Mission Report from a mission on

Update of the Cartography Base

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TA for the Scandinavian Support Program to Strengthen the Institutional Capacity of the National Statistics, Mozambique

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Acronyms / Abbreviations

CENACARTA	Centro Nacional de Cartografia e Teledetecção	National centre for cartography and sattelite images
DINAGECA	Direcção Nacional de Geografia e Cadastro	National Directorate for Mapping and Cadastre
GIS	Geographic Information System	Digital system with a combination of mapping and database features
GPS	Global Positioning System	Sattelite based system for determination of geographic coordinates
INE	Instituto Nacional de Estatística	National Institute for Statistics, Maputo, Mozambique
MAE	Ministério de Administração Estatal	Ministry for State Administration.
WAAS	Wide Area Augmentation System	System that delivers signals to enhance GPS signals to achieve 3m accuracy with single receivers.
WMS	World Map System	System to integrate maps from different sources via Internet.
WGS84	World Geodetic System 1984	Map Datum used by the GPS, sometimes (not in this text) also used for the ellipsoid used in WGS84.

1. Executive summary

The overall objective was to assist INE in the further development and organization of the already ongoing work to digitize the cartographic information from the last census.

Recommendations:

- It is recommended that the transfer of geographic data about the Enumeration Areas from analogue to digital format is continued and intensified. Detailed recommendations on the steps to take are described further down in the section Conclusions and recommendations and in nine (9) of the annexed documents. This work includes introduction of existing numeric data, capturing of additional necessary GPS coordinates, scanning of all relevant maps and vectorization of all Enumeration Area lines to digital area features.

- It is recommended that an investigation about Map Datum is carried out as soon as possible. Details can be found further down in this document under the headline Map Datum.

- It is recommended that a database with information on all maps at INE is setup. Details on such a subproject is to be found further down under the heading Database for computerized organisation of maps .

- It is recommended that all staff at the Cartographic section shall receive further education and training in the use of GIS software as described under the headline Human resource development.

- It is recommended that the cooperation with DINAGECA and MAE is intensified as described in the section Coordination / cooperation with others.

2. Introduction

Terms of reference for the mission are enclosed in the document Termos de Referência para consultor escandinavo.doc. The primary objectives with this mission were to specifically help the cartographic section at INE with some equipment and generally give advice in questions regarding digital mapping and GIS technology. It was also understood that the mission should note the situation on available maps both at INE and at National level.

The mission was carried out by Mr Per Backman, Sweden. Counterpart during the mission was Mr Antonio Adriano, Head of Departamento de Cartografia e Operações at INE. Also all other staff at the department took active part in the activities. Three meetings were held with the INE Management on the objectives of the mission.

3. Background

The year 1997 a general census of the population of Mozambique was made. Ten years later, in 2007, it is planned to carry out a new census. The maps for the last census was made with analogue technique, it is now planned to produce the maps for the coming census with digital technique. Computers and GIS software has been in use at INE for some years but the main part of geographic data at INE is still in analogue format and needs to be digitized. The staff at the cartographic department has been working with computers, GIS and GPS for some years but had very few possibilities to exchange experiences with others working with GIS. The available geographic data is to a great extent obsolete and needs updating.

4. Outline of work

The main objective for this mission was to help the cartographic section at INE in some cartographic matters:

- See to that the cartographic equipment is working correctly i.e. scanner and digitizing tables.
- Define the best way to organize the maps with Enumeration Areas and Master Sample maps.
- Verify that the technical objective that was stated for the actualization of the Master Sample Maps was achieved.
- Help the Cartographic Department in finding solutions to the problems they meet in the digitizing work.

As the digital technique gives possibilities to use the data beyond the actual census, it is now necessary to look at the preparations for next census with a broader perspective.

The first and most obvious goal with preparations of cartographic material for next census is to produce maps for the counting teams, maps that show the limits of the Enumeration Area for that specific counting team.

The second goal is to have GIS-prepared area-features that can be used to illustrate the data once the counting is made.

The third goal is to map areas with such a geographic quality/accuracy that they can be used in future census and other work.

A fourth goal is to make the delimitation with such a quality as they can be exported to other organizations for their use, e.g. MAE when deciding boundaries of municipalities.

The Enumeration Area that is produced digitally should coincide with the areas that where used in the 1997 census. The 1997 limits must, where possible, serve as a base for the coming censuses.

The limits of the Enumeration Areas must coincide with the administrative boundaries of the country. As the Administrative Boundaries sometimes are vague and doubtful, due to a number of reasons, it can be cumbersome to map the limits.

