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République Algérienne Démocratique et Populaire
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Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
جامعة عمار ثليجي- الأغواط

Faculté : Génie Civil et d'Architecture
Département : Génie Civil

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Land registry Course Notes

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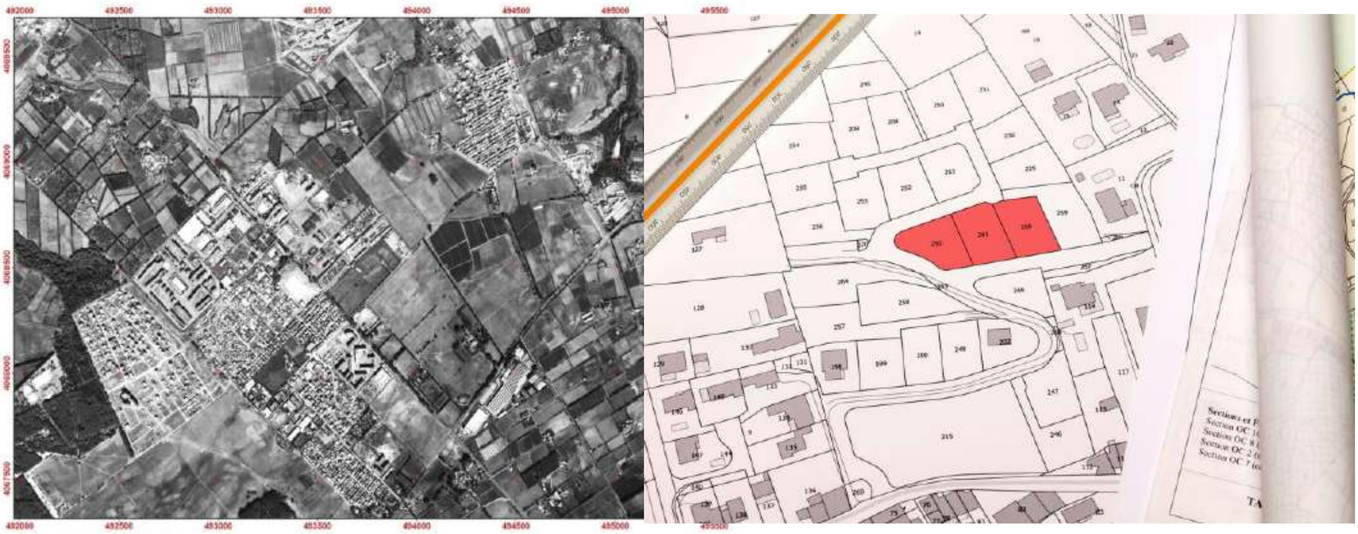
Ministry of Higher Education and Scientific Research

Amar Telidji University of Laghouat

Faculty of Civil Engineering and Architecture

Department of Civil Engineering



Land registry Course Notes

Level: S5

Specialty: Geomatics and Topography

Written by Dr. GUERROUDJ Abdelhalim
Faculty of Civil Engineering and Architecture
Department of Civil Engineering| 2025/2026

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GENERAL INTRODUCTION

Land Register in Algeria

Foundations, Procedures and Modernisation

Target audience	Semester	Speciality	Field
3rd Year — Licence	S5 — Fifth semester	Geomatics & Topography	Land Register (Cadastre)

Introduction

Land registration constitutes one of the most fundamental pillars of territorial governance in modern states. By guaranteeing property rights, preventing boundary disputes, and providing a reliable information base for economic and urban development, the land register system serves as an indispensable tool for both legal security and national planning.

In Algeria, the establishment of the general land register has been an ongoing process since its initial launch, progressively covering urban and rural territories. More than 70% of operations in the northern regions have been completed, and the National Land Register Agency (ANC) continues to adapt its methodology to address the specific challenges of steppe and Saharan zones through the integration of satellite imagery and digital tools.

This course is structured around two complementary parts. Part I establishes the theoretical and institutional framework of the land register system, while Part II addresses the practical methodology for establishing the rural land register, with a comparative analysis of three successive technological solutions.

PART I	PART II	PART III
Theoretical Foundations	**Rural Land Register**	**Exploitation of Satellite Imagery for Cartography**
Definition · Documents · Procedures · Digital evolution	*Preparatory work · Field operations · Documentation*	*Preparatory work · Field operations*

Course Objectives

- Understand the legal, social, and economic role of the land register in Algeria.
- Master the official establishment procedure and the associated documentary system.
- Compare the three methodological approaches for rural land register production.
- Apply international cartographic accuracy standards (NMAS, FGDC) to satellite imagery.
- Appreciate the role of modern technologies (ERDAS LPS, GIS, satellite imagery) in cadastral modernisation.

Prerequisites

The study of the Land Register course requires prior knowledge in Mathematics. Students enrolled in this subject must have foundational understanding in the following disciplines:

T	P	S	D
Topography	Photogrammetry	Statistics	Technical Drawing

Reference body	Key directive	Accuracy standards
ANC — National Land Register Agency	Instruction No. 16 — 24 May 1998	NMAS (USA) · FGDC (USA)

Part I

Theoretical Foundations

Part I:
Theoretical Foundations

I.1 Introduction

Currently, territorial information is the subject of extensive research by actors responsible for land management, such as land register and urban planning services, whose efforts are sometimes aimed at improving the general procedure for the production of documents (land register maps, etc.), or at using other data from various sources.

In this first part presents an overview of the Algerian land registry, through a description of its general establishment procedure, the data sources used, and the documents produced. It also addresses the evolution of the land register towards a digital land register incorporating heterogeneous data (photogrammetry, remote sensing, etc.).

I.2 Presentation of the land register

I.2.1 Definition

The land register serves essential functions in modern societies: to guarantee property rights and thereby prevent conflicts and promote stability on the one hand, and on the other hand to provide a reliable and accurate information base relating to the territory, which serves as a foundation for any action aimed at addressing the challenges of economic development, political and social stability, urbanisation, demographic growth, and environmental protection (HAMEL and BROUTHEN, 2007).

The definitions of the land register are numerous and varied. The following have been selected:

> Definition provided by the **ANC** (**A**gence **N**ationale du **C**adastre / National land register Agency): it is the set of documents methodically established on the basis of topographic surveys intended to determine landed property (land, buildings, equivalent real rights, etc.) of an entire territory.
>
> In other words, carrying out a land register survey consists, on the one hand, of graphically representing all immovable properties (built or unbuilt) to scale and orienting them on a map. On the other hand, it consists of specifying all information

concerning the physical or material description of the properties, the nature of land use, the mode of exploitation, the owners, and the apparent holders of real rights.

- Other stakeholders define the land register as a comprehensive, permanent, descriptive, and evaluative inventory of land ownership.

The establishment of a land register system and its maintenance constitute a costly registration system inasmuch as it does not produce a tangible and quantifiable result. This type of result only manifests itself in the long term. In order to persuade decision-makers of the utility of such a system, some of its advantages are presented below. These are linked to the political, social, religious, and financial system of the country concerned (Missoumi, 2006):

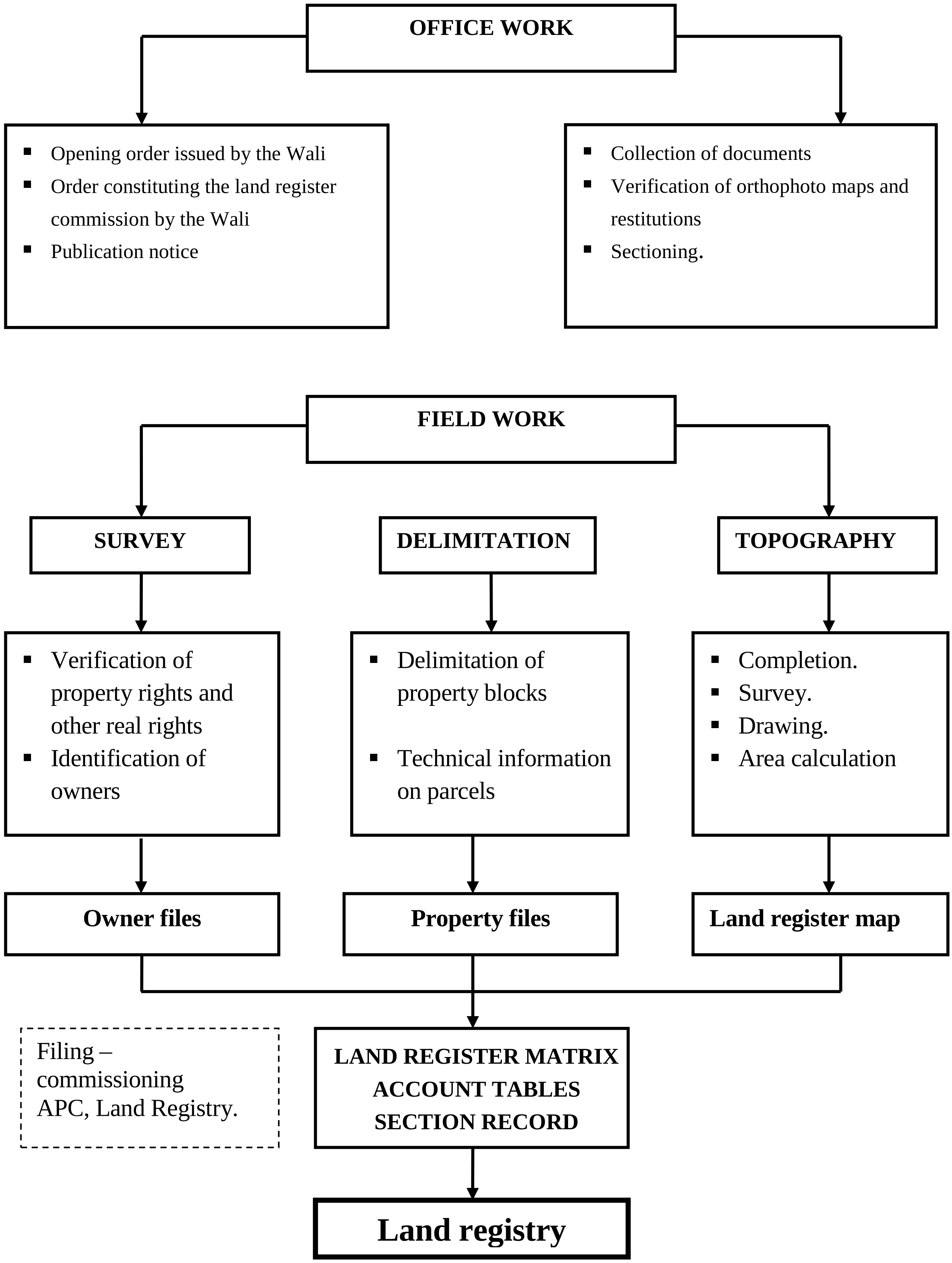
- The establishment of a well-conducted registration system ensures security and clarity of the legal status of the land, the persons concerned, and third parties;
- It encourages financial institutions to grant loans;
- Legal security contributes to the reduction of conflicts by reducing boundary disputes, thereby saving time and cost and fostering good neighbourly relations;
- Taxation is made easier, as land is considered a source of income and, in order to legally collect this income, the land register is indispensable;
- It is possible to obtain information for other purposes; the land register provides the required data facilitating the execution of works of national importance: land consolidation – planning – statistics – urban planning, etc.

I.2.2 Establishment Procedure

The land register requires a set of technical operations, namely:

- Delimitation of properties;
- Determination of rights and encumbrances;
- Publication;
- Maintenance and updating of data.

The general land register establishment procedure in Algeria is based on photogrammetric products, namely orthophoto maps for rural areas and restitutions for urban areas. This is reflected in the varying density of information between the two zones. The practical implementation of land register operations involves both office and field work with the aim of producing the land register documentation necessary for the issuance of the land register booklet (see Flowchart I.1).



Flowchart I.1: General land register establishment procedure.

I.2.3 land register Documents

land register documentation provides both the graphic representation and the land inventory of the municipal territory. The land register is responsible for the census of all land properties, the identification of their owners, and the definition of property boundaries. This inventory gives rise to documentation that is:

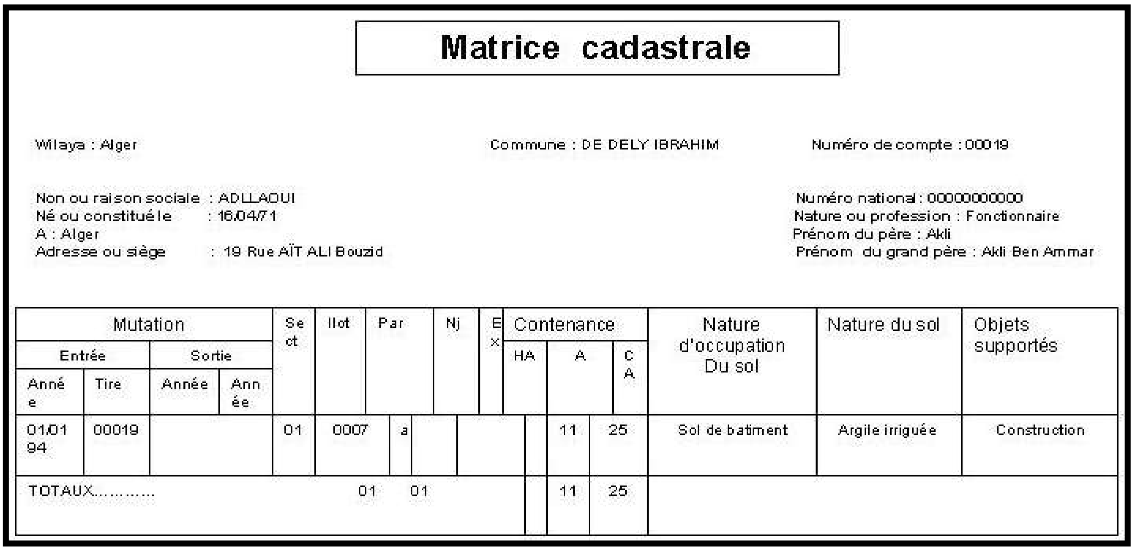
- **Graphical: the land register map**
- **Literal: land register matrix and section record**
- **Graphical databases using DEMETER.**
- **Literal databases using the Ingres RDBMS.**

I.2.3.1 Literal Documents

land register Matrix:

The land register matrix is a register that provides, per owner's account, the nomenclature of property blocks belonging to that owner within the territory of a commune, and for each block, the designation of the section, the block number broken down into parcels, and their respective areas (see Figure I.1). Materialised by a matrix sheet M3 or M4, the matrix sheets are classified in alphabetical order of owners.

At the head of the matrix appears the account table (Figure I.2), which gives the name of the owner according to the account number.



Matrice cadastrale

Wilaya : Alger Commune : DE DELY IBRAHIM Numéro de compte : 00019

Non ou raison sociale : ADLLAOUI
Né ou constitué le : 16/04/71
A : Alger
Adresse ou siège : 19 Rue AÏT ALI Bouzid

Numéro national : 0000000000
Nature ou profession : Fonctionnaire
Prénom du père : Akli
Prénom du grand père : Akli Ben Ammar

Mutation				Sect	Ilot	Par	Nj	Ex	Contenance			Nature d'occupation Du sol	Nature du sol	Objets supportés
Entrée		Sortie												
Année	Tire	Année	Année						HA	A	CA			
01/01 94	00019			01	0007	a				11	25	Sol de batiment	Argile irriguée	Construction
TOTAUX…………					01	01				11	25			

Figure I.1: The land register matrix.

Table des Comptes de la Matrice 27/09/2000

Wilaya : ALGER
Conservation: BAB EL OUED
Commune : HAMMAMET **Page :** 1

Numéro	Nom	Prénom	Date
162400000600017	ABD-EL-KADER	BELKACEM	01.08.1936
162400000600018	ABDELAZIZ	KHOUDIR	18.08.1941
162400000600019	ABID	MOHAMED TAHAR	20 04.1945
162400000600110	AGERFA		
162400000600020	AID	TAKLIT	--.--.1912
162400000600125	ALLOUNI	ABDELKADER	25 10.1956
162400000600021	AMMAR ET CONSORTS	SALAH	23.10.1930
162400000600023	BATTATA	ABDELHAMID	05.10.1931
162400000600106	BEHIDJ	BOUALEM	04.01.1948
162400000600024	BELAOUNE	MEBROUK	09.03 1945

Figure I.2: Account table.

