GPS_DAO – APPLICATION TO USE GPS FOR TOPOGRAPHIC AND CADASTRAL PLANS

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INTRODUCTION

The Global Positioning System (GPS) was developed by the U.S.D.O.D, United States Department Of Defense, to support military applications (Logsdon 1992). But recently, the civilian users stretch the limits of this technology and they explore its suitability for civil applications. Some of the nonmilitary uses of GPS can be listed below:
  – hydrographic surveys,
  – geodetic network densification,
  – crustal deformation monitoring
  – civil engineering,
  – cadastral surveying … etc.

Civilian users, surveyors in particular, have known that GPS can replace conventional surveys employing a theodolite and level or a total station because this technology that has been extended and used in various fields measures geographical coordinates, velocity and time with astonishing speed and accuracy. Its effects in research field become also important.

The use of GPS technique in land surveying proved a great efficiency and permitted to accelerate data acquisition and maintained the accuracy needed for topographic plans. The aim of this study is to conceive a new methodology to set up, automatically, topographic and cadastral plans from survey data files obtained with GPS method.

Within the section of topography, at the IAV Hassan II Institute, after purchasing an Ashtech Z-surveyor GPS, we conducted a research designed to develop software for setting up topographic and cadastral plans by using this new technology.

The application so called GPS_DAO, developed within section of topography includes three important tasks:
  – Conceiving of an efficient methodology for land surveying by GPS,
  – Import of co-ordinate files resulting from post processing by GPS software (WinPrism) in order to codify and arrange observed points.
  – Automatic drawing of topographic and cadastral plans in AutoCAD environment

The principal hardware and software packages used in developing this application and the adopted methodology for the proposed scheme will be described in this paper. The results of GPS_DAO application will also be discussed.

PRINCIPAL HARDWARE

The most important decision that surveyor has to make is to choose the right survey software. But, he must initially choose the suitable hardware causing changes in the way

he works. For that raison, it's necessary to present in the first time the hardware components.

The first hardware party used in this research is the Z-surveyor GPS receivers and their antennas. This system supports collection and post processing of static, rapid static, and kinematics data. It uses twelve channels for Coarse/Acquisition, code phase, and carrier phase measurements on the L1, and precise (P) code phase and carrier phase measurement on L1 and L2 bands (Ashtech, 1998). The receiver operates as a reference or over station. The amount of data that can be stored in the Z-surveyor depends on the internal PCMCIA card (from 2Mb to 85M). The second party is the computer with these recommended characteristics:
  – Operating system: Windows 95/98,
  – Processor: Pentium II,
  – RAM: 32 Megabytes,
  – Free disk: 500 Megabytes so as to install all software,
  – Graphics card: SVGA,
  – Mouse: Microsoft or compatible.

SOFTWARE PACKAGES

In order to, effectively, explore the presented hardware, we have to choose the suitable and require software. On the way, we used WinPrism, an Ashtech GPS survey software, that allows us planning and processing collected data by GPS and Glonass-GPS receivers (Ashtech, 1998). This software uses a system of different interface packages fully compatible, enabling us to handle in a softly manner its modules (figure 1): Planning, Transfer, Process, Database, Setup, Adjust, CAD, and Tools.

PLANNING	TRANSFER	PROCESS
DATABASE	PRISME	SETUP
ADJUST	CAD	TOOLS

Figure 1: WinPrism modules

Each module can be described bellow:
– **PLANNING**: this module lets us graphically view satellite availability for a desired date and time. Its helps us to plan surveys for optimum satellite periods.
– **TRANSFER**: it used for downloading data files stored in a receiver.
– **PROCESS**: lets us process survey data files obtained from receivers after using transfer.
– **SETUP**: to configure specific parameters (directories, printers, ..etc.).
– **ADJUST**: it is a network adjustment package.

- **CAD & DATABASE**: these modules are available as options. The CAD module allows us to manipulate the processed data files so as to produce CAD drawings. The second module is used for string all our GPS observation.
- **TOOLS**: to convert time system, edit receiver data files, create printed barcodes and convert data in RINEX format.

