Case Studies in SDI Components (Geodetic Datum, Data Transformations, Cadastre, Planning etc)

Momath NDIAYE, Senegal

Key words: Case studies in SDI components (Geodetic Datum, Data Transformations, Cadastre, Planning, etc...)

SUMMARY

In nineteen seventy two, the National Geographical Service was created from the former Topographical Service. In nineteen ninety, it was promoted as a full department of the Ministry of Infrastructures, Equipment and Transports.
In other hand, Cadastre, Land Registration and Land Administration belong to the Ministry of Finance.
In Senegalese geodetic network there are five reference systems:

- Adindan Datum
- Yoff 200 Datum
- 1974 Datum
- Datum
- Hatt Datum

The first three of them use the UTM projection and the assigned ellipsoid is Clark 1880, while the last one refers to a stereographical projection.

It is clear that the adoption of the GDS (Geocentric Datum of Senegal) will enable the production of a homogeneous series of Senegalese maps. There has been clear evidence in recent years that Senegalese Geodetic Datums are inadequate for some current and emerging applications. A new geocentric datum, New Senegalese Geodetic Datum 2004 (NSGD2004), designed and built during 2004, is realized through ITRF2000 and uses the GRS80 ellipsoid. The new datum will be implemented in conjunction with the updating of the map at the scale of 1:200 000 and the extension of the Geodetic Network. . A description of the new datum, its design, planning and implementation will be presented.

The basic needs to access, organize, update and analyze the host of data in any way led to the concept and the development of geographical information system with narrow into the field of digital data visualization. That allows improving quality and reducing costs related to geographic information with the view to make geographic data more accessible to the user. This study will show how Cadastre and Survey Department is moving from analogue to digital data. Then it is to highlight on application of Data transformation knowledge to manage spatial information.

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1. GEODETIC DATUM

1.1 Historical Outline of Senegalese Geodetic Datums

Before 1933 and until 1970, Senegal ensured the Cartographic and Topographic Works for Oust-Africa. The Service was managed by IGN-French. And at that time there is no geodetic network yet. For making maps, for example 1:200 000,1:500 000, they used astronomical points.
The geodesy of SENEGAL was marked from1933 to 1997 by five reference geodetic systems:

- *Yoff-200* Datum(the astronomical point of Yoff in SENEGAL)
- *The point-58* Datum(located on the boundary between Niger-Nigeria)
- *Adindan* Datum (located on the boundary between Sudan-Egypt)
- *1974* Datum(on the main building of the Geographical service)
- Hatt Datum

1.2 Leveling Network

In Senegal we have a sufficiently leveling network covering all country. The fundamental Datum is located in Dakar-Port. That was established by IGN-French. Before establishing this Datum of Benchmark, IGN measured during three years the Mean Sea Level and its value is 1,320m.The undulation between Geoid and Ellipsoid is small and quite uniform. And that will allow us to carry out the geoidal height on using GPS

The main Objective is to resolve all the difficulties we meet today; we notice some discrepancies from: 106m to 332m in E and –16m to 138m in N; in other hand if I consider the map of Dakar area 1:50000 realized by IGN (Datum system 1974) and the adjacent region Thies which the map was realized ,at the same scale, by JICA project (Datum Yoff 200). Those two sheets can't match because the discrepancies are important. For that multiple reasons we want to move to the New System: World Geodetic System 84

2. INTRODUCING OF GPS SURVEY FOR NEW SENEGALESE GEODETIC DATUM (NSGD)

In geodetic practice it is today common to have coordinates derived from GPS and also from traditional terrestrial methods. For computations we convert the local topocentric coordinates to geocentric coordinates, which can be compared with GPS derived coordinates. Thus physical control points may have two sets of coordinates, one derived from classical methods and one derived from GPS

The connection between topocentric and geocentric coordinates is established by transformation formulas. In the past horizontal and vertical datums have been treated separately,and still are to some extent,but with the evolution of technology and practice a 3-D datum will integrate the two. As background,we need to dicuss the difference between local geodetic datum and global geodetic datum.In a simplified way,a local geodetic datum must be one chosen for its ”best fit” in a particular place.The Yoff Datum of 200 is a senegalese datum based upon the Clarke Spheroid of 1880.

