

# Quality Check on Wells' Locations

Geomatics training report  
Certificate of Geomatics 2013,  
University of Geneva

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## Abstract

The quality check of the well locations is of fundamental importance for the Oil & Gas Industry. It is from these well locations that the correctness and consistency of the technical projects depends. This can be seen when considering decisions made based on correct correlations with the 2D/3D seismic models, correct matching with all the surrounding facilities like pipelines and platforms etc.

In order to quality check the well locations, we (the Technical Data Management Team at Sinopec Addax Petroleum) created a workflow called “Spatial Integrity Procedure” (SIP) for wells. This workflow is detailed in the first part of the present report and an example of one SIP applied to a real well is in the Annex 1.

Well locations depend on fundamental and standardized geodetic parameters. Our well quality checking highlighted that some Addax well data does not always follow such standards. This leads to discrepancies and thus uncertainties on the well locations. Furthermore, we realized that the company geoscientists are not always aware of some fundamental geodetic concepts (e.g. what is a Coordinate Reference System, a Datum, etc.) and how to use them in their technical projects. In order to solve this problematic situation, we organized short geodetic courses given to the other teams of the company. During these courses we clearly explained the significance of those fundamental geodetic concepts and we addressed a list of all the geodetic standards we must use in Addax technical projects. This analysis is demonstrated in the second part of this report with supplements in the Annex 2.

### Key Words:

Sinopec Addax Petroleum, Geomatics, Petroleum Company, Well data Management, Geodetic standards, Coordinate Reference System, Datum, Projection, Spatial Integrity Procedure.

## Introduction

### Context

Founded in 1994, Addax Petroleum is an international oil and gas exploration and production company with a strategic focus on Western Africa (Nigeria, Cameroon, Gabon), the Middle East (Iraq) and the English part of the North Sea. The Company has grown by acquiring under-developed properties in established basins and has increased its production by using advanced and proved technologies.

Petroleum companies are nowadays prospecting all over the world and collaborating together in their exploration and production projects. Such collaborations imply to share blocks, oil fields, wells data etc. and so the centralization all those data into corporate databases becomes a necessity. Before 2011, Addax did not have any corporate and centralized database for wells. So wells data were stored in diverse and individual technical projects and updated manually. As a consequence of this individual and manual update, we observe discrepancies on the wells' locations. Such discrepancies are mainly related to:

- Misunderstandings of the geoscientists regarding to some of the really complex and fundamental concepts of geodesy (e.g. what are coordinate reference systems, geodetic datums, how to switch from one datum to another one, the projections, etc.)
- A lack of standardization of all the key concepts of geodesy
- Typographical errors (e.g. latitude = 453769 mN\* becomes 453679 mN leading to a 90 m shift).

### Problematic

The resulting problematic of this situation is the following:

**With many different locations for the same well, how to be sure that our wells are correctly located?**

### Organisation

In order to simplify the well data management, the Data Management Team at Addax established an SQL\* database called NeuraDB (NDB\*) for wells. In October 2013, more than 6000 wells have been loaded in NDB and 1409 of them have been Quality Checked (QC). The Data Management Team created a QC\* workflow for wells called "Spatial Integrity Procedure" (SIP\*) for wells.

During this internship, I work with Mike Slee, Manager of the Data Management Team, and my supervisor Philippe Chessel, Spatial Data Coordinator. My mission was "to SIP" wells located in Cameroon and Nigeria. All examples of the present report correspond to real data and so are unfortunately confidential. Consequently all the well names will be erased.

### Description

My training lasted 5 months from August to December 2013. This report summarises my training program in 4 parts:

- 1) Theory: concepts of geodesy,
- 2) Methodology: the successive steps of the Spatial Integrity Procedure (SIP)
- 3) Result: details of a SIP report
- 4) Knowledge transmission: creation of courses about concepts of geodesy.

\* : acronyms with a star are listed in the « List of Acronyms » at the end of this report

# 1. Theory: concepts of geodesy

Few notions of geodesy were important to keep in mind during all this geomatics training. They are detailed in this first part.

## 1.1. Introduction: from the Earth to the Geoid

*“The true shape of the Earth is known as the geoid, and this can now be defined as the equipotential surface that most closely corresponds to mean sea level.” (J. Iliffe & R. Lott, 2012).*

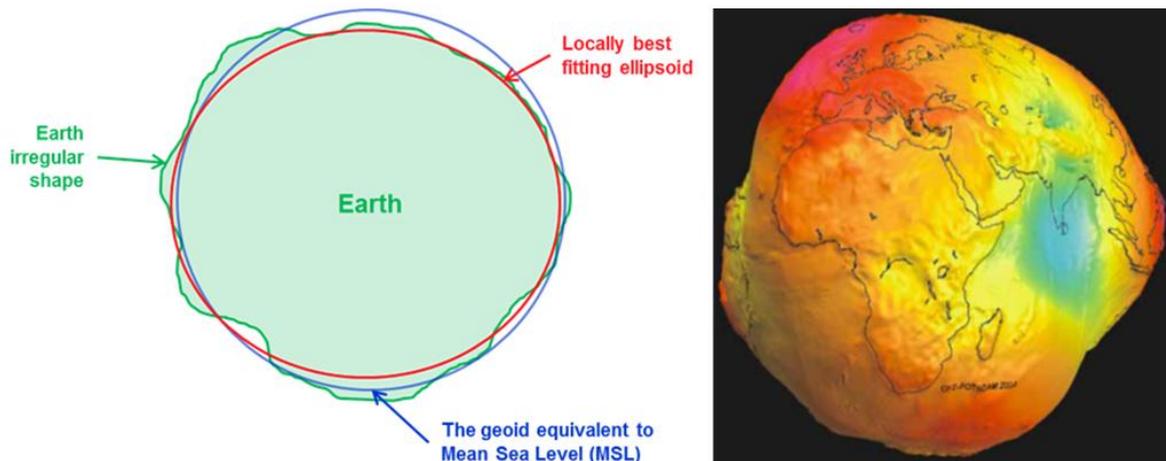


Figure 1: Representations of the Earth and the Geoid. Modified after [www.swisstopo.ch](http://www.swisstopo.ch)

Because of its complexity, the geoid is difficult to compute. One solution is to simplify its shape into an ellipsoid.

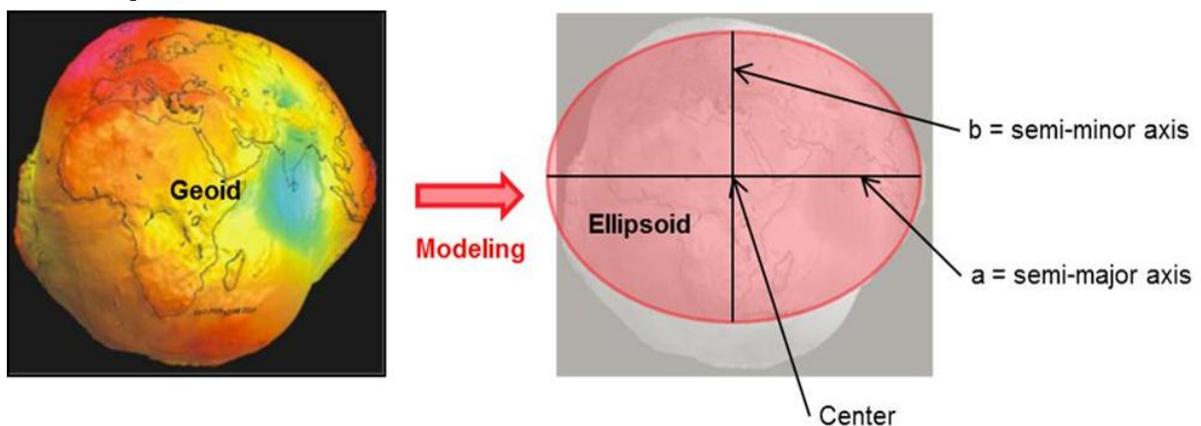


Figure 2: from the geoid to the Ellipsoid. Modified after [www.swisstopo.ch](http://www.swisstopo.ch)

## 1.2. From the Geoid to the Ellipsoid

“An ellipsoid is formed by [...] flattening a sphere at its poles” (After J. Iliffe & R. Lott, 2012). Fig. 2 illustrates the modelling of the geoid into an ellipsoid:

So the ellipsoid is defined by:

- **a**, its semi-major axis and
- **b**, its semi-minor axis.

On Fig.2 the flattening has been exaggerated. The true flattening of the Earth is about 22 km in 6378 km (After J. Iliffe & R. Lott, 2012).

As we already said, the Earth has an irregular shape. Consequently, several ellipsoids with better local fit are used around the world. Table 1 lists the ellipsoids I used during my training:

Blocks	Ellipsoids
All blocks in Cameroon	Clarke 1880 (IGN*)
OML* 124 (Nigeria)	Clarke 1880 (RGS*)
All blocks in Nigeria except OML 124	WGS84
Taq Taq (Iraq)	WGS84

Table 1: Addax's standard ellipsoids

WGS 84 is an international ellipsoid which can be worldwide used. It is the reference ellipsoid used at Addax when technical projects take place over several countries.

### 1.3. Geographic Coordinate System (GCS)

A GCS\* uses a 3D ellipsoidal surface to define locations on the earth. It is defined by one latitude (angle North or South from the equatorial plane) and one longitude (angle East or West from an identified Prime Meridian).

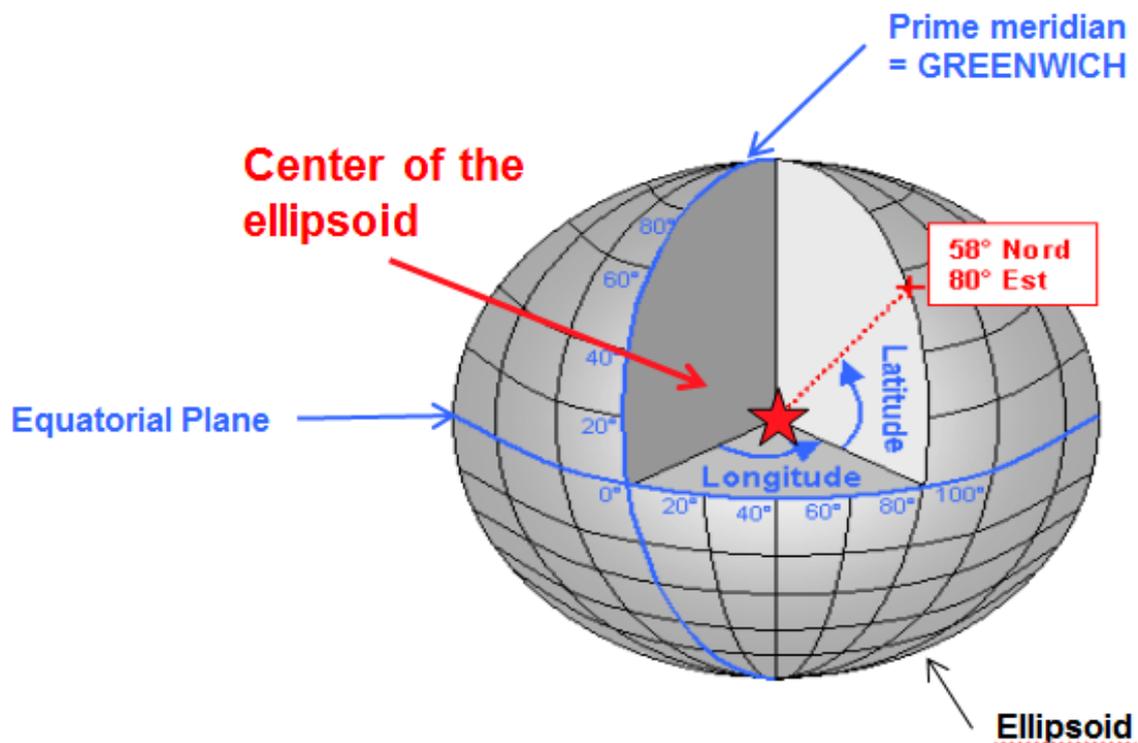


Figure 3: Geographic coordinate system. Modified after <http://ressources.esrifrance.fr/>

### 1.4. Projection: from the ellipsoid to the map

The projection is the transformation of the ellipsoid (earth) into a plane surface (map). Many projections exist. During my training at Addax I used the Transverse Mercator (TM\*) and the

\* : acronyms with a star are listed in the « List of Acronyms » at the end of this report

Universal Transverse Mercator (UTM\*). Both are cylindrical projections. Figure 4 schematises the concept of a cylindrical projection:

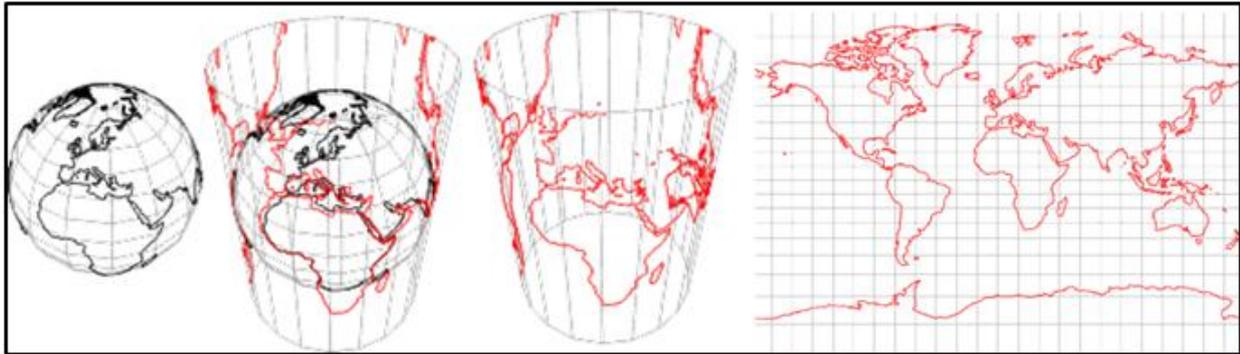


Figure 4: Cylindrical projection, from the globe to the map. Modified after <http://mathworld.wolfram.com/>

The cylindrical projection tends to minimize the shape alteration of the continents and countries near the equator. The UTM is a specific implementation of TM. It divides the Earth into 60 zones of 6° longitude in width and two hemispheres (see Figure 5), so finally, there are 120 zones. In Cameroon I used the projection called UTM zone 32N and in Iraq, I used the UTM zone 38N.