Other software components used in this study are AutoCAD drawing environment and Visual Basic. AutoCAD program is adopted for design process so as to establish topographic and cadastral plans. Every one, is familiar with engineering design procedures inside AutoCAD system, for this reason we incorporate it in our application. In addition if we want to make our job faster and easier with AutoCAD, we have to use another professional programming tool, Visual Basic, for creating and maintaining the calculating and processing modules of GPS_DAO.

THE METHODOLOGY

Applying GPS technology to setting up topographic and cadastral plans in Morocco is of a great importance for private and public surveyors. Their major purpose is to take advantage of the increase of technology. In addition the conventional measurement, user friendly methods, often have significant problems. Therefore, we proposed a new methodology for GPS surveying to overcome some difficulties of conventional approach. More efficiency can be achieved if we deal with the following steps.

OBSERVING SCHEDULE

Reconnaissance

In the first time we must use a topographic map at 1/50.000 scale (case of Morocco) in order to plot all potential control geodetic points that exist on the area to be surveyed. This map also provides a wide variety of required information like: location of power lines, boundaries, roads and buildings. Secondly, a preliminary visit to the site of survey is necessary and recommended. Then general information about topography of area and density of area features can be obtained. After these two stages, we must make sketches of details to survey including name of parcels, name of roads and name of natural limits.

Planning mission

All GPS receivers require free sight to the satellite and four satellites at least must be above an observer's horizon. Then we have some conditions we have to become aware of to determine a good observing mission by using the planning software GPS (Sickle, 1996).
- The reference station must be placed in an area without obstructions and each receiver must be in contact continuously to at least four satellites.
- The satellite geometry has to be good, this is indicated by PDOP (Position Dilution Of Precision) which it must be low than five.
- The representation in the graphic forms for different area in a given day the number of visible satellites, the time of appearance and disappearance of each one.

Observing mission

Choosing the right GPS positioning method for a particular survey application is very interesting. It depends on the accuracy the user needs. This part is intended to offer some general guidelines that are used in our methodology.

– **Initialization**: before the survey begins, we need to resolve the phase ambiguity and we process by initialization. There are at least two ways to accomplish this task. Firstly, we can use a baseline between two known points. Receivers occupy each station for a few minutes. Secondly, we can use another method called the antenna swap. It requires that the two receivers are active and collecting data from at least four satellites during the operation. One receiver occupies a control point while another receiver occupies the first known point of the survey. In a few minutes of observation we switch the receivers. After another few minutes we switched back the receivers to their original points (Leick, 1995). In our case of study, we used the first procedure. We placed one receiver in a control point (base station) with known co-ordinates and we placed the second receiver as a rover in the first point of survey.

– **Observing mode**: In order to facilitate the codification and arrangement of details, the user has the freedom to move from point to point through the area. He only must respect the same direction to complete survey when he observes two successive points of the same details. But the order of numerous is not interesting because each point has a code name depending on its nature. The figure 2 illustrates the senses of surveying during the collection of data.

– **Codification**: Before proceeding into the area to gather data, a model for codification is conceived and must be applied. This model helps us to automate design in AutoCAD environment. In the area to be surveyed, the user makes sketches of each detail (parcel, road, building, ..etc.) on paper including the appropriate code. If the user has the Huskey unit he can enter a specific code for each detail, otherwise he can enter all codes after importing collected data. In our approach, we identify three main categories of codification that are labeled: points (table 1.a), lines and area (table 1.b).

a. Code of points					
Code	**Descriptions**	**Code**	**Descriptions**	**Code**	**Descriptions**
AN	Antenna	FI	Fountain	PD	Panel
AR	Tree	KB	Dome	PG	Geodetic point
B	Boundary stone	LD	Double lamp	PH	Pylon high tension
BC	Manhole	LG	Left lamp	PL	Pylon
BL	Buoy	LR	Right lamp	PM	Pylon mean tension
BU	Land bushy	MT	Minaret	PR	Triangular panel
CA	Cactus	OL	Olive tree	PS	Traffic sign
CD	Candelabra	OR	Orange tree	PT	Telephone
CE	Water tower	PA	Palm tree	PU	Well
CN	Conifer	PB	Pylon low tension	RG	Look
EO	Windmill	PC	Point	RT	Telephone look
FE	Traffic light	PB	Pylon low tension	SE	Water source
FG	Fig tree	PC	Point	$T	Station