In the Terms of Reference the following objectives was pointed out:

Portuguese	English	Result
Precisão na informação digitalizada;	Precision / quality in the information.	See
Procedimentos seguidos para georeferenciar e digitalizar as áreas urbanas;	Procedures for the georeferentiation and digitisation of urban Enumeration Areas.	
Incluir as coordenadas geográficas retiradas no campo durante a actualização da amostra;	Include the coordinates captured in the field during the actualisation of the.	
Conciliar os limites administrativos da DINAGECA com os do INE;	Reconcile the administrative boundaries of Dinageca with the boundaries of INE.	
Fazer um Check-up de todos os layers (temas) digitalizados;	Make a check-up of the digitized layers (themes).	
A escala do Zooming para digitalizar uma entidade (rio, estrada, limites administrativos);	Convenient zoom scale for digitizing of different features (rivers, roads, boundaries).	
Definição de atributos nas entidades de forma a ser compatíveis com os da DINAGECA;	Definition of attributes that they are compatible with the ones from DINAGECA.	
Digitalização e armazenamento da informação digitalizada na rede, isto é, trabalhar em rede;	Digitizing and saving of data in a network – working in a computer network.	
Harmonizar os trabalhos realizados pelos técnicos existentes na área;	Harmonize the works made by different technicians.	
Estabelecer mecanismos de controle do trabalho de digitalização;	Establish controle mechanisms for the digitizing work.	
Métodos para mensurar o progresso do trabalho da digitalização.	Find methods to meassure the progress of the digitizing work.	

Among the objectives it was necessary to choose and prioritize. A major task that was not foreseen was the problem with Datum / coordinate systems. A considerable time of the consultancy was spent on investigating the best – most accurate settings for the work at INE. The results can be seen in the annexed document Datum a usar no trabalho com GPS.doc .

5. Activities

Most of the first week was used to get the digitizing tables and the scanner to work and to become acquainted with the existing data, organization and equipment.

During the second week two field trips was made, one to a rural area and one to an urban area. The urban area visited, was not the well mapped Maputo but a municipality outside Maputo where no regular town-maps are available. The field trips included a study of the methods used so far and some training in more extensive use of GPS.

The third week has been used for 1.) training in download of data from GPS, 2.) joint testing of methods for digitizing and above all 3.) joint testing of differences in results originating from the use of different datums in GPS, in download software, in transfer formats and in GIS.

6. Experience and findings

6.1. General impressions

The general impression of the cartographic section at INE is that it is very well kept. The material is well taken care of. As far as existing installations permits everything is well organized, this to say that with enhanced possibilities the organization of data can be expected to improve further.

The skills of the staff are good for Mozambican circumstances and there are all reasons to believe that courses for further education should be well worth the effort. There is already an ongoing internal improvement of working manners and a production of manuals for this. The understanding of new technology is generally high but there is a need for further education in GIS and details on some specific methods to be used with this kind of data.
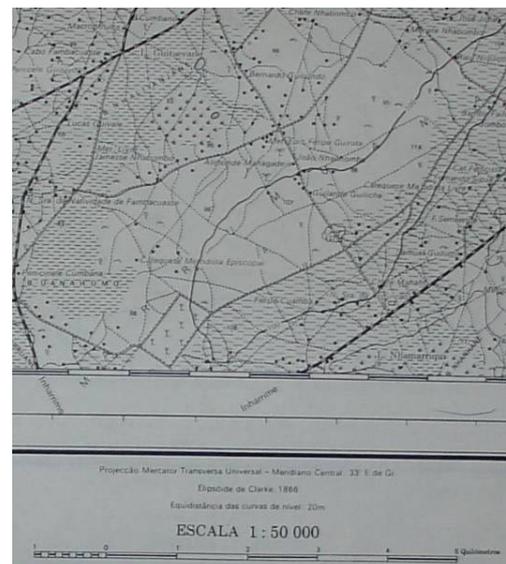
6.2. *Available background maps*

6.2.1. **Rural areas**

6.2.1.1. Printed maps

The most useful maps for the rural areas are the topographic maps with the 1: 50 000 scale, they cover almost the whole country, only lacking a small area in the north. Unfortunately the most of the 1: 50 000 maps are quite old, most of them are produced from 1958 to 1971. Since a great deal of the peasants use the technique of burn-beating the smaller villages/settlements have moved a number of times since the map was produced.

 For a complete coverage of the country you must turn to the 1:250 000 scale which is much to small to serve as a good background for the Enumeration Areas.

6.2.1.2. Digital maps

More orthodox GIS experts would use the words Spatial databases or Databases with geographic information but in this text this is referred to as Digital maps.

The printed topographic maps (1:50 000) are available as scanned images, INE has acquired all sheets available. Apart from these scanned images of old topographic maps there are some vectorised layers from the same maps. These vectorised layers e.g. roads, rivers, administrative boundaries are updated by a project that used satellite images and some field checks during the late 1990:ies. This same project also added information about the type and the use of the land. Unfortunately there are some problem with the datum used on these layers. During the consultancy INE and DINAGECA came agreed to investigate this further. It is possibly due to the difference between the datum Tete on the scanned maps and the WGS84 used on the vectorised layers. More on the solution of this in the section Map Datum

More about the background maps can be found in the annexed list Mapas_de_mocambique.xls and the document Mapas na Dinageca.doc and on the DINAGECA homepage www.dinageca.gov.mz .

