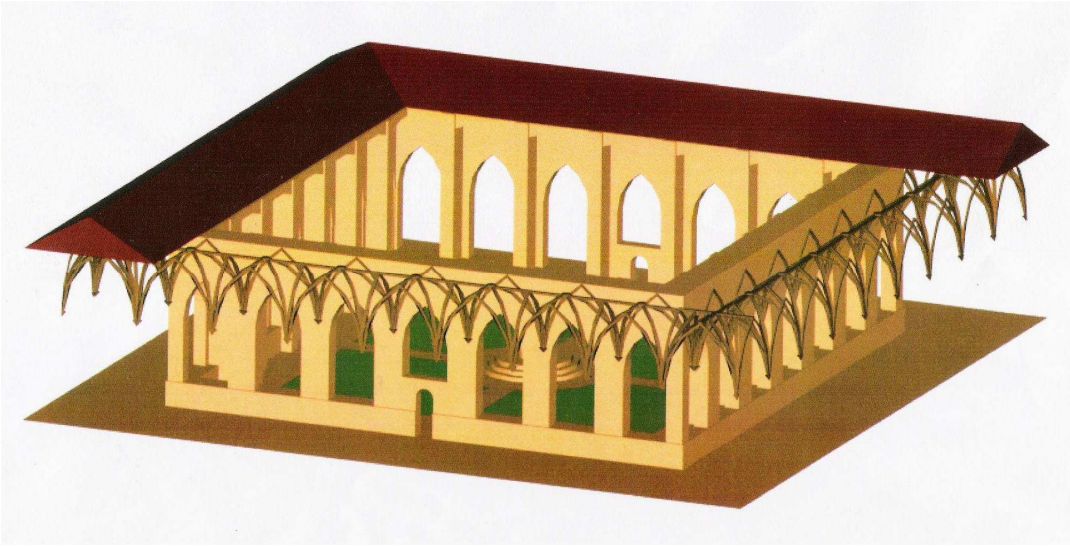
PFC

Gestión del Patrimonio Cultural
Nuevas Tecnologías

Year of realization:	February 2007
Subject	Three-dimensional modelling

TITLE: Topographic survey of the cloister of the cathedral of Sigüenza in the scale 1:200



SUMMARY

1. Introduction

1.1. Objectives

The project consists in a survey of the cloister of the Cathedral of Sigüenza (Guadalajara). To achieve this, we will determine the coordinates and elevation of a network of 5 points. Once this calculation made, we will conduct a series of points using a total station without prism. The survey will enable us to achieve the 3D representation of the cloister. Once we calculated the points taken with laser, it only remains for us to implement the plan.

1.2. Localisation

The city of Sigüenza is located in the province of Guadalajara, 130 km from Madrid, 75 de Guadalajara and 200 of Zaragoza.