A local geodetic can be defined with 7 parameters/conditions:
- Two elements to define the geometrical ellipsoid
- Latitude and longitude of the initial point
- A reference azimuth for orientation
- The geodal height at the initial point,usually assumed to be 0,0.
- The assumption that the ellipsoid minor axis is parallel to earth’s spin axis.

*Global***:**while a local geodetic datum has an arbitrary origin,the origin of a global geodetic datum is taken to be earth’s center of mass and a reference ellipsoid is chosen on the basis of a global ”best fit.”Thus,points on or near any part of the can be accurately related to any other point tied to the same datum.

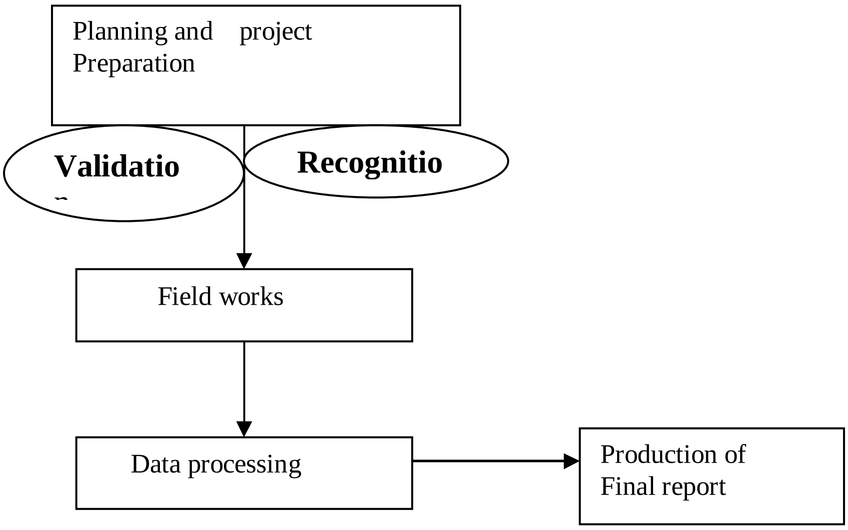
According to Helmut Moritz(1980),a global geodetic datum is defined by:
- The datum origin is located at earth’s center of mass.
- The Z axis points in the direction of the Conventional InternationalOrigin (CIO) defining a mean North Pole.
- The axis is parallel to the Zero Meridian adopted by the BIH and know as the Greenwich Mean Astronomical Meridian.
- A reference ellipsoid defined by 4 physical geodesy parameters