The Section Record:

The section record is a register in which the records are classified in topographic order, that is, in the order of sections and block numbers, and in which is indicated, for each block, the account number of the owner (see Figure I.3).

ETAT DE SECTION 23/05/2001

WILAYA : ALGER

COMMUNE : CASBAH

SECTION : 004 PAGE N° 1

Ilot	Lot	N° Compte	Tire de
0007		160700000600161	
000		160700000600162	
0010		160700000600160	

Figure I.3: Section record.

I.2.3.2 Graphic Documents

The land register Map:

The land register map provides the graphic representation of the municipal territory in all its details, showing its subdivision into parcels or property blocks. Numbering is carried out by property block, within which the subdivisions (parcels) are indicated by dashed lines and assigned an indicative letter a, b, c…

The usable format is (76 cm × 51.4 cm) and the exterior format is (84 cm × 59.4 cm). The main information shown on the map is as follows:

- Municipal, section, locality, and parcel boundaries;
- Materialisation of boundaries (wall, hedge, fence, ditch, embankment, etc.);
- Rights-of-way for communication routes (path, road, bridge, railway);
- Hydrography (lake, pond, watercourse, well, etc.);
- Constructions (buildings, public facilities, etc.);
- Joint ownership signs;
- Sheet grid, framework points and their coordinates;
- Boundary markers and benchmarks (geodetic points, property markers, etc.);
- Toponymy (name of commune, sections, localities, streets, watercourses, etc.);
- Section, block, and parcel numbers.

The choice of scale is dictated by the degree of parcel fragmentation and the nature of the zones to be surveyed (urban or rural). The main scales used are:

- Urban areas: 1/500 (high-density urban areas) or 1/1,000 (low-density urban areas).
- Rural areas: 1/2,000 or 1/2,500 (highly fragmented rural areas) or 1/5,000 (sparsely fragmented rural areas).

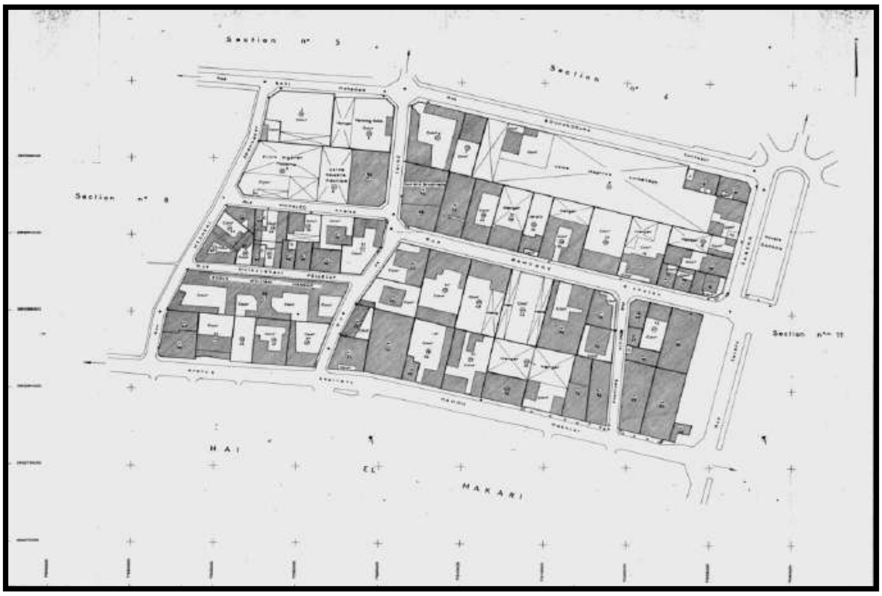


Figure I.4: Example of a land register map.

The production of land register maps in rural areas is based on the orthophoto map (Figure I.5), which is produced at the I.N.C.T (Institut National de Cartographie et de Télédétection / National Institute of Cartography and Remote Sensing).

Figure I.5: Example of an orthophoto map.

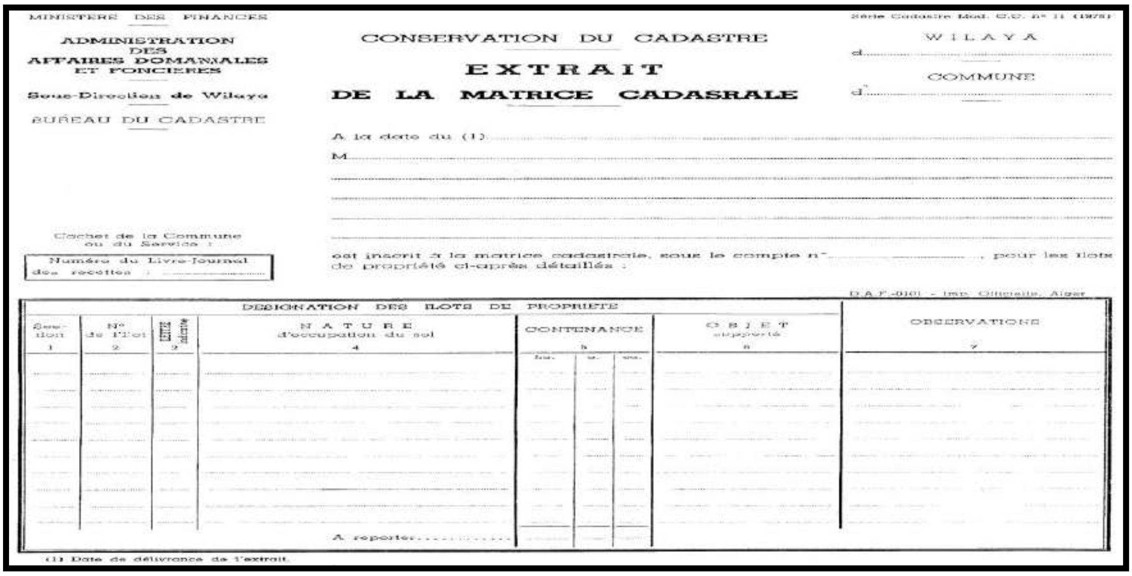
An assembly table is established for each commune. This document is a schematic image of the municipal territory drawn up approximately at scales of 1/10,000 or 1/20,000. On the assembly table, planimetric details are represented (settlements, hamlets, watercourses, communication routes, section boundaries), enabling the user to quickly identify the section of interest (see Figure I.6).

Figure I.6: Example of an assembly table.

I.2.4 Nature of Documents Issued by land register Services

I.2.4.1 Extracts from the land register Matrix

Notaries and expert land surveyors may request extracts from the land register matrix concerning all communal properties belonging to the same owner (see Figure I.7).



MINISTERE DES FINANCES

ADMINISTRATION DES AFFAIRES DOMANIALES ET FONCIERES

Sous-Direction de Wilaya

BUREAU DU CADASTRE

CONSERVATION DU CADASTRE

EXTRAIT

DE LA MATRICE CADASRALE

WILAYA

d.........

COMMUNE

d.........

A la date du (1) ....

M.........

est inscrit à la matrice cadastrale, sous le compte n° .... , pour les ilots de propriété ci-après détaillés :

Cachet de la Commune ou du Service :

Numéro du Livre-Journal des recettes : ....

DESIGNATION DES ILOTS DE PROPRIETE								OBSERVATIONS
Section 1	N° de l'Ilot 2	3	NATURE d'occupation du sol 4	CONTENANCE 5			OBJET 6	7
				ha.	a.	ca.		
			A reporter.........					

(1) Date de délivrance de l'extrait.

Figure I.7: Extract from the land register matrix [DCW].

I.2.4.2 Map Extracts

Apart from extracts used for land publicity purposes, the land register office issues extracts of maps or assembly tables limited to the zone of interest to the applicant. The map extract indicates the last known state of the property. These extracts are subject to a fee (see Figure I.8).

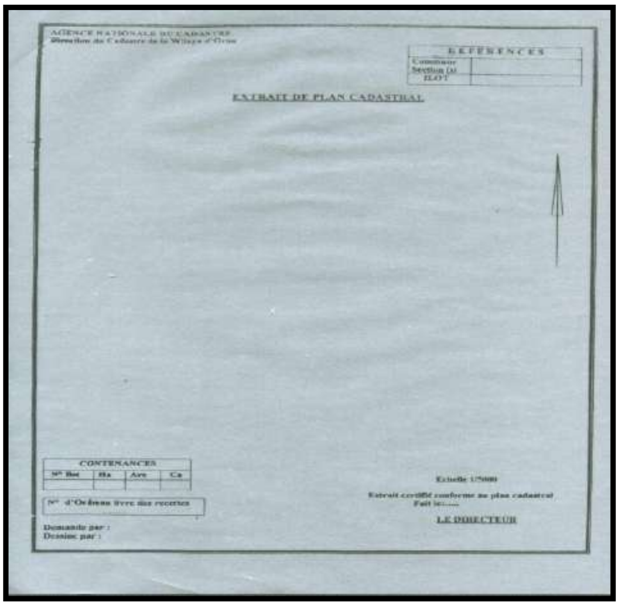


Figure I.8: Standard layout of a land register map extract [DCW].

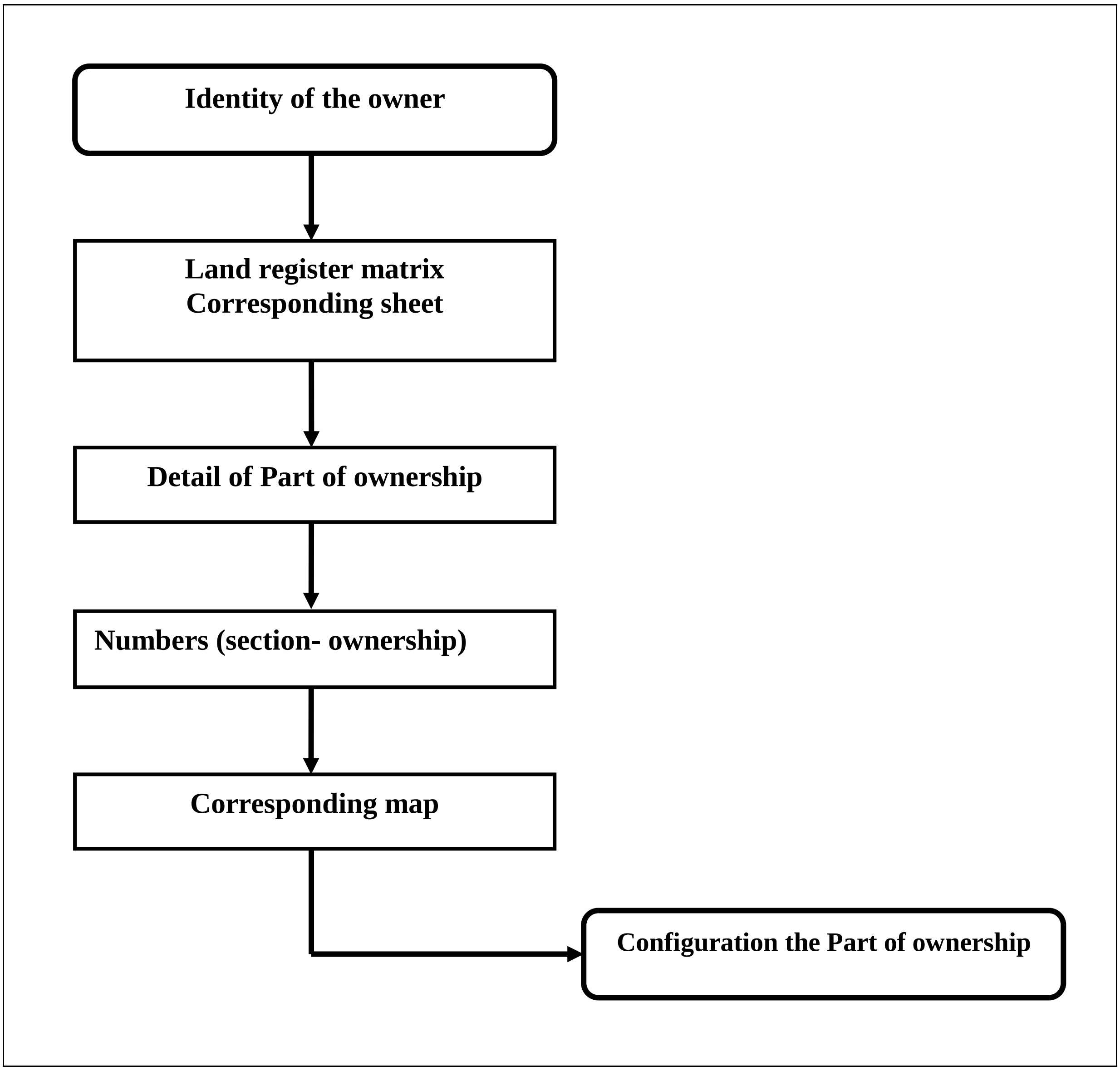
I.2.5 Methods of Consulting land register Documentation

The practical procedures for consultation vary according to the nature of the information from which the search is initiated:

- Designation of the owner (surname and given name);
- Designation of the property block (section number and block number);
- Location of the property.

I.2.5.1 Designation of the Owner

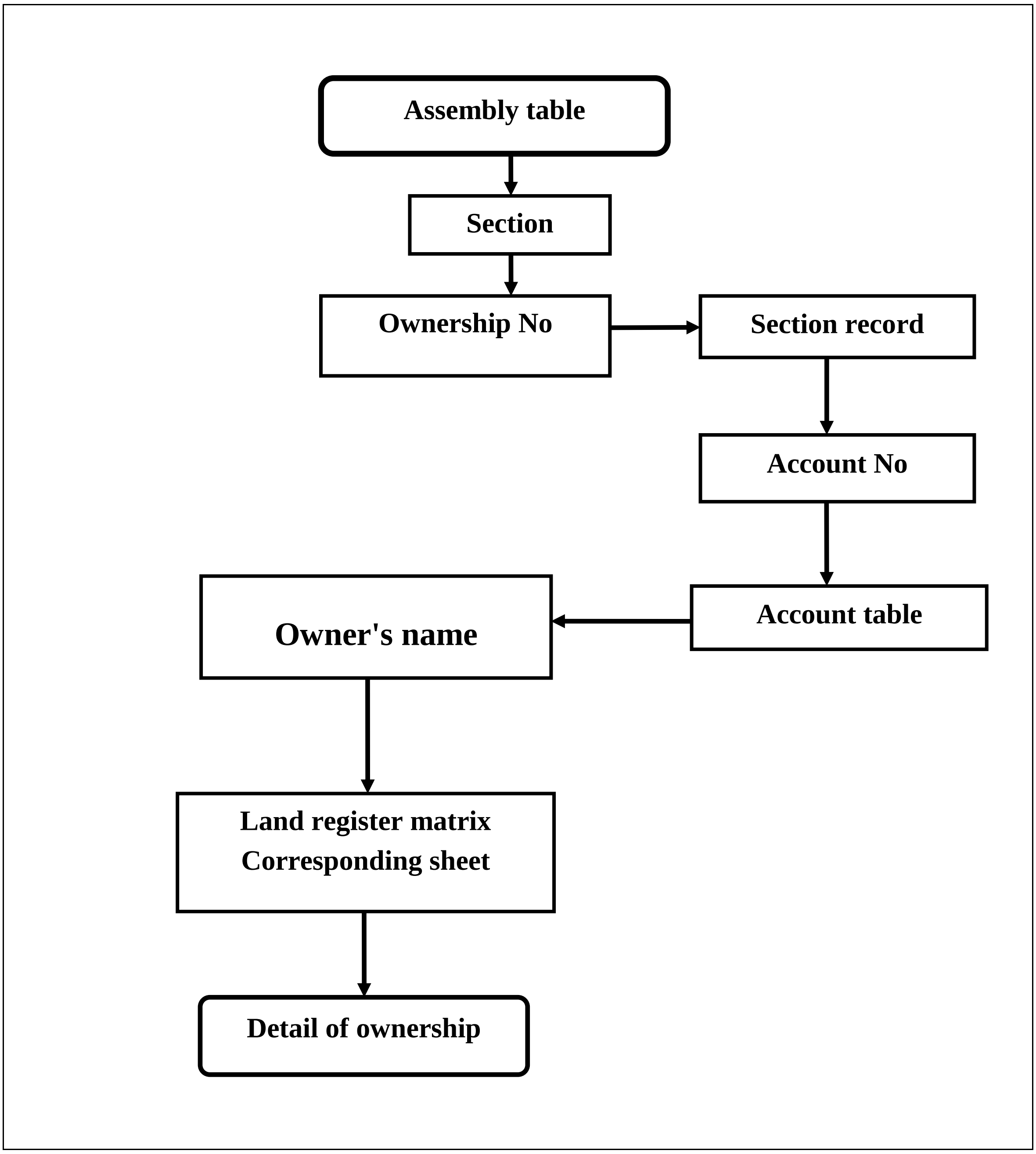
Knowing the identity of the owner, one consults the owner's matrix sheet, classified in alphabetical order, which provides the details of the property blocks belonging to that owner. To determine the configuration of the block, one looks up the number on the section map of the person concerned (see Flowchart I.2).