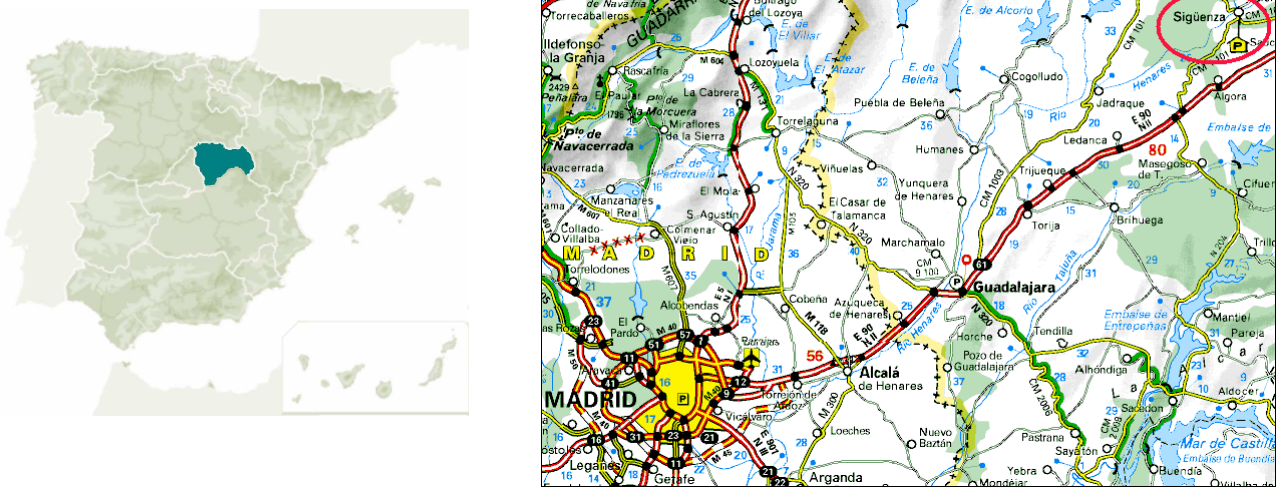


Image 1 : Location

1.3. Historic context

The installation of the population in upper course of the river Henares has started millennia ago. Segontia appears from the fifth century BC. Segontia appears, as one of the largest cities of Celtiberia. Its name means precisely "that dominates the valley." The campaigns against the Roman Celtiberia has defeated the people of the plateau, including those of Segontia.

Thereafter, Sigüenza was divided in two poles: on the one hand, the military center, consisting of a Roman fortress located where today is the castle, and the other the residential sector, whose growth helped fur by the river Henares fresh and fertile

The known history of Sigüenza begins on the eve of the twelfth century, with the Christian reconquest of the area. Castilian-Leon monarchs, one border traditional Douro reached, will seek to achieve the Tagus, to seize and populate Transierra Castilian. Thus, King Alfonso VII presents the bishopric of Sigüenza, still in Arab hands, Don Bernardo de Agen, which will aim to recapture the city in 1123

From that date, the highest part of the city has stabilized around the castle, which became the prerogative of the bishop, and in the lower part, more dense density and enjoying rapid growth, will be built the new cathedral which will serve as the headquarters of the diocese restored.

2. Classic topography Observations

2.1. Objectives

The objective was to determine the coordinates, in elevation and plainer, of a basic network, which consists of 5 peaks. These summits will then be taken with laser.

To do this, we used the total station Leica TCR 705. With this device we can make measurements without prism using the laser (LR), but also measures with prism through infrared (IR)

Figure 2: station TCR 705

2.2. Observation method

The method used to establish the network is the overview. We covered all the points raised consecutively and angles distances and angles between the different stations.

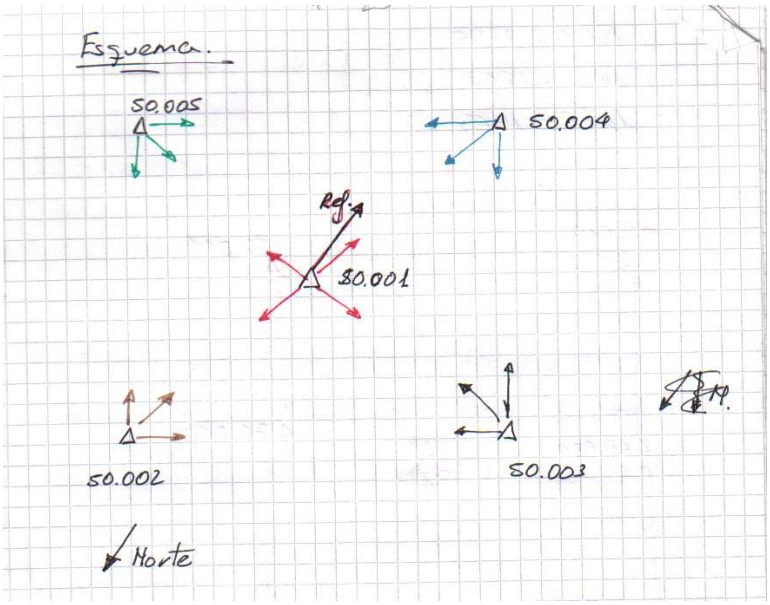


Figura. 3: Sketche

Each item is have its sheet station, if we want to come back.