Table 1.a : List of code points

b. Code of lines and areas					
lines	**Descriptions**	**lines**	**Descriptions**	**Areas**	**Descriptions**
AX	Center line	MM	Common wall	BA	Building
BL	embankment	M	Wall	BC	Building block
CA	Talweg	PI	Track	BR	Brushwood
CB	Barbed fencing	RV	River	BV	Shanty town
CF	Railway	TR	Pavement	CI	Israelite cemetery
CG	Wire fencing			CM	Muslim cemetery
CH	Tree hedge			CS	Area of cactus
CL	Pipeline			CT	Christian cemetery
CT	Cactus line			CV	Cultivation
FA	Cliff			DM	Area of palm tree
HA	Tree line			FR	Wood
LE	Line tension			MJ	Marshland
LP	Boundary			PE	Area of stones
LT	Telephone line			VI	Vineyard

Table 1.b : List of code lines and areas

– **Organizing codification**: The user assigns for each detail a code indicating its physical nature. The letter (P) for punctual details, (L) for linear details and (Z) for zonal details must precede the code, so as to identify each detail and to distinguish between them. Once, the user has different linear or zonal details to survey he must add a number at the end of the each code. In addition, if the user wants to collect curved details, he has to allocate the letter (C1) in the beginning of the curve, (C2) in the middle and (C3) in the end of the curve. We can see these possibilities showed in the figure 2. For the points that are on the intersection of two or three details (linear or zonal) we affect to the same point all codes indicating each detail. The software arranges each detail with its code and stores it properly in the database (table 2).

Nature of details	Number	Code	Nature of details	Number	Code
Building (area1)	1	ZBA1	Pavement (line 2)	11	LTR2
Building (area1)	2	ZBA1	Pavement (line 2)	12	LTR2C1
Building (area1)	3	ZBA1	Pavement (line 2)	13	LTR2C2
Building (area1)	4	LTR1	Pavement (line 2)	14	LTR2C3
Building (area1)	5	AR	Pavement (line 2)	15	ZBA2
Pavement (line 1)	6	LTR1	Pavement (line 2)	16	ZBA2
Tree (point)	7	AR	Building (area2)	17	ZBA2
Pavement (line 1)	8	ZBA1	Building (area2)	18	ZBA2
Tree (point)	9	ZBA1	Building (area2)	19	LTR2
Pavement (line 1)	10	LTR1	Building (area2)	20	LTR2

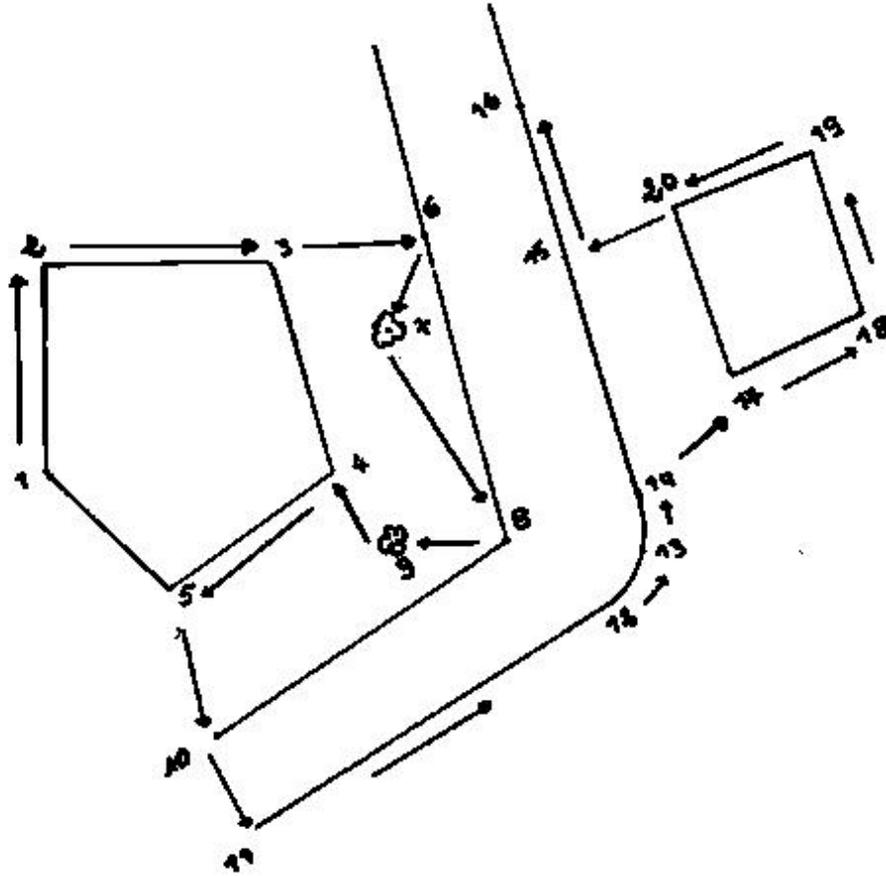**Table 2:** surveyed details with their codes