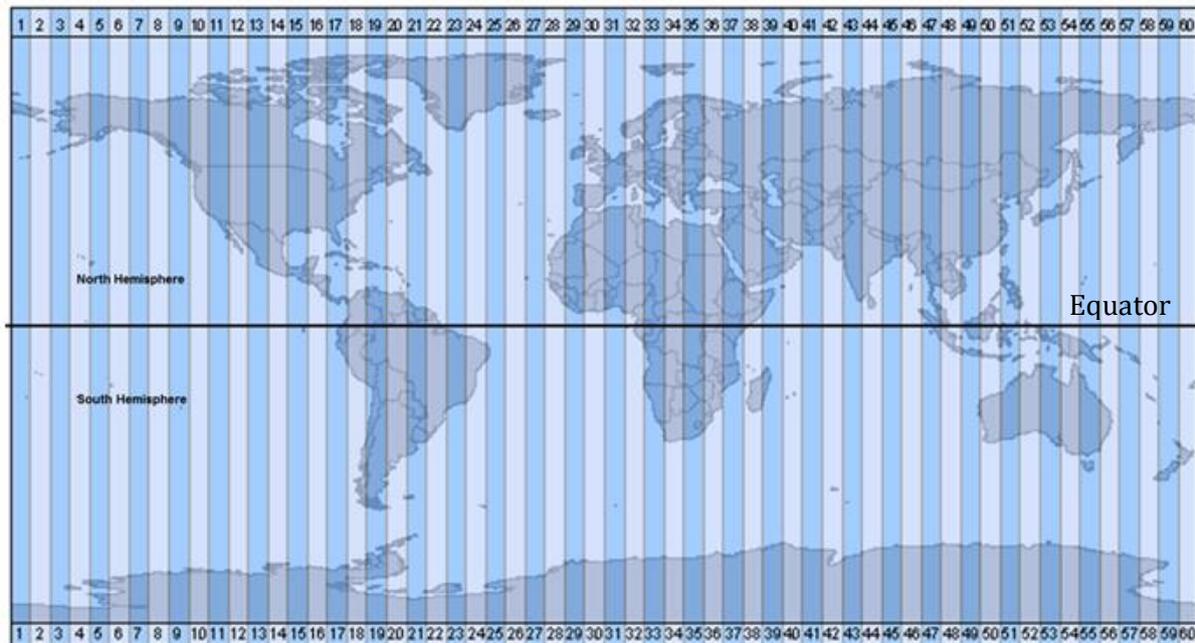


Figure 5: Universal Transvers Mercator projection. Modified after <http://ressources.esrifrance.fr/>

### 1.5. Geodetic Datums and Datum Transformations

A **Geodetic Datum** describes the relation between the ellipsoid and the geoid and is defined by the position and orientation of the ellipsoid at its fundamental point (FP\*), also called “anchor point”. The same ellipsoid anchored at a different place will constitute a new datum.

Example:

Figure 6 represents two ellipsoids which are originally the same but oriented and fixed differently. So they are two distinct geodetic datums.

\* : acronyms with a star are listed in the « List of Acronyms » at the end of this report

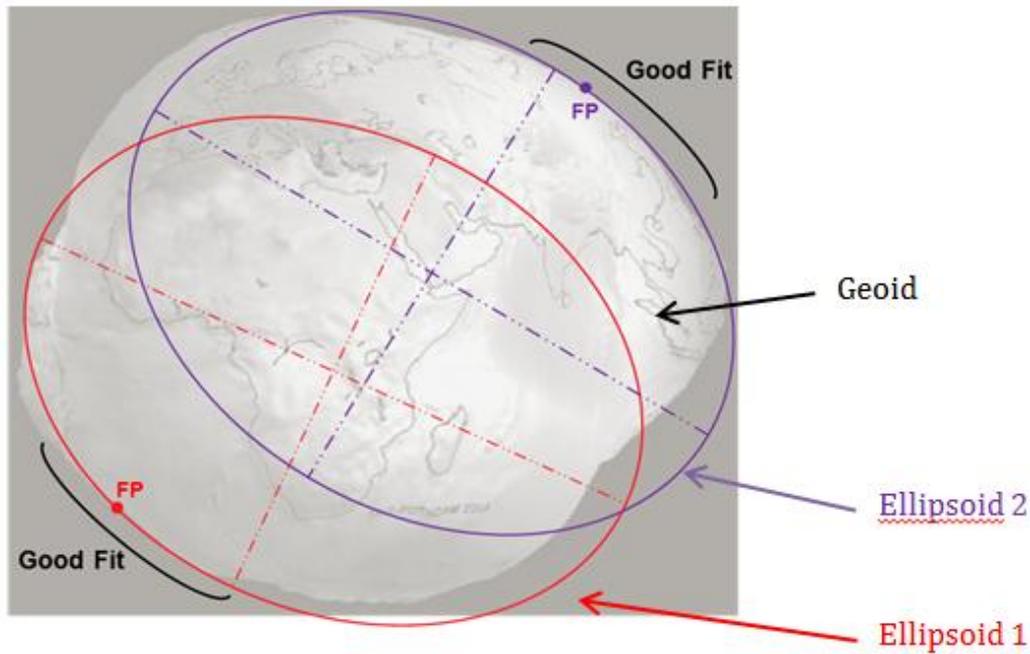


Figure 6: Geodetic Datum and Datum Shift. Modified after [www.swisstopo.ch](http://www.swisstopo.ch)

A **Datum Transformation**, also called Datum Shift, is a mathematical transformation from one source datum to one target datum. The following example illustrates a datum shift.

Example:

One well is plotted twice on the map of Figure 7. The first yellow plot uses the source datum Manoca 1962 and the second blue plot uses the target datum WGS 84. For switching from the source datum to the target datum, a datum transformation is needed.

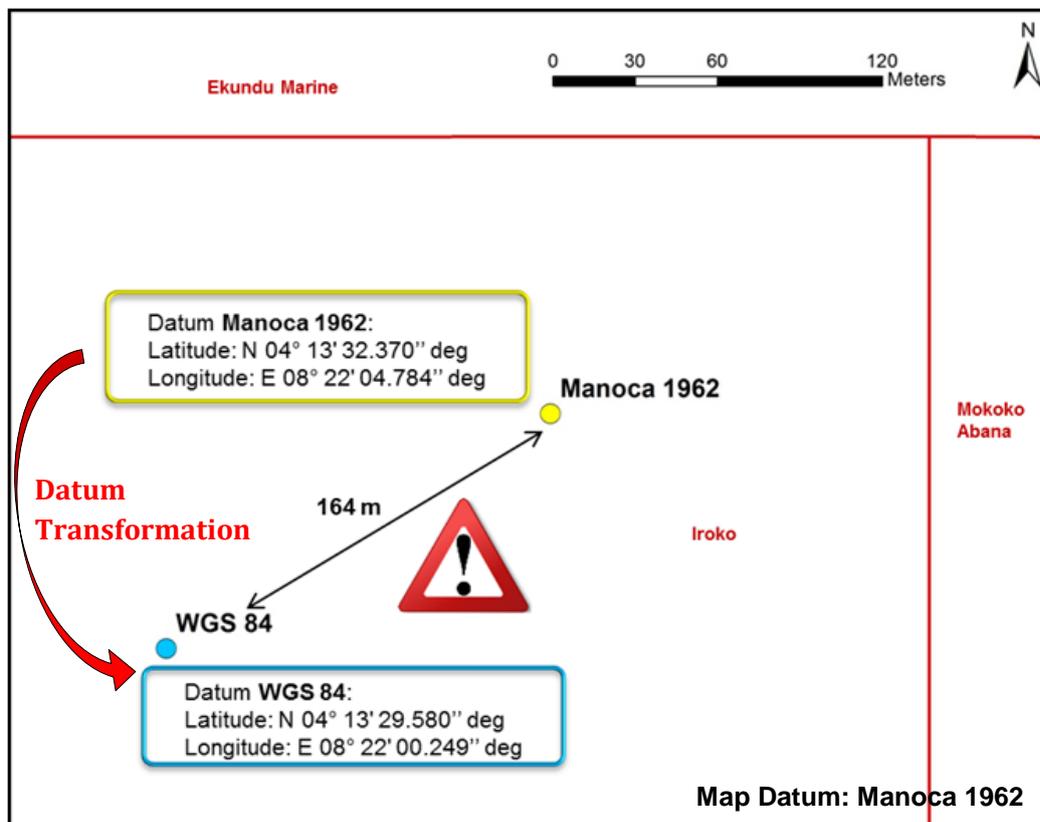


Figure 7: Datum transformation

Consequently, a good definition of the geodetic datum (ellipsoid + its anchored point location) we use is really important to avoid such uncertainties.

### 1.6. Coordinate Reference System (CRS)

A Projected CRS\* is a flat, 2D representation on the Earth. A CRS is defined as the addition of one datum (Ellipsoid and anchor point) and one projection.

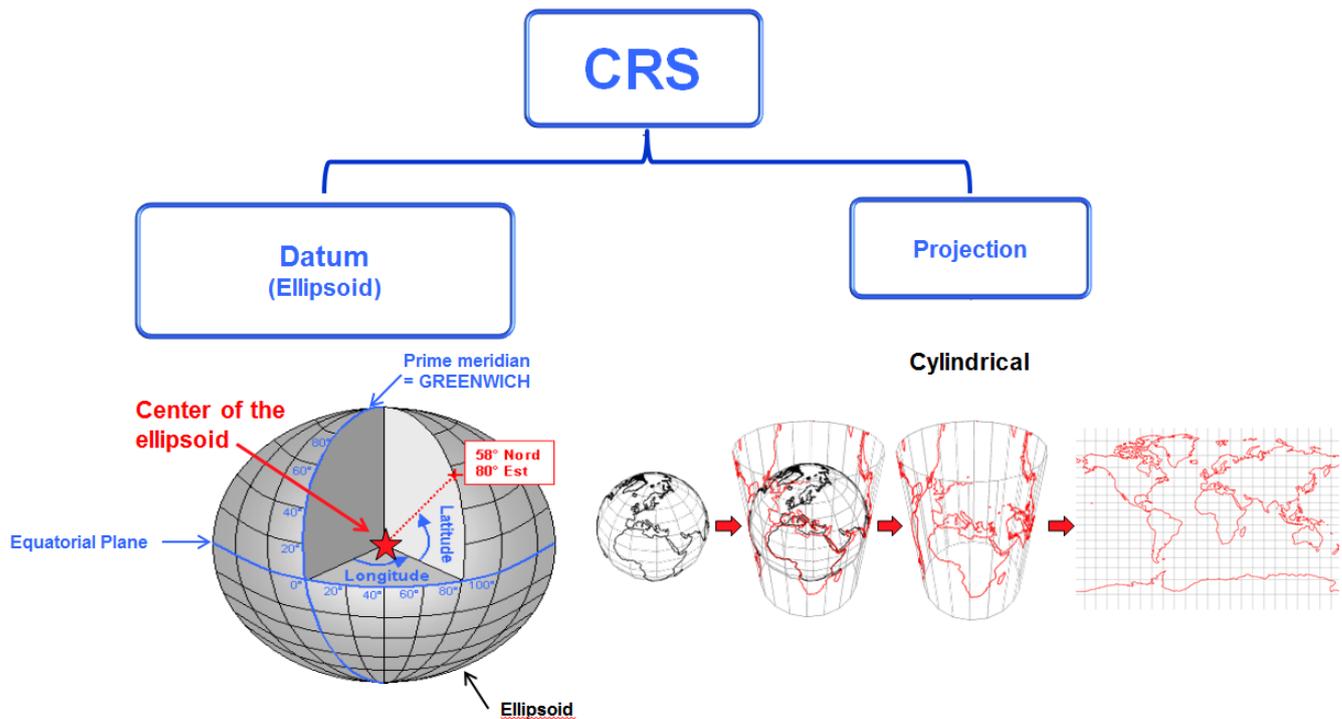


Figure 8: Coordinate Reference System. Modified after <http://ressources.esrifrance.fr/>

According to the European Petroleum Survey Group (EPSG\*), 3685 CRS have been registered around the world. They are listed in the EPSG database available on <http://www.epsg-registry.org/>. EPSG's objective is to provide a free worldwide database in which users can find all the CRS existing and used around the world with their corresponding EPSG codes. EPSG standard codes are important to implement consistent CRS parameters into the technical software applications used in the petroleum industry.