The angles and distances was made through direct observation and reciprocal of summits visible from the station, noting the readings with an azimuth referred to the tip of a nail, in order to reduce the angular error in measuring distances without prism. Zénithales readings were performed on the central part of the prism.

2.3. Calculations and ajustements

In this part of the project, we used the Topography calculation program TopCal 21.

To achieve the approximate calculation of the coordinates of the vertices, we considered a fixed point, the summit 50001, we have given as coordinates 1000, 5000, 900. For this work, approximate north has been taken as the reference of directions. The coordinates of the points approximates 50,002, 50,003, 50,004, 50,005 were obtained by performing a measure from the station 50001.

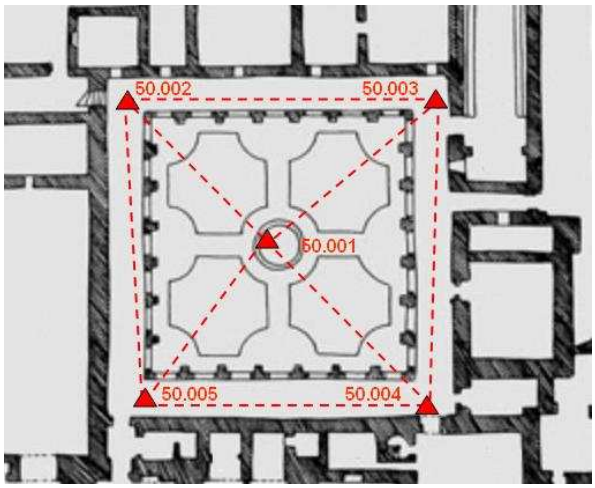


Figura. 4: location of the points.

The final calculation of the coordinates of the stations was carried out using the square method

Station	Final coordinates			
	X (m)	Γ(x) (m)	Y (m)	Γ(y) (m)
50001	1000,000	0,000	5000,000	0,000
50002	977,803	0,012	5001,744	0,001
50003	998,513	0,001	4977,095	0,013
50004	1026,714	0,015	4997,949	0,001
50005	1002,371	0,001	5025,368	0,014

Data for calculating the trigonometric denivelation, was conducted with planimetry. For this there was the basic net, in which it was referred highs in each CD (right circle) and

CG (left circle), distances and zenith angle of each set made have allowed us to calculate altitude.

Below the result of adjustments:

Station	Final coordinates	
	Z (m)	Γ(z) m
50001	900,000	0,000
50002	899,248	0,006
50003	899,221	0,007
50004	899,345	0,006
50005	899,338	0,006

Once the calculations made, it was determined the final coordinates of the peaks.

Sation	Final coordinates		
	X	Y	Z
50001	1000,000	5000,000	900,000
50002	977,793	5001,745	899,248
50003	998,512	4977,085	899,221
50004	1026,713	4997,948	899,345
50005	1002,372	5025,368	899,338
60000	991,666	5012,392	899,286
70000	1008,59	4987,268	899,289

Once the coordinates of the 5 major peaks known, we calculated the two points Of densification.

Based on the coordinates of summit obtained by the square method, there has been an intersection directly from stations 50001 and 50005 to get the coordinates of the top 60,000 and 50,004 and 50,003 stations to get the point 70,000.