Figure 2: The approach to organize collecting data into the field or after downloading observations.

POST MISSION PROCESSING

Data processing

After collecting observations, we proceed by importing data files into WinPrism software, calculating the geographical co-ordinates of transferred data and computing local co-ordinates (figure 3).

Designing of topographical and cadastral plans

After data processing, we transfer ASCII files to the database and we begin the concept of designing topographical and cadastral plans. In the first step, we take care for the rules made by the Administration of land titling, cadastral mapping and cartography according to the specific standards adopted in Morocco for setting up any graphic or textual documents. In the second step, the huge amount of downloaded data must be arranged and checked. With the managed database we are able to establish suitable plans (figure 4).
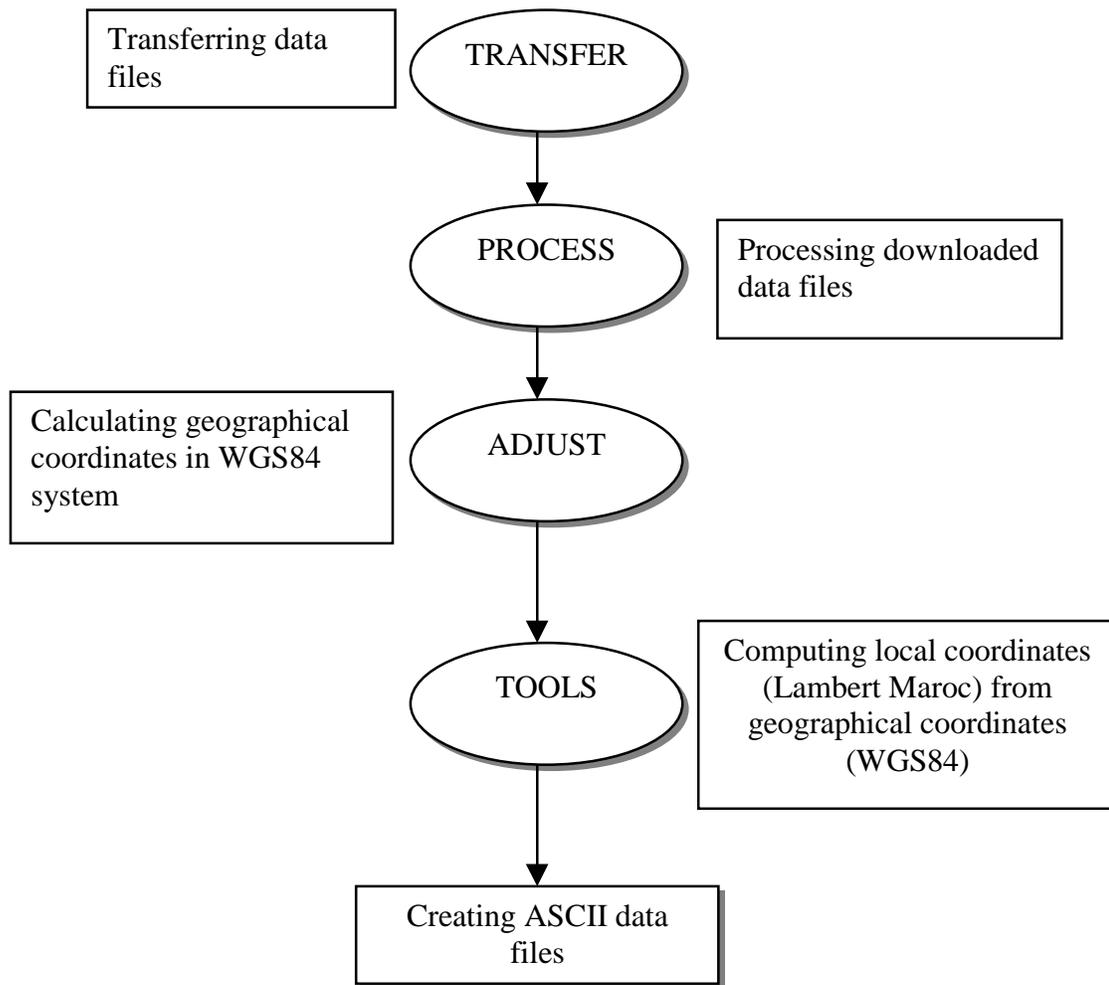
6