During my training, I used several CRS. They are listed in Table 2:

Country	Related Blocks	CRS (Datum/Projection)	CRS EPSG code
Cameroon	All blocks	Manoca 1962/UTM zone 32N	2215
Iraq	Taq Taq, Sangaw North	WGS 84 / UTM zone 38N	32638
Nigeria	Onshore purpose or old data	Minna / Nigeria Mid Belt	26392

Table 2: Addax's standard CRS and their corresponding EPSG codes

The software used for coordinate transformations was Blue Marble. Blue Marble is really useful for all kind of coordinate conversions and transformation from geographic or projected coordinates.

Figure 9 illustrates a datum shift from Manoca 1984 / UTM Zone 32 N to WGS 84.

\* : acronyms with a star are listed in the « List of Acronyms » at the end of this report

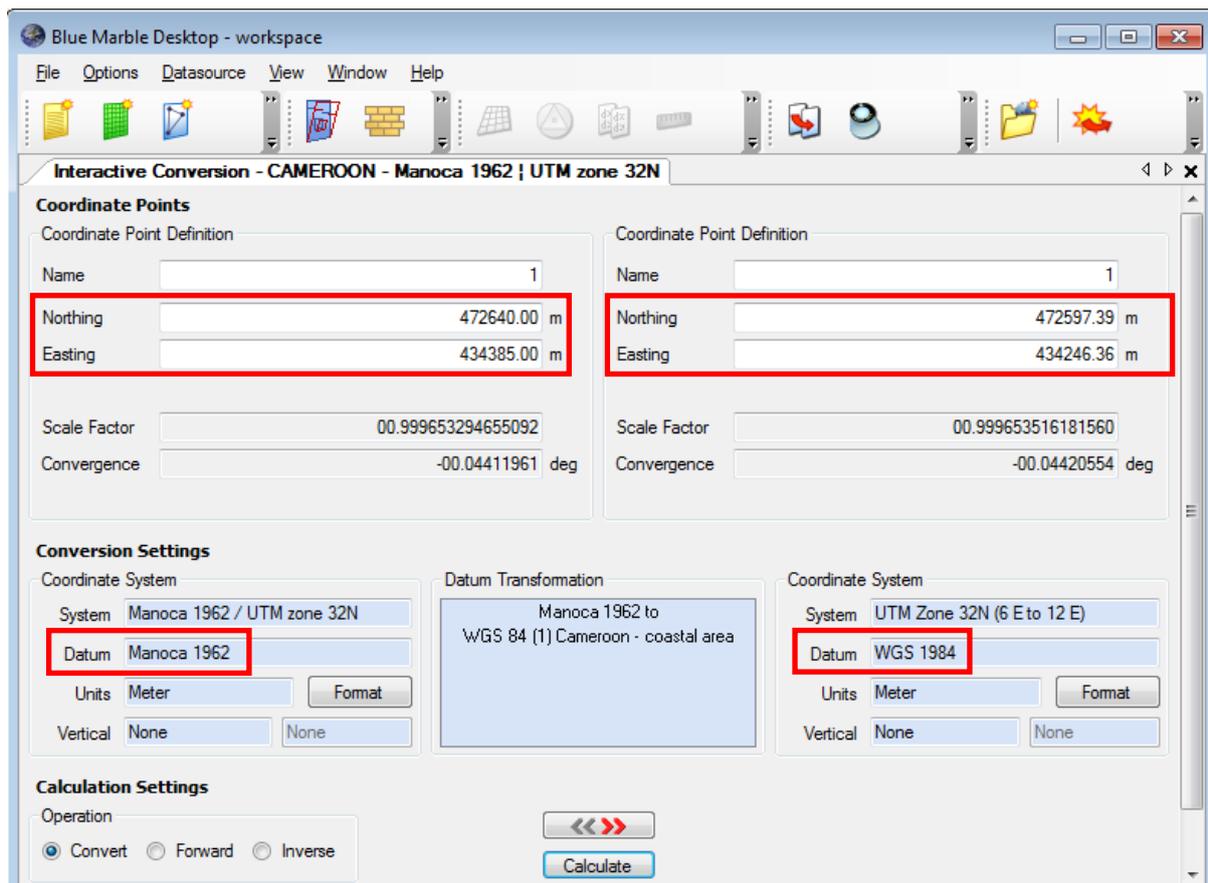


Figure 9: Datum transformation using Blue Marble GIS software

So we see that using Manoca 1962 datum we have:

- Northing = 472 640.0 mN and
- Easting = 434385.0 mE.

After the datum shift we obtain:

- Northing = 472 597.39 mN and
- Easting = 434 248.36 mE.

Those discrepancies lead to roughly 138 m shift on the final well location (3 m on the North axis and 136 m on the East axis).

## 1.7. Conclusion

The first part of this report was about the main concepts of geodesy used during my training. So we summarized several important definitions of the geoid, geodetic datums, etc. The 2 most important notions of this first part are:

- Latitude and Longitude are not unique and
- A Coordinate Reference System is the addition of a datum and a projection.

In the second part of this report we will see how do those theoretical concepts can be applied in the Spatial Integrity Procedure established by the Data Team Management.

## 2. Methodology

### 2.1. Spatial Integrity Procedure for Wells

#### 2.1.1. Introduction: wells descriptions and locations

##### Onshore and offshore platforms

Wells are always drilled from platforms. Platforms are located at the surface above hydrocarbons and it can be onshore or offshore. Figure 10 schematizes an onshore platform:

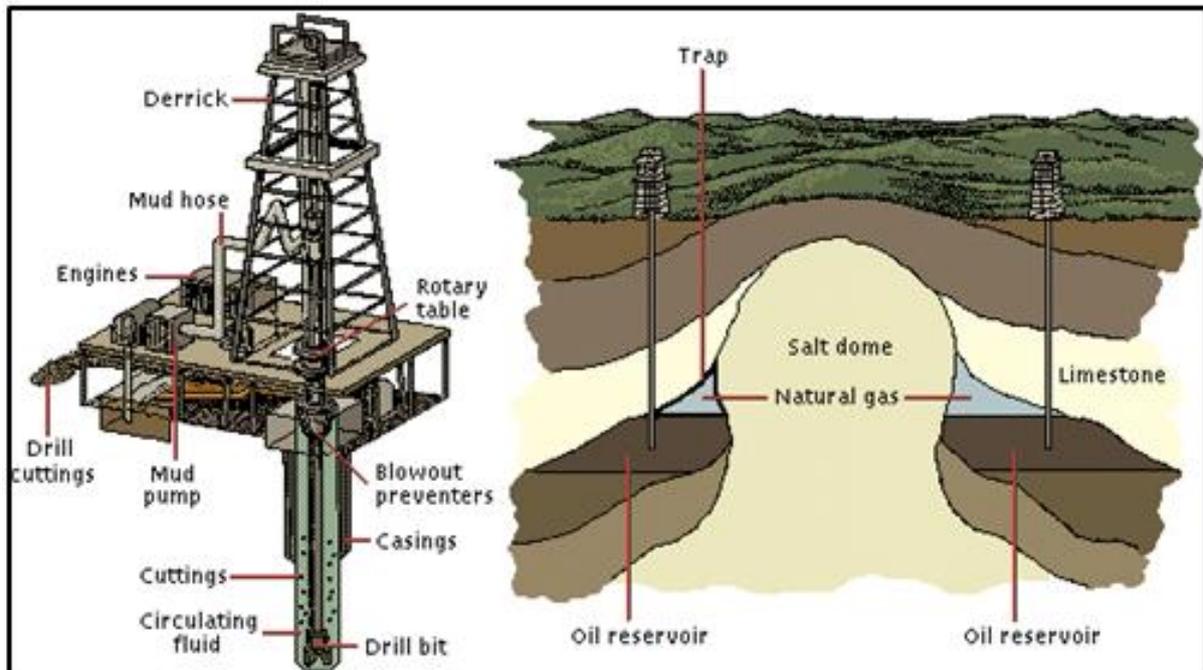


Figure 10: Onshore platform representation. After <http://www.foxoildrilling.com/>

On Figure 10, wells are strictly vertical however, it also exists oblique and horizontal wells, depending on a lot of factors (e.g. the geological structure of the underground, etc.).

The next figure represents the different types of offshore platforms. Most of them are located in shallow water (<300 m deep). This corresponds to the platform 1, 2, 3 and 4. They are directly and linked to the wellhead located at the sea floor. The mobile platforms (cases 5 to 8) are essentially used for deep water petroleum exploitation.

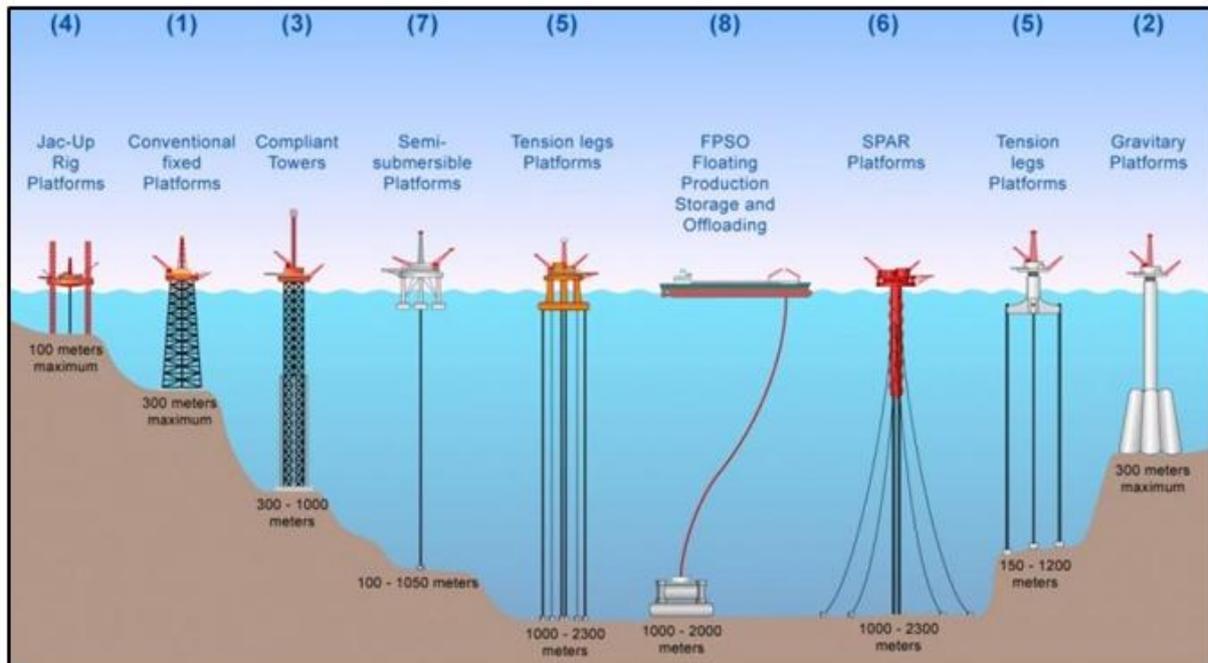


Figure 11: Offshore platform representation. After <http://www.connaissancedesenergies.org/>

Addax Petroleum explores and produces hydrocarbons using offshore and onshore platforms located in several part of the world: North Sea, Western Africa and Middle East.

### North Sea

In the North Sea, Addax has 87 blocks all using the same CRS: ED50 / UTM zone 31N, which EPSG code is 23031. This CRS is the addition of one datum, the European Datum 1950 (EPSG code: 6230), and one ellipsoid called International 1924 (EPSG code: 7022).

Figure 12 is a Petroweb map representing Addax's blocks in the North Sea. Petroweb is the internet GIS\* Portal used at Addax for displaying and query petroleum data (wells, blocks, seismic, etc.) from various databases.