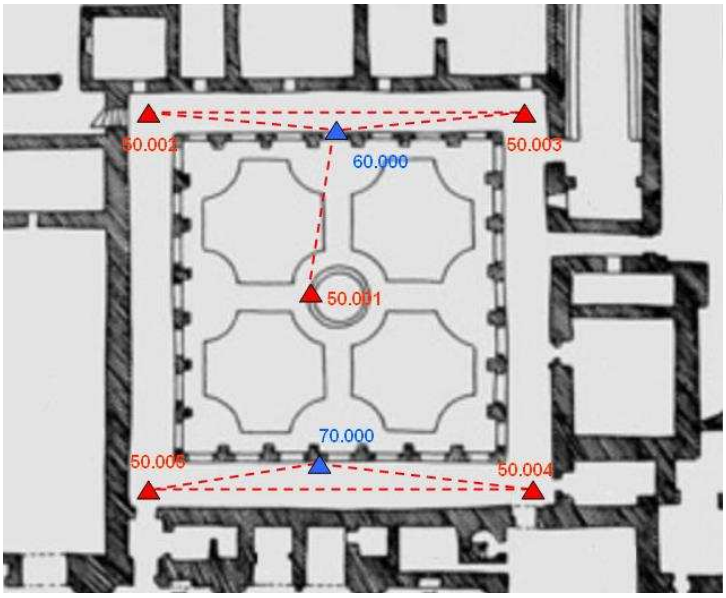


Figure. 5: location of the points of densification

Here are the details of the final points densifications **:**

Station	Final coordinates		
	X	Y	Z
60000	991,666	5012,392	899,286
70000	1008,59	4987,268	899,289

3. Measurements with laser

3.1. Objectives

With this method, we will define the coordinates of points needed to define tridimensional cloister. The task is made easier by TCR 705 total station, which allows us to make measurements without prism.

3.2. Method

After having stationed the points identified above, we focused on all the points that we have targeted. We have also included references remote and well-defined to ensure that the station remains stable during the measurement.

Before we did a sketch of the cloister. This will enable us to locate the points that we measure the laser, and thus to facilitate the future realization of the plan.

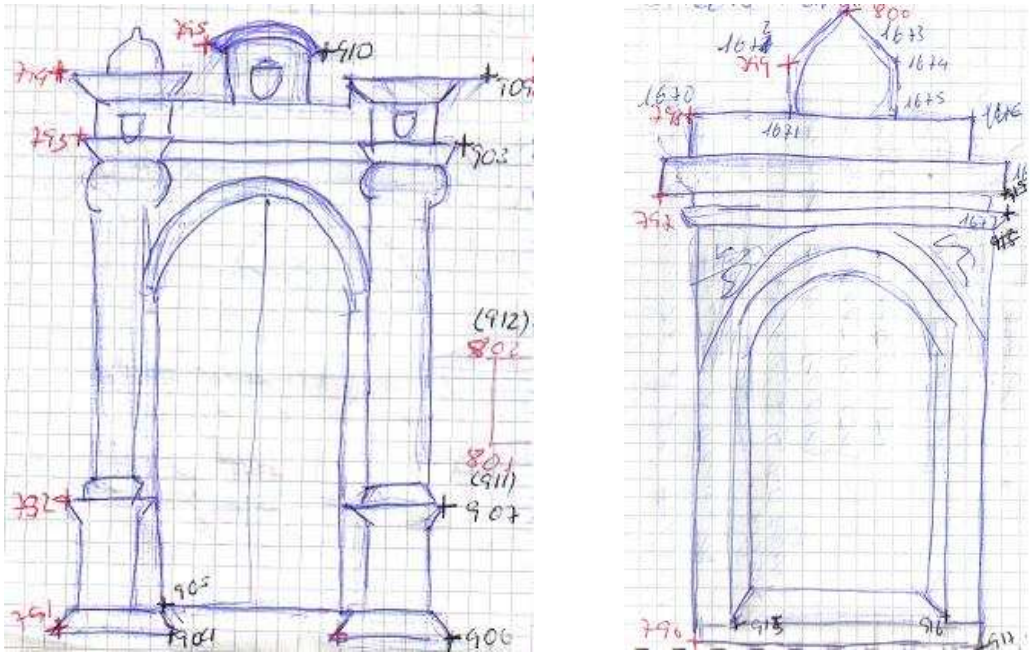


Figure 7: Croquis des éléments caractéristiques du cloître

The maximum measurements distance is 316m. Below this distance, it is ensured that systematic errors can not be on a map at 1 / 200, i.e. an error of less than 4 cm. We have never taken any measures over 316 m during this mission.