Flowchart I.2: Search based on the designation of the owner.

I.2.5.2 Location of the Property

One searches the assembly table for the section in which the property is located, then the corresponding map sheet to obtain the block number, which is retrieved from the section records (files or registers). The information relating to the block, notably the account number opened in the owner's name in the land register matrix, and the account table, allows the latter document to provide the designation of the owner and ultimately to refer to the corresponding sheet classified in alphabetical order (see Flowchart I.3).



Flowchart I.3: Search based on property location.

I.2.6 land register Conservation

land register documentation is only reliable if it is regularly updated as changes occur that may affect either the legal status — transfer of ownership (partial transfer or partition) — or the physical condition of the immovable properties (displacement of boundaries due to new constructions, road construction, change of crop, erosion, or natural alluvial deposit).

The purpose of land register conservation is to keep the established documents (maps, matrices, section records) up to date with all mutations and other changes that have occurred.

Any change affecting the legal status of a property necessarily involves the intervention of the deed writer (notary, etc.), the accredited surveyor (for the preparation of the survey document), the land register office (in its capacity as the holder of the initial land register document), and the land registry (as the holder of the property register).

Any change affecting the physical condition of a property is recorded during periodic land register inspections or based on information communicated by the Municipal Assembly (APC).

I.2.7 Conclusion (The land register and New Concepts)

The last decade has witnessed enormous changes in the spatial, cartographic, and computing fields, with the launch of metric and sub-metric resolution sensors (e.g., LANDSAT-7, SPOT-5, IKONOS, QUICKBIRD, etc.) and the development of new computer-aided design (CAD) software, image processing tools, and geographic information systems (GIS). This has compelled managers of this type of information to adapt or change their data acquisition and processing systems.

Since the land register is a service affected by these changes, several developed countries have changed the process of producing their land register documentation, which has become essentially digital. One of the major advantages of land register digitalisation is the elimination of assembly problems, and the possibility of producing on-demand outputs at any scale and any format, easily accessible to users via the Internet (E-land register), and sometimes considered as a data source for land register partners (multipurpose land register).

These new concepts emerged with the use of data other than photogrammetric data: namely, satellite imagery, with the aim of reducing the cost and time required for the production of land register maps. The advantages are as follows:

- Coverage of large surface areas;
- Digital cartography;
- Less expensive compared to the use of photogrammetry and ground surveying;
- Accessibility;

- It constitutes an up-to-date source of information, enabling the updating of land register data;
- Ease of integration into GIS.

Furthermore, the use of satellite imagery accelerates the process of producing accurate and cost-effective maps (CNES, 1999).

In the face of these changes, the land register establishment procedure initiated in Algeria and described above has become conventional. It is therefore necessary to consider developing the process by using other data sources, such as satellite imagery and new processing tools.

Annexe part I

The land register Matrix

, The land register Map

MATRICE CADASTRALE

15/04/2009

03 **Wilaya :** LAGHOUAT
Commune : HASSI DELAA

Nom : Bien de l'état
Prénom :
Né ou constitué le :
Nationalité :
Adresse : Hassi Delaa– Laghouat

Numéro national : 030500000 100000
Nature ou profession :
Prénom du père :
Prénom du gd-père :
Page : 01

Se	Ilot	Pa	Lot	Bat	Esc	Niv	Surf	Tant	QPart	Ha	A	Ca	Adresse	N Jur N Sol	Appr Util	Dr.C Har	Obj.
01	0001		0	0	0			000	0	21336	11	14	Hassi Delaa	06	22	29	12
	0002		0	0	0			000	0	41614	43	79	"	06	22	29	

MATRICE CADASTRALE

15/04/2009

03 **Wilaya :** LAGHOUAT **Nom** : Bien de l'état **Numéro national :** 030500000 100001
Commune : HASSI DELAA **Prénom :** **Nature ou profession :**
Né ou constitué le : **Prénom du père :**
Nationalité : **Prénom du gd-père :**
Adresse : Hassi Delaa– Laghouat **Page :** 01

Se	Ilot	Pa	Lot	Bat	Esc	Niv	Surf	Tant	QPart	Ha	A	Ca	Adresse	N Jur N Sol	Appr Util	Dr.C Har	bj.
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	0002		0	0	0			000	0	984	51	58	"	06	22	29	
	0003		0	0	0			000	0	20038	34	94	"	06	22	29	
	0004		0	0	0			000	0	5832	72	27	"	06	22	29	
	0005		0	0	0			000	0	1967	33	61	"	06	22	29	
	0006		0	0	0			000	0	44476	61	45	"	06	22	29	
	0007		0	0	0			000	0	88474	75	14	"	06	22	29	
	0008		0	0	0			000	0	5655	13	80	"	06	22	29	
	0009		0	0	0			000	0	28096	09	60	"	06	22	29	
	0010		0	0	0			000	0	1415	49	95	"	06	22	29	
	0011		0	0	0			000	0	678	56	40	"	06	22	29	

MATRICE CADASTRALE

15/04/2009

03 **Wilaya :** LAGHOUAT
Commune : HASSI DELAA

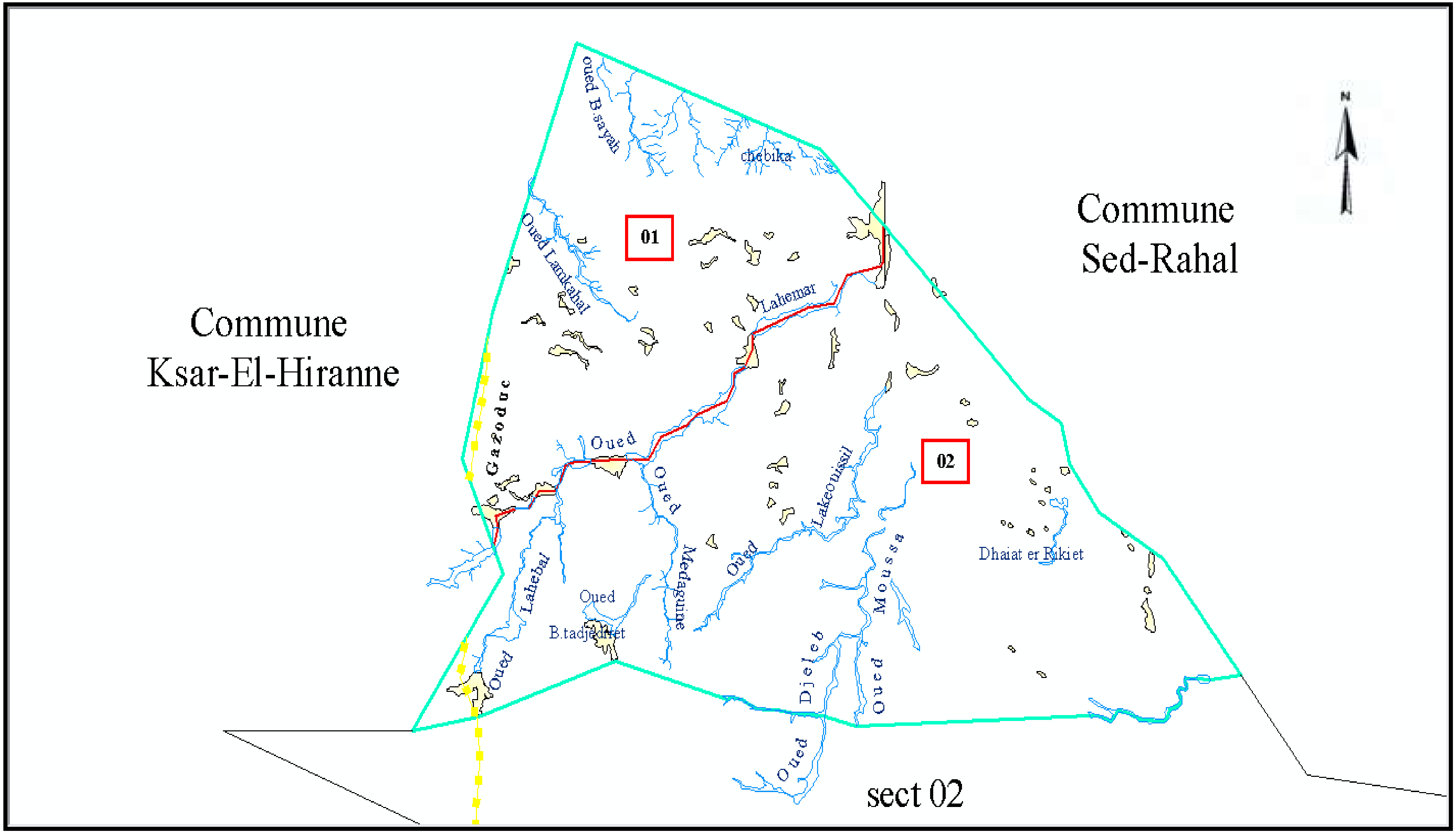
Nom : Bien de l'état
Prénom :
Né ou constitué le :
Nationalité :
Adresse : Hassi Delaa– Laghouat

Numéro national : 030500000 100002
Nature ou profession :
Prénom du père :
Prénom du gd-père :
Page : 01

Se	Ilot	Pa	Lot	Bat	Esc	Niv	Surf	Tant	QPart	Ha	A	Ca	Adresse	N Jur N Sol	Appr Util	Dr.C Har	bj.
03	0001		0	0	0			000	0	141764	75	20	Hassi Delaa	06	22	29	
	0002		0	0	0			000	0	10853	06	44	"	06	22	29	

Commune HASSI DELAA

Section O1



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Part 02:

Issues relating to the establishment of the rural land register in Algeria

Part II:

Issues relating to the establishment of the rural land register in Algeria

II.1. Introduction

Since the launch of the initial operations, the establishment of the general land registry in Algeria has been based on aerial imagery. The initial challenge was to select rural pilot areas to test the establishment methodology; this methodology was subsequently extended to urban areas with an expansion of the scale of operations.

Currently, over 70% of the work has been completed for both urban and rural cadastres in the north of the country. The National Cadastral Agency has adopted a new multi-scale methodology, promulgated in the form of a new directive, which focuses on the establishment of the steppe and Saharan cadastre using multi-sensor and multi-resolution satellite imagery.

This diversity of solutions and data has also extended to the hardware side, driving technological advancement to acquire the most high-performance tools in terms of accuracy; to this end, the ANC has taken charge of producing orthoimages and restitutions (aerial and satellite) through the acquisition of ERDAS LPS-type photogrammetry stations, at both central and regional directorate levels, which were supplied by the INCT.

In this context, the Land Registry has also made available to its regional directorates new equipment specifically designed to produce cadastral documentation in digital form and within a shorter timeframe compared to the current solution.

II.2. Establishment of the general cadastre in rural areas

The establishment of the general cadastre is carried out using several distinct methods depending on the area in question. In this section of the course, we will attempt to explain all the stages of establishing the general cadastre in rural areas in accordance with the ANC’s instructions, as well as the relevant documents, comparing the three possible solutions at each stage.

II.2.1. Preparatory work: traditional approach

II.2.1.1. Basic documents

The starting point for these investigations is the land use map. The following list sets out the different categories of plans that may be encountered:

- The map at a scale of 1:25,000 or 1:50,000
- Standard plans under the 1873 Act at a scale of 1:4,000
- Plans of state-owned properties that have been subject to transfers or concessions by the State Property Office, of which only a single copy exists, attached to the relevant administrative documents.
- Plans from partial surveys and comprehensive surveys;
- Topographical maps archived at the Land Registry;
- Forest maps;
- Plans of the right-of-way for roads, paths, railways, canals, etc.;
- Aerial photographs;
- Boundary maps of land returned following the agrarian reform;
- Plans of model farms;
- Maps of agricultural holdings (E.A.C. and E.A.I.).

The survey work results in the compilation of a list of old maps, specifying the archive location of each document for retrieval. Documents deemed useful for survey and demarcation operations are deposited at the land registry office. These documents are restored where necessary, and tracings are made so that field teams can be provided with the necessary reproductions, as, of course, the original plans will under no circumstances be used in the field. The aim of the survey is to provide field teams with a certain amount of information useful for survey operations:

- The results of the General Agricultural Census (RGA);
- The census conducted by the National Statistics Office (ONS);
- The tax register [2].

II.2.1.2. Verification of orthophoto maps

The verification of orthophotomaps provided by the INCT in analogue format is carried out on the basis of four criteria:

- **Area covered:** Check that the orthophotomaps cover all the areas to be registered.
- **Image clarity:** The orthophotomaps must be as clear as aerial photographs.
- **Misalignment:** The tolerance for misalignment between scan bands is set at 0.3 mm.
- **Note:**

Check carried out in the office

First, an ‘assembly grid’ is produced: a stable, transparent plastic sheet measuring 1m x 1m is marked with a decimetre grid. Particular care is taken to ensure that this work, on which the accuracy of the orthophoto map assemblies depends, is carried out with the utmost precision.
Using this assembly grid, the orthophotomaps are assembled in pairs on a light table. Any discrepancies in the alignment of details within the overlap area are noted.

- **Field checks**

For the tolerance on distance measurements, the following formula is used:

$$\boxed{Tr(cm) = 200 + \frac{D(m)}{10}}$$

Where D is the actual length of the measurement expressed in metres; for distances greater than 800 m, D is taken as the constant value of 800 metres.
The results of this check are recorded on the form **‘classification of observed discrepancies’.** [2]
For area measurements, the agricultural parcels used to calculate areas must be surveyed in the field or extracted from a precise document. With regard to the applicable tolerances, empirical formulas are used to verify the areas of blocks and parcels.