In the legend we have a red polygons for Addax blocks and black polygons for the Quadrants. Quadrants are delimited rectangular zones used for simplifying the location of the blocks and many other facilities, oil and gas fields etc. which are not mentioned on this map.

Talisman is an Addax subsidiary operating in North Sea.

\* : acronyms with a star are listed in the « List of Acronyms » at the end of this report

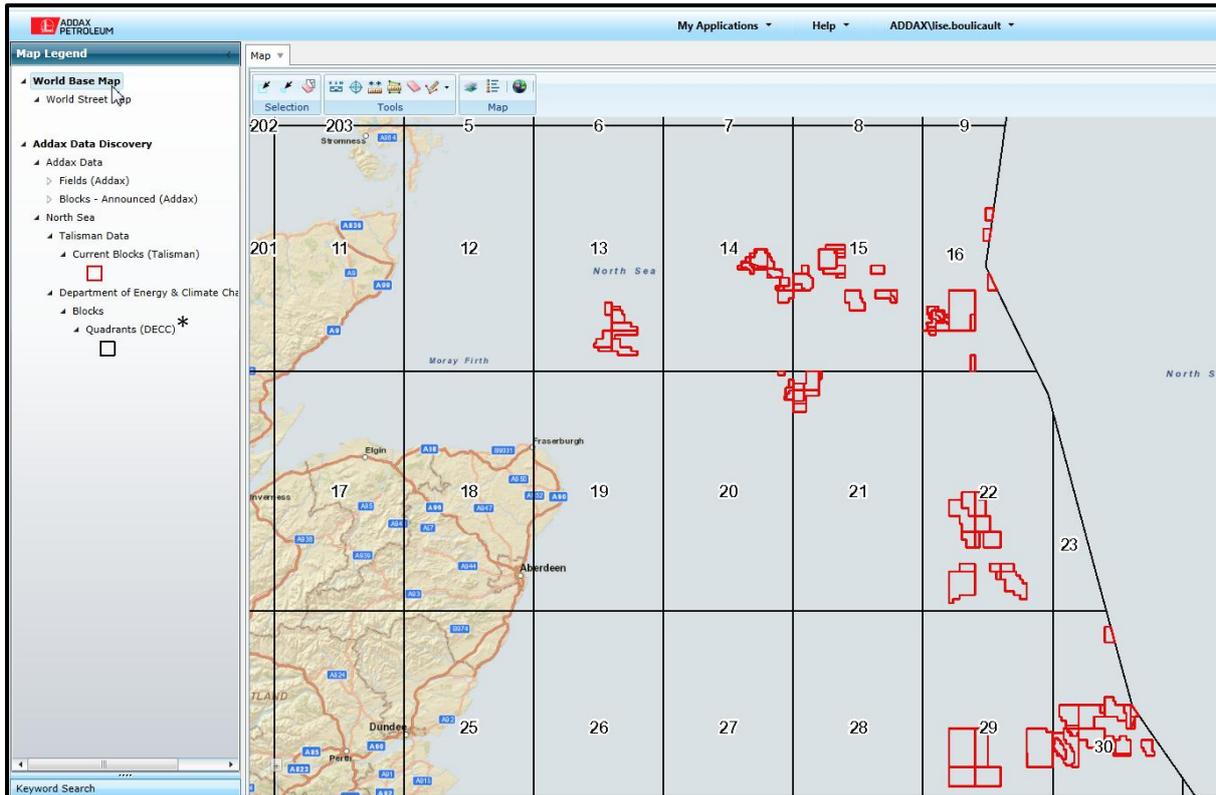


Figure 12: Location of Addax’s blocks in the North Sea region and limits of quadrants

Western Africa

As visible on Figure 13, Addax Petroleum is present in 3 zones in Western Africa: Nigeria (1), Cameroon (2) and Gabon (3).

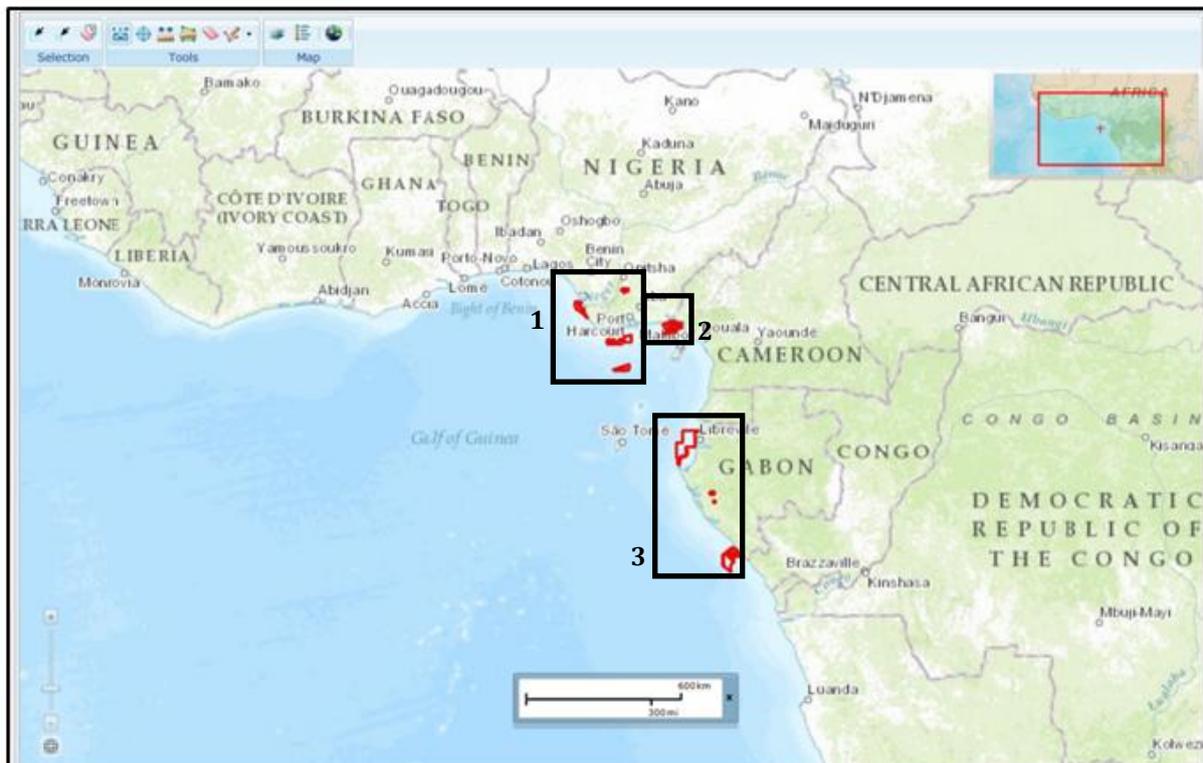


Figure 13: Location of Addax’s blocks in Western Africa region

\* : acronyms with a star are listed in the « List of Acronyms » at the end of this report

## 1) Nigeria

7 blocks but they are not all using the same CRS. The 3 CRS in use are:

- WGS84 / UTM zone 32N (some offshore blocks),
- WGS84 / UTM zone 31N (some offshore blocks) and finally
- uses Minna / Nigeria Mid Belt (unique onshore block).

## 2) Cameroon

13 blocks. All use the CRS “Manoca 1962 / UTM zone 32 N” (EPSG code: 2215).

## 3) Gabon

4 blocks. All use the CRS “M’poraloko / UTM zone 32 S” (EPSG code: 26692).

Such differences of CRS depend on a lot of factors: colonial past history, political border delimitations, onshore/offshore locations of the blocks, etc. CRS for all the operating regions and blocks are summarized in Table 3.

Figure 14 is a compilation of the three maps of Nigeria, Cameroon and Gabon with the different Addax’s blocks.

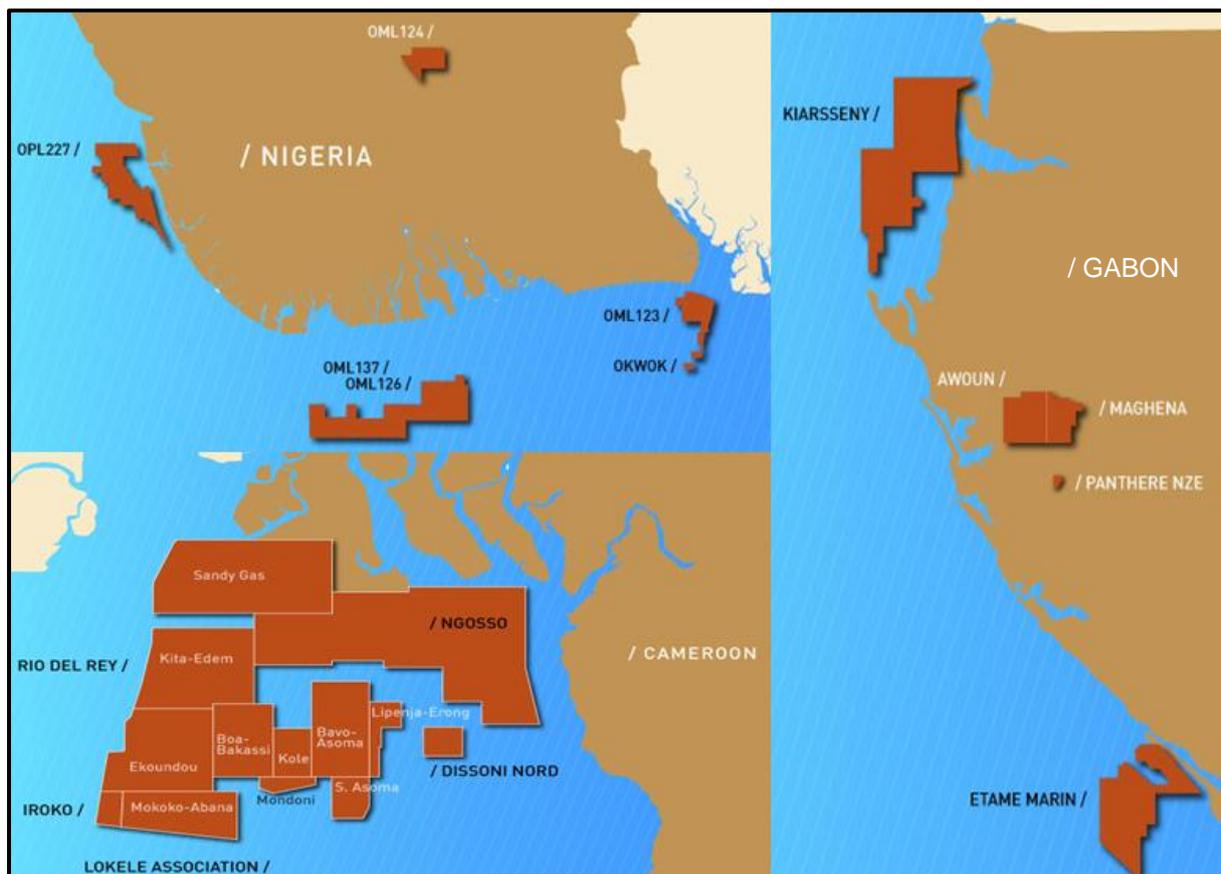


Figure 14: Western Africa operating region. Modified after [www.addaxpetroleum.com](http://www.addaxpetroleum.com)

*Middle East: Kurdistan region of Iraq*

Addax has one block in Kurdistan called Taq Taq and located onshore. Figure 15 is a map of this region. The CRS we use there is WGS84/UTM zone 38N (EPSG code: 32638).