We have made a total of 1524 points to achieve the survey of the cloister**.**

To determine the relative precision of points, we considered the top 50,001 as the origin of the reference system. Planimetry and altimetry errors will be null

To calculate the planimetric accuracy, we used the phrase**.**

$$E_{R_{XY}} = \sqrt{E_{R_P}^2 + E_{P_{XY}}^2}$$

E_{Rxy}: planimetric accuracy of points taken with laser method

E_{Rp}: accuracy of of points taken with laser method

E_{Pxy}: planimetric accuracy of the station from which the measurement is done

In order to calculate the precisions, we always imagine the worth case. So we choose the point with less presion. To do so we choose the point 70.000, the error is E_{Rp} = 0,015 m.

Precision in planimetry: $E_{R_{XY}} = 0.021m$

In order to calculate the altimetric precision we use this expression

$$E_{R_Z} = \sqrt{E_{R_A}^2 + E_{P_Z}^2}$$

Precision in altimetrie: $E_{R_Z} = 0{,}017m$

4. CARTOGRAPHIC DESIGN AND EDITION OF THE TOPOGRAPHIC MAPS

4.1. Introduction

The previous phases of survey and processing necessary to define geometrically the cloister gave us a cloud of points, from which, and with help of the field sketches, there was elaborated a plane of the plant and of the standard of the cloister to scale 1:200.

4.2. Preparation of the files of work

The obtaining of the points of the survey was realized by means of classic topography by total station. Later one proceeded to calculate the planimetric coordinates of the points that were defining the plant of the cloister, as it explained previously.

After these operations there was created a file ASCII that transformed to the format .dwg, in order to be able to overturn this information in a program of graphical design (CAD). In this case the above mentioned transformation of format was realized by the same program of topographic calculations TopCal21

CAD's program used in this case was Autocad 2005.

4.3. Drawing of the maps

Some of the realized planes appear in the Attached II.

5. THREE-DIMENSIONAL RECONSTRUCTION OF THE CLOISTER

5.1. Introduction

After the capture of information, which result has been the cloud of points that defines the cloister, the three-dimensional reconstruction had to be realized

The cloud of points was corresponding to the walls and to the central court of the cloister, by what there were marked the hollows of the dependences to which one was acceding from this one

5.2. Three-dimensional reconstruction of the Cloister

The great difficulty of this phase was the work with the third dimension, together with the great quantity of points taken (about 1600), which was provoking a heaviness of the information, as a consequence the location of the points that were forming walls and details of the cloister in the space, was complicated.

Figura 8: Cloud of points of the cloister

To facilitate the work we didn't used the total cloud of points, but once obtained the plant of the cloister, and knowing the dimensions of each one of the elements that were composing it, it was considered more suitable to resort to the tool of extrusion in Autocad

By means of this procedure the three-dimensional model of the cloister was obtained