The formulas provided by Instruction No. 16 of 24 May 1998, concerning the conduct of cadastral land registration operations, technical procedures relating to the organisation of general cadastral work and the preparation of cadastral documents:

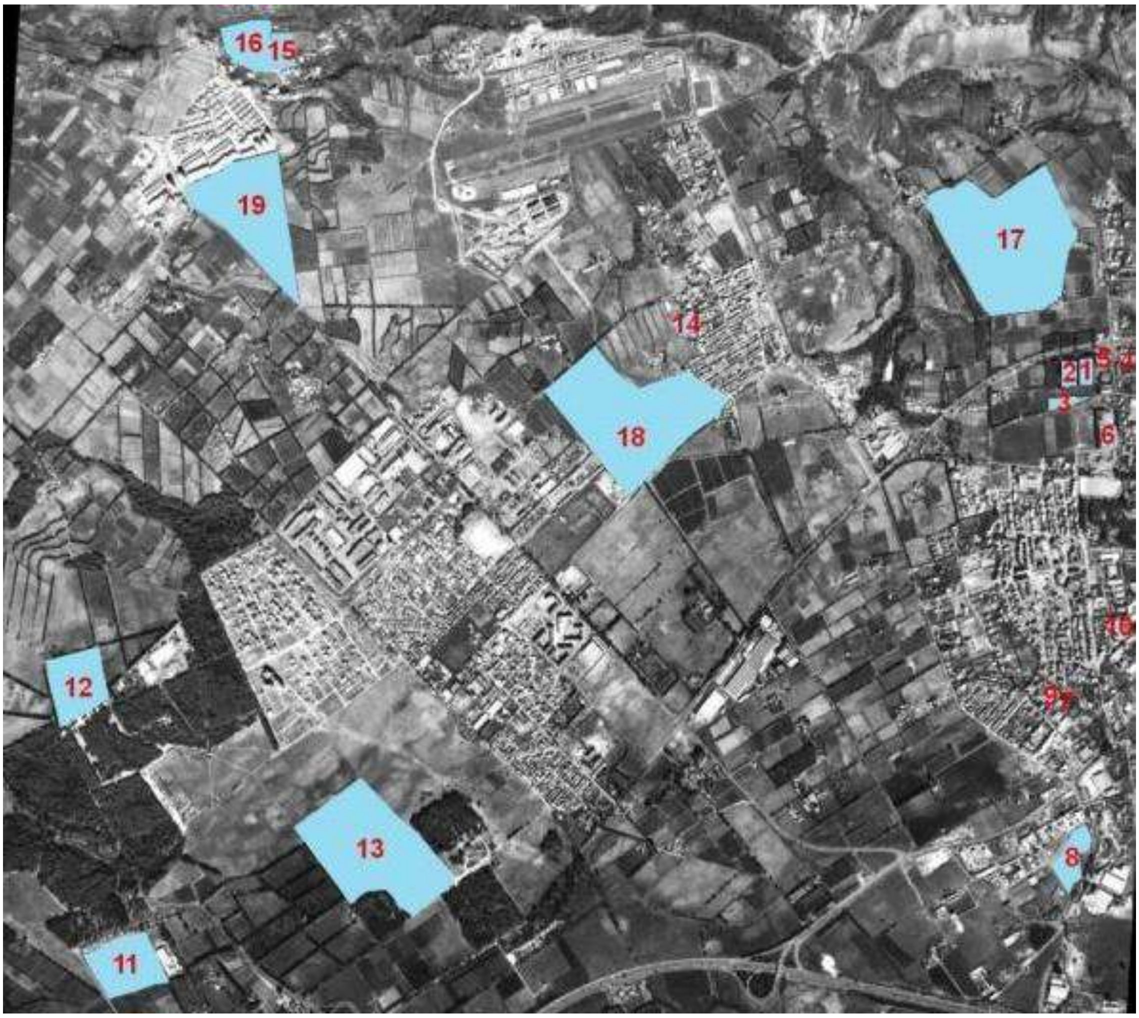


Figure II.1. Distribution of plots [3]

$$E_p = \frac{E}{5000} \times S\sqrt{}$$

$$E_m = 1.5 \times \frac{E}{5000} \times \sqrt{S}$$

$$T = 4 \times \frac{E}{5000} \times \sqrt{S}$$

Where: E: scale factor, S: area (in ca), Ep: probable error, Em: mean error, T: tolerance. [3]

II.2.1.3.Division of the municipality into sections

A cadastral section is a portion of the municipal territory defined in such a way that it can be fitted onto a cadastral map sheet with a working area of 76 cm × 51.4 cm.

The outer dimensions of a map sheet are set at 84 cm × 59.4 cm; the section is drawn within a template that leaves a margin of 4 cm.

The division of the municipal territory into sections is carried out in accordance with the following principles:

• The perimeter of the sections shall, as far as possible, consist of property boundaries that are sufficiently fixed in nature: roads, paths, permanent watercourses, canals, ditches, walls, etc.

• It is recommended to avoid cutting through blocks of property.

• The north will be aligned, to within approximately 10 degrees, with the short side of the sheet.

In practice, the officer responsible for the work will use a template drawn on tracing paper, which they will apply to the base map selected to receive the division into sections. The dimensions of the template are related to the effective size of the map sheet, the scale of the cadastral map and the scale of the base map via the following formula:

$$L_G = \frac{e_f}{e_p} L_P \qquad l_G = \frac{e_f}{e_p} l_P$$

LG: length of the template LP: length of the cadastral map

lG: width of the template lP: width of the cadastral map

ef: scale of the base map (1/EF) ep: scale of the cadastral map (1/EP) [2].

- **Numbering of sections**

Cadastral sections are numbered in each municipality starting from 1, in ascending order, without interruption.

The section located in the north-west of the municipality is given the number 1, and the numbering continues horizontally eastwards to the boundary of the municipality, then returns westwards and continues in this way in a zigzag pattern.

- **Marking of section boundaries on the sketch map**

The section boundaries are marked on both sets of the boundary sketch map. They are represented by a solid red line 2/10 mm wide, with a coloured pencil border pale enough to allow the details of the orthophoto map to show through [2].

II.2.2. Preparatory work: current solution

The preparatory work differs from the previous case in that the orthophoto map is produced rather than acquired; consequently, specific procedures will apply.

• **At the document collation stage**

In addition to the documents gathered, we must produce aerial orthoimages of the area to be surveyed. To this end, the preparatory work becomes stereopreparation work.

• **Regarding the verification of the orthophotoplan**

Verifying the quality of the orthophotoplan using the previous method becomes optional, as we already know the accuracy of our orthoimage during processing, which is directly linked to the accuracy of the control points and the quality of the DTM.

• **Regarding sectioning**

The resulting aerial orthoimages can be mosaicked after radiometric correction, and the sectioning is carried out on these corrected images by calculating the template and setting the working scale.

- **Example of orthophotoplan production in ERDAS LPS**

The aerial photography mission allows aerial photographs to be acquired at different scales depending on the flight altitude; for example: an altitude of 3,041.4 m gives a scale of 1:20,000, and an altitude of 1,220 m gives a scale of 1:4,000.

The longitudinal overlap between photographs is generally more than 60%, and the lateral overlap between 10% and 20%.

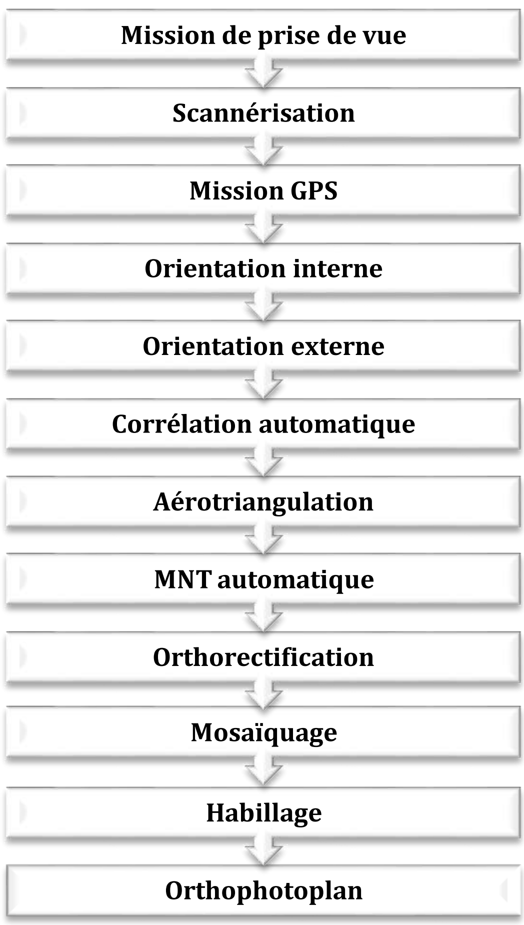
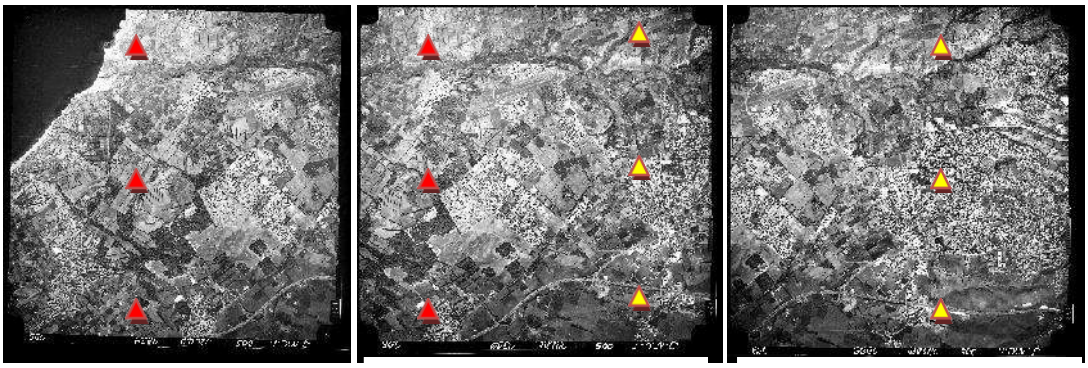


Figure II.2. Steps in creating an orthophotoplan

Once the aerial photographs on positive or negative media have been organised, we set the scanning parameters according to our requirements in terms of accuracy, and cartographic and aerial scales.

The resolutions obtained after calculation, for scales of 1:20,000 and 1:4,000, are 1,270 DPI and 1,016 DPI respectively.

The digital photographs must undergo radiometric correction to improve their contrast and produce a uniform mosaic. [3]



Photographie197 Photographie198 Photographie199

Figure II.3. Distribution of control points on the digital photographs [3]

The points acquired during the GPS survey are control points selected according to the distribution required for aerotriangulation; once the locations have been chosen, data sheets must be created for each point to facilitate access to the point in the field.

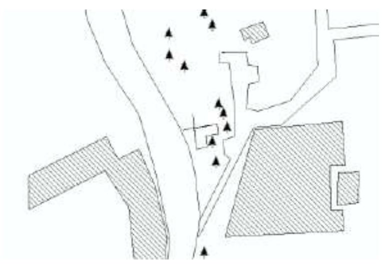
No. 519730	House corner	
		
X=495641.4586 m	Y=4066397.649 m	Z=156.3816 m

Figure II.4. Point location on photograph and data sheet [3]

Digital internal orientation involves transforming the coordinates of each point from a machine system (screen in pixels) to a photo system (image in millimetres) using the coordinates of the reference marks provided by the calibration certificate.

External orientation is performed by entering the coordinates of the control points; for automatic point acquisition, the ERDAS software tests the columns and rows corresponding to the point's position in each image. Performing external orientation on the images yields the ground coordinates of the perspective centres and the three rotation angles.

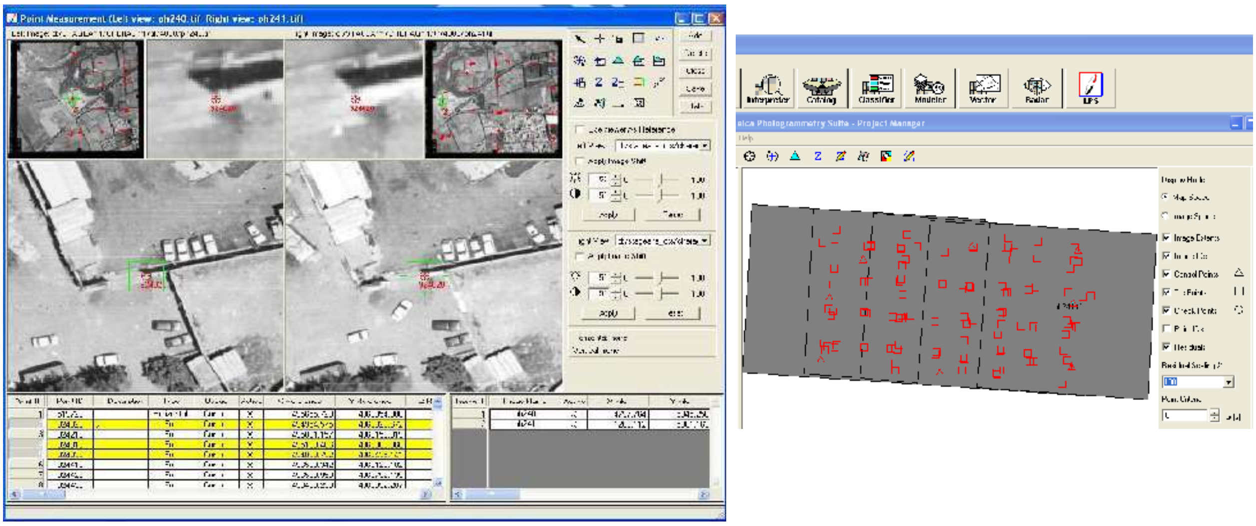
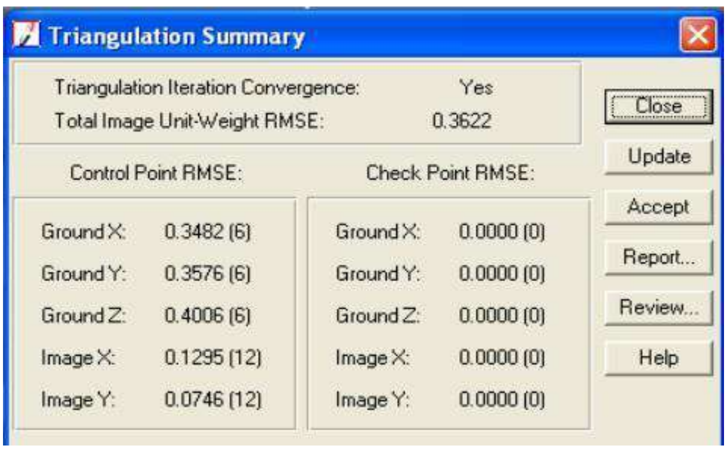


Figure II.5. Control point input and distribution using automatic correlation.

Performing aerotriangulation—a method for determining the coordinates of control points created by automatic correlation—yields a root mean square error (RMSE) expressed in pixels, which provides an indication of accuracy relative to the scale of the map to be produced.

Table II.1. Accuracy of Aerotriangulation [3]



Orthorectification involves correcting for the effect of terrain relief by introducing a digital elevation model to rectify the aerial photographs.

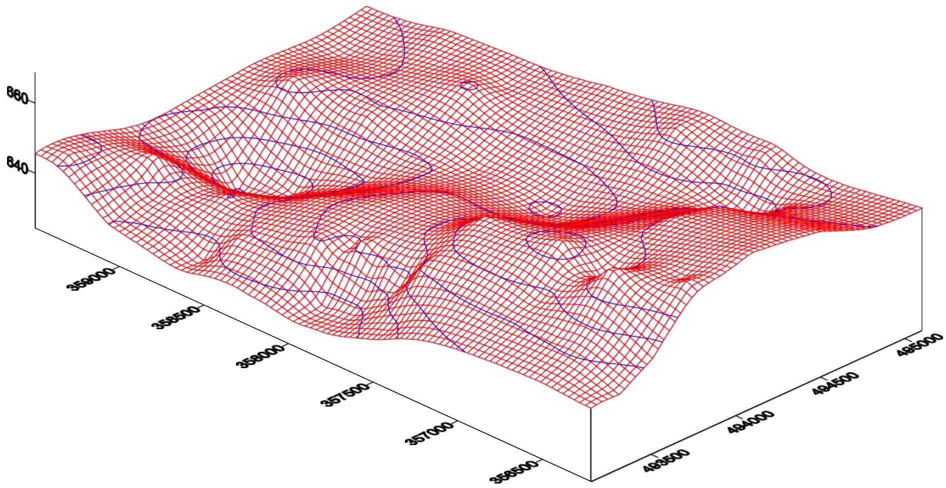


Figure II.6. Mesh representation of a DEM

Figure II.7. Example of an orthophoto map [3]

As mentioned earlier, checking the resulting orthophotoplan is optional. This is done solely to assess the quality of the orthoimage in cases where the DTM used is not very accurate. We check whether the area difference values are below the tolerance limit, and then evaluate the quality of the generated product.

II.2.3. Preparatory work: solution currently being demonstrated

The procedure for creating the spatial map differs from previous cases: instead of acquiring or creating an orthophoto map, a satellite image is corrected; consequently, there will be changes to the approach.

- **At the document collation stage**

These include standard documents and stereopreparation documents, as is the case with aerial images.

- **Regarding the verification of the spatial map**

  Verification of the spatial map's quality using distance and area measurement methods becomes optional, for the same reasons as with aerial images.

  This stage involves determining the cartographic scale of the satellite image, which depends on its spatial resolution and the accuracy of its geometric correction. This is no longer the case for aerial images, where we know the focal length of the camera used; the task now is to apply international standards for determining cartographic scales from spatial maps.

- **Regarding the division into sections**

  Unlike in the previous case, the satellite image is a single document covering a large area, so no mosaicking is required. The template is applied directly to the background of the satellite image.

The process of orthorectification of satellite images remains almost identical to that for aerial photographs, as described previously, except for a few changes to the internal sensor parameters, which are different; in the case of satellite images, an RPC file is used to perform the internal and external orientation.

The ERDAS LPS software offers two options for orthorectifying satellite images: the first uses the OrthoBase module for stereoscopic pairs, and the second uses the Image Correction Tools function within the Data Preparation module for single images.