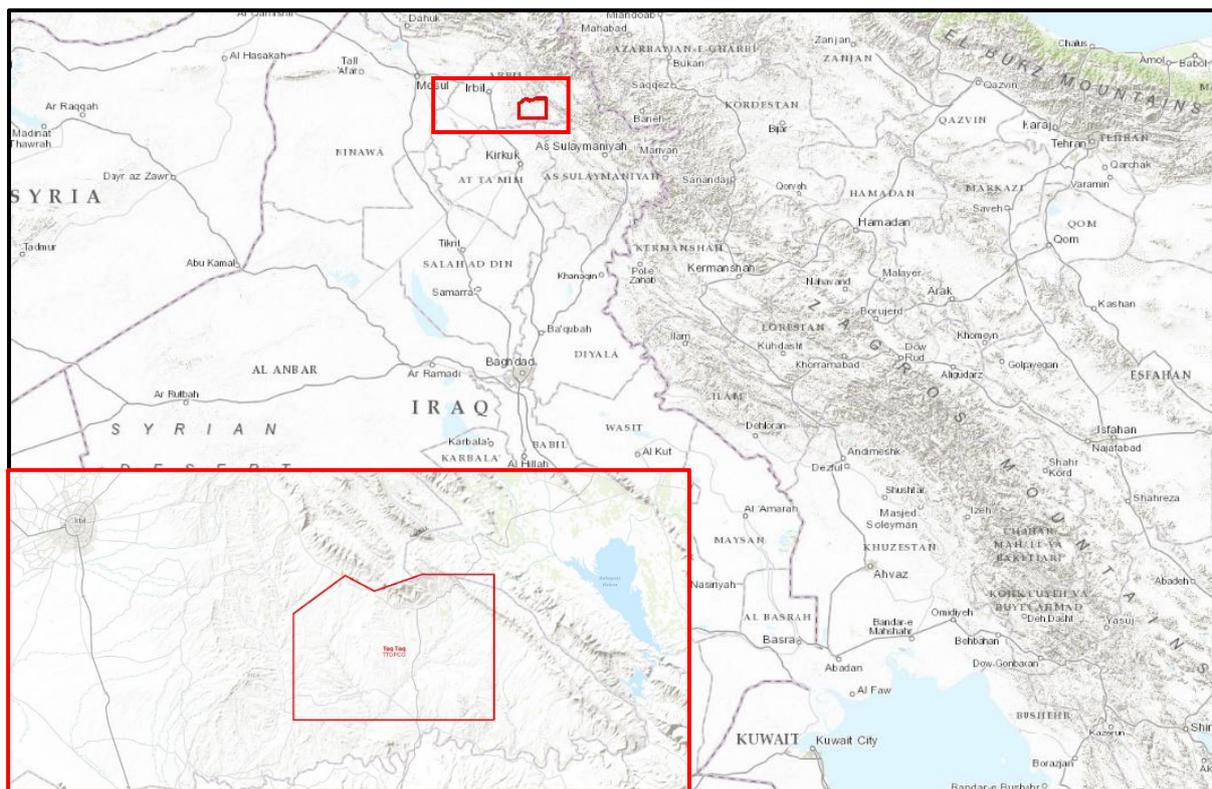


Figure 15: Location of Addax’s block in Kurdistan (Iraq)

Table 3 gives us all the CRS in use for each Addax’s block:

Country	Related Bolcks	CRS (Datum/Projection)	CRS EPSG code
Cameroon	All blocks	Manoca 1962/UTM zone 32N	2215
Gabon	All blocks	M’Poraloko / UTM zone 32N	26692
Iraq	Taq Taq	WGS 84 / UTM zone 38N	32638
Nigeria	OML 124	Minna / Nigeria Mid Belt	26392
Nigeria	OML 123	WGS 84 / Nigeria Mid Belt	*
Nigeria	OPL 227, OPL 291	WGS 84 / UTM zone 31N	32631
Nigeria	OML 137, OML 126, Okwok	WGS 84 / UTM zone 32N	32632
UK	Talisman blocks	ED50 / UTM zone 31N	23031

Table 3: Addax’s Standards CRS for each operating block

\*: OML 123 does not have EPSG code because his CRS (WGS84/Nigeria Mid Belt) is used only at Addax and does not exist as a standard CRS regards to the European Petroleum Survey Group (EPSG). This is due to the history of the company: in the 80’s, a seismic acquisition has been shot using this CRS and since that moment, all the new data have been acquired using this CRS in order to be consistent with the first seismic data.

### 2.1.2. Objectives of the SIP for wells

The objective of the Spatial Integrity Procedure (SIP) for wells is to apply a standard workflow to wells in order to ensure that their surface location are validated against available documents sources and geodetic standards.

There is one SIP report for each well. This report contains all the coordinates' document sources found for the well in question as well as documents screen shots, ArcGIS maps and a summary with the final coordinates for the well. Once I have completed a SIP report, the Spatial Data Coordinator (my supervisor Philippe Chessel) reviews it and signs it off. The SIP report is then available in Petroweb, NDB and PSApphire (another Addax documents database) and so begins to be available to geoscientists of other teams.

### 2.1.3. Workflow of the SIP for wells

The workflow is divided into 8 steps:

1. Look for original documents containing Eastings/Northings; Latitudes/Longitudes and Datums/Projections,
2. Check if the projected coordinates (East/North) match with the geographic coordinates (Latitude/Longitude),
3. If needed, convert the original coordinates from the local CRS to the Addax standard CRS for the block,
4. Check if the converted CRS corresponds to the one that is used in technical projects. If discrepancies are noticed, try to identify the error that has generated the wrong coordinates,
5. Once the error is identified, go back to the original projected coordinates and convert them to the Addax standard CRS for the block,
6. Load the correct coordinates into the corporate well database (projected + WGS84 geographic coordinates) and inform the owners of technical projects about the error that have been discovered.

Figure 16 illustrates the SIP workflow:

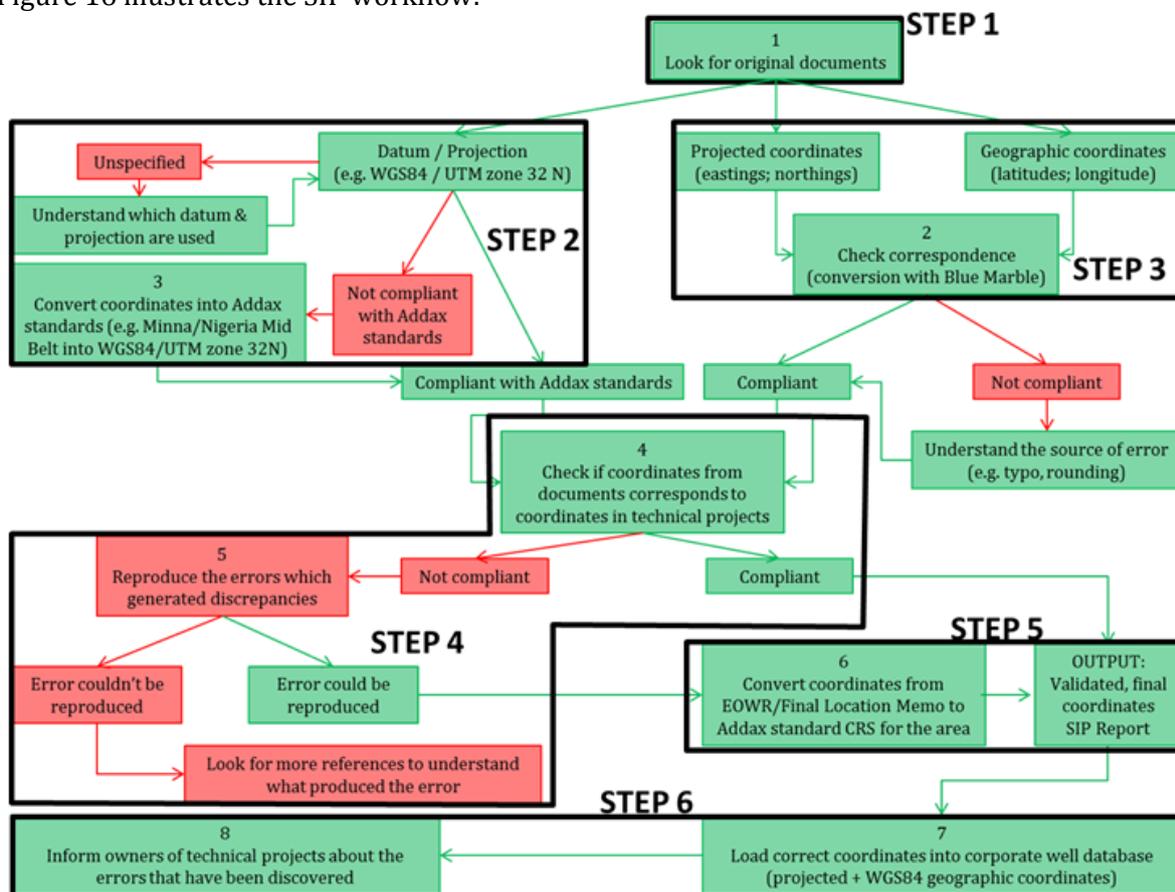


Figure 16: Spatial Integrity Procedure workflow. Modified after Chessel and Tuveri, 2012

Steps 1 to 6 are explained into detail:

Step 1: Look for original documents

Documents which can help to validate the well's spatial location are:

- Application to drill (ATD),
- End of well report (EOWR),
- Final well report (FWR),
- Geodetic survey reports (GSR),
- Deviation survey reports (DSR),
- Daily drilling reports (DDR),
- Logs (Sonic, Induction etc.),
- ...

The possible sources for those documents are:

- NDB and/or PSApphire (two Addax's databases)
- Technical drives
- Data Center
- ThirdParty (IHS or Mackenzie databases) and finally
- Addax's archives: if paper documents are found they need to be scanned and indexed in PSApphire.

All the well coordinates found are recorded into the corresponding SIP well excel file. In order to identify the correct coordinate, we check the workflow after each step.

Step 2: CRS (Datum/Projection)

CRS is not always specified on coordinate document sources. If it is, then we need to check that it corresponds to the standard CRS in use in the region in question. If it is not, we have to read the all document in order to find more information about the well in question and to identify the country where it is located and when it was drilled. Most of the time, it belongs to a group of drilled. With more coordinate document sources it is easier to identify the CRS in use for this well.

Step 3: Projected VS Geographic coordinates

When we do not have CRS but only projected and geographic coordinates, the first option is to identify the country were the well is located. Then we convert the coordinates (from the geographic to the projected and vice versa) using the standard CRS in use at Addax in this identified country. If coordinates match it means that we found the correct CRS. If it is not matching, it means that we need to try with other CRS or to find more documents.

Step 4: Check correspondences

Usually, when CRS and geographic/projected coordinates are specified in a single document, they match. However, we already observed some discrepancies and so it is always good to check that those coordinates are correctly linked by the specified CRS.

When CRS and coordinates are coming from different document sources we also check there correspondences in order to have a homogeneous dataset before the completion and validation of the SIP report.

Step 5: SIP report completion and validation

Once all the coordinates have been collected and converted to Addax standards for CRS, we can map all the coordinates onto an ArcGIS map. It helps us to have a global view of the coordinates repartition for the well.

The SIP abstract is written once all the SIP report is done and it takes place at the first page of the SIP report. It is composed by:

- A summary which exposes the results of the analysis,
- An action that describes what did we decide to do regarding to all the coordinates found. So we can decide to update NDB or not if we consider NDB as the right location
- The coordinates from the SIP, expressed in the standard projected CRS, the WSG84 latitudes and longitudes in Degrees-Minutes-Seconds (DMS) and finally the WGS84 latitude and longitude in Decimal Degree (DD).

All the Sip report I did were validated by the Spatial Data Coordinator before their publications on Petroweb.

Step 6: SIP publication in Petroweb

Once the SIP for well has been validated, it is loaded in NDB and so it becomes available on Petroweb.

## 3. Results

### 3.1. SIP for wells: an example

In this third part we will use a real well as a good example. Well names are confidential so are erased from all the documents. I found 6 different coordinate document sources. They are listed below.

#### 3.1.1. Step 1: Look for coordinate document sources

4 documents were found in the archives:

- Application To Drill (ATD),

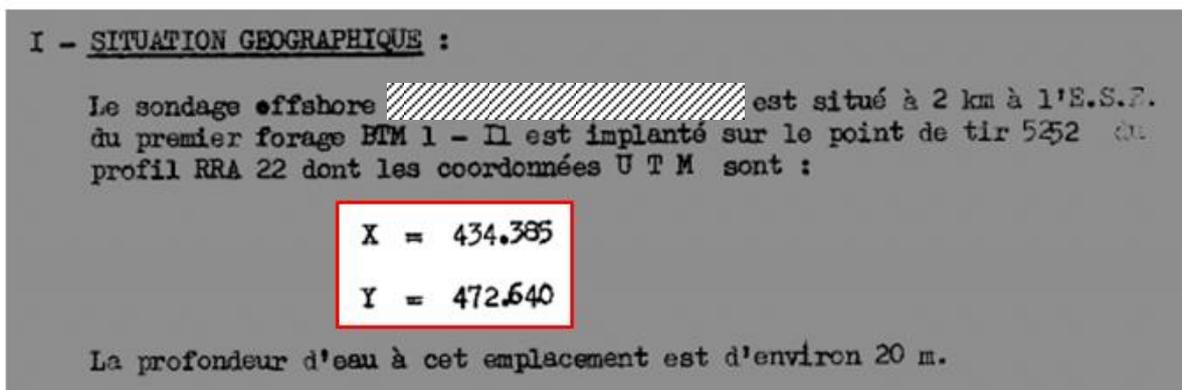


Figure 17: Well coordinates taken from the well Application To Drill official document

In Figure 17, CRS is not specified.