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┌─────────────────┐          ╭─────────────╮
│ Transferring data│          │  TRANSFER   │
│ files            │          ╰─────────────╯
└─────────────────┘                 │
                                     ▼
                            ╭─────────────╮    ┌──────────────────┐
                            │  PROCESS    │    │ Processing downloaded│
                            ╰─────────────╯    │ data files        │
                                     │          └──────────────────┘
                                     ▼
┌──────────────────┐        ╭─────────────╮
│ Calculating geographical│  │  ADJUST     │
│ coordinates in WGS84│     ╰─────────────╯
│ system           │                │
└──────────────────┘                ▼
                            ╭─────────────╮    ┌──────────────────┐
                            │  TOOLS      │    │ Computing local coordinates│
                            ╰─────────────╯    │ (Lambert Maroc) from│
                                     │          │ geographical coordinates│
                                     ▼          │ (WGS84)          │
                            ┌─────────────┐     └──────────────────┘
                            │ Creating ASCII data│
                            │ files       │
                            └─────────────┘
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Figure 3: flow chart of different stages to undertake data processing (WinPrism)
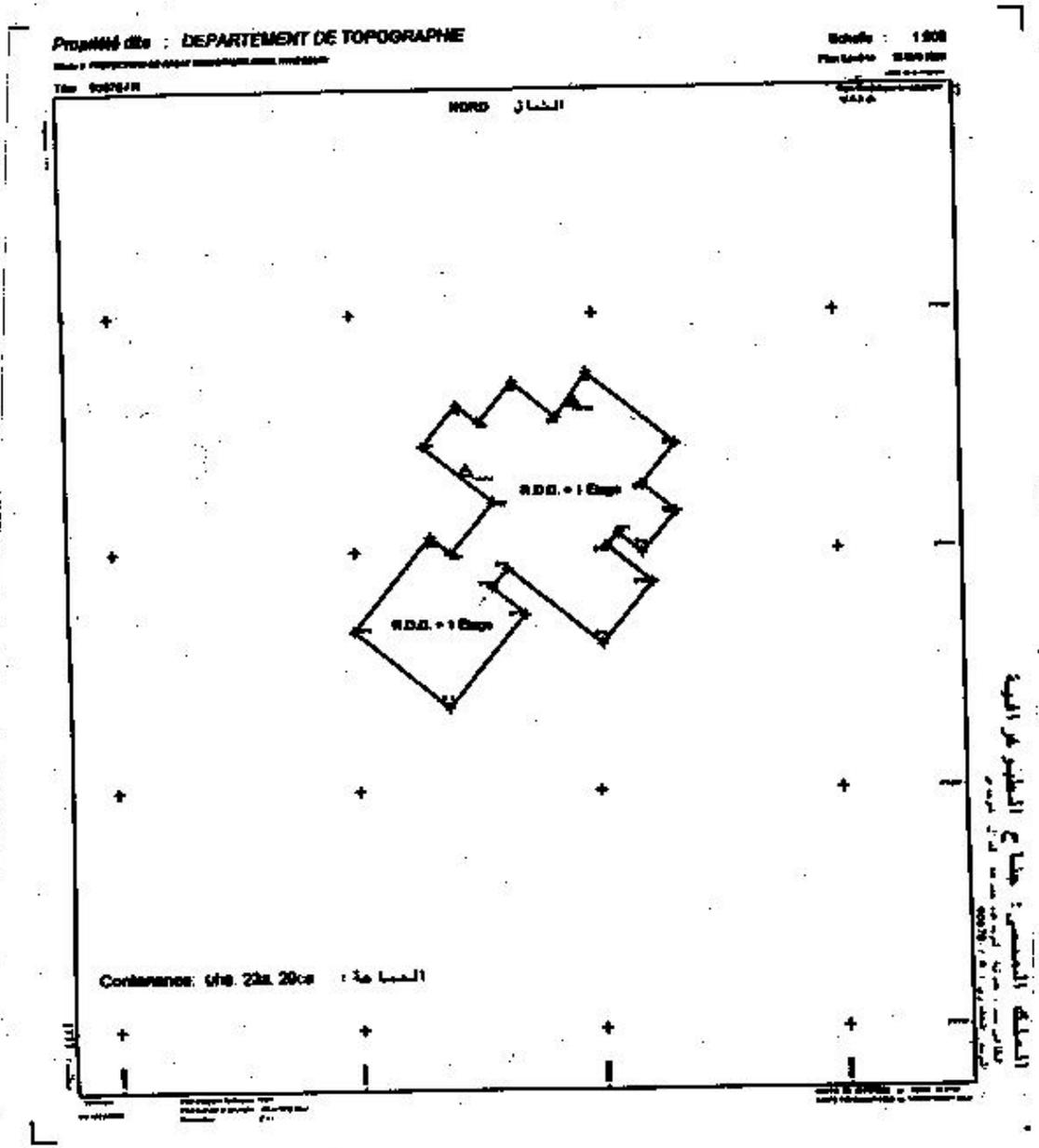
Figure 4: cadastral plan of department of topography