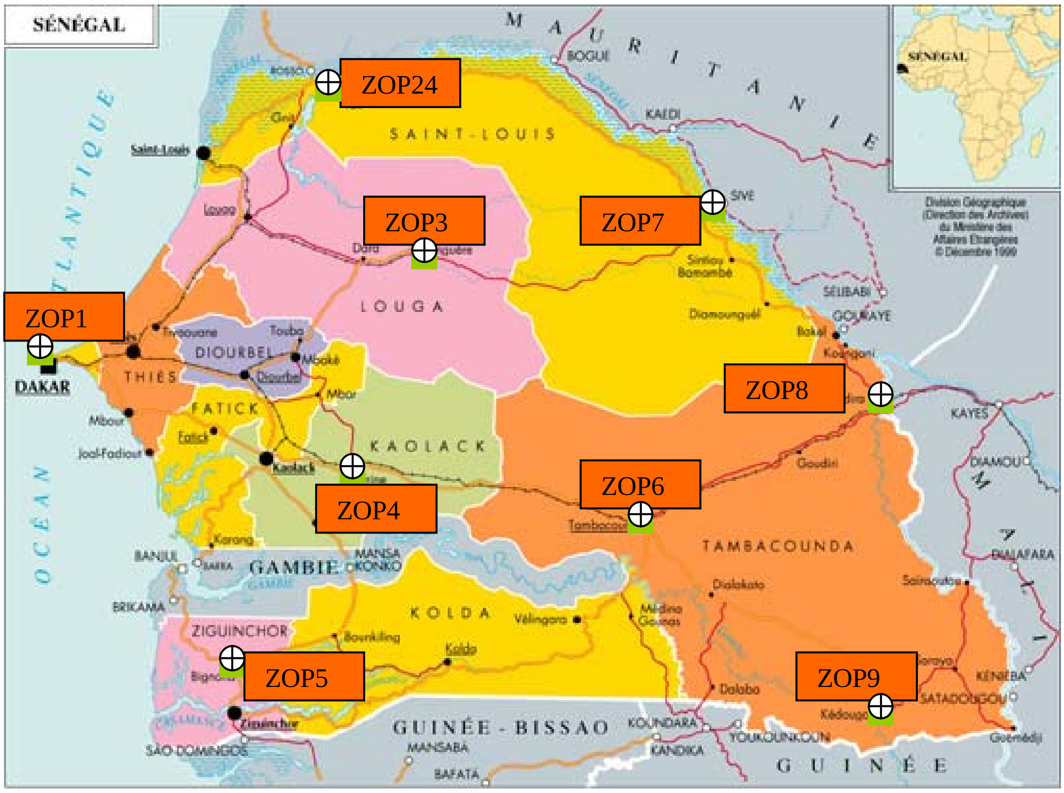
2.1 GPS Procedures

Different types of GPS positioning exist, they are so many: point positioning, relative positioning using carrier wave, however the procedures to follow can be divided into four common phases: planning and preparation, validation, recognition, field works, data processing and production of final report

To move to the World Geodetic System 1984, we have to establish first: the zero order. For that case we can use GPS Static/Geodetic and three permanent ITRF Stations at least around. And that allows us to know the motion of the continent. Main points must be selected with a good distribution through the country. See the Fig: a .

Phases of a GPS project





th order

BM: Benchmark

Fig. a:

Two selected points are observed simultaneously; the timing is for three days. To reach the good and expected precision for the computations we have to use for that Bernese GPS

Software 4.2. And Bernese Processing Engine (Automation) can realize and improve the vertical component of the Leveling .The conditions of observations are summarized on the Table 1

From now we may establish the GCPs in first order Network; its have 50 km each others and the timing for observation is one day; on other hand we observe all the old GCPs in order to determine the parameters of Coordinate Transformation

Observations	Timing	Baselines
Zero order	3 days	More than 100 km
1st order	1 day	50 km

Table 1: Duration of sessions and long baselines of different linking up

The selectable GPS Permanent Stations on the will be: Kour Kou1, Vesl, and Mald, see Fig: b

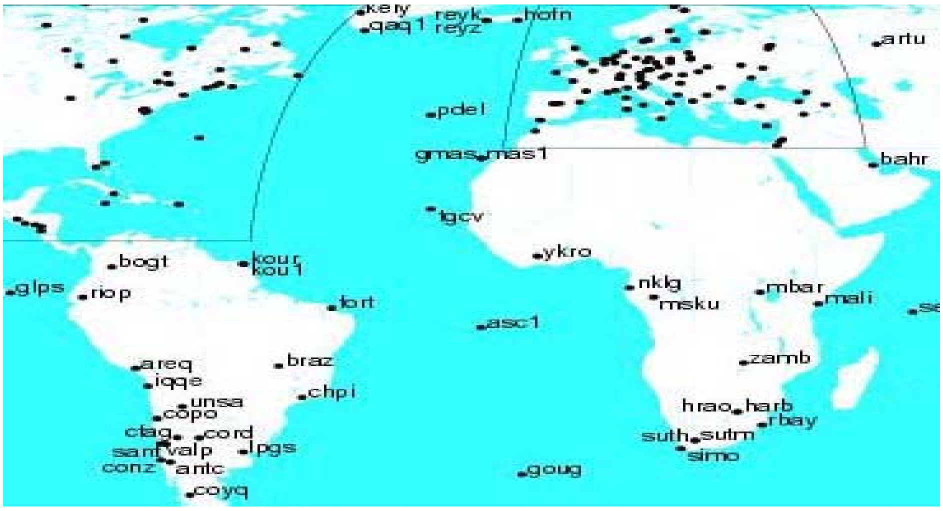


Fig b: Maps of GPS Permanent Stations

Using Bernese GPS Software 4.2 must do this 0th order and BPE can help to carry out and to improve the vertical component for the leveling; so we can obtain a good precision. In this case we have nine points for 0th order. After this, it is quit possible to implement the 1st order by using the method of GPS observation surveying static classic; allow to me, now to come back to the different stages of the procedures a little bytes

