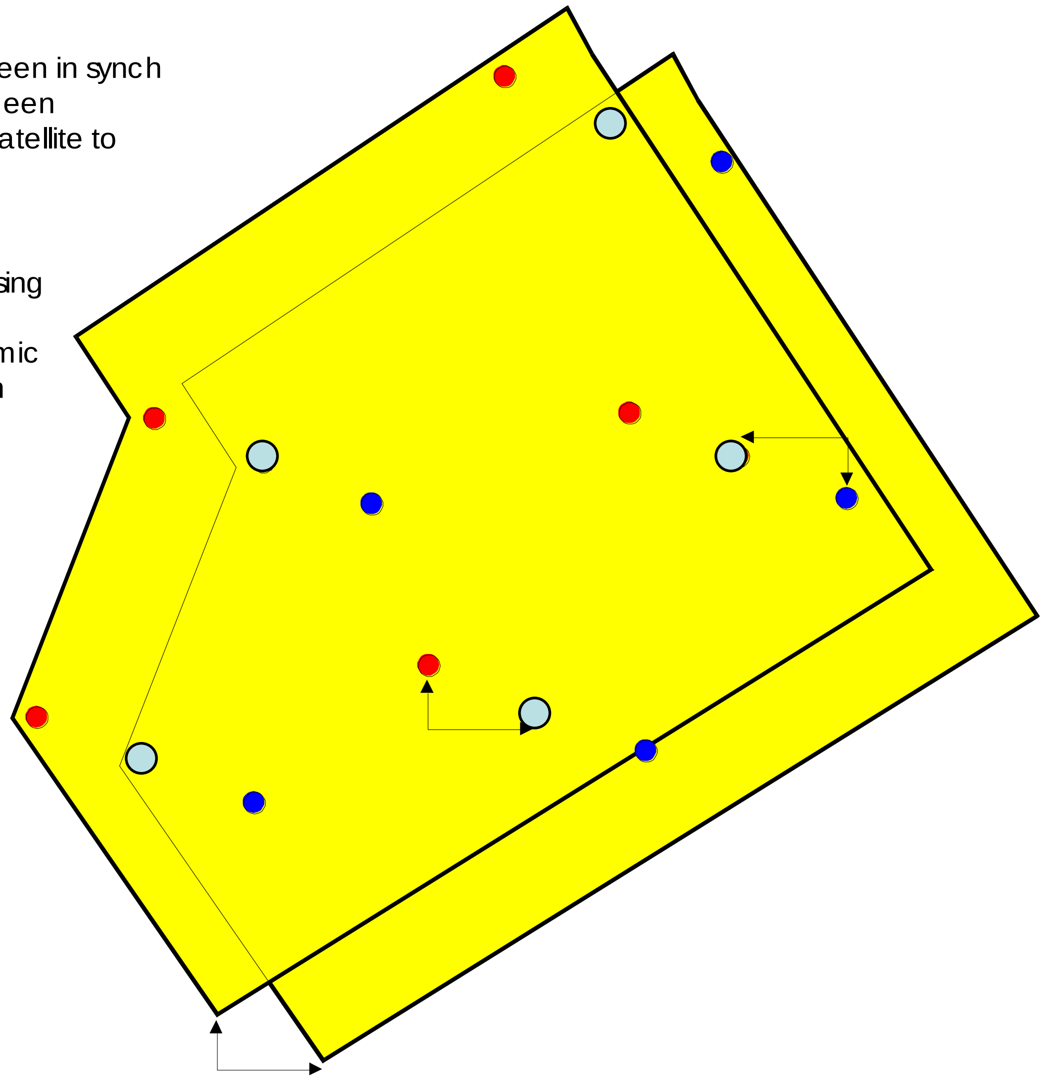
IF transformation parameters are supplied using Coordinate Frame convention, ROTATION signs above must be reversed.

ASSUMING we know to do so!

Example

- Well locations would have been in synch with 3D seismic if they had been correctly transformed from satellite to local datum

- Well locations transformed using reversed signs place wells 450 m out of synch with seismic after incorrect transformation from satellite to local datum

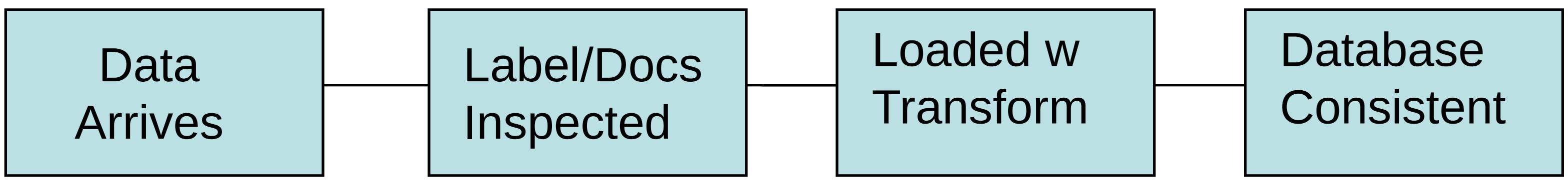


3D Survey correctly transformed from satellite to local datum

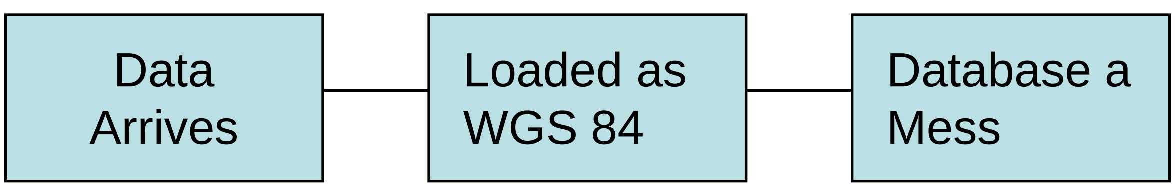
Example 2

"Our database is homogeneous. All Data is WGS 84"

Management perception:



Actual Situation:



Overview: Present

We have seen that although acquisition geodesy is well-controlled, there are still pitfalls

Pitfalls tend to manifest as data management issues:

- **Data trading/ Merging data**
- **Populating databases**
- **Integrating cultural data/ GIS**
- **Baseline and 4D survey planning**

Overview: Breakdown

Over the last 3 years, positioning problems handled by the author break down:

- Acquisition	1 in 20 (5%)
- Processing/ Merging	4 in 20 (20%)
- Management/ Integration	13 in 20 (65%)
- Other	2 in 20 (10%)

Management Problems

The problems related to data management seen by this author in the last 3 years can be categorised:

Datum incompatibilities	**30%**
Datum "detection"	**15%**
Projection problems	**15%**
Data Sub-Optimal	**20%**
Other (eg data loss!)	**20%**

Overview: The Future

More of the same! Datum and projection errors in databases and GIS will continue to cause problems

We have actually only scratched the surface

Management systems have improved in the last 10-15 years

BUT:

- There is a lot of legacy data out there
- Operator in-house expertise reducing
- More data is being traded
- Precision requirements increasing

The Future

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Hopefully, a rosy one where Geodesists and Geometers are fully appreciated for their expertise, and comments about the expense of re-processing data "when I can buy an in-car Sat-Nav for £100" are consigned to the history books!

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