RESULTS OF CASE STUDIES

The developed application has been tested not only into our Institute's campus but also in the other fields so as to improve the suitability of the tool for different surfaces, shapes, and kinds of boundaries. Four sites have been chosen and the time of realization has been taken in consideration. The obtained results are in norms adopted in Morocco (10 cm for relative accuracy). The following table 3 shows us the past times to designing topographical or cadastral plans by the proposed tool.

Applications		Site 1	Site 2	Site 3	Site 4
Surfaces		0.2329ha	1ha	3.0495ha	57.5062ha
Amount of surveyed points		25	278	49	45
Time (min:minutes)	Reconnaissance	10 min	1h	15min	-
	Planing mission	20 min	4h	30min	-
	Observing mission	5 min	15 min	5min	-
	Post processing	5 min	40min	10min	10min
	Designing	2 min	5 min	3min	3min
	Total	42 min	6h	1h3min	-
* ha: hectare.					

Table 3: Estimation of past time to surveying sites

CONCLUSION

We are proposing a methodology for establishing topographical and cadastral plans by using the new technology: GPS and CAD drawing environment. This new investigation allows us to enhance the manner of working. The obtained results are very satisfying and we are absolutely sure that surveyors will alter the conventional procedures and they will take advantage of the new tool. Using this method, it is seen that the survey labor has been certainly reduced comparing to conventional methods.

On the other hand, the stop and go mode of GPS survey affords the desired accuracy and the use of intelligent code in field is successful. To adopt this method, it's necessary that the staff have to be well trained.

Through this education we have not seen any bad results, but the following works have to be accomplished:
1- An investigation needs to be conducted for the integration of data files collected by the total stations with the data files of GPS survey.
2- A conceptual model of data must be designed in order to perform the management of database.
3- Another research has to be done for implementation of RTK method of GPS survey.

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BIOGRAPHICAL NOTE

Moha Elayachi holds diploma of Engineer in geodetic and topographic sciences in 1995. His research was about conceiving and development of a cadastral database. He conducts research in the area of cadastral information systems and using GPS for land surveying. He is teaching astronomy and adjustment computation. Currently, he is a graduate student at the "Institut Agronomique et Vétérinaire Hassan II" where he pursues research on "investigation of a new approach of conceiving geographical information system related to the cadastral field".

Hicham Salimi and **Said Souhaili** received their diplomas of Engineer in geodetic and topographic sciences in 2000 with a focus on applying GPS for surveying. Currently, they are with ADM society (the Moroccan Society of Motorways) as surveyors and they provide technical procedures on roads monitoring.