2.1.1 Planning and Preparation

- Planning and preparation begin by wording needs of positioning and end we are entirely ready to execute with success
- Preliminary step: identify the new GCPs and attach the accuracy, reporter these points and old geodetic control points on the map (1:50000)

2.1.2 Choice of the technique of GPS positioning

Some aspects influence on the choice of the type of GPS positioning such as: accuracy, distance between points of positioning, coast and geographical area. In this case we know that the first order requires height accuracy and it has long baseline vectors; therefore we select the GPS static classic. But for updating the scale *1:200 000* ,we used the *DGPS* positioning

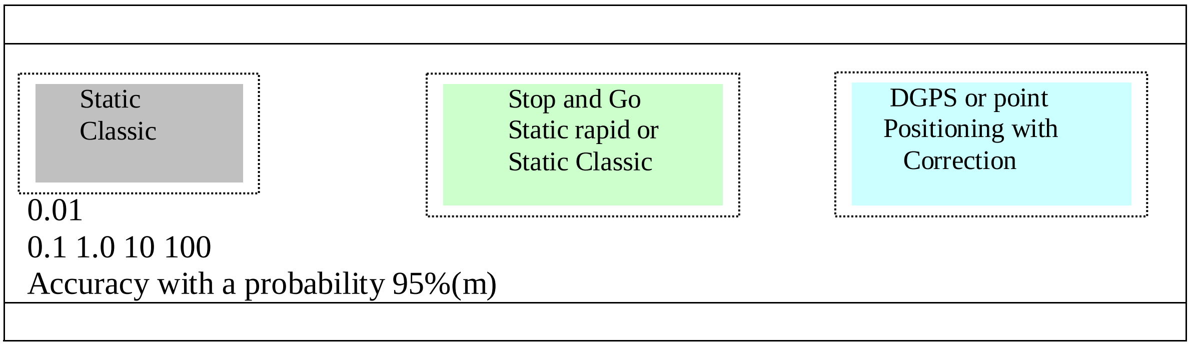


Table 2: Proposed technique of GPS positioning according to the required accuracy

2.1.3 Choice of Receiver

On survey, when a height accuracy is required for long vectors we use in this case Bifrequences (correction of ionosphere errors).

Method	**GPS observations**
Point Positioning Differential GPS Stop and Go Static rapid Static classic	Pseudoranges Pseudoranges Pseudoranges and carrier wave Pseudoranges and carrier wave: Bifrequences Pseudoranges and carrier wave Bifrequences for long vectors

Table 3: GPS observations for different positioning

2.1.4 Validations

On other hand, in the case of GPS planning project we should do some tests of procedures and of the equipment which will be used in order to insure that its allow to get reliable results; on other word we call it "processes of validation" as following:

- Adopted technique of GPS positioning
- Equipment to use
- Selected method of processing

However, this processing consists to use known points with upper height accuracy than the project; in order to instill a norm of validation of the technique of GPS survey, we have to establish at least one Standard Network. The Validation is an important stage of Evaluation and retroaction in the establishment of a project plan

Concept of Validation
Experience all the procedures by using
Known points with upper height accuracy

Elements of experiment
- Type of GPS positioning
- Equipment
- Method

Advantage
- Detection and Resolution of problems
- Rationalizaton of operations
- Establishment of preview

Concept of validation

2.1.5 Recognition

It consists to verify on place of the project before taking any GPS observations. We should consider verifying if all the new selected GCPs are good or not and in the same way, we effect the control of existing geodetic points; the important components of the recognition on the field are summarized as following on the Table 4.