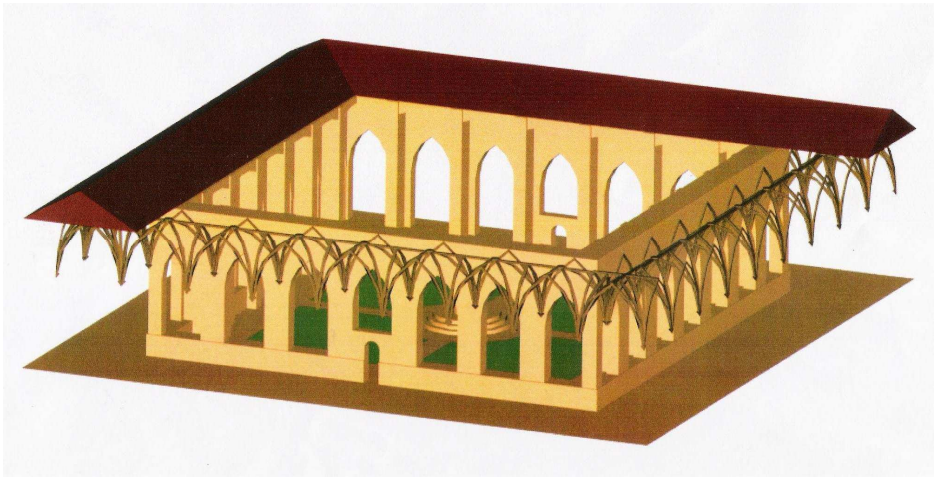


Figura 9: Three-dimensional reconstruction of the cloister

Figura 9: Detail of the vault of the Corners

Figura 10: Detail of the vault of the Pandas

6. BUDGET

Though the budget of the accomplishment of this project was calculated without taking in account the phase of learning of the multiple and varied technologies involved in the execution.

ACTIVIDAD	COSTE
Fase previa:	
Reconocimiento del lugar	250,00
Planificación del Proyecto	320,00
Preparación del equipo de trabajo	320,00
	890,00
Observación de la poligonal:	
Localización y croquización de los vértices	250,00
Observación	450,00
	700,00
Radiación:	
Croquis de elementos representativos	250,00
Toma de puntos	2.970,00
	3.220,00
Cálculos:	
Volcado y edición de los datos	672,00
Calculo y ajuste	1.312,00
	1.984,00
Diseño cartográfico y edición de los planos:	
Diseño de los planos	1.148,00
Edición	820,00
Impresión	328,00
	2.296,00
Reconstrucción Tridimensional	1.640,00
	1.640,00
Preparación de la documentación	3.280,00
	3.280,00
Subtotal	**14.270,00**
Beneficio 14%	**1.997,80**
Total	**16.267,80**
Total + IVA(16%)	**18.870,65**

The costs are in Euros.

7. CONCLUSION

In the elaboration of this project the following processes followed:

- To look for the necessary documentation to use certain topographic instruments, and the opportune methodology for every case.
- To be able to use each type of topographic material for every phase of the project and use them in a most suitable way.
- To take information later to work with them.
- To follow the processes necessary for the development of a work.

As for the conclusions relating to the project, it is important to emphasize that in the elaboration of any project, there is a vital importance to follow the planning and the organization of the same one. Of the same way, the phases of local recognition and the signposting of the bases are indispensable

Concerning the observations using the total station without prism of reflection, it is necessary to to bear in mind that it facilitates the observations in the area of the raising front and buildings

Finally, it is important to rely on a few suitable sketches that should guarantee an easy location of the points, in case of the edition of the planes. The existence of programs of computer-aided design and the quality of the same ones increases the productivity and the quality opposite to the previous methodologies, but they force us to learn how it works.

Acknowledgment

To the student Silvia Peces Rata, and all the supervisors and students who made possible the project and this report.

8. BIBLIOGRAPHY

- **FEDERICO, Aurelio de** (1954): "La catedral de Sigüenza"; Ed. Plus·Ultra.
- **GARCIA Y BELLIDO; TORRES BALBAS; CERVEDA; CHUECA; BIDAGOR** (1968): "Resumen histórico del urbanismo en España"; Instituto de Estudios de Administración Local, Madrid.
- **PECES RATA, Felipe Gil** (1984): "La catedral de Sigüenza"; Ed. Everest S.A.
- **PECES RATA, Felipe Gil** (1986): "Sigüenza, La Ciudad del Doncel"; Ed. Everest S.A.
- **HERRERA CASADO, Antonio; ASENJO PELEGRINA, Juan José; PECES RATA, Felipe Gil** (1992): "La catedral y el museo diocesano de Sigüenza"; Ed. Ludion S.A.
- **JUSTE BALLESTA, José; BARCELÓ DE TORRES, Eduardo; MONTAÑÉS GARCÍA, Manuel** (2006): "La catedral de Sigüenza. La puesta en práctica de un Plan Director"; Ed. Lunwerg Editores.
- **PARIAGUA, José Ramón** (1978): "Vocabulario básico de arquitectura", Ediciones Cátedra, S.A.