Satellite image with overlay of vector features

6.2.1.3. Satellite images

There are Satellite images available in the country, handled by CENACARTA.

Landsat - 20 m pixels

```
        Cores          ....?... USD/km²,
        Preto e branco ....?... USD/km²,
        Infravermelho ....?... USD/km²,
Spot – 10 m pixels
        Cores          ....?... USD/km²,
        Infravermelho ....?... USD/km²,
Spot – 2,5 m pixels
        Preto e branco ....?... USD/km²,
Ikonos – 1 m pixels
        Cores          ....?... USD/km²,
        Preto e branco ....?... USD/km²,
        Infravermelho ....?... USD/km²,
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As the time did not admit to achieve the actual prices in Mozambique I can only give an estimation funded on the prices in Sweden. With specially treated images from the Spot satellite you can purchase images in color with a resolution of 2,5 m pixels to accost of approximately 10 000 Euro for an area of 60 x 60 km (ca 27 km²).

6.2.2. Urban areas

6.2.2.1. Printed maps

There are some printed maps of Maputo and some of the other cities. The most thorough printed maps of Maputo are done by the "Celula de Enderecamento".

6.2.3. Aerial photography's

Aerial photography's are to be found at DINAGECA. Unfortunately most of the aerial

photography's are obsolete. The Niassa province and parts of the Cabo Delgado province are covered by recent aerial photography's

6.2.3.1. Digital maps

In the large scale area there is only one digital production of maps available. The project "5 cities – rapid mapping" made maps of Maputo, Beira, Nampula, Pemba and Quilemane in the 1:25 000, 1:10 000, 1:5 000 and 1:2 000 (the last only for Maputo) scales. Those maps are based on aerial photographies from 1996.

6.2.4. Available census maps

The work for the 1997 census was done in a considerably thorough way but there where areas that where difficult to access why there are uncertainties in the material. The pre-census mapping was made from 1994 up to the 1997 census.

6.2.4.1. Rural areas

The delimitation was mainly done on top of 1:50 000 scale maps. The investigator took a copy of the topographic map to the field and designed the limits directly on top of this. Sometimes there was made sketch maps on special millimetre squared papers. Normally there is also a written description accompanying the field map.

After the capturing of the situation in the field the limits was transferred to other copies of the 1:50 000 maps, this was done in the office based on the information from the field. The transfer of limits to new maps was normally made by the same staff that had made the field study which means that the designer had a good knowledge of the actual situation on the ground.

6.2.4.2. Urban areas

In the urban areas there was normally a sketch map produced in the scale 1: 5 000. The final sketch map was produced in the office. The capturing of data was mainly made by GPS why there are a lot of points with coordinates of good quality.

6.3. Field work

For the 1997 census most of the cartographic material was made without GPS but today the GPS is almost considered indispensable. The staff is already familiar with the use of hand-held single frequency GPS receivers. There are a number of Garmin12 at INE which is a very adequate model for this kind of work. So far the

gathering of data in the field has been done by capturing a waypoint in the GPS and at the same time making a note on a paper, a specially prepared form where attributes and coordinates are filled in and also store the waypoint in the GPS with a specific symbol. The 16 different symbols available in the Garmin12 are used to define different features e.g. symbol 1 describes a "posto de saude com maternidade", symbol 2 describes a "escola secundaria e pre-universitária" etc. This has proved functional but implies some unnecessary risks. When noting the coordinates there are three risks, the datum can be wrongly set, the numbers can accidentally be wrongly written and the numbers can be misinterpreted when introduced in the computer. These risks are eliminated if the data are downloaded via cable to the computer, instead of entered from the written form. Unfortunately there are not enough facilities in the Garmin12 to store enough data about the attributes. So far the form must prevail but only to keep the attributes, the coordinates should be kept in the GPS. The Garmin12 is a very robust GPS and the internal memory is not affected by, for example loss of power.

During the consultancy a new software was introduced, the GPSU. The main reason for this choice is that GPSU allows download (and upload) from a number of different GPS, it can be set to use a number of different datum and coordinate presentations and it is the only software, so far, that includes the datum Tete which is the datum used on the topographic maps.

6.4. Organisation of available data

6.4.1. Physical organisation of maps and paper files

Today the maps and field data papers are kept together which is very good and highly recommendable. The largest problem with the old field data is that it is very difficult to find the map and data sheets of a specific area. There is need for an organised storage of these valuable data. For storage there is need for special shelters.

Once all maps are produced by digital technology there will be no more need to keep the original topographic maps (from DINAGECA) stored in the hang cabinets where they are found today. It can then be discussed to free these cabinets to be used for other purposes.