Verify the new GCPs location	Absence of obstacle? Absence of interference sources?
Verify the existing geodetic points	The stations, are they located? The benchmarks, are they stable?
Formula needs of logistics	Transport mode Time to join points Procedure or special equipment
Measure to adopt	An other choice if necessary Establishment if necessary station of eccentric point Deposition of results Update the descriptions when it is necessary

Table 4: Recognition of field

2.1.6 Concept of survey

The conception of survey constitutes an other important stage of process of the planning and project preparation. We take care of the following aspects: requisite control, configuration of network and redundancy. The conception of survey varies according to the accuracy required and the type of GPS positioning as you see on the Table 5.

Type	Requirement of control	Configuration of network
Point positioning	No	Without object
DGPS	1 point 3D or more	Radial
Static classic	3 points 3D or more	Closed geometrical figure
Static rapid, Stop and Go	Variable	variable

Table 5: Specification of Control and Configuration of Network

2.1.7 Preparations

Several aspects of preparation stay handling as following:

- Select a good period for the collection of GPS data
- Determine optimal number of GPS receivers
- Plan the conception of survey, on taking care the requirements of the Control, the Configuration of Network, the time necessary to join points between them, the visibilities of satellites and the logistic constraints
- Establish a no ambiguous system of registration or designation which allow to clearly identify the GCPs on the field and the numerical files
- Organize the transport
- Teach the personnel how to operate the receivers, procedures of GPS observations and data treatment
- Organize the lodgings on the field if necessary
- Prepare equipment and necessary supplies

The GPS observations must be downloaded and treated after finishing the session in order to insure if all data are successful
Treat GPS static classic application to survey is more complex and may require the combination of several sessions of observations; for that, let us see in details this technique

2.1.8 Cadastre

Such as the most of many countries, in Senegal, the cadastral survey has and uses old maps for survey. All the cadastral sheets were putted out with a known coordinate system, Hatt system; it is not easy to handle these analogue data .Then that takes time to answer to the public needs. The next aspect is, the most these established maps did not match each others. However some efforts were done on digitizing by hand some sheets. Today the main objective is to reduce the time consuming for users; for that purpose, we need to establish a Database. That will allow us to get a Digital Format which can be used basically for GIS. To reach this objective ,we must respectively .scan all the analogue data, convert the raster data to vector data and then build the attribute data

2.1.9 <u>Preparation</u>

This stage consists to select the necessary maps that we want to scan and the corresponding area. We make a planning. For each map or sheet we have to identify at least four points for georeferencing. We check the equipment for scanning. After that it becomes easy to start the scanning

2.1.10 <u>Scan data or Raster data</u>

Raster data files consist of rows of uniform cells coded according to data values. An example would be land cover classification. The computer can manipulate raster data quickly, but they are generally less detailed than vector data. As you can see from the previous illustration, the raster cells approximate the boundary line between the areas of hardwood and soft pine. The degree of approximation is related to the size of the cells. A grid consisting of smaller cells will follow the true location of the boundary line more closely; however, the size of the raster file will likewise increase

Bisecting the grid spacing will quadruple the number of cells to be manipulated. Maps plotted from raster data may be les visually appealing than vector data files, which have the appearance of more traditional hand–drafted maps. For these reasons, the raster data model is generally used to model continuous map features .Like vector data, raster data can have attribute data attached to individual cells. This data can include map feature attributes such as types, measurements, names, values, dates, and classes

2.1.11 <u>Vector data</u>

Vector digital map data is recorded as distinct points, lines or areas. In the vector model, information about points, lines, and polygons is encoded and stored as a collection of X, Y coordinates

The location of a point feature such as a manhole is described by a single x, y coordinates. Linear features, such as roads and rivers, are stored as a string of point coordinates. Polygonal features, such as sales territories and lakes, are stored as a closed loop of coordinates. The vector model is useful for describing discrete features, such as buildings, but less useful for describing continuously varying features, such as oil types or vegetation land cover. The vector format also provides for a more accurate description of the location of map features