- End Of Well Report (EOWR),

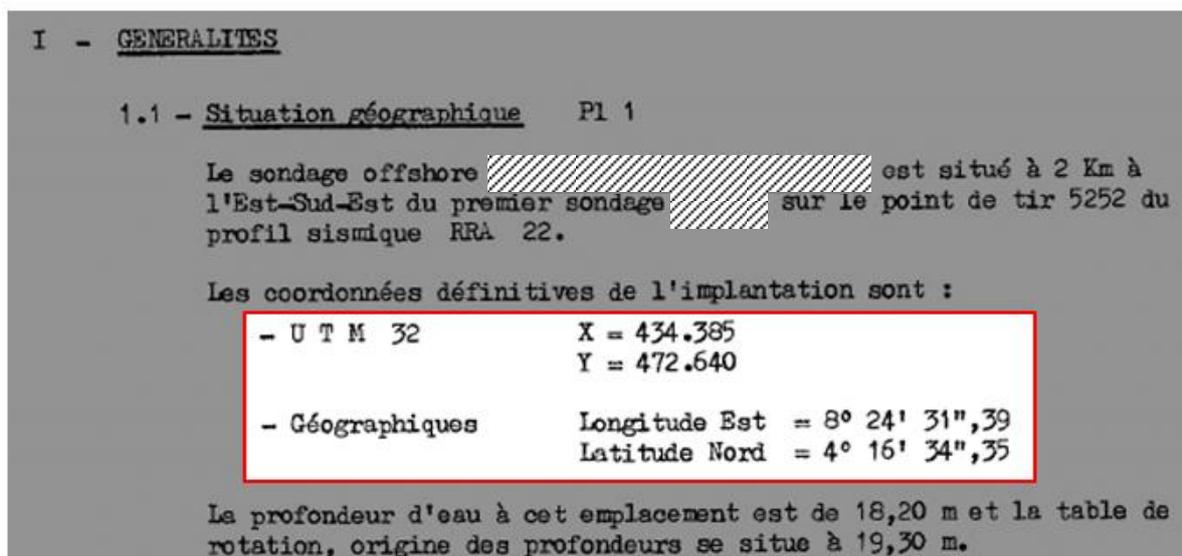


Figure 18: Well coordinates taken from the End of Well Report official document

In this figure 18 we only have a part of the projection: UTM 32. We do not know if it is North or South.

- Log Sonic (LS) and Formation Tester (FT),

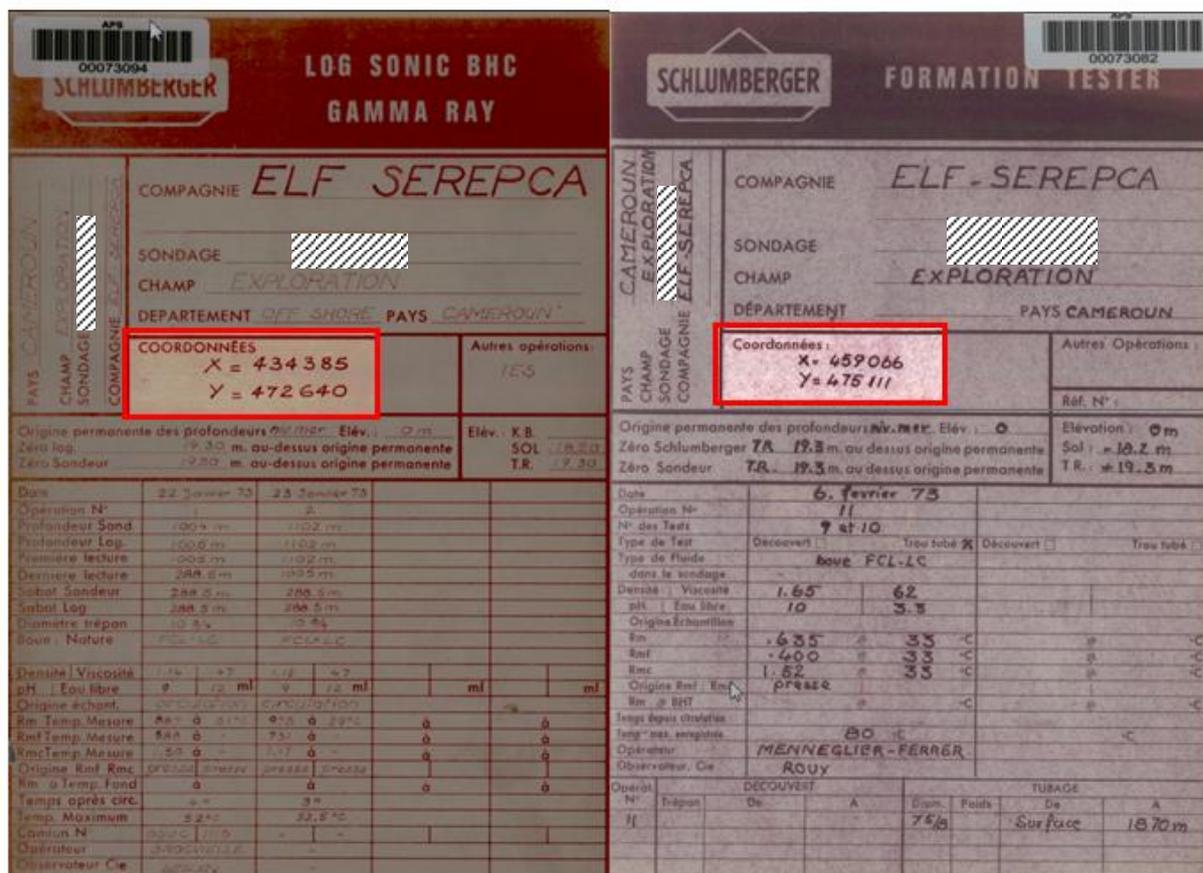


Figure 19: Well coordinates taken from two different Logs (Log Sonic and Formation Tester)

On those two log documents, we do not have any information concerning CRS nor datum. Furthermore, the Formation Tester Log is really different from the three other document coordinates (~24 km shift).

The two other coordinates were found in the two databases NDB and IHS (ThirdParty):

- Extract of the NeuraDB database (NDB)

Surface Latitude	Surface Longitude	Datum Name	Datum Epsg Code	Easting	Northing	Projected CRS Name	Projected CRS Epsg Code
4.2754279	8.4074612	WGS 84	4326	434385	472640	Manoca 1962 / UTM zone 32N	2215

Table 4: Extract of the NDB database for this well

- And finally an extract of the IHS database:

Latitude Origin	Longitude Origin	Datum Origin	Coordinate System	NS Metric	EW Metric
N 04° 16'34.320"	E 008° 24'31.320"	MANOCA	UTM Zone 32 N	472640.1	434384.9

Table 5: Extract of the IHS database for this well

### 3.1.2. Step 2: CRS (Datum/Projection)

CRS for each document:

- Doc 1 (ATD): CRS not specified

- Doc 2 (EOWR): only an incomplete projection
- Doc 3 and 4 (the two wells): unknown CRS
- Doc 5 and 6 (NDB and HIS databases): CRS = Manoca 1962 / UTM 32N

### 3.1.3. Step 3: Consistency between geographic and projected coordinates

In this third step we check with Blue Marble if the geographic and the projected coordinates of the same document are consistent or not. Usually, when both types of coordinates are specified, they match.

Check correspondence for each document:

- Doc 1 (ATD): only projected coordinates so impossible to compare
- Doc 2 (EOWR): As visible on Fig. 20, geographical and projected coordinates match

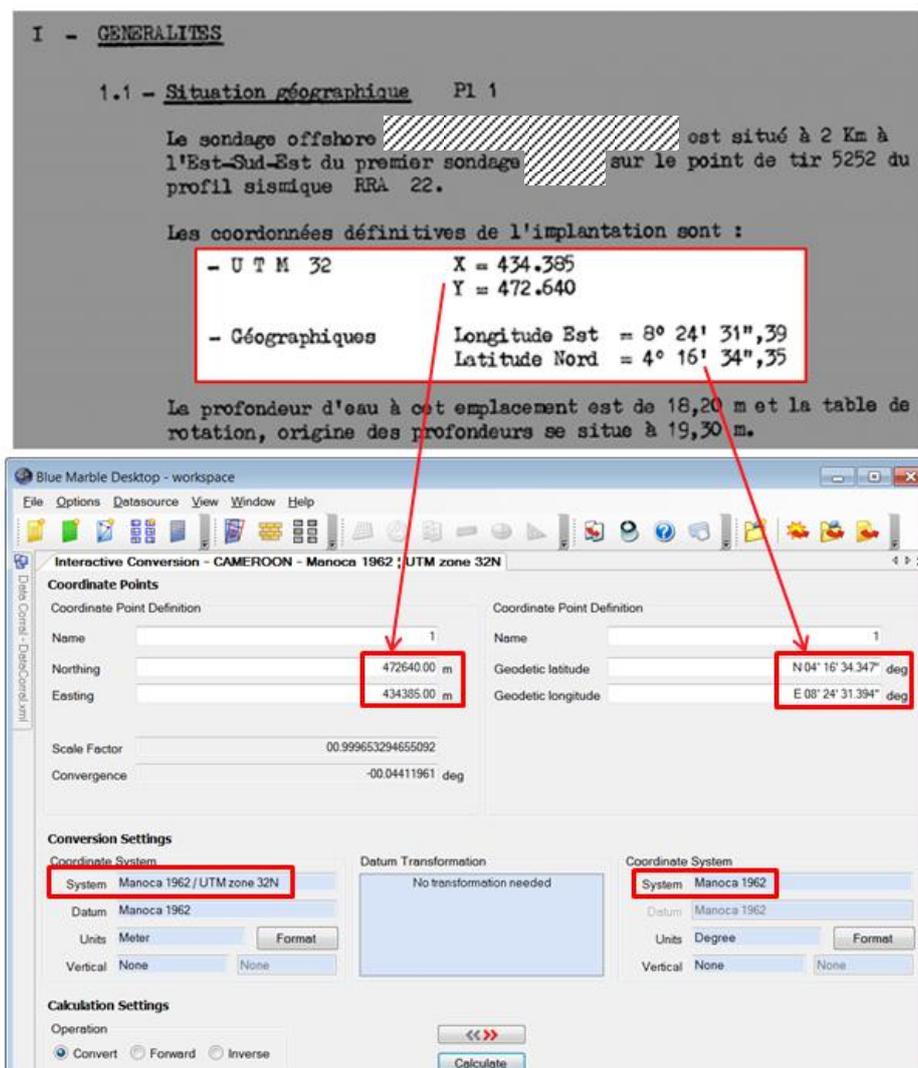


Figure 20: Check coordinate correspondences of the End Of Well Report document

We observe in Fig. 20 a tiny discrepancy between the given geographic coordinates (Longitude: 8° 24' 31.39" and latitude: 4° 16' 34.35") and the Blue Marble geographical coordinates (Longitude: 8° 24' 31.394" and latitude: 4° 16' 34.347").

This discrepancy (of few mili-seconds) is typically due to a rounding to two decimals. Remember that this is an old well and maybe in the 70's, when they published the EOWR document, geoscientists decided to round the values to 2 decimals.

- Doc 3 and 4: only projected coordinates so they are impossible to compare
- Doc 5 (NDB database): good correspondence between both types of coordinates (see Fig. 21). Because NDB is a corporate database in which there are data from different countries using different CRS and Datums, geographic coordinates are also given using WGS 84 in order to be able to project on a single map all the wells coordinates using the global CRS WGS 84 which fit globally to all the geoid.