6.4.2. Database for computerized organisation of maps

Discussions have been held with the Head of Department on different possible solutions. The conclusions so far, is that it is advisable to start with a rather simple database running on Microsoft Access, this can then at any time be transferred to another platform e.g. SQL Server or Oracle. The time given for this consultancy did not allow the development of a database solution.

It is suggested that Mr. Adriano, Head of Department is the counterpart in a development of a database where the other part is a consultant working on distance via e-mail. Details are to be decided upon.

7. Conclusions and recommendations

7.1. To be done at the cartographic department

During the nearest future the following tasks ought to be fulfilled in order to produce the best possible base maps for the census field work and the following presentation of the census data.

- Introduce numeric data about the Enumeration Areas and other objects.
- Scan all maps from the last census.
- Georeference the scanned maps.
- Digitize (vectorize) the relevant information from the scanned maps.
- Digitize (vectorize) on the digitizing table, relevant information from the maps that were not possible to scan.
- Find limits for Enumeration Areas by field work, where earlier limits were uncertain or needed to be changed.
- Produce Enumeration Area maps for the census field work.
- Produce Enumeration Area maps for the presentation of census data.

Numeric data. Where numeric data is available they give a higher geometric accuracy than digitizing the same features from paper maps. The best accuracy and the most reliable data is obtained where the numeric data can be downloaded directly from a GPS (since that avoids errors caused by misinterpretation of protocols and errors caused by erroneous mapdatums). For details on downloading data from GPS se the document Uso do GPS Garmin 12XL para capturar dados.doc . The secondly best quality is obtained by entering data from field notes.

Scanning. All maps, with information about the Enumeration Areas used in the 1997 census, that have a reasonably clean picture must be scanned as soon as possible. One specific person should be dedicated to this work. The scanning should not occupy more than one month if done intensively. Details on how to go about is found further down in the section Scanning. Technical details about the maintenance of the large format Calcomp scanner is found in the document Scan com Calcomp Scanplus III-A0.doc .

Georeference all scanned maps. When georeferencing the maps it is important to have a close cooperation with the producer of the base maps i.e. DINAGECA as these questions are under investigation. At the moment the georeferencing method that gives the best result is described in the document Georeferenciação em MapInfo e ArcView.doc .

Vectorizing. The staff at the cartographic department must of course continue with the work that is already running but now include the use of scanner and digitizing table. The methods to use are described below in the section Transfer of limits to digital format, and more thoroughly in the document Digitalizar as Areas de Enumeração.doc . This transfer of the limits of Enumeration Areas from the earlier census will probably occupy the whole department for a long time. If prioritized and given special attention i.e. specific remuneration, it could be speeded up and concluded within the running year.

Those maps that are not possible to scan, due to size or a too blurry picture, must be specially marked and put aside for easy access for the person(s) working with the digitizing table(s)..

Education. Besides investigations and development within the institution it should be useful for the staff to attend courses on GIS, digital cartography, field work with GPS etc. Such courses might be possible to find outside INE or they could be arranged by consultants visiting INE. The curriculum for such a course should benefit from inputs both from the INE staff and experts outside INE.

Background maps for production of new field maps. The work to check alternative backdrops for the Enumeration Area maps should begin immediately.

7.2.   Future consultancies

It is hereby proposed the following consultancies in order of importance:

- Map datum. For details see further down under the headline Map Datum.
- Course in GIS for all staff, see further down under Human resource development.
- Database for "Mapoteca" as a joint development project between head of department and a consult on distance, see above under headline Database for computerized organisation of maps.
- General consultancy on mapping. In order to check the development that the cartographic department will run and the outcome of the "e-mail" consultancies proposed, it should be useful to have a follow-up. For this it is proposed that a consultancy similar to the actual is conducted after approximately six (6) months from now.
- GPS modernization, see further down under GPS Future purchase.

In the following chapters are presented some of the recommendations that were made during the consultancy. Apart from this there are still other cartographic questions to be resolved at INE. Most of the questions and problems can be resolved by the skilled staff but in some questions it will be necessary to consult experts outside INE, as proposed, this can to some extent be done via e-mail.

7.3.   General viewpoint on Areas, lines and points for GIS

