

# FORMA TARRACONIS? GIS use for urban archaeology

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## ABSTRACT

*In this article we describe the use of a GIS for the archaeological compilation of the town of Tarragona and the inclusion of old plans of town which have been georeferenced. For this last fact we have used techniques of geometric corrections of aerial photographs.*

*From here on we have been able to begin a work of analyze of the collected information, allowing the confirmation of previous theories about the urban morphology of town in roman times, as so as new hypothesis of work for future investigations.*

## 1. INTRODUCTION

At the end of XX century some projects which allowed the compilation of archaeological interventions made in Tarragona (Ted'a, 1988; Rifà, 2000; Macias, 2000; Fiz, 2000), were tried to materialize; they were always limited to the use of database associated to archaeological plans made with CAD. However, it's not until the year 2002 that the first rough estimates with GIS were begun, promoted by History Museum of Tarragona as a part of the archaeological study of harbour area of town for the composition of General Plan of Town-planning of Tarragona.

This project allowed the compilation of the plans obtained in archaeological interventions and its most important information, including it not only in a GIS (ArcView 3.2) but also in a database made with Filemaker. The project allowed the obtaining of a PhD Thesis (Fiz, 2004) which its main objective was developing an archaeological information system (SIA) that allowed the management of archaeological activity of any town.

The idea of compiling the historical cartography of town emerged from both situations, including it among several present archaeological and topographic layers. This initiative was due to the verification that certain problems associated to the interpretation of old topography of Tarraco couldn't be resolved because of the great and destructive dynamics of town-planning made since XIX century. The superimposition of these historical plans over the available archaeological information would make easy the task of archaeologists "retrieving" archaeological traces already missing but they were registered in maps by their contemporaries.

The methodology of investigation has been already applied to the study of Town-planning evolution of imperial *thermae* of harbour of Tarraco and it has allowed the comprehension of historical evolution of building as so as the reuse in Middle and Modern Age of old roman structures (idem/Macias, 2004). Since year 2004 a project is being developed, financed by *Catalan Institute of Classic Archaeology* and *History Museum of Tarragona*, which consists in the compilation of all archaeological excavations made in town since the beginning of XX century to make an archaeological global plan; the objective of this is the town-planning comprehension of a roman town as Tarraco, which reached the 80 hectares. This project has made evident the important scientific lacks caused by the urban developments and stone quarries of XIX century. It's in this phase of the process when the historical cartography and the methodology which we developed in parallel to the archaeological documentation must take part in it.

## 2. TECHNICAL BASIS

The historical cartography, raster images, can be georeferenced to be situated in a GIS. The registration of an image applies a geometrical transformation which relates coordinates of image (line, column) with coordinates of a reference system.

The system of transformation, adaptation and georeference of old plans is based on technology of geometrical correction used in air photographs. When an image is taken from the air, some mistakes are introduced coming from distortion of sensor (for instance distortion of lens), the slant of the medium with regard to the vertical, the speed of the platform or the altitude, among other ones. The most common method to correct an image geometrically is finding a polynomial of a certain order, that allows minimize the mistake made in the transformation of an original image to another corrected. We get this transformation making polynomials, using a series of points of control introduced by the user as coefficients. When the most adequate transformation is found, the one which minimizes the mistake, then it's applied to every pixel of the image to be transformed. The transformation can be represented using a polynomial of order  $m$  as:

Here  $x$  and  $y$  represent the coordinates known at the image of reference whereas  $x'$  and  $y'$  represent the coordinates of last transformation.

The use of polynomial transformation is so common in the registration of images. They establish the link between the coordinates of the image and the ones in the system of reference, through **points of control** (methodology explained in Fiz/Macias, 2004). The points of control are topographical features of easy identification not only in the image but also in the land, that is to say, they are elements which coordinates are known not only in the image to be transformed but also in the system taken as reference. Crossings of roads, runways and confluences of rivers are very common candidates used as points of control.

The determination of parameters of the polynomial transformation chosen is made by means of the resolution of a system of equations. The coordinates of points of control must be known not only in the image but also in the system of reference so that this system could be made. These coordinates of the image (line, column) are obtained by pointing the user with the mouse over one of the topographic points chosen, and looking for their parallel at the image taken as a reference for making it. So, a program of these characteristics stores a pool of points that will be useful to make the polynomial transformations needed. The main advantage is that the difficulties associated to the conversion of different local measures are avoided, for example the *vara* (unit of length equal to approximately 33 inches), previous to the generalization of the international metric system.

However, the treatment of old plans produces some problems which are different to the ones corresponding to the rectification of air photographs. One of the main problems is that the system doesn't adapt well to situations where mistakes not accumulated would have been produced when the plans would have raised. That is, the cartographer would make dispersed mistakes and not proportional ones. In these situations, it's necessary to raise the grade of the polynomial of transformation, so that it's also absolutely necessary increasing the number of points of control. But this modification means that the rest of the image has a great distortion, being only corrected if the points of control are uniformly distributed. In the treatment of old cartographies, both conditions are difficult to get because as their antiquity is increased, the number of common points is decreased. For this reason, it's necessary to collect from one plan to the previously one not only the common points of control, but also their combination with the archaeological remains contemporary to the times which the cartographies represent.

## 2.1 TARRACO: URBS SUPRA COLLEM

*Colonia Iulia Urbs Triumphalis Tarraco*, capital of the *Hispania Tarraconensis* was one of the largest cities of the Occidental Mediterranean. A prosperous town that achieved an urban area between 80 and 90 hectares and distributed, roughly, in an area within the city walls up on a hill (aprox 60 ha), a *suburbia* at the lower slopes (10-15 ha) and a large harbour area (8-10 ha). It's a town so known because of its great public buildings – *Concilium Provinciae*, the Circus, Amphitheatre, the Theatre and the Forum – and it had a lot of thermal estates. In spite of this the town-planning – *viae* and *insulae* – is one of the least known aspects of the present archaeological investigation. The reasons of this are the technical characteristics of domestic architecture and that the residential areas were changed by the urban development and the numerous fortifications of Middle and Modern Age after its abandoning in late Antiquity.

It wasn't until 1999 when a first proposal of restitution of road network was presented, and what is more, this was limited to the residential area within the city walls causing a lot of questions which have not been resolved (Macias, 2000). This theory was made with the archaeological findings of town including them in the present topographic and establishing a ratio of 1 per 2 *actus*. This is, on the other hand, one module of common *insula* in *Hispania* and that, in the case of Tarraco, is due to a town-planning program projected around the year 100 BC. Later archaeological works have proved that the residential area within the city walls was object of three town-planning phases clearly different (Fig. 1).

The first area (2 ha) developed from an Iberian settlement and its road network hasn't been identified (Díaz *et al.*, in press). The second one (24,6 ha) is due to the great town-planning of the ends of II BC century and it has a ratio of 1 per 2 *actus* with *viae* of 6 metres of width and one *kardo maximus* of 7 m. This area has a scientific lack without solution because of an excavation of an urban stone quarry during XIX century and it reached an area of 7 ha. The third urban area has 11 ha and it is due to a town-planning of the ends of republican times. In this area the urban