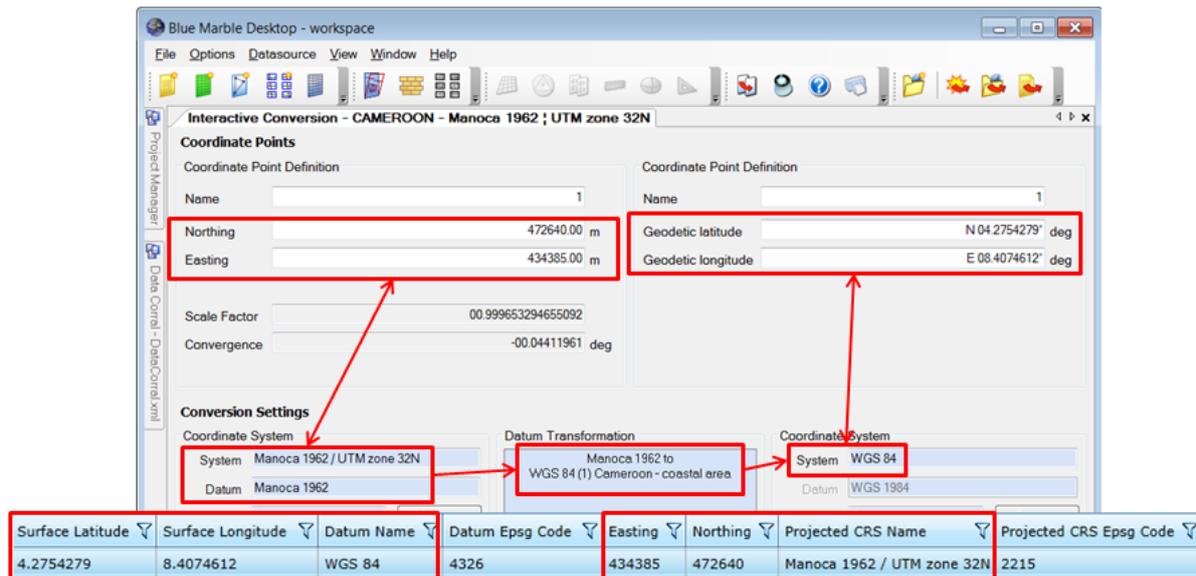


Figure 21: Check coordinate correspondences in NeuraDB

- Doc 6 (IHS database): good correspondence between both types of coordinates

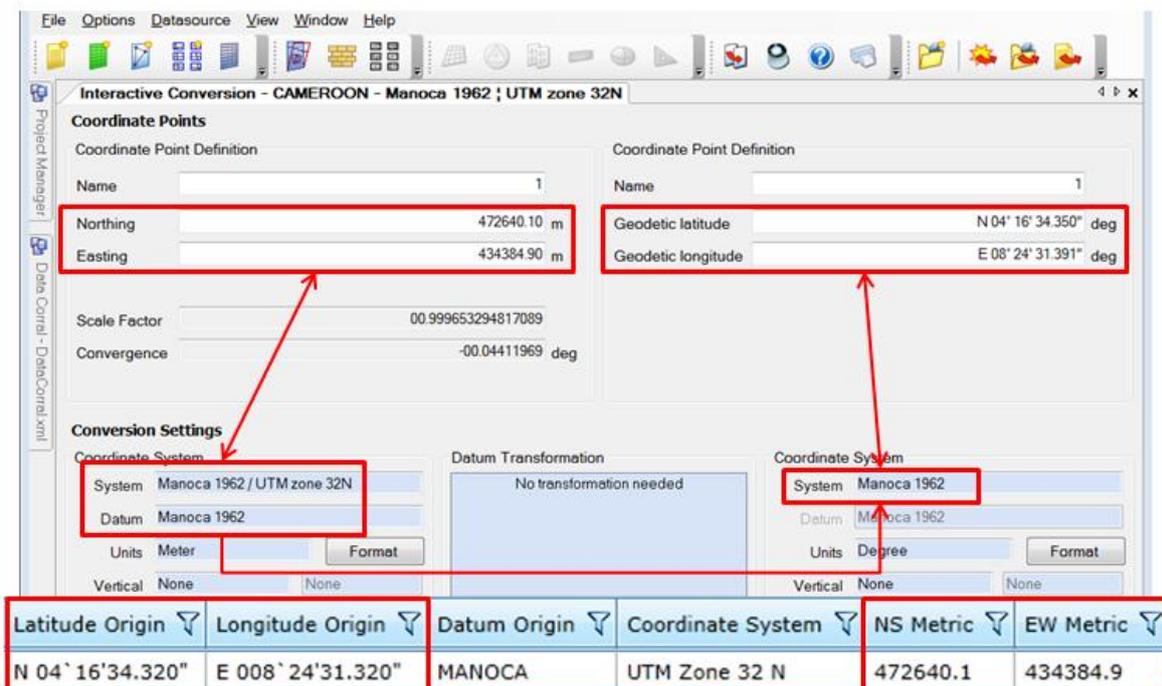


Figure 22: Check coordinate correspondences in IHS database

On Figure 22 we observe a tiny difference between IHS values and Blue Marble values. This is probably due to an incorrect rounding of the IHS values.

### 3.1.4. Step 4: Check correspondences between CRS and coordinates

In this fourth step we check if the specified CRS and the coordinates match for each document. Table 7 summarizes the different coordinates and CRS for each document.

Docs	Geographic Coordinates	Datum	Units	Projected Coordinates	Projection	Units	CRS (Datum/Projection)
ATD	X = 434 385 Y = 472 640	unspecified	m	unspecified	unspecified		Assumed as Manoca 1962 / UTM zone 32N
EOWR	X = 434 385 Y = 472 640	unspecified	m	Lon: E 8° 24' 31.39" Lat: N 4° 16' 34.35"	UTM 32	DMS	Assumed as Manoca 1962 / UTM zone 32N
SL	X = 434 385 Y = 472 640	unspecified	m	unspecified	unspecified		Assumed as Manoca 1962 / UTM zone 32N
FT	X = 459 066 Y = 475 111	unspecified	m	unspecified	unspecified		Assumed as Manoca 1962 / UTM zone 32N
NDB	X = 434 385 Y = 472 640	WGS 84	m	Lon E = 8.4074612 Lat N = 4.2754279	WGS 84	DD	Manoca 1962 / UTM zone 32N
HIS	X = 434 384.9 Y = 472 640.1	Manoca 1962	m	Lon E = 8° 24' 31.32" Lat N = 4° 16' 34.32"	UTM Zone 32 N	DMS	Manoca 1962 / UTM zone 32N

Table 6: Comparison between CRS and the coordinates for each document

*Just to remember:*

- DMS = degree minute second
- DD = decimal degree

$$DD = (Seconds/3600) + (Minutes/60) + Degrees \text{ and so } 8.55 DD = 8^\circ 30' 30.00'' \text{ DMS.}$$

Thanks to the many different coordinate sources, it was possible to determine the final well location and its CRS: Manoca 1962 / UTM zone 32 N. So now we can plot correctly this well on a map.

### 3.1.5. Step 5: SIP Completion and validation

The Figure 24 represents the ArcGIS map with the 6 different coordinates. FT Log is (map n°1 at the top) roughly 20 km away from all the other coordinates and IHS is (map n°2, bottom left) 15 cm at the North West from the 4 other coordinates.

This map gives us all a relevant information for representing all the coordinates positioning together. So we can appreciate directly which coordinates are grouped and so potentially right and which one are isolated and so potentially wrong.

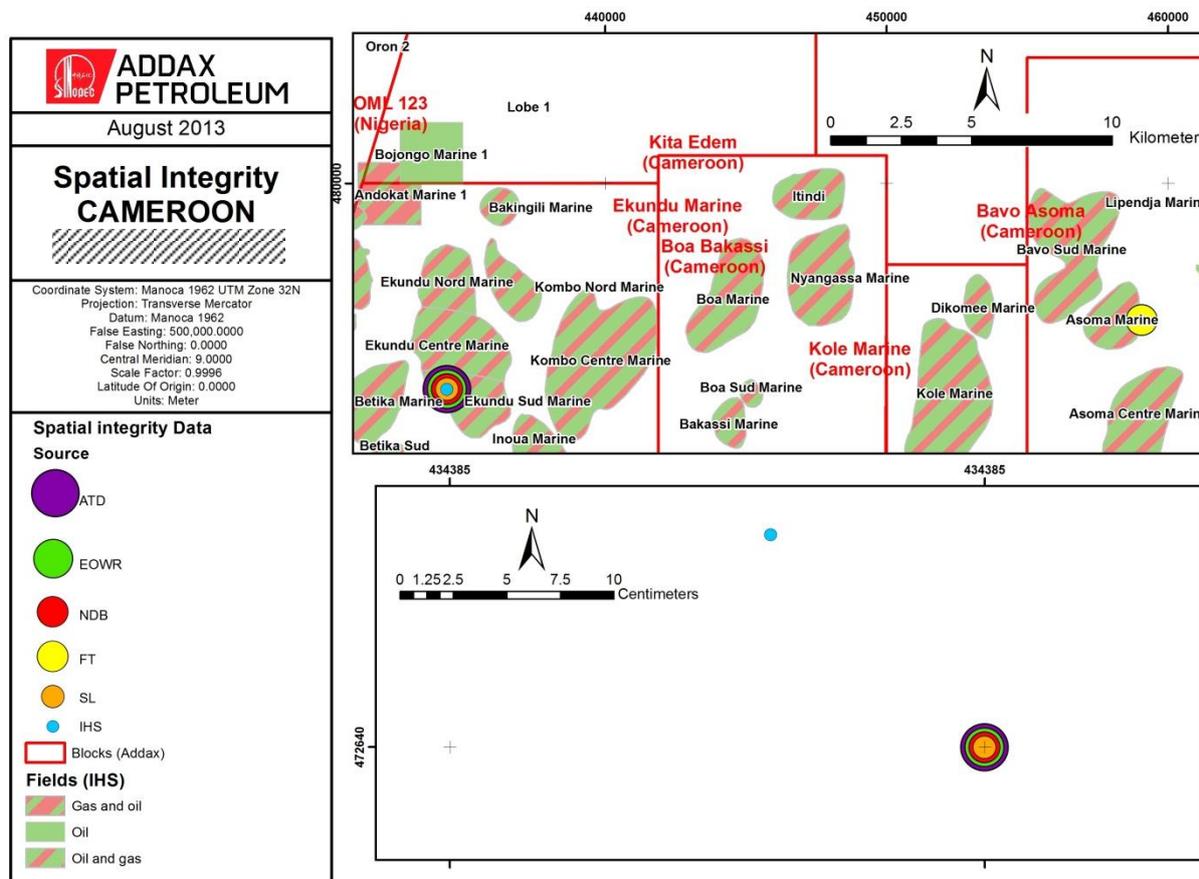


Figure 23: SIP mapping with ArcGIS

### 3.1.6. Step 6: SIP publication on Petroweb

The SIP report for this well is then loaded in Petroweb and the position of the well is updated in NDB.

On Figure 24, Addax's wells are plotted in Petroweb in the region of our interest (border Cameroon/Nigeria). Wells in yellow signify that we are confident of their spatial location. At the contrary, wells in orange signify that we do not have sufficient material to be confident on their actual location. So for those wells we need to find more documents sources in order to solve their uncertainties.

Just under the map of the next figure, we see a Petroweb window where we can find pdf SIP report for the selected wells. The Confidence Indicator (right column) tells us if we are confident (Y for yes; corresponding color on the map: yellow) or not (N for no; corresponding color on the map: orange) on the well location. This indicator is important for geoscientists of other teams: they need to know if their well locations are correctly known or not.

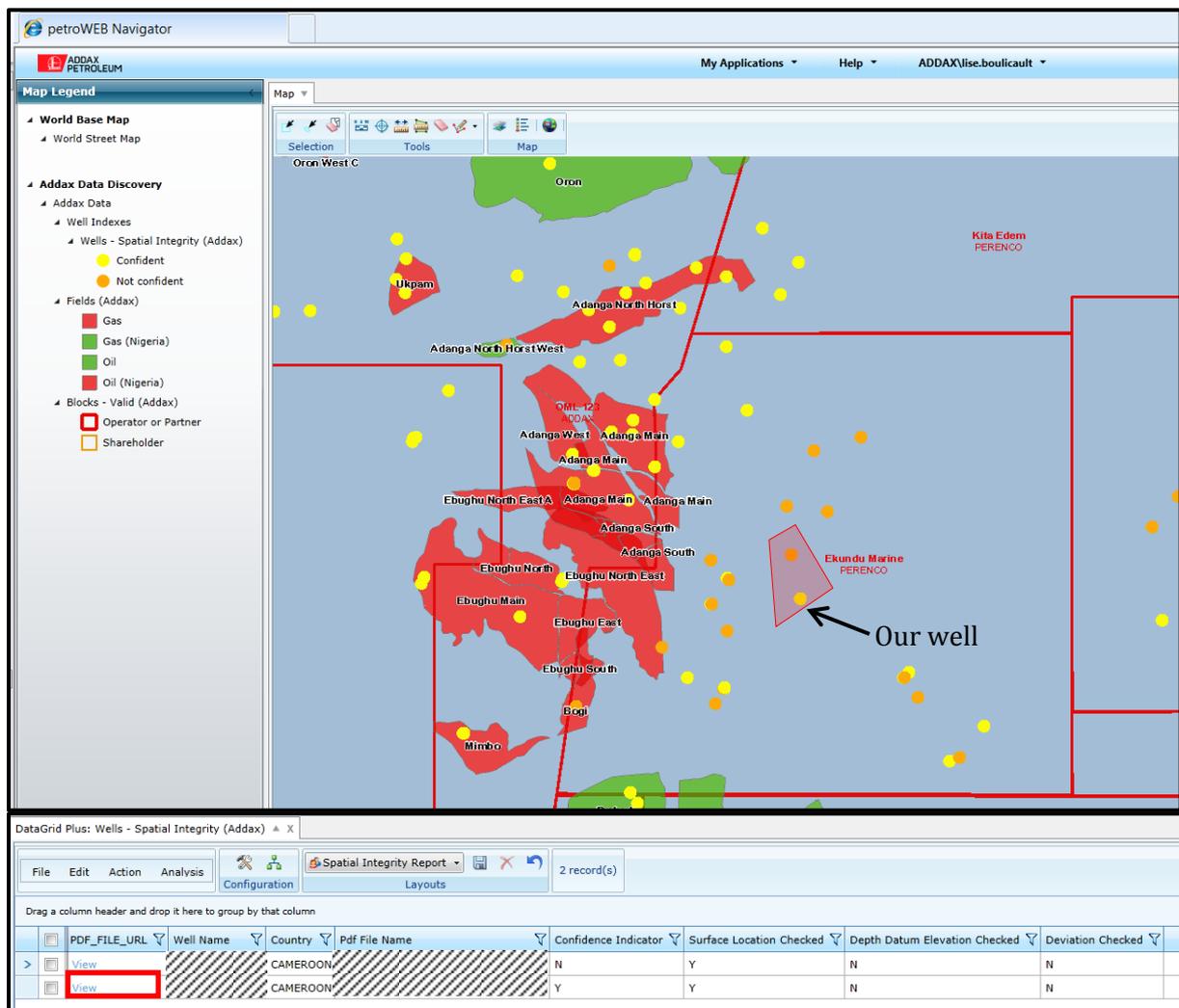


Figure 24: Petroweb Spatial Integrity wells. Source: Lise Boulicault.