For the future use as a GIS material it is necessary that all objects that have an area on the ground should be represented by an area. By using area as feature type for Enumeration Areas it is easy to add and illustrate attributes in a correct way. Lines (polylines) can be used to illustrate long and thin features like rivers and roads. Points should be used to

illustrate features that, in comparison to the scales to be used, have a very small coverage like houses, trees, wells etc.

All relevant attributes should be attached to the features and non relevant attributes should be left out. As actualisation is a cumbersome task the number of attributes should be kept at a minimum. Mostly it is enough to have the identification of the geographic object by a name or number and then attach all other information only when asked for. This is when other information are catered for by other institutions or other entities at INE, hence they will be kept with the responsibility to update their data and the cartographic section will only have the responsibility for the geographic objects.

7.4. Transfer of existing limits to digital format

There are two possible ways to make the division digital – either by finding the old limits or by producing new limits. For statistical reasons the "recycling" of the old delimitation is normally to prefer. In the work of transferring the limits of the Enumeration Areas to a digital format the recommendation is to use the different technologies in the following order.

1. If there are coordinate in numeric form, written on paper or downloaded from GPS to a file those should be used according to what is written under the title When GPS coordinates are available. Coordinates in numbers gives the best accuracy of the possible methods.

2. Scanning. Details about the scanning procedure can be found in the document Scan com Calcomp Scanplus III-A0.doc.In most cases scanning is to prefer before the use of the digitizing table. Once the maps are scanned the images can be processed in a number of computers, the limiting factor being only the number of computers with GIS software and the number of technicians with the right skills

3. Digitizing table. In some cases it is difficult to use the scanner, e.g. the sheet is too big for the scanner or the information is too blurry to be distinguished in a picture on screen. As the available scanner only gives black and white pictures, coloured originals sometimes are faster and easier to digitize on the table.

7.4.1.   When GPS coordinates are available

When GPS has been used and lists of coordinates exists, the following two alternative techniques is proposed.

Alternative 1.

- Check that you have both the sketch map and the field data from the GPS.
- Introduce the coordinates in an Excel sheet with columns for ID, X and Y.
- Open the Excel sheet in MapInfo
- Make objects from the coordinates in the columns

Alternative 2.

- Digitize symbols, roughly where the corners of the area should fall.
- Double click on the symbols, one at the time.
- Alter the coordinates on the corners according to the written data (from the GPS).
- Draw an area with the symbols as corners using the snap function.
- Check that the new profile of the area corresponds with the sketch map, if not start fault-detecting.

7.4.2.   Scanning

7.4.2.1.   Maps with known coordinates

By scanning the copies of, for example, the topographic maps where the Enumeration Areas are designed you can get a picture with both the area limits and coordinate ticks, by doing the following:

- See to that the lines representing the limits of the Enumeration Areas are well visible, if necessary fill in the lines.
- If you can use the limits of the sheet for geo-referencing that is ok.
- If you can not use the limits of the sheet for geo-referencing. Use a ruler and a pencil to make coordinate ticks in the map and write the applicable coordinates directly on the map to be seen in the scanned image.
- Scan the map.
- Open the scanned image in the GIS software.

- Geo reference the map by the ticked points.
- Where the Enumeration Area completely falls within the limits of the map – design an area feature that coincide with the EA.
- Where the EA falls on more than one map - design a line feature on top of the area limits that are visible in the map.
- Construct area features by joining line features that surround an Enumeration Area.
- Fill in the identification of the area in the table that is attached to the area layer.
- When one EA is a completed area feature that should be used as a mould for the neighbouring areas in order to

7.4.2.2.   Maps without coordinates

Where there are designed maps without coordinate ticks and no available list of coordinates on objects in the map the problem is to find ways to geo-reference the map. The work must start with a search for possible sources of coordinates.

- Start to check if there exist some field data that might have coordinates on objects that are visible on the map.
- Secondly check if there are other maps of the same area that have coordinates in some form. This could for example be maps covering a greater area where this map can be referenced with features (roads, houses etc) that occur in both maps.
    - In this case the map with known coordinates is geo-referenced in the GIS software,
    - then the coordinates of the common objects/features are noted
    - and finally the other map is geo-referenced using the coordinates of the common features.