Otras fuentes de información:

Proyectos:

- **CASTAÑO SUÁREZ, Angélica; CRIADO VALDÉS, Marta** (2005): "Levantamiento topográfico y generación del modelo tridimensional del "CASTILLO DE LA ADRADA" y de sus alrededores. Elaboración de un documento multimedia del castillo".
- **ALONSO RODRIGUEZ, Miguel Ángel** (2001); "Levantamiento topográfico del interior de la cúpula del Monasterio de San Lorenzo de El Escorial".

Location Internet:

- www.sigüenza.com
- www.pueblos-espana.org
- www.Goolzoom.com
- www.spain.info
- www.terra.es
- www.fuenterrebollo.com/Heraldica-Piedra/catedral-siguenza.html

ANNEXE I. REVIEW OF THE PEAKS OF THE NET

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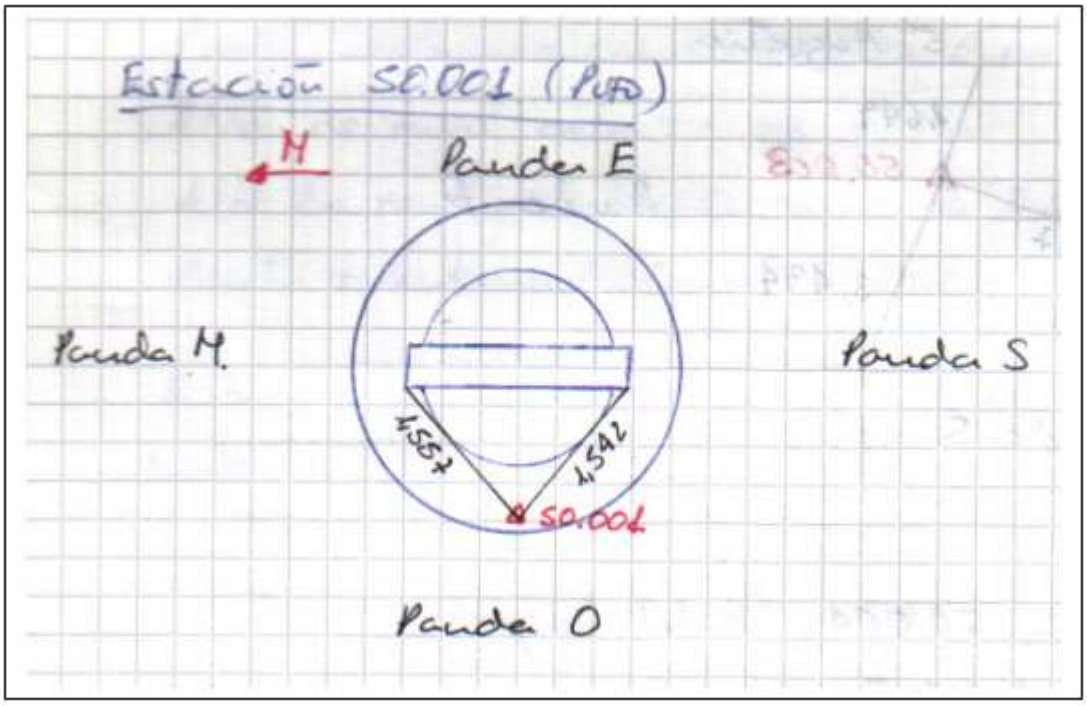
Nº de estación: 50.001

Coordenadas Sistema Local:

X: 1000,000 m
Y: 5000, 000 m
Z: 900,000 m

Tipo de señal:
Marca de pintura naranja.

Reseña literal:
Situada en la parte oeste del escalón superior de la plataforma que da acceso al pozo.