In Petroweb (Fig. 25), we selected 2 wells thanks to the red polygon. One of the two is our well and it is in yellow so we are confident on his location. By clicking on “View” we can load the SIP.pdf for each selected well.

### 3.2. Conclusion

This third part illustrates each step of the SIP workflow through a real example. The most important to remember is that when documents have all the requested information (CRS and geographic or projected coordinates), well location can be easily checked. At the contrary - and that was the case in our “badly good” example - when some information is missing, it can become a detective mission to find the right CRS/datum and it takes much more time to SIP a well.

During my training at Addax, I have “SIPed” approximately 80 wells located in Nigeria, Cameroon and Kurdistan. Annexe 1 is an official SIP report for the well we used in this third part.

The last following part is about a course we presented with the Spatial Data Coordinator (my supervisor Philippe Chessel) to the other teams of the company. This course is focused on the basic concepts of geodesy and is entitled “Overview of Geodetic Concepts and how they apply at Addax”.

## 4. Short courses of geodesy applied at Addax Petroleum

### 4.1. Introduction

The objective of this course of geodesy applied to petroleum industry is to review the basic concepts of geodesy with the other employees (geologists, geophysicists, drilling engineers, etc.). Indeed, they probably had, a long time ago during their studies, some courses of geodesy. However they do not always have a clear understanding of the various fundamental concepts.

Every day, geoscientists use well coordinates in their projects in order to correlate their seismic lines to the wells. So if wells are not correctly located, then the seismic is not either! That's the reason why it is very important to operate with the biggest accuracy possible. A little discrepancy (up to 10 m) does not seem to be important if we stay in a small region, but it can have huge and catastrophic repercussions on the other side of the block at the end of a project!

### 4.2. Outline

This short course should last less than 1h. It is divided in two parts: theory and practice with concrete examples.

The main points of this presentation are:

Theory:

- What are the geoid and the ellipsoid?
- Why do we use several ellipsoids?
- What is a geographical coordinate system? A datum?
- To change from one datum to another one, we need geodetic coordinate transformation
- What are the projections that we use at Addax?
- What is a coordinate reference system (CRS)?
- CRS standards in used at Addax?
- What is a SIP report and where to find it?

Practice:

- How does these concepts translate in the different software (Petrosys, Petrel, Kingdom, ArcGIS, Blue Marble)

### 4.3. Result

This geodesy course is entitled "Overview of Geodetic Concepts and how they apply at Addax" and corresponds to the Annexe 2 of the present report.

### 4.4. Conclusion

This part concerns the geodesy courses we gave with my supervisor Philippe Chessel to other teams of the company. I was really happy to diversify my job through those short courses and to feel that Philippe Chessel and Mike Slee were confident enough to allow me to do those short presentations in front of other teams. It is true that the first presentations were relatively stressing however such experience taught me a lot and also gave me the opportunity to communicate and meet new persons. I really appreciate this second task of my geomatics training.

## Discussions

There are 6 very important steps in the SIP workflow. Could it be possible to automate some of them? Which step is appropriate for automation?

From my point of view, step 1 (to look for original coordinate document sources) is not really appropriate for automation. Indeed, this step does not just consist of looking for original documents loaded into the databases. It also implies to look in the archives, to talk with other geoscientists about their technical projects (“do you remember this well? Do you have any official documents about it? ...”). Consequently, I think that real person contact is needed for this first step.

Secondly, due to the diversity of the original document formats (.img, .gdb, .pdf, .tiff, paper documents, etc.) a human check is necessary in order to find, between all the information related to the documents, the one we really need (i.e. the well surface coordinates). A script will hardly do it for us in these instances, therefore, steps 2 and 3 are not appropriate candidates for automation.

Once all the coordinates have been collected and written into the SIP report, the next step is to verify that the collected coordinates correspond to the Addax standards for the region in question. So maybe this fourth step can be automated. In that case, we will have to connect several databases (e.g. Addax’s standards) to our SIP report and in order to facilitate such automation, I think that we should simplify the SIP report (less text, more tables, like a database). It is my opinion that this step can effectively be automated with some modifications to our workflow.

Step 5 is the SIP completion and validations. In this step, I have to review the SIP report, create an ArcGIS map and the Spatial Data Coordinator (my supervisor Philippe Chessel) needs to validate the SIP report. I do not really see how to automate this step. In fact, the ArcGIS map is unique and needs to correspond to each document source (size label, position, what is important to show with this map? how to figure it out? etc.). Furthermore, the validation cannot be done by a script because it is a visual check in which the Spatial Data Coordinator checks each point of the SIP (good map naming, etc.).

Finally, the last step (number 6, “publication in Petroweb”) is already partly automated (I asked a colleague to run some scripts in order to update the well locations in our database). However, a human verification of Petroweb is still very important because we already observed errors due to some problems in the script, therefore, Petroweb was not updated.

Consequently, we can say that some of the workflow procedure could be automated, with some modifications of the SIP workflow. It is possible that other companies within the industry may benefit from more established experience from their well QC. It would be prudent to companies such as Addax to try to meet and communicate with other companies in order to discuss and share knowledge and ideas to improve our workflows.

## Conclusion

The two objectives of this training (the well QC and the short courses of geodesy to other teams) highlighted that geomatics is really important for all our petroleum technical projects and all the geoscientists should take it into consideration and have a good understanding of it. Furthermore, we must all use the same geodetics standards and the same namings because concepts are important, but the right implementation in technical projects is also very important! To do so would avoid many errors on the locations of the wells, of the seismic lines, of the blocks, etc.

Maybe another solution to solve such inconsistencies between documents and so limit the wells' locations discrepancies would be to have a "Spatial Integrity Checker" in the company. This person would check all the geodetics parameters of the official documents published on wells before, during and after the drillings. So the "Spatial Integrity Checker" would be able to detect any inconsistency relative to wells' locations.

In general, before the short geodetic courses the teams were a bit dubious about the utility of those courses and the SIP workflow. However, after all our geodetic short courses we had very good feedbacks from the teams and that was really gratifying to feel useful for our geoscientists colleagues.

This training at Addax was a very rich professional experience. I discovered the functioning of a medium-size petroleum company and I also realized the importance of GIS into technical projects. That was also a unique opportunity for me to meet other geoscientists and communicate with them on a geodetic purpose.

I definitely recommend Addax Petroleum and the Data Management Team in particular for doing a geomatics training. As I said previously in the introduction of this report, we have checked approximately 1400 wells over the 6000 loaded into the Addax database. So there are still many wells to SIP. However, more than wells, there are seismic lines, platforms, blocks delimitations etc. which, for the moment have not all been QCed. Such really interesting projects could also be perfectly adapted for geomatics trainings.

## Acknowledgments

Thank you very much to Philippe Chessel and Mike Slee without whom this geomatics training would not have been possible and who also gave their approval for my contract extension. I have a lot of recognition for them.

I also would like to thank Pr. Mario Sartori who kindly accepted to mentor my training at the university and who was one of the two jury member during my presentation. Warm thanks are also addressed to the Pr. Hy Dao, the second jury member of my presentation, for his very interesting courses during the Certificate of Geomatics and his kind encouragements.

Last, but not least, I would like to thank all the Professors and PhD of the Geomatics Certificate of the University of Geneva which took time for us, the candidate students. I learn a lot during the geomatics courses and this was a very rich experience. I have no doubt that my GIS knowledge will help me in my future geologist career.

## References

### Websites (last visit: 2013/12/18):

- Petroweb: <http://petroweb.adx>
- Swisstopo: [www.swisstopo.ch](http://www.swisstopo.ch)
- Math World: <http://mathworld.wolfram.com/>
- Esri: <http://ressources.esrifrance.fr/>
- EPSG: <http://www.epsg-registry.org/>
- OGP: <http://www.ogp.org.uk/>
- DECC: [https://www.og.decc.gov.uk/web\\_files/quad\\_maps/quadmaps.html](https://www.og.decc.gov.uk/web_files/quad_maps/quadmaps.html)
- Fox drilling: <http://www.foxoildrilling.com/>
- Connaissance des énergies: <http://www.connaissancedesenergies.org/>
- Wikipedia for definitions

### Books:

- Flake, W., Kraus, B., (2005), *Working with Projections and Datum Transformations in ArcGIS, Theory and practical Examples*, Point Verlag.
- Iliffe, J., Lott,R., (2012) *Datums and Map Projections For Remote Sensing, GIS and Surveying*, Second Edition, Whittles Publishing.
- Maher, M.M., (2010), *Lining Up Data in ArcGIS. A Guide to Map Projections*, ESRI Press.
- Snyder, J.P., (1993) *Flattening the Earth, Two Thousand Years of Map Projections*, The University of Chicago Press.

### Course:

- Dubois, A., (2013), *Géodonnées et géotraitements*, Université de Genève, Certificat de Géomatique

### Article:

- John P. de Wardt, *Wellbore Collision Avoidance and Interceptions – State of the Art*, JPT March 2013

### Addax Petroleum Corporate Policies and Procedures:

- Chessel P., Tuveri E., (2012), *Spatial Integrity Procedure for Wells*, unavailable confidential document

### Student report:

- Rusillon, E., (2012), *Spatial Integrity Procedure, Certificat complémentaire en géomatique 2012*, University of Geneva

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## List of Acronyms

- ATD: Application To Drill. Official document published before the well drilling
- Block: Geographical delimited area defined in a petroleum context for prospecting, exploration and extraction of natural resources
- Coords: Abbreviation for coordinates
- CRS: Coordinate Reference System
- DD: Decimal Degree
- DDR: Daily Drilling Report
- DECC (Quadrants): Department of Energy and Climate Change. Quadrants are surface polygons represented on the North Sea maps. They are 1° long by 1° large (see the DECC website listed in the references for more details)
- DMS: Degree Minute Second
- DSR: Deviation Survey Report
- ED50: European Datum 50 (Datum in use in the North Sea Addax Blocks)
- EOWR: End Of Well Report
- EPSG: European Petroleum Survey Group. A part of the OGP group.
- Fields: Underground reservoirs from which are extracted oil, gas, water etc.
- FP: Fundamental Point
- FTL: Formation Tester Log
- FWR: Final Well Report
- GCS: Geographical Coordinate System
- GIS: Geographical Information System
- GSR: Geological Survey Report
- IGN: National Institute of Geography (France). For the Clarke 1880 (IGN) ellipsoid
- IHS: IHS Inc. Energy: database company located in Geneva
- IL: Induction Log
- JPT: Journal of Petroleum Technology
- SL: Sonic Log
- mE: Meter East (Easting) for projected coordinates
- mN: Meter North (Northing) for projected coordinates
- MSL: Medium Sea Level
- NDB: NeuraDB, the Addax's database
- OGP: International Association of Oil & Gas Producers
- OML: Oil Mining Lease. Block naming when the block is already producing hydrocarbons
- OPL: Oil Prospecting Lease. Block naming when the company is still prospecting hydrocarbons is the block
- Petroweb: Internet GIS Portal used at Addax
- PSApphire: Database used at Addax and integrated into the NDB database
- QC: Quality Check
- RGS: Royal Geographical Society (UK). For the Clarke 1880 (RGS) ellipsoid
- SIP: Spatial Integrity Procedure
- SQL: Structured Query Language
- TM: Transverse Mercator (cylindrical projection)
- UTM: Universal Transverse Mercator (cylindrical projection)
- WGS84: World Geodetic System 1984
- X: synonym of Easting
- Y: synonym of Northing

## Annex 1:

# Example of a Spatial Integrity Procedure report

## Annex 2:

### Short course of geodesy: “Overview of Geodetic Concepts and how they apply at Addax”