- Thirdly go to the field with a GPS and capture coordinates of some features that are visible on the map.

In the third case, using GPS, you must be careful not to take to few points.

7.4.3.   Digitizing table

7.4.3.1.   Maps with known coordinates

Where coordinate ticks/marks are found on the map the work is done in the following manner:

In rural areas the lines of the Enumeration Areas are normally drawn on the topographic maps which can be digitized on a digitizing table. As those maps have coordinate marks the work contains the following steps.

- Fixate the map on the table.
- Georeference by pointing at known points and insert the coordinate numbers in the software.

- Pick points along the lines to be digitized. More details on this work is to be found in the annexed paper Digitalisação em MapInfo.doc .

The time needed to set up and digitize one topographic map with a normal content of areas to be digitized was approximately 20 minutes during the tests. The physical work with the digitizing is not very time consuming but the investigation on what limits to use etc can take hours why it is difficult to calculate the total time needed to complete this work. Only after weeks of continuous work it will be possible to get a good estimation of the mean time needed per sheet. There are 1207 sheets of the 1:50 000 topographic map. The estimated time needed for digitizing all sheets varies from some months to two years with one person.

For maps covering urban areas the work on the table is very much the same as with the topographic maps, in the cases where there are coordinates on the map to use. In a number of cases there are no coordinate grid on the sketch map from the urban areas. In those cases the coordinates for the referenciation has to be found in some other way:

7.4.3.2. Five cities

In the areas covered by the digital maps from the project "Five cities – rapid mapping" the following technique can be used.

- Start the software (e.g. MapInfo or ArcView) with the "five cities" maps visible.
- Fixate the sketch map on the table.
- Georeference the sketch map by picking points that are visible both in the computer and on the sketch map.
- Digitize the lines of interest.

As always, try to pick points well spread over the map and as far out as possible in order to minimize the reference error.

7.4.3.3. Without known coordinates

In the cases where there are sketch maps without GPS coordinates the work must start with a search for possible sources of coordinates.

- Start to check if there exist some field data that might have coordinates on features that are visible on the map.
- Secondly check if there are other maps of the same area that have coordinates in some form. This could for example be maps covering a greater area where this map can be referenced with features (roads, houses etc) that occur in both maps. In this case the map with known coordinates is fixed to the table and geo-referenced, then the other map is fixed on the right place on top of the other map, using the common features as fix points.
- Thirdly go to the field with a GPS and capture coordinates of some features that are visible on the map.

In the third case, using GPS, you must pick enough points to reference the map. The more features the more quality checks of the sketch map. The least number necessary is three but it is advisable to pick at least five points. If the memory of the GPS is big enough to store track data until downloading to a computer, this can be used to capture line features. Especially roads are easily captured by using the tracking facility and easy to use for referencing by road crossings etc.

7.5. *New limits*

Recycling of old limits are normally to prefer but there are situations where new delimitations are to prefer. When for example the migration has been significant or the old limits are uncertain.

In the cases where it is found best to produce a new delimitation of the Enumeration Areas, this can be done in various ways. Normally this is done by a manual field survey. In some cases, when for example the migration has been significant and there are no accurate and updated background maps, it might be most efficient to pinpoint every household with GPS coordinates. Especially in vast, sparsely populated areas where it can be difficult to get an good overview the points on the map will give a better ground for decision.
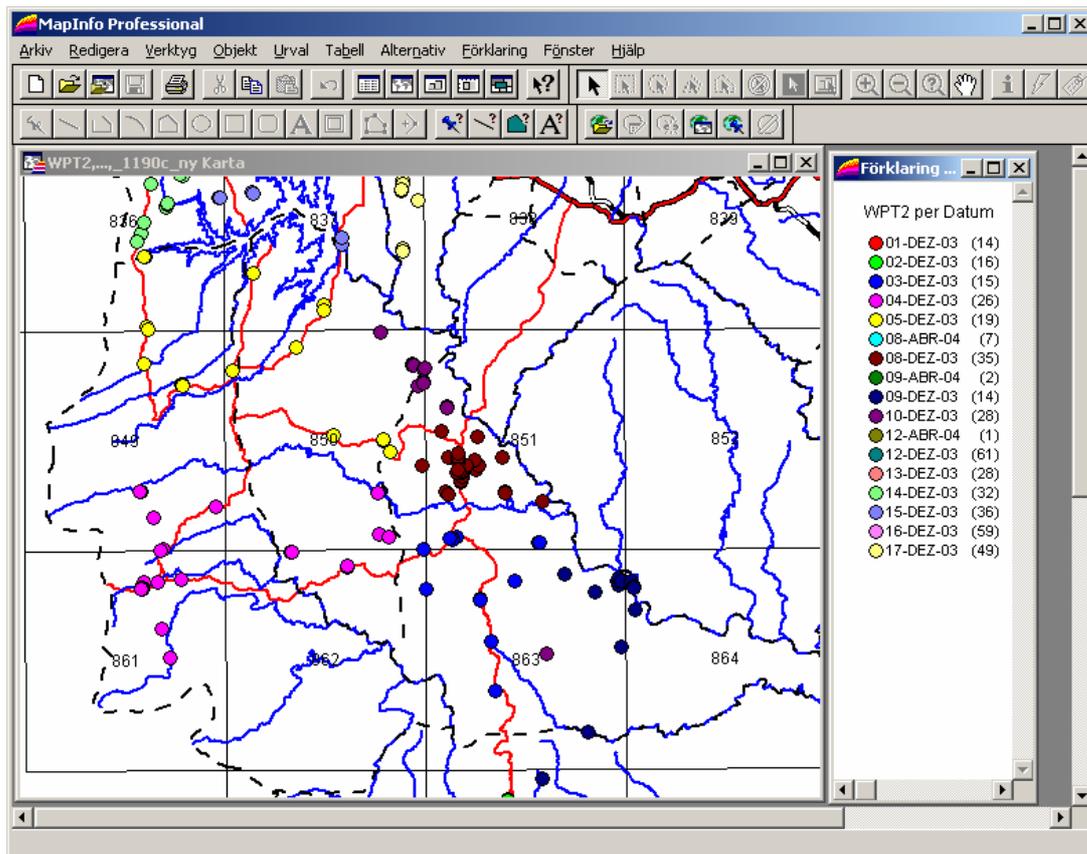
**Example on use of GPS data to define area extents.**

The technique to use for pinpointing every household is suggested as follows. The cartographer must visit every household. Once in front of the house he/she makes a mark in the GPS and moves on to the next house. By this there will be one geographically distinguished point for every household. When mapping some other kind of feature e.g. a school, a church, a rivercrossing etc then he should note the number of that specific mark and use the specific symbol in the GPS for that kind of feature.

7.6. Map Datum

One of the most important conclusions from this consultancy is that it is extremely important to take the map datum (=coordinate system) into consideration when working with maps in Mozambique.

So far we have learnt a way to handle the data from the GPS and we know that the design of new objects should be based on 1.) field data and if that is not available 2.) the image of the 1:50 000 maps. Now is the time to resolve the problem with the discrepancies between the scanned topographic maps and other maps.