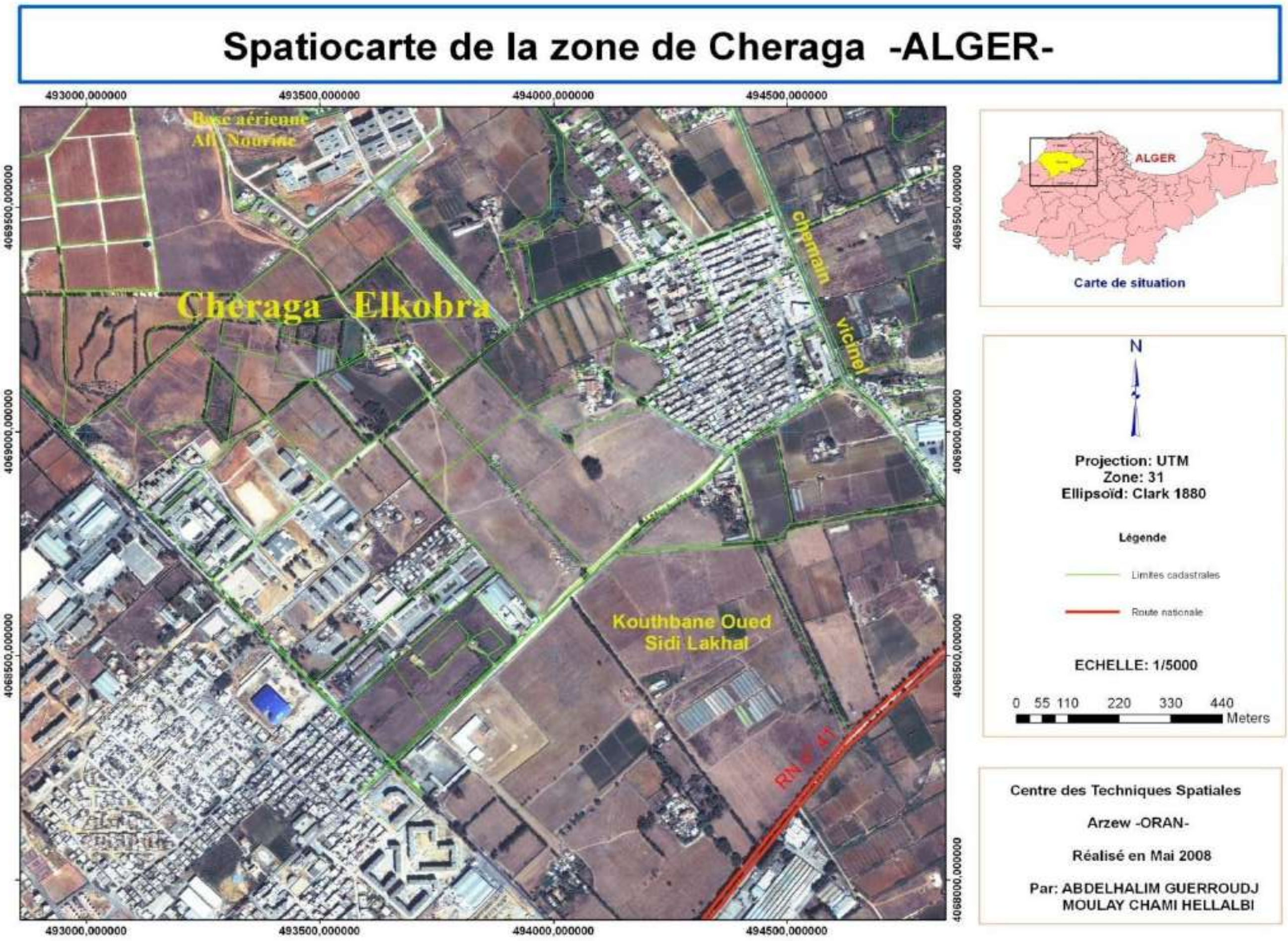


Figure II.8. QuickBird spatial map [3]

As mentioned previously, determining the cartographic scales of satellite images is a step that follows their correction; we provide an example of the application of two international standards.

The validation of the generated products must therefore be carried out in accordance with predefined standards. Unfortunately, standards relating to this type of application do not exist in Algeria. The choice of a particular standard must take into account the specific characteristics of each country in terms of the nature of the areas to be surveyed (extent and detail), the resources available, and the timeframes for completion. In this context, we have settled on the standards defined in the 'United States National Map Accuracy Standards' [NMAS], applied in the USA; this standard is well suited to large areas (as in our steppe and Saharan regions) and the FGDC standard for urban and rural areas.

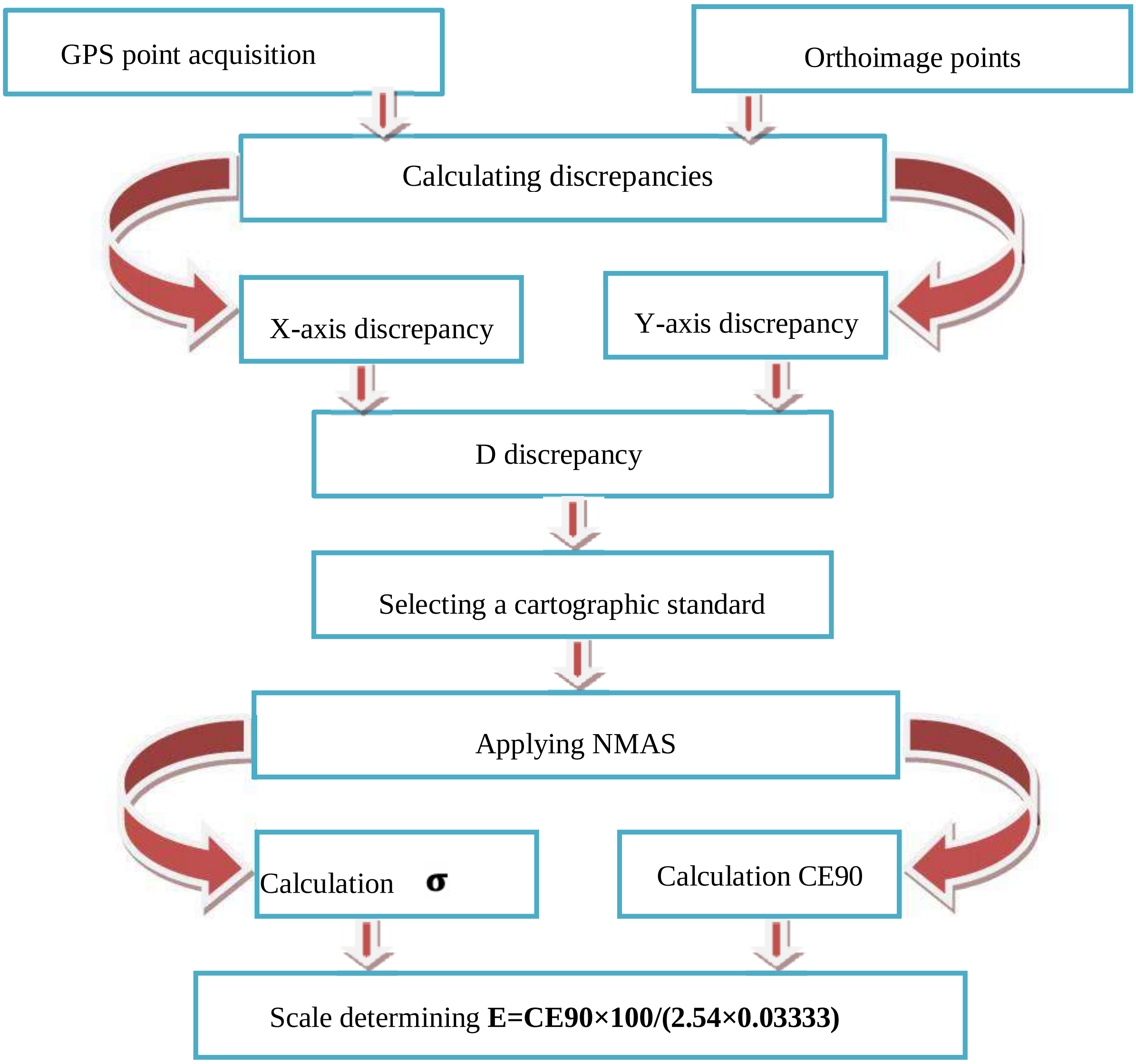


Figure II.9: Orthoimage Mapping Scale Determination Flowchart. [3]

The NMAS standard defines a relationship between the CE90 index and the map scale. For scales greater than 1:20,000, it is given by:

E = CE90 × 100 / (2.54 × 0.03333), where CE90 is given in metres for the 1:10,000 scale, as suggested by the National Land Registry Agency in the context of steppe and Saharan cadastral surveys; this standard requires a tolerance index: CE90 = 8.47 m.

The NMAS uses the CE90 index, which is the error at a 90% confidence interval, to assess the quality of the documents; these values can be interpreted as follows: 90% of the correct measurements lie within a circle with a radius of CE90 and a centre at the 'mean coordinates' (which are considered an approximation of the true values). [3]

The standard deviations in X and Y are calculated using the following standard formulas:

$$\sigma_X = \sqrt{\frac{\sum_{i=1}^{n}\left((X_i - X_i')^2\right)}{n-1}} \qquad \sigma_Y = \sqrt{\frac{\sum_{i=1}^{n}\left((Y_i - Y_i')^2\right)}{n}}$$

Where:

σ**:** The standard deviation; xi**:** the measured value; $\bar{x}$**:** The arithmetic mean; n**:** number of measurements.

Table II.2. Scales as a function of CE90 [CNES, France]

***CE*90=2,146×$\boldsymbol{\sigma_l}$**

Map scale	CE90 (m)
1/10,000	8.47
1/25000	12.7
1/100,000	50.8
1/250,000	127
1/500,000	254
1/1,000,000	1016

Applying the above formula, for measurements yielding **σ_l= 3.21165001** for a Spot5 image compared with a field survey map.

CE90=2.146× σ_l

CE90=6.89220093 metres.

- **Determination of the scale:**

Therefore, 1/E = 1/8000.

Determination of the scale and calculation of the root mean square (RMS) error using the formulas given by the following FGDC standards:

$$RMSE_X = \sqrt{\frac{\sum_{i=1}^{n}\left((X_i - X_i')^2\right)}{n}} \qquad RMSE_Y = \sqrt{\frac{\sum_{i=1}^{n}\left((Y_i - Y_i')^2\right)}{n}}$$

Where n: total number of points

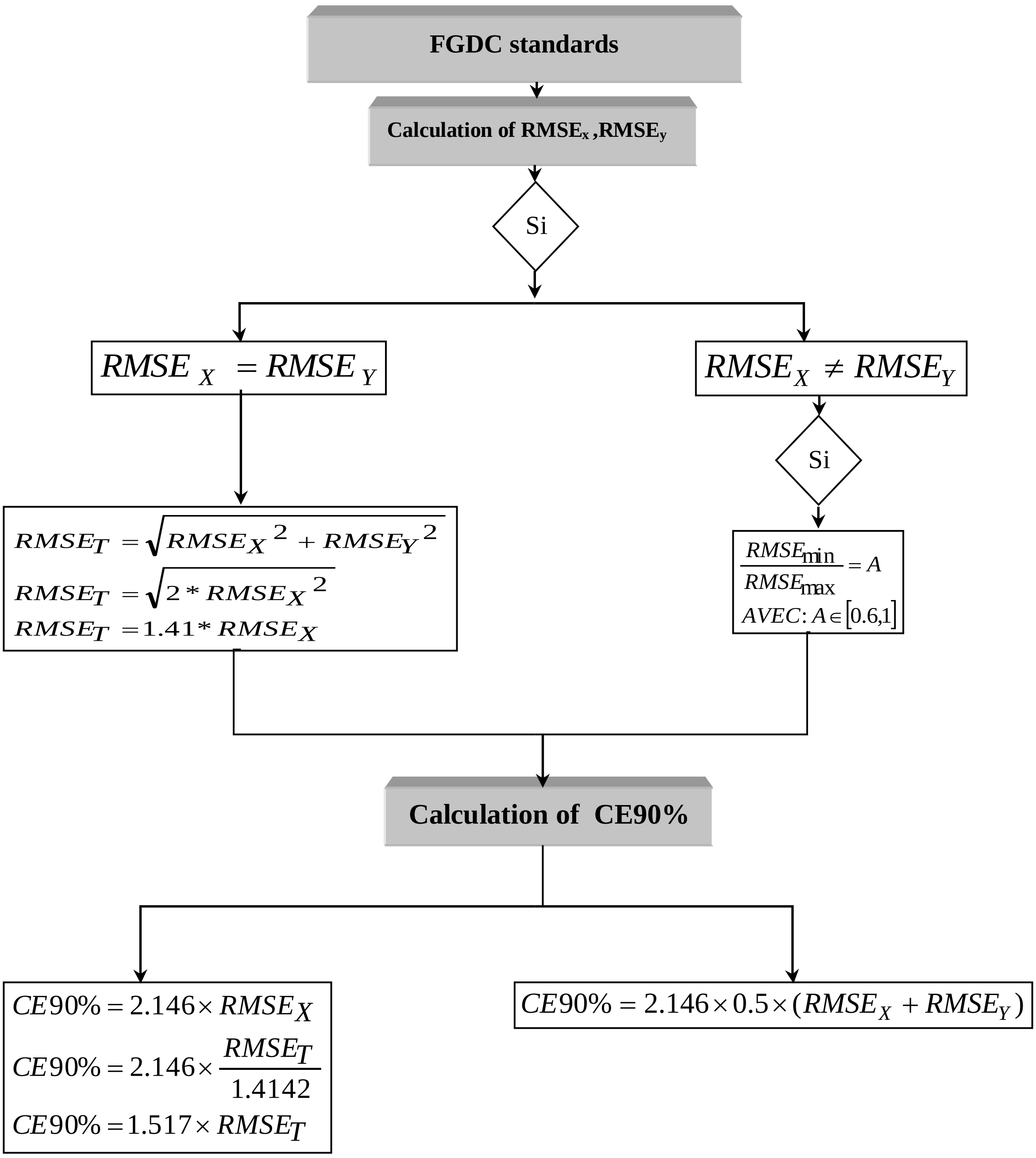


Figure II.10: Accuracy calculation and scale determination based on the US FGDC standard [3].

$RMSE_{min}$is the smaller of $RMSE_x$and $RMSE_y$ $RMSE_{max}$is the larger of $RMSE_x$and $RMSE_y$

II.2.4. Survey and boundary demarcation work

II.2.4.1. Delimitation work

The demarcation of a property involves identifying and establishing (between two or more owners) the boundaries of that property. In practical terms, this means determining how far the property extends. It is for this purpose that, when establishing the boundaries, the consent of the adjacent owner is sought in order to ascertain 'how far their property extends'.
The demarcation is initially carried out for the purposes of the land registry, i.e. 'preparation of documents'. This demarcation will become 'legal', i.e. the determination of the extent of the right, once the formalities of publication in the land register have been completed. [2]

a) The demarcation of the municipal territory

This process involves identifying the boundaries of the municipal territory on the basis of official documents and describing them in a document known as **the boundary demarcation report**, to which a sketch of the boundaries is appended. It is drawn up by the land registry inspector in consultation with the chair of the municipal council of the municipality concerned, as well as those of neighbouring municipalities. Where applicable, any objections or proposals for minor amendments to the boundaries, in order to bring them into line with features of a sufficiently fixed nature, are noted in the minutes. This document, signed by all those present at the demarcation, is submitted to the wali for approval. For border municipalities, situated in other wilayas or on international borders, the demarcation report must be submitted for approval to the Minister of the Interior.

- **Procedure**

• Reconnaissance work
• Preparation of visual sketches
• Drafting of the minutes by the land registry officer
• Signing of the report by the chair of the relevant Local Council and the neighbouring municipalities [2]

b) **The demarcation of properties**

A property block consists of all contiguous plots subject to the same rights and charges, belonging to the same owner or to the same joint ownership, situated in the same locality and forming an independent land unit in accordance with the layout of the property.