2.1.12 <u>Attribute data</u>

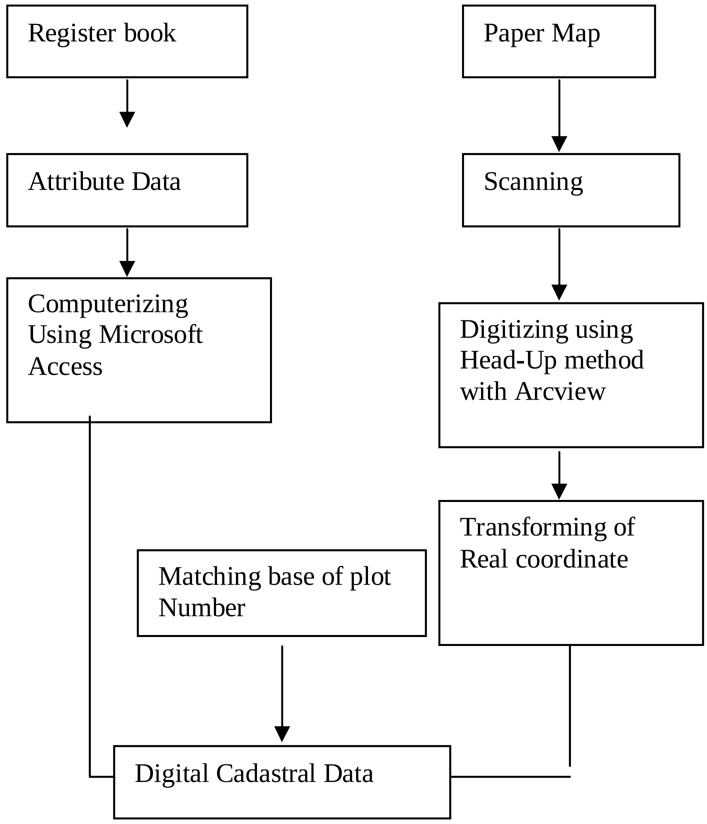
The cadastral maps of Senegal have to use together with register books. All register books stored many attribute data such land classification data, land utilization data, revenue range. All these data are very important for the data management . We would to use effectively with GIS technology for all attribute data. For this purpose we well be making all attribute data by using Microsoft Access.

2.1.13 Transformation of real coordinates

For this process we can use GPS and Orthophoto. For our project the Orthophoto is better because now Senegal is making the new UTM map project for the whole country with scale 1:200,000. To use digital orthophoto map because of we can easily identify each parcel and can be update. This project is making by Survey Department. We can share aerial photo and produce orthophoto map. But we need high technology, hardware and software to make orthophoto.

After computerization and digitization process, we will match the digital map and attribute data. Finally we can get digital cadastral map, the basic layer for land management

2.1.14 The Cadastral Process



3. CONCLUSION

Today, introduction of GPS survey is revolutionary for control point survey projects; thank to GPS, establishment of one unique and coherent Geodetic Network is quite attainable; the accuracy and reliability of survey results have been highly improved. Reduction of time and cost for obtaining survey results is eminent. Especially, continuous observation of outside by permanent GPS stations provides as very interesting data unimaginable so far.

From my experience increased during my studies, I have no hesitation that the Technique of GPS static classic and the appropriate Bernese software will be very useful in conducting Geodetic Network, basic support for Mapping projects and engineering surveys.

REFERENCES

Global mapping news letter, my Technical Study (GSI JP): Planning, Management and Evaluation of geodetic Network by GPS and OKINAWA 2003

BIOGRAPHICAL NOTES

Formations

From. 19 65 to 1971 I frequented the primary school in my home town: Keur Yoro Khodia,after that I want to the *Faidherbe height school in Saint-Louis* where I got my diploma in order to go to DAKAR UNIVERSITY in 1978

So, from 1978 to 1980 I was student in Dakar University in Physical and chemical Department, I obtained my first certificate in this subject. At the same year, I prepared and I was successful the test to enter to the IGN in Parish

Here, I was student from 1980 to 1982 so I got my license to become a surveyor, with a specialty in geodesy. After that I join the survey department of Senegal

In 1991 I want to Japan in order to accomplish a training course in Map Production for three months.

Last time .I participated to the group training Course in Planning and Management of National Mapping and Surveyor .That was in GSI –Japan, from 30/09/02 to 27/08/03

At the end of the course every participant must prepare a Technical report; so my subject was: Planning, Management and Evaluation of Geodetic Network by GPS (Global Positioning System)

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