The old topographic maps that are used as a background for the major part of enumeration area illustrations, are made with a datum called Tete. When using GPS the coordinates are received in the datum WGS84. Transformation of coordinates from one datum to another can be done but it is always important to be aware of this situation and the influences that different datums have. A description of how to transfer the GPS coordinates to the map is given in the document Datum a usar no trabalho com GPS.doc.

Illustration on discrepancies when superimposing the same road using different datums
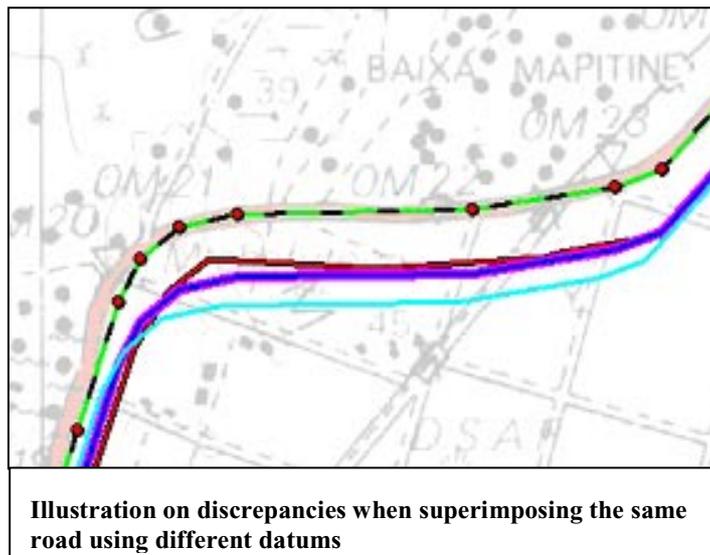
The available datum settings in the GIS softwares MapInfo and ArcView does not include the Mozambican "Tete" datum hence the data received in a GPS is approximately 30m beside the object on the topographic map (in the best of cases). On the actual paper map with 1:50 000 scale this means less than a millimetre but when the map is scanned and used in a GIS this is considerable.

A recommendation is to calculate and insert the parameters for the Tete datum in the GIS softwares. This can be done as a consultancy on distance, it does not have to be done "*in situ*", the results can be delivered via e-mail. This should be done as fast as possible. The proposal is to contract a consultant immediately to make a study and propose a solution within a month.

7.7. Field work and field equipment

7.7.1. GPS

7.7.1.1. Use of current GPS.

When using the current model of GPS, Garmin12, it is recommended that identification (number or name) and attributes continues to be noted on the special form but without noting the coordinates. The coordinates are captured by using the "MARK" feature on the GPS and later downloaded from the GPS to a computer. With this method it is even more important than before that the identification is noted correctly, the id-numbers must not be switched. Besides the form it is important to make a rough sketch containing the id given in the GPS, and lines that will serve as a help to design the limits when the waypoints from the GPS are downloaded and plotted.

The Garmin12 is a very robust GPS that for example withstands up to 3 meters of water and never drops information that is stored in the internal memory (unless deleted). The only restraints is that the memory has a limit of 500 waypoints and they consume a set of batteries in one or a couple of days. When more than 500 points are to be surveyed this implies that there is access to a computer with relevant software, a cable for download and sufficient number of batteries. Access to one computer per province should be enough.

For the download of data from GPS to computer it is suggested that the software GPSU is purchased. The cost is 40 USD (or 40 Euro) per license and the only way to buy is through Internet at http://www.gpsu.co.uk . There is a freeware version but that has restrictions in the number of points you can download (100 waypoints, 500 trackpoints and 5 routes) why I suggest that at least one license is bought. The software is small, in zipped format it fits on one diskette and it is easy to install. The downloaded files are also small, typically under 100 kb why transportation of data is a minor problem. It has to be stressed that diskettes are vulnerable to various errors, when e-mail is available that is normally a safer way to transport data.

The settings in the GPSU and in the GIS softwares (MapInfo or ArcView) are noted at the last page in the document Datum a usar no trabalho com GPS.doc.

7.7.1.2. Future purchase

When planning purchase of new GPS the market should be checked at the moment of purchase. The GPS equipment is due to a rapid development. At the moment there exist a number of GPS receivers with attribute facilities (where you can add attribute data to the captured point already in the field). When choosing GPS there are a number of details to take into consideration, e.g. storage capacity, WAAS ability (for better precision), visibility of screen in sunlight, battery capacity, ease of use, support etc. For best result it is recommended that this market survey/evaluation is done jointly between the head of department and a consultant. This can be done via e-mail.

7.8. Office equipment

For the **storage of scanned images** it will be necessary to increase the hard-disc space. As soon as the scanning of images starts in a larger number it is advisable to either purchase a new file server or add a new hard disc to an existing server, at least 160 Gb will be needed.

For the **storage of paper maps** there is need for more cabinets for the large format maps that was used in the field either hang-cabinets or, alternatively they can continue to be stored in rolls. Maps that are already rolled sometimes have a tendency to break if forced to a flat storage why a continuous rolling is preferable. To keep a better order and to get an easier access to the rolled maps a special roll cabinet should be purchased, see illustration.
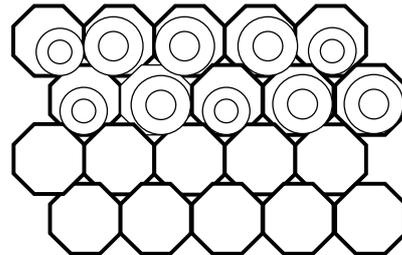
The A4 format paper files that accompany the field maps could preferably be stored in book-shelf files.

Once digitised, this material will not be used but it should be retained as a backup and historical archive. When for example the data for one entire Province is digitized those paper maps and files could be moved to another room, a storage room. As both ink and paper deteriorate faster in sunlight the storage should preferably be done in a room without windows.