- **Demarcation procedure**

During demarcation work, the property boundaries must be marked on a heliographic print, produced from the orthophoto. The demarcation officer then faces three scenarios when identifying the boundaries of property blocks on the prints:

1. **Case of visible boundaries**

In this case, the boundary surveyor proceeds methodically as follows:

• Identification of the property block on the print (based on the declaration of the owner or their representative).
• Marking the property parcel on the print by carefully joining the vertices that make it up with a solid line (0.2 mm pen, red ink).
• Numbering of the block (0.2 mm pen, red ink).
• Where applicable, representation of the parcels into which the block is subdivided (0.2 mm pen, green ink).
• Numbering of the plots (alphabetical letters, 0.2 mm pen, green ink).
• Depiction of features associated with the property block, such as:
  - Buildings shown according to their footprint.
  - Access roads shown as dashed lines.
  - Topographical details using their standard symbols.
• The surveyor proceeds in the same manner for all blocks belonging to the same owner and situated in the same locality.
• He may then move on to the next owner and repeat the same procedure.

2. **Cases of non-visible boundaries**

This situation is generally encountered following a recent change in ownership (division, sale, exchange, etc.) where the boundaries are recent and therefore not visible on the orthophotos.

In this case, the boundary surveyor will proceed as follows:

- He will identify the non-visible area on the map, marking it with an approximate outline, and will add the note
- He prepares his chain survey sketchbook, in which he will note the sketch number, the section number, the local place name and the direction of north.
- He identifies the details (or boundaries) adjacent to the land that are visible on the map: these will serve as a framework for the chain survey measurements.
- He draws up a chainage sketch (to an approximate scale) in which the boundaries visible on the map are shown in black ink (0.2 mm pen) and the surveyed boundaries (or details) in red ink. The chainage measurements must be clearly legible on the sketch in black ink.
- He proceeds, on the one hand, to number the blocks and plots thus surveyed and, on the other hand, to mark the numbers of the adjacent blocks already demarcated.

NB: Upon arrival at the office, the boundary surveyor must proceed to finalise the drawing on the second set of orthophotos (office set).

3. Case of an area to be completed

This situation is very common in wooded areas where property boundaries (or topographical details), where they exist, are obscured by tree foliage. In such cases, the demarcation requires preparatory office work to determine the appropriate surveying method, depending on the size of the area to be completed, as well as the scale to be used. In such a scenario, it is preferable to survey this area at the end of the work in the section.

- The boundary surveyor will then have at their disposal a completion team, whom they will accompany in the field so that the survey and boundary demarcation work can be carried out simultaneously with the field survey.
- In this case, the completion team will carry out the field survey, preferably using the declination method. The survey procedure must be carried out methodically, i.e. starting with the property blocks, then the parcels and finally the supported features (topographic details).
- Block boundaries visible on the map and situated in the immediate vicinity of the area to be surveyed must be surveyed; they will serve as reference points for the planimetric survey. The draughtsman will thus be able to easily incorporate this survey when drawing the section plan.

- The boundary surveyor will work in collaboration with the operator and will number the blocks and parcels on the plan's original.

c. Delimitation of cadastral parcels

A cadastral parcel is a contiguous portion of a block of land owned by a single party, with a uniform land use.

The demarcation of cadastral parcels within a property block is a technical procedure carried out on the basis of the nature of land use or land classification and in accordance with the requirements set out in the parcel definition. The various types of land use or land classification are indicated on the reverse of the T4 model property block forms. [2]

- ***Completion of the property block form***

For each property block, and at the very moment of its demarcation on the ground, the surveyor draws up a Model T4 property block form.

- ***Creation of owner forms***

There is a single owner form: natural persons – legal entities. This form is intended to record information concerning the owners and, upon completion of the work, should contain the list of blocks. If the owner has already been surveyed, the surveyor transfers the following to a new (yellow) form:

- The provisional account number and the owner's surname and first name;
- The provisional block designations, and completes the original record held by the owner.

The surveyor staples this new form to the copy of the original form in their possession. If the owner has not been surveyed, the surveyor:

- Draws up an owner's form in duplicate;
- Assigns a provisional account number to the owner;
- Enters the provisional designations of the surveyed blocks in box B.

For the allocation of provisional owner numbers, each boundary surveyor has at their disposal, for the area assigned to them, a continuous series of one thousand numbers. At the end of the fieldwork relating to a section, the boundary surveyor shall, where applicable, draw up the following two lists, which they shall forward to the chair of the A.P.C.:

- List of owners who have not responded to summonses for intervention by the local authorities.
- List of plots whose owners could not be identified (unknown) [2].

II.2.4.2. Land survey work

The purpose of the survey is to gather:

- All information necessary to establish ownership and other rights in rem or encumbrances on the property;
- Information relating to the identification of the entitled parties;
- Legal information relating to the property block.

It applies equally to all properties demarcated for the purposes of establishing the land registry, regardless of their legal nature and the specific status of their owners or occupants.

- **The procedure**

The survey is conducted by the surveyor in parallel with the demarcation operations.

The establishment of rights is carried out either on the basis of a title issued in accordance with the legislation in force, or, in the absence of a title, through investigations. It involves the identification of the rightful claimants (owners and holders of rights in rem). The surveyor must bear in mind that his role is purely descriptive, in the sense that he must confine himself to gathering claims, consulting and carefully examining supporting documents.

The investigations must aim to determine the property rights, whether divided or undivided, the facts of possession and all other rights and encumbrances, as well as the method of use. [2]

- **Completion of the land survey form**

For each plot surveyed, the data resulting from the survey are recorded on the survey form; to facilitate the surveyor’s task, the questionnaire below, presented in the form of a land survey form, has been drawn up. (Form T7). The header of this form, intended to record details regarding the property block and its owner, must be carefully completed to avoid any confusion (identical to those entered by the delimiter on the owner’s form).

Box I – entitled "**Legal status and title to the property**" – must clearly and unambiguously set out the legal status of the property. To this end, provision has been made for all scenarios that may arise during the investigation; the agent need only tick the relevant box to specify this status [2].

II.2.5. Preparation of cadastral documentation

II.2.5.1. Preparation of cadastral documentation: standard approach

The cadastral map

Final numbering of blocks and parcels: The final numbering of property blocks is carried out on a provisional copy of the cadastral map, in accordance with the principles set out below:

In each section, blocks are numbered starting from the unit, in ascending order of numbers, without interruption.

The block in the bottom-left corner of the sheet is given the number 1, and numbering continues horizontally to the right until the edge of the sheet, then returns to the left and continues in this way in a zigzag pattern.

Two consecutive numbers must be assigned to blocks that are adjacent or very close to one another.

Within the blocks, each plot is designated by a lower-case letter: a, b, c... For plots, the original designation shall be retained. [2]

Drawing up the plan

The annotated provisional reproduction (sketch map of boundaries – office set) includes:

- The final numbering (blocks and plots);
- The boundaries of the sections and neighbouring municipalities;
- The designation of transport routes;
- The boundaries of built-up areas;
- Topographical details;
- The various entries to be included on the cadastral map.
- It is then forwarded to the draughtsman for the preparation of the cadastral map.

Procedure:

• Preparation of a grid map;

• Transfer of control points onto the map;

• Assembling the orthophotomaps onto the grid sheet;

• Gridding the section plan sheet;

• Drawing of the section plan [2].

The work is carried out by tracing over orthophotoplans. Cadastral maps will be digitised or scanned, as appropriate, in order to create the computerised cadastral map required for the implementation of a geographic information system.

Drafting of textual documents

Creation of the master file

The term '**master** file' refers to the file comprising the individual records (forms T5 and T6) and the block records (form T4). The literal cadastral documents will be drawn up solely on the basis of the master file. The master file must therefore contain all the necessary information, in particular the definitive block numbers, the definitive owner numbers and the calculated areas of the blocks and parcels.

- Drawing up the correspondence table between the provisional and definitive designations of blocks and parcels.
    - Correspondence table No. 1 (containing the provisional designations of blocks and parcels)
    - Correspondence table No. 2 (relating to block numbers). The provisional designations are written in red ink next to the corresponding definitive designations.
- Transfer of the definitive designations of blocks and plots to the T4 model block forms.
- Transfer of the calculated capacities to the T4 block forms.
- Transfer of the definitive block designations to the T5 and T6 owner forms.[2]

II.2.5.2. Preparation of cadastral documentation: current solution

For the cadastral map

The only difference between the current method and the traditional method of producing the cadastral map lies in the quality of the sketch map:

• The delimiter encounters problems identifying boundaries when the boundary sketch map is a simple copy of a paper orthophoto map;

• The current solution allows them to print an original copy of the orthophoto, providing greater clarity and sharpness of the image.

For the textual documentation

The procedure for compiling the comprehensive file remains unchanged, except that the file is digitised by entering it into a standard database within the DFG (General Land Registry).

II.2.5.3. Production of cadastral documentation: solution currently being demonstrated

For the cadastral map

The difference between the method currently being demonstrated and the other two methods of producing the cadastral map lies in the following points:

- The boundary surveyor encounters difficulties in identifying boundaries when the boundary sketch map is a simple copy of a paper orthophoto map;
- The quality of the sketch map has improved significantly compared to the second solution, as the spatial map or aerial orthophoto forms the direct background of the sketch map, thanks to the use of a digital tablet. Boundaries are thus drawn directly onto the digital background of the images in the field;
- The final numbering of the parcels, carried out in the office, is completed quickly on the resulting digital cadastral map.

For textual documentation

The digitisation of the overall file involves data entry into a database at the ANC, which offers advantages over the DFG.

II.3. Conclusion

The discussion on improving the methodology for establishing the cadastre in Algeria is put into practice through the production of aerial orthoimages and the integration of very high-resolution satellite imagery into the overall process.

This chapter covers not only spatial imagery, but also the equipment to be used, such as ERDAS LPS photogrammetry stations and the digital drawing board.
As for textual documentation, an application has been developed by the ANC which is currently being rolled out, enabling the digitisation of textual cadastral data. The ANC has also acquired ArcGIS software, which is specifically designed for the creation of geographic databases and their use in GIS for long-term purposes.

Part III:

Exploitation of Satellite Imagery for Cartography

III.1 Introduction

Since the launch of the first Earth observation satellites, numerous studies have been dedicated to the extraction and exploitation of the information content of acquired images. This has been particularly relevant with the emergence of sensors providing metric and sub-metric resolution imagery. In this chapter, we address the concepts related to the use of satellite imagery for cartography, in accordance with the needs of various users and decision-makers.

III.2 Users of Geographic Information and Their Needs

III.2.1 Users of Geographic Information (GI) and Their Level of Expertise

Three categories of users can be distinguished according to their level of expertise (or competence) in handling geographic information (GI), in the fields of spatial planning and urban development:

Expert users: highly skilled in the integration and processing of geographic data.

Informed users: moderate knowledge of geographic data manipulation within their specific domain.

General public: no precise knowledge of geographic data or the tools to exploit it.

Expert users are characterised by their high capacity for integrating and processing geographic data. They handle and manage large volumes of geographic data in urban databases adapted to daily territorial management (technical management of networks, urban furniture, etc.). These expert users — GI technicians — operate at an 'operational' level.

Informed users have an average knowledge of geographic data manipulation and exploitation. They are only interested in it within their own area of competence. They have a basic knowledge of GIS tools. Their competences are related to urban planning, pre-operational urbanism, impact studies, observatories, and prospective studies. These informed users — planners — operate at a 'tactical' level.

General public users have no precise knowledge of geographic data and are unfamiliar with the tools to exploit it. This category encompasses both decision-makers, who make decisions at a 'strategic' level in an urban context (through the presentation of final documents, such as maps), and the general population who must be informed of territorial planning policies [1].

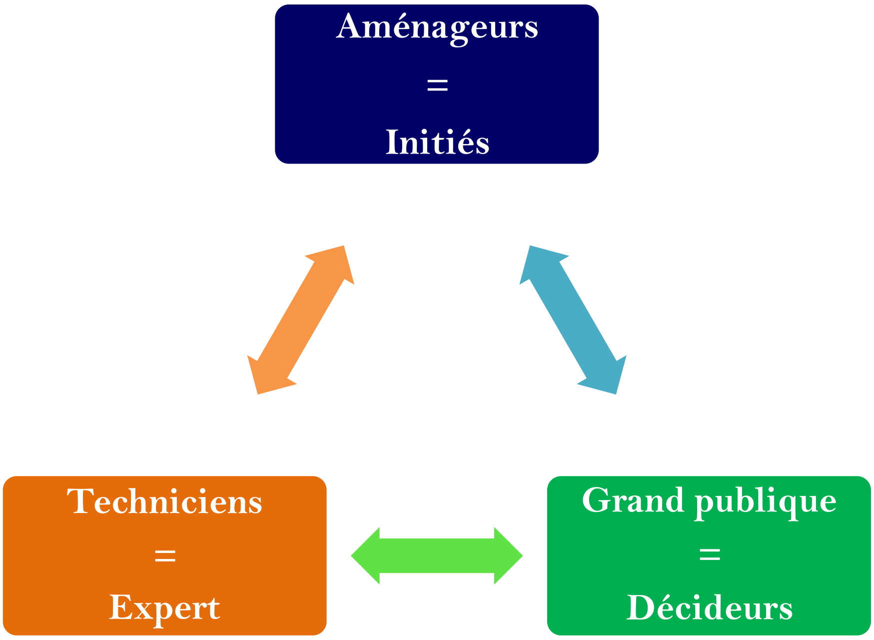


Figure III.1 Geographic information users classified according to their level of expertise

Regardless of the planning, management, and decision-making process, all stakeholders and users need precise information about the administered territory — both to respond to residents' needs and to anticipate future developments or ensure the maintenance of infrastructure. Interactions occur through urban practices between the various stakeholders and users [1].

III.2.2 Information Needs and Application Types

Each category corresponds to a level of responsibility, associated with a need for basic data that is distinguished by the volume of data required, the level of generalisation, the required precision, and the form in which this information must be delivered. Each level interacts with the level above [1].

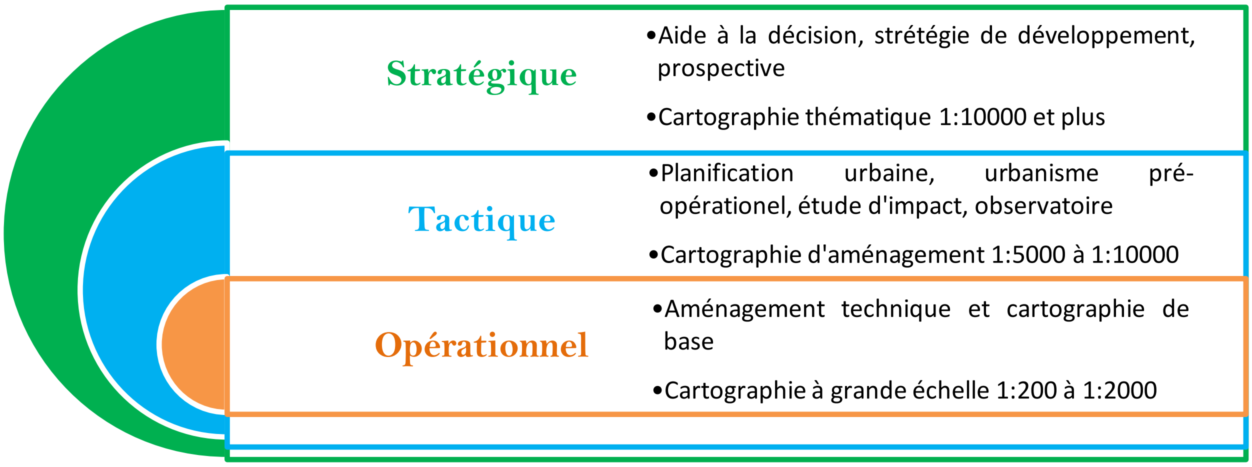


Figure III.2 Stakeholders and their associated needs in geographic information. [1]

The first group — 'territorial managers' — comprises public law organisations (administrations and local authorities) or private entities (network operators, for example). Their activities have a strong geographic component (GIS experts). They form the core of the GI market. Their applications require large-scale base data (from 1:200 to 1:10,000, from topographic surveys, cadastral plans, etc.) and high geometric precision. Technical planning applications require data at 1:200 to 1:300, while base cartography requires data at around 1:1,000 to 1:2,000.

The second group — 'territorial analysts' — comprises organisations whose common aim is to understand, analyse, and forecast the functioning of a territory or its components. It includes Urban Planning Agencies and Planning Consultancies. Applications include urban planning, pre-operational urbanism, impact studies, and road engineering studies. Data used are multi-source and multi-scale, originating partly from the operational level. Unlike group 1, high precision is not required, but spatial analysis processing is often needed. Data scales range from 1:3,000 to 1:10,000 and come from cartographic documents, aerial photographs, and orthophotos.