ANNEXE II. MAPS

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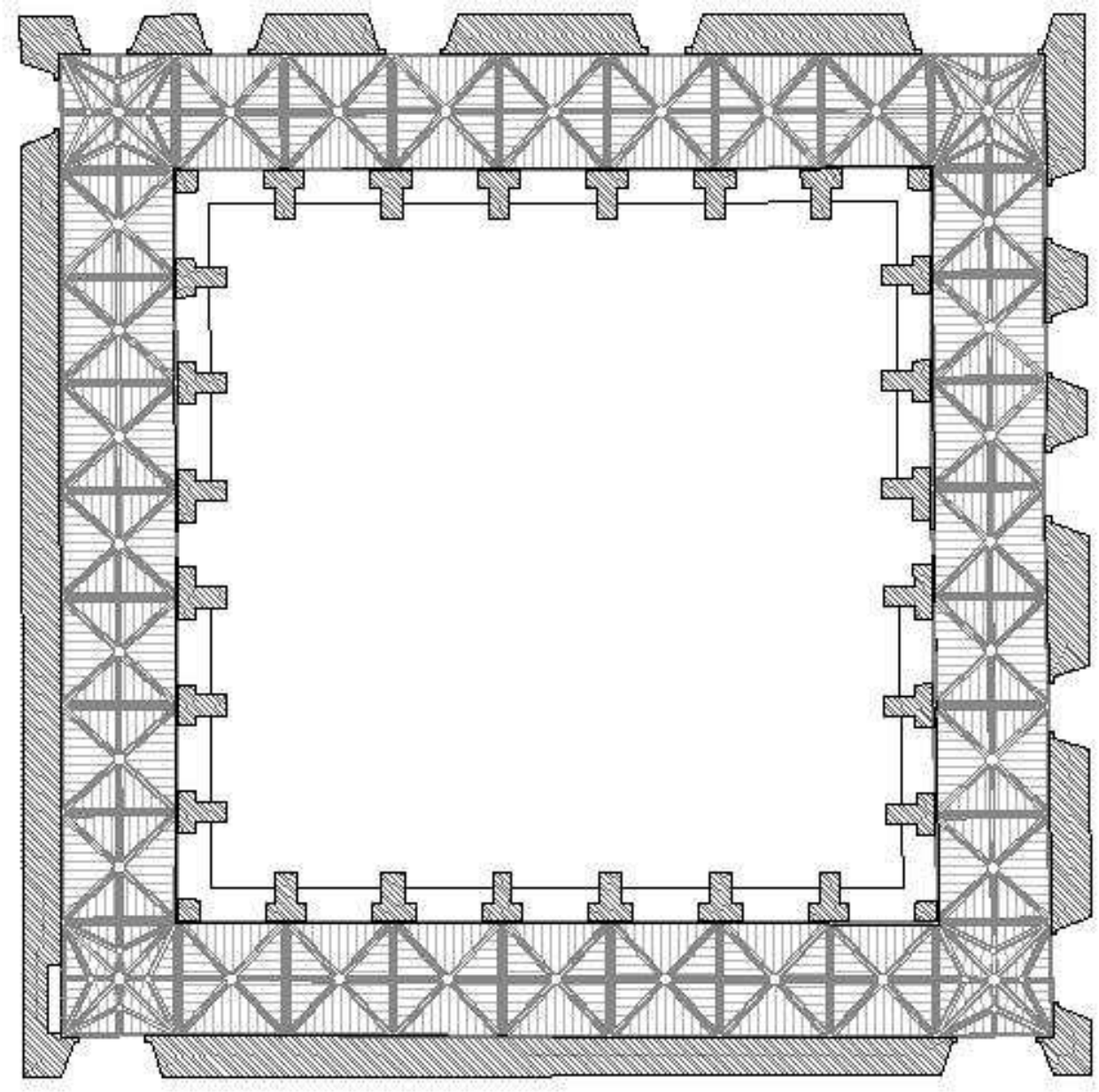
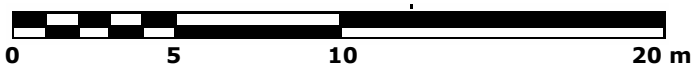
Vault of the cloister



Grafic Scale 1/200



Topographic survey of the cloisterof the cathedral of Sigüenza in the scale 1:200	July 2006

Plant of the cloister