7.8.1.1. Software

For the download of data from GPS to computer it is suggested that the software **GPSU** is purchased. More details are found under the headline Use of current GPS.

As far as I know there is no representative of MapInfo in Maputo, this should be checked. There is a representative of ESRI (ArcView / ArcGIS) in Maputo that gives courses and a good support why a change in software can be taken into consideration. In my personal opinion MapInfo still has advantages as it has more facilities in making thematic maps, 3D maps etc.

If Oracle Spatial will be used for storage of geographic data at INE it has to be taken into consideration that MapInfo among almost all other GIS software stores and reads data directly to/from Oracle Spatial and the ESRI products does not.

For the continuous work at the cartographic department my suggestion is to buy the **latest version of MapInfo**. Among a number of smaller changes the version 7.5 has one great advantage in comparison to older versions. When you are producing a final layout for printing on paper or as a file you have much more control over the graphic result and above all a much easier way to control map scales. The facility of directly opening shape files is also time saving and eases the work at the department.

Another facility that should be tested is the WMS map technology, more on this under the headline .

7.8.1.2.   Hardware

To make the best use of the excellent plotter, HP 2500CP, it is advisable to supply it with the **special ink** that is resistant against UV rays, **HP Designjet CP UV Ink Cartridges**. With that ink the colours on the plotted images will last for years, even when exposed for sunlight.

When testing the different workstations at the cartographic section many had problem with the mouse. As the climate brings more dust and sand in the air than in Europe the mechanical parts of any equipment is destroyed much faster in this environment. For this reason I suggest that generally the mechanical mouses with roller ball are changed for **optic mouses**.

7.9.   Human resource development

The overall level of the staff at the cartographic department is good. As the technical development in the field of GIS and mapping is rapid there is however always a need for education to stay up to date with what the equipment can do for you and what solution to choose. As already stated the evolution of technical equipment is fast, it is not always necessary to have the latest equipment but it is necessary to have notions about the development and being aware of not entering into technology that is about to be obsolete.

To make the best use of existing equipment and software, special courses for further training in GIS should be useful. The best way to arrange such an education should of course be to arrange courses *in situ*. The course(s) should be adapted to the real needs for the job to be done.

Study visits to similar institutions in neighbouring countries are recommended.

In order to rapidly overcome minor computer related problems it is suggested that one person in the department is indicated as the computer expert of the department and that he/she is given extra training or education in the IT field.

7.10. Coordination / cooperation with others

7.10.1.   Sharing of costs for field work

There are a number of other organisations that also could benefit from the mapping that INE is carrying out, most obviously MAE and DINAGECA. Hopefully the already started discussions can lead to a joint planning and use of the field work that INE and the other institutions already are doing.

7.10.2. Data sharing

At the meeting that was held with DINAGECA future cooperation was discussed. DINAGECA presented a plan where they seemingly want to be the hub in an information network. They presented an investment in a sophisticated database solution that is planned to have the capacity to store data from a number of institutions. Before entering in detailed discussions about transfer of data to and from the DINAGECA database I would suggest to check the possibilities to use WMS technology. With WMS the data stays by its producer, you only distribute the possibility to look at your data and combine them with other data. The WMS technology is based on live communication via the Internet why it is essential that the communication via Internet is fast and reliable. If this is viable with existing Internet facilities it would make the actualisation of data much easier.

This same Friday, the 23 of April 2004, DINAGECA will officially present their plans on an information hub. In the planning and implementation of this there has been a group of six (6) technicians from different part of the State Administration this group is named "Comité Geográfico". There are no representatives from INE in that group, so far. It is suggested that INE start lobbying to get a representative in the committee.

7.10.3. Cost sharing in purchase of new map data

In the planning for the production of field maps for the census staff, satellite images or sometimes even aerial photographs must be considered as a possible way to get updated backdrops to the Enumeration Areas. Most of the available maps, both for urban and rural areas, are obsolete. Since the time when the now available maps where produced the settlement structures has changed substantially. When considering purchase of satellite images a close cooperation with other state- or private agencies should be pondered as a way to cut costs by sharing.