The third group — decision-makers and elected officials — require 'geographic syntheses' (e.g. mapping social policy effects, market penetration by district) in terms of thematic editing (communication support) and distribution analysis for decision-making. Data used are generally at small to medium scales from 1:10,000 to 1:1,000,000. Processing consists of map dressing and thematic overlays, planning scenarios (3D simulations, etc.).

The fourth category — transversal to the other three — corresponds to persons responsible for the administration and daily management of data integrated in a GIS. Their activity concerns archiving, formatting, and storing geographic and non-geographic data manipulated by all other levels. The primary objective is to facilitate data access across different departments. These data administrators require standardised data to facilitate GIS integration [1].

III.3 Use of Satellite Imagery

III.3.1 The Information Content of the Image

The generation or updating of topographic maps using satellite or aerial imagery requires consideration of the relationship between spatial resolution and map scale, taking into account not only geometric precision but also the level of reading and generalisation of the output map.

In general, it is not the geometric precision of the image that poses a problem — the real limiting factor is the informational content of the image. What objects can be seen in the image? The distinction between detection and interpretability must therefore be considered.

Example

A white line may be detected on an image. But is this white line a road, a path, or simply a boundary between agricultural plots? This illustrates the problem of interpretation.

For reference, NATO developed the concept of image interpretability analysis, in which object interpretation is organised into four hierarchical levels:

Detection: discovery of an object without recognition. Example: 'There is a white linear object in this part of the image.'

Recognition: ability to assign an identity to an object within a group. Example: 'This white linear object is a road.'

Identification: ability to identify the object as a specific type. Example: 'This road has two carriageways.'

Technical analysis: ability to precisely describe the attributes of the object. Example: 'The two carriageways are separated by a wall.' [2]

Objective	Detection	Recognition	Identification	Analysis
Terrain features	800 m	90 m	3 m	0.73 m
Urban areas	60 m	13 m	3 m	0.73 m
Roads	6 m	4.3 m	1.3 m	0.38 m
Railways	13 m	4.3 m	1.3 m	0.38 m
Bridges	6 m	4.3 m	1.3 m	0.3 m

Table III.1. Ground pixel size for image interpretation [3]

Applications	Scale	Resolution	Geometric Accuracy	Source Images
Operational level — Technical planning	1:200 to 1:300	20 cm	13–30 cm	Orthophoto / Airborne images
Operational level — Base cartography	1:1,000 to 1:2,000	20–30 cm	13–30 cm	Orthophoto / Airborne images
Tactical level — Territorial planning	1:3,000 to 1:10,000	30 cm – 3 m	±1 m	Orthophoto, IKONOS-2, QuickBird-2, OrbView-3, SPOT3
Strategic level — Prospective	1:10,000 to 1:100,000	>3 m / 10–30 m	±10–100 m	IRS, SPOT, Landsat, QuickBird-2, OrbView-3

Table III.2. Applications and images used [1]

III.3.2 Applications and Images Exploited

Few studies analyse exclusively the demand of users for image data (aerial or satellite). At the European scale, a report commissioned by the Centre of Earth Observation (CEO) on 'the identification of tasks and user needs in European cities' analyses the use of satellite images by various organisations. The study specifies the type of image products currently used according to the categories of users and applications defined in Table III.2.

Analogue and digital aerial photographs (orthophotographs) are currently the most widely used image products for applications at 1:200 to 1:10,000. High-resolution satellite images of the LANDSAT and SPOT type are used only in urban prospective applications at scales of 1:23,000 and smaller [1].

- 'Image data' are used in urban applications (orthophotographs only) at scales from 1:200 to 1:10,000.
- Satellite images are used only by a minority of users at scales of 1:23,000 and smaller (land use change analysis).

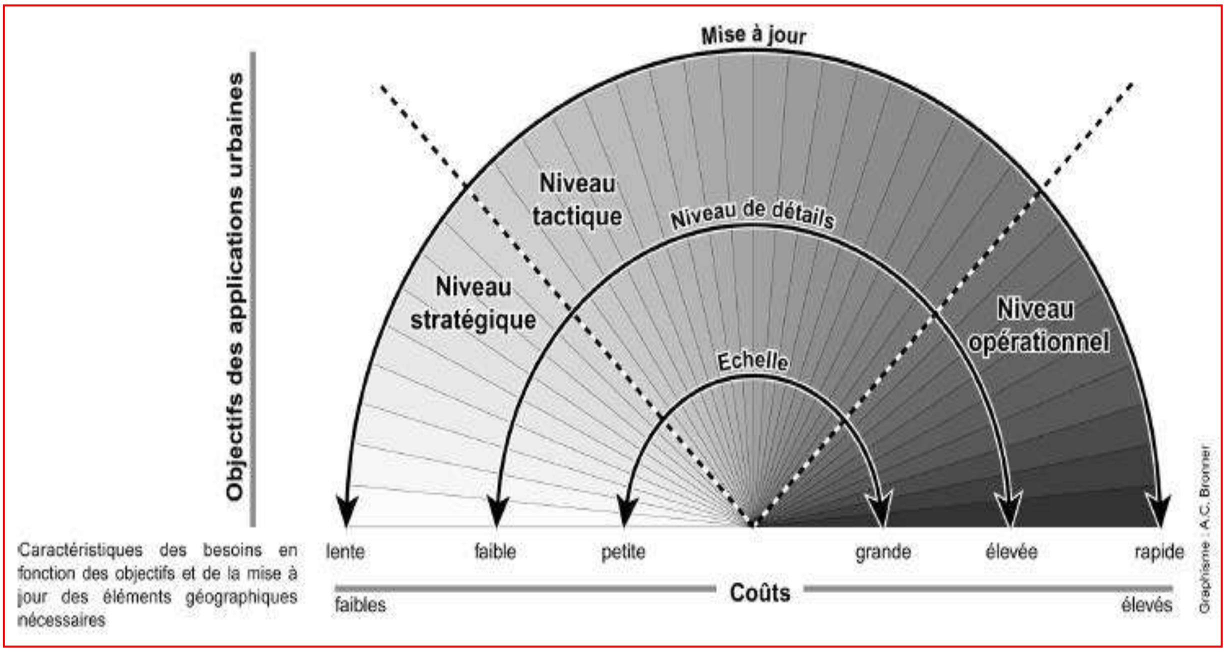


Figure III.3 Relationship between objectives, needs, and costs during data acquisition and updating

Relationship between objectives, needs, and costs during data acquisition and updating: Operational level (large scale, high detail, frequent updates — high cost); Tactical level (medium scale, moderate precision — moderate cost); Strategic level (small scale, low precision, slow updates — low cost). [1]

III.4 From Land Use Maps to Cadastral Plans

Application	Percentage (%)
Land use mapping	30%
Identification of green spaces	22%
Identification of impervious surfaces	11%
Change detection	11%
Complementary territorial view	6%

Table III.3. Applications of satellite imagery [1]

The primary use of satellite imagery — by far predominant — is land use mapping, followed by the detection of green spaces. These two applications represent three quarters of all applications [1]. A small number of users employ imagery for the identification of impervious surfaces, change analysis, or as a complementary territorial view at a different scale from other information layers.

III.4.1 High-Maturity Operational Applications

Operational applications in which satellite images are used as the primary source of information are few in number. They are carried out mainly from LANDSAT and SPOT images by fusing panchromatic and multispectral channels.

Level	Applications
Operational	Land use/occupation mapping (1:23,000 to 1:100,000) and statistical production; land use change mapping; flood plain mapping; flooded and marshy zone mapping; fire-risk forest zone mapping; urban morphological unit boundary mapping; control of agricultural plots under the CAP; production of Digital Terrain Models (DTMs). Cartographie et évolution des limites de « l'unité urbaine », correspondant à l'enveloppe de l'espace urbain, encore appelé Zone Morphologique Urbaine (Weber, 1993) ;
Tactical	Calculation of runoff coefficients; biomass index calculation to characterise urban structure; optimal location search for new commercial or industrial zones; road impact studies including land use consumption, vegetation rarity,

	noise exposure, and flood risk assessment.
Strategic	Thematic cartography as communication support for new planning projects. 3D simulations.

Table III.4. High-maturity operational applications of satellite imagery [1]

At the operational level, the most common processing operations concern thematic mapping and statistical production. At the tactical level, index calculations are most frequently performed. At the strategic level, the contribution of natural colour allows the development of this type of application, since the satellite image then becomes as readable as an aerial photograph to the general public — whereas previously it was the preserve of remote sensing specialists (with its false colours) [1].

III.4.2 Low-Maturity Non-Operational Applications

These applications — belonging exclusively to the research domain or in demonstration phase — are of low maturity. The images used are SAR, IRS, and increasingly IKONOS and QUICKBIRD (from 2000 onwards).

Level	Research / Demonstration Applications
Operational	Cadastral updating (new construction, changes); plant species identification; automatic tree counting; updating of existing databases (BD Topo); production of 3D databases (Digital Elevation Models); road network identification; mapping of disaster zones and assessment of material damage.
Tactical	Urban morphology analysis (urban fabric types); updating of planning documents; search for potential sites for communication networks; emergency management; production/updating of risk prevention plans; assessment of urban area vulnerability.
Strategic	Risk prevention (decision support); population estimation based on built-up morphology criteria; urban growth and sprawl modelling; DTM/DEM navigation.

Table III.3. Low-maturity non-operational applications of satellite imagery [1]

These applications correspond to those for which improvements in spatial, spectral, and temporal resolution — through the proliferation of VHR satellite images — should generate new application domains and multiply users in the fields of spatial planning and urban management [1].

III.3 The Advent of Very High Resolution (VHR)

From a technical standpoint, the main difference between High Resolution (HR) and Very High Resolution (VHR) lies in the following: at decametric resolution, the landscape in an image can be considered as a 'texture' draped over a low spatial-frequency relief (smoothed, flattened). At metric (and decimetric) resolution, high spatial-frequency altitude variations become visible. Hidden faces (buildings, trees), cast shadows, and the three-dimensional aspect of objects become perceptible. This 3D information appears at resolutions below 3–4 m (the average size of urban objects).

HR allows progression to the stage of recognition or identification of all objects, whereas VHR enables technical analysis of all objects/observations [1].

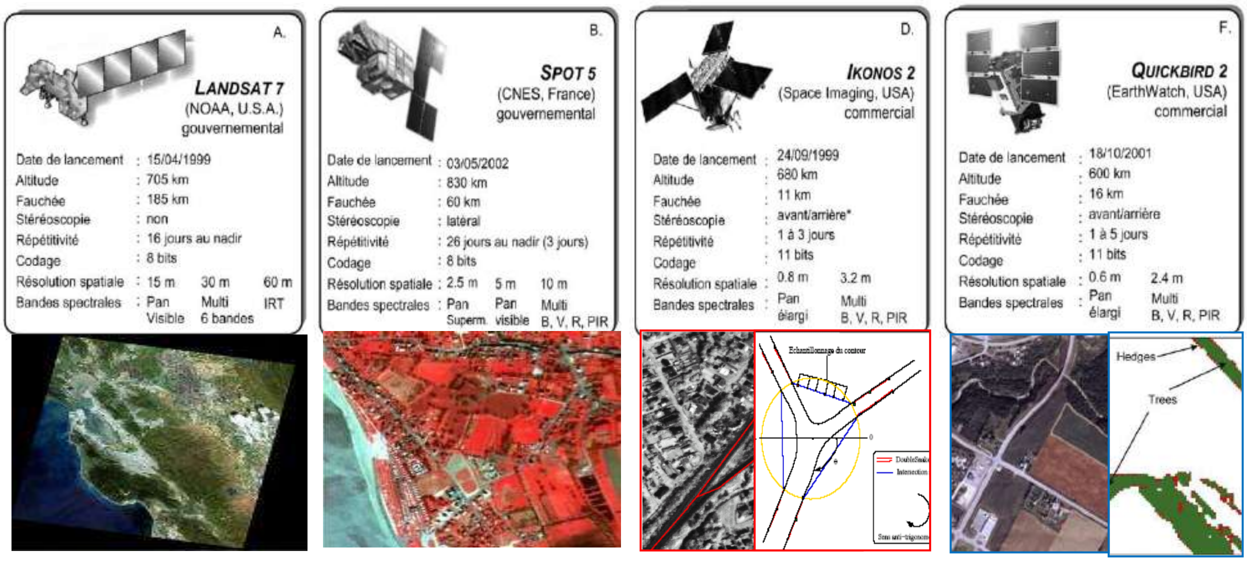


Figure III.4 Main sensors providing images at various resolutions: from coarse-resolution sensors

Main sensors providing images at various resolutions: from coarse-resolution sensors (MODIS, LANDSAT, SPOT) through high-resolution (SPOT3, IRS) to very high resolution sensors (IKONOS, QuickBird, OrbView) at metric and sub-metric levels. [1]

III.6 Matching Sensor Type to Cartographic Scale

III.6.1 Detection Thresholds

In general, several pixels are required to detect an object. A minimum of 4 pixels is needed, except for objects that contrast strongly with their immediate environment — such as a pond in the middle of grassland [4].

III.6.2 Identification Thresholds

Identifying an object requires 3 times more pixels than its detection — i.e. a minimum of 12 pixels. A figure of 28 pixels is recommended for complex agricultural landscapes [4].

III.6.3 Cartographic Thresholds

In cartography, an important factor to consider is the size of the object to be mapped. The minimum cartographic threshold for an object is generally 2 × 2 mm. The corresponding area depends on the map scale. For example, at 1:23,000, an object of 2 × 2 mm has an area of 0.23 ha.

The following table indicates various possible combinations as a function of the sensor. For example, with IKONOS multispectral (spatial resolution 3.2 m), maps at 1:10,000 can be produced with objects of 0.04 ha, good identification capacity (28 pixels), and good cartographic representation (2 × 2 mm) [4].

Formula

Maximum pixel size (m) = √(area in m² / number of pixels) | Example: for 0.23 ha and 12 pixels → √(2,300/12) = 14.43 m

Map Scale	1:3,000		1:10,000		1:23,000	
Cartographic threshold (mm)	2×2	3×3	2×2	3×3	2×2	3×3
Object area (m²/ha)	100/0.01	223/0.023	400/0.04	900/0.09	2300/0.23	3623/0.36
Identification threshold (pixels)	12 / 28	12 / 28	12 / 28	12 / 28	12 / 28	12 / 28

Max pixel size (m)	2.89 / 1.89	4.33 / 2.84	3.77 / 3.78	8.66 / 3.67	14.43 / 9.43	21.63 / 14.17
QB panchromatic — 0.64 m	✓	✓	✓	✓	✓	✓
IKONOS panchromatic — 0.8 m	✓	✓	✓	✓	✓	✓
EROS panchromatic — 1.8 m	✓	✓	✓	✓	✓	✓
QB multispectral — 2.44 m	✓	✓	✓	✓	✓	✓
SPOT3 panchromatic — 2.3 m	✓	✓	✓	✓	✓	✓
IKONOS multispectral — 3.2 m	—	—	✓	✓	✓	✓
SPOT3 multispectral — 10 m	—	—	—	—	✓	✓

Table III.6. Cartographic and identification thresholds at 1:3,000, 1:10,000, and 1:23,000 [4]

III.7 Accuracy and Correction of Satellite Images

III.7.1 Geometric Accuracy

Geometric accuracy estimates the variation in discrepancies between nominal positions (positions in the nominal terrain) and the positions contained in the dataset. It is decomposed into two types: the accuracy of point and linear positions, and shape accuracy [3].

III.7.2 Semantic Accuracy

Semantic accuracy represents the conformity of the values of dataset elements with the values of their counterparts in the nominal terrain. It concerns the classification of objects, the coding of attributes, and the relationships between objects.

For satellite images to be usable in cartography and GIS projects, pre-processing operations are required — operations applied to images upstream of all processing, in order to correct or improve them geometrically and thematically. Two types of pre-processing exist: radiometric corrections and geometric corrections [3].

III.7.3 Radiometric Corrections

Radiometric corrections are applied to images to reassign to each pixel a radiometric value as close as possible to that measured in the field. The recorded variations may be due to ageing of sensors, their deregulation, or instrument design defects. SPOT images have a slight banding problem, and LANDSAT MSS and TM images exhibit an important striping phenomenon (particularly at the start of the series).

It is often the distributing organisations of satellite images that carry out radiometric pre-processing (equalisation of detector sensitivity, etc.), but this can also be performed using appropriate procedures. Fourier analysis, for example, can reduce the banding in LANDSAT images [3].

III.7.4 Geometric Corrections

In 1972, the effects of geometric distortions were quite negligible for several reasons: images such as Landsat-MSS were taken at nadir with coarse resolution (~80–100 m); processed products were analogue on paper; evaluation was visual; and multi-source data fusion did not exist.

Today, geometric distortions are no longer negligible because: images are taken off-nadir with sub-metric resolution; processed products are entirely digital; evaluation is computer-based; and multi-source image fusion (different platforms, sensors) and multi-format data (raster/vector) are a general trend in geomatics.

Sources of distortion fall into two major categories: the observer/acquisition system (platform, sensor, measurement instruments) and the observed (atmosphere and Earth).

Category	Sub-category	Description of Error Sources
Observer / Acquisition system	Platform	Movement variation; altitude variation (below frequencies)
	Sensor (VIR, SAR, HR)	Sensor mechanical variation (scan rate, scan speed); panoramic effect with wide field of view
	Measurement instruments	Time variations
Observed	Atmosphere	Refraction and turbulence
	Earth	Curvature, rotation, topographic effect
	Map	Transition from geoid to ellipsoid and from ellipsoid to map

Table III.7. Sources of geometric errors in satellite images [3]

III.7.3 Geometric Modelling of Satellite Systems

Geometric models represent the relationship between object space and image space — they are theoretical models describing how the image of a given object is constructed by the system. Two major categories of models exist for very high resolution imaging systems [2]:

Explicit models: models based on the physical parameters of the acquisition system.

Implicit models: models that represent the acquisition system through a mathematical transformation between the two spaces.

Due to the unavailability of precise information about detectors (calibration parameters), most models are implicit or non-parametric, which can optimally describe the true (physical) geometry of the system [2].

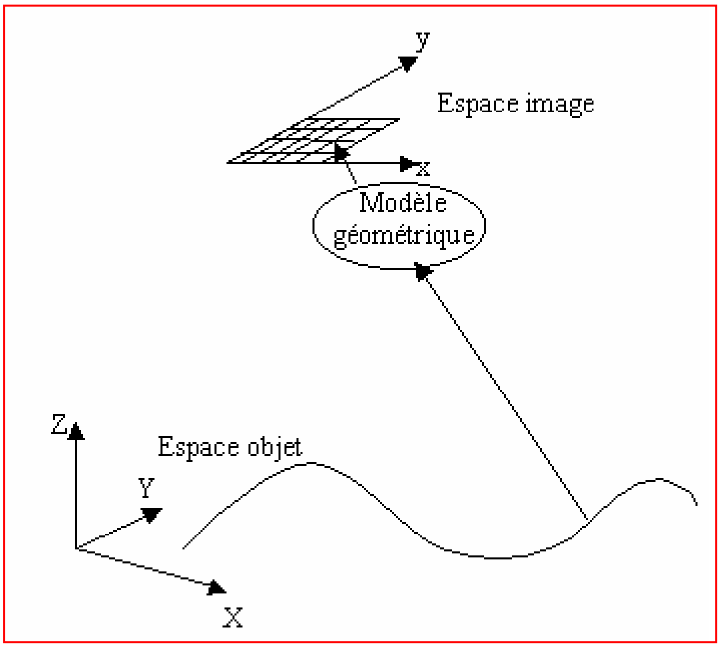


Figure III.3 The geometric model

The geometric model: relationship between object space (ground coordinates X, Y, Z) and image space (pixel coordinates x, y), mediated by the acquisition system's geometric parameters. [2]

Non-Parametric (Empirical) Models

These models are independent of the sensor and platform, do not account for the physical process of image capture, and are flexible and easy to use. The main types include:

Planar affine transformation: a 6-parameter plane transformation (translations, rotation, different scale factors in u and v, plus axis non-orthogonality).

$$\boxed{\begin{aligned} x &= A_1 X + A_2 Y + A_3 \\ y &= A_4 X + A_5 Y + A_6 \end{aligned}}$$

Planar projective transformation: an 8-parameter transformation representing a projection between two planes.

$$x = \frac{L_1 X + L_2 Y + L_3}{L_7 X + L_8 Y + 1}$$

$$y = \frac{L_4 X + L_5 Y + L_6}{L_7 X + L_8 Y + 1}$$

DLT (Direct Linear Transformation): created by Abdelaziz and Karara (1971) for terrestrial photogrammetry. Based on the collinearity condition. Requires a minimum of 6 ground control points.

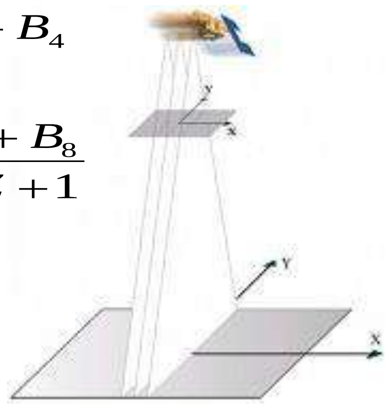
$$x = \frac{L_1 X + L_2 Y + L_3 Z + L_4}{L_9 X + L_{10} Y + L_{11} Z + 1}$$

$$y = \frac{L_5 X + L_6 Y + L_7 Z + L_8}{L_9 X + L_{10} Y + L_{11} Z + 1}$$

Parallel Perspective model: acquisition by a push-broom instrument represented by a perspective in the Y direction and affine in the X direction.

$$x = B_1 X + B_2 Y + B_3 Z + B_4$$

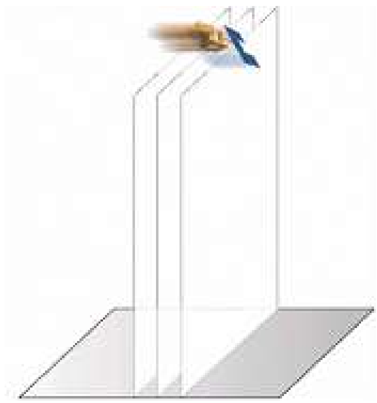
$$y = \frac{B_5 X + B_6 Y + B_7 Z + B_8}{B_9 X + B_{10} Y + B_{11} Z + 1}$$



Affine model: describes an affine transformation from 3D object space to 2D image space. Defined by 8 parameters: translations (2), rotations (3), non-uniform scale (2), and skew distortion (1).

$$x = A_1 X + A_2 Y + A_3 Z + A_4$$

$$y = A_5 X + A_6 Y + A_7 Z + A_8$$



2D/3D polynomial functions: empirical models based on polynomial functions. 3D polynomial functions extend 2D polynomials by adding a Z term for terrain elevation. Applicable to small areas with homogeneous control point distribution.

3D Rational Function Model (RFM): used by commercial satellite providers (e.g. Space Imaging) in place of confidential sensor models. Facilitates exploitation by non-specialist users.

2D fonctionnements polynômes	$P_{2D}(XY) = \sum_{i=0}^{m} \sum_{j=0}^{n} a_{ij} X^i Y^j$
3D polynomial functions	$P_{3D}(XYZ) = \sum_{i=0}^{m} \sum_{j=0}^{n} \sum^{p} a_{ijk} X^i Y^j Z^k$

X, Y, Z are the terrain coordinates or cartographic coordinates; i, j, k are integer increments; and m, n, p are integer values, generally ranging between 0 and 3, with m + n (+ p) being the degree of the polynomials, generally three [3].

3D polynomial functions are an extension of 2D transformation polynomials through the addition of the Z term, which represents the third dimension of the terrain.

In general, the polynomial order is less than three, and is used with certain precautions in order to maintain good accuracy:

- Applicable to small images (areas).
- Homogeneous distribution of control points.
- The correction is local (at the control point).
- Highly sensitive to errors in the input data.

These polynomials correct all systematic distortions except those caused by terrain relief; the altitude-related term in 3D polynomials must be reduced to a first-degree term for high-resolution images, regardless of the polynomial order used [2].

3D Rational Function Model (RFM)

3D rational functions (RFM) have recently regained interest among civilian users of remote sensing and photogrammetry, due to the launch of new civilian high-resolution satellites. The main reason for this interest is that certain image providers, such as Space Imaging, do not disclose information about the satellite and sensor. These functions are used to replace the sensor model — which remains confidential — and on the other hand to facilitate the exploitation of these images by non-specialist users.

In general, this type of function is written in the following form:

3D RFM	$R_{3D}(XYZ) = \dfrac{\sum_{i=0}^{m} \sum_{j=0}^{n} \sum_{k=0}^{p} a_{ijk} X^i Y^j Z^k}{\sum_{i=0}^{m} \sum_{j=0}^{n} \sum_{k=0}^{p} b_{ijk} X^i Y^j Z^k}$

X, Y, Z are the terrain coordinates or cartographic coordinates; i, j, k are integer increments; and m, n, p are integer values, generally ranging between 0 and 3, with m + n (+ p) being the degree of the polynomials, generally three.

Parametric (Explicit) Approaches

CCRS 3D Model (Canadian Centre of Remote Sensing)

Although each imaging system has its own specificities, the same general principle is used to develop 3D parametric models to correct all distortions present for this type of imager. These models integrate the geometry of the following elements:

- The platform (position, velocity, and attitude),
- The sensor (viewing angles, panoramic effect),
- The Earth (ellipsoid, relief),
- And the cartographic projection.

Geometric correction can be performed step by step — with each distortion corrected separately — or all at once. In practice, the best approach is to consider the acquisition geometry in its entirety (platform + sensor + Earth + map), given that certain distortions are correlated.

Theoretically, it is more judicious to calculate the combined parameters and separate them afterwards. For example, image orientation is a combination of the track azimuth (the inclination of the orbital plane relative to the pole), the yaw effect, and meridian convergence. The scale factor along the track is a combination of the velocity effect, pitch, the CCD signal recording time (exposure time), and the Earth rotation component along the track. The correction for the lateral viewing effect is a combination of roll, the viewing angle, and Earth curvature.

In general, the starting point for these models remains the collinearity condition, which is always valid for each image line. Since the parameters of neighbouring lines are correlated, it is possible to link the perspective centres and rotation angles using additional data.

IGP Model (Institute of Geodesy and Photogrammetry, Zurich)

A rigorous model was proposed by Daniela Poli, developed at IGP Zurich, for the geo-referencing of images acquired by linear (push-broom) sensors for satellite and airborne systems. The collinearity equations describe the perspective geometry for each image line; the position of the detector and its attitude are represented by a second-degree polynomial function of time. This trajectory is divided into segments according to the distribution of control points, with a zero constraint at the junction points of adjacent segments and continuity of the first and second derivatives of the trajectory function. The solution is based on observations of position, velocity, and attitude provided by on-board platform instruments.

This model also includes a self-calibration procedure for internal parameters, which are necessary for the correction of systematic errors due to:

- Displacement of the principal point,
- Variation in focal length,
- Radial and tangential distortion parameters,
- Scale variation in Y,
- Rotation of the detector array in the focal plane.

The functions modelling the external and internal orientations are integrated into the collinearity equation.

Parametric (Explicit) Models

Despite the specific characteristics of each imaging system, the same principle is generally used to develop 3D parametric models to correct all distortions present. These models integrate the geometry of: the platform (position, velocity, attitude), the sensor (viewing angles, panoramic effect), the Earth (ellipsoid, relief), and the cartographic projection.

CCRS 3D model (Canadian Centre of Remote Sensing): integrates the full geometry of the imaging system. Geometric correction can be performed step-by-step or simultaneously for all distortions. Theoretically, it is more judicious to calculate combined parameters and separate them afterwards.

III.8 Conclusion

Satellite imagery serves cartographic needs at three user levels: operational (large scale, high precision), tactical (medium scale, spatial analysis), and strategic (small scale, decision support). The informational content of an image is characterised by four interpretability levels: detection, recognition, identification, and technical analysis. VHR imagery (below 3–4 m resolution) enables 3D object analysis. Geometric corrections are essential for cartographic use, involving either non-parametric models (polynomial, DLT, RFM) or parametric models (CCRS, IGP) that account for platform, sensor, Earth, and projection distortions.

GENERAL CONCLUSION

Land Register in Algeria — From Theory to Digital Practice

This course has provided a comprehensive introduction to the land register system in Algeria — from its theoretical and legal foundations to the operational realities of rural cadastral establishment and the technological evolution that is reshaping its methodology. The two parts have progressively built a coherent body of knowledge, grounded in Algerian institutional practice and informed by international standards.

Key Takeaways by Part

Part I Theoretical Foundations	The land register is a state-administered system that fulfils two essential functions: guaranteeing property rights and providing a reliable territorial information base. Its documentation system — comprising the cadastral matrix, account table, section record, and cadastral map — constitutes the legal backbone of land management in Algeria. The ANC (National Land Register Agency) oversees the establishment and conservation of this documentation, while the progressive adoption of digital tools and satellite imagery is transitioning the system towards an E-Land Register model.
Part II Rural Land Register	The establishment of the general land register in rural areas is carried out through three successive methodological solutions: the traditional approach (based on INCT-supplied orthophoto maps), the current solution (producing aerial ortho-images in-house using ERDAS LPS), and the solution currently under demonstration (using corrected satellite imagery validated against NMAS and FGDC international standards). Each stage — preparatory work, delimitation and survey, and documentation production — has been compared across these three solutions, highlighting the progressive gains in speed, accuracy, and cost-effectiveness.
Part III Exploitation of Satellite Imagery for Cartography	Satellite imagery has transformed cartographic production at all levels of spatial planning. The progression from HR to VHR sensors has dramatically expanded the range of operational applications — from land use mapping at 1:25,000 to cadastral updating at 1:10,000 and below. Geometric and radiometric corrections, coupled with appropriate parametric or non-parametric geometric models, are prerequisites for cartographic-quality satellite image exploitation.

The Evolving Role of the Land Register

The land register is not a static administrative system. Since its initial establishment in Algeria, it has undergone a continuous methodological evolution driven by technological progress and the need to address the specific geographic and demographic challenges of the country — from the densely populated northern communes to the vast steppe and Saharan territories that remain partially uncovered.

The shift from analogue orthophoto maps to in-house aerial ortho-image production (ERDAS LPS), and from there to satellite-based cadastral mapping (SPOT5, QuickBird, IKONOS), represents a fundamental transformation in both the speed and cost of cadastral operations. Equally significant is the transition from paper-based literal documentation to fully digital databases — a process currently being rolled out through the ANC's information systems, including ArcGIS-based geographic databases.

For students in Geomatics and Topography, the concepts taught in this course — land register definitions, establishment procedures, documentary architecture, delimitation techniques, geometric correction of imagery, and cartographic accuracy standards — form the operational and theoretical foundation upon which all cadastral and land management professional practice is built.

Perspectives

Looking ahead, several trends will continue to shape the Algerian land register system:

Completion of national coverage: with more than 70% of northern territory covered, the priority is now the steppe and Saharan zones, where the multi-sensor, multi-resolution methodology described in Part II will play a central role.

Very High Resolution (VHR) satellite imagery: sensors such as Pléiades, WorldView-3, and GeoEye now offer sub-50 cm resolution, enabling cadastral-quality mapping without aerial missions — particularly valuable for remote or inaccessible areas.

Digital tablet and field GIS: the solution currently under demonstration, using digital tablets for direct boundary tracing on geo-referenced images in the field, represents a major productivity gain for delimitation and survey operations.

E-Land Register and online access: the digitalisation of literal documentation and the deployment of web-accessible cadastral databases will progressively make cadastral information available to notaries, surveyors, municipalities, and the general public through secure online platforms.

Integration with GIS and urban planning systems: the cadastral database, enriched with satellite-derived land use layers, is increasingly serving as the geographic foundation for urban planning, environmental monitoring, and agricultural policy — fulfilling the multipurpose cadastre vision.

3D cadastre: emerging international practice is extending the cadastre into the third dimension, recording volumetric rights for underground infrastructure, above-ground structures, and multi-storey properties — a future development that Algerian institutions are beginning to consider.

Final Note for Students

The land register is, at its core, a system of trust — trust between the state, property owners, and society. Its accuracy, completeness, and currency directly determine the security of property rights and the efficiency of land markets. The professional skills developed through this course — photogrammetric processing, satellite image correction, boundary delimitation, and documentary management — are not merely technical competences. They are contributions to one of the most socially significant functions of the state: the fair, accurate, and transparent recording of who owns what, where, and under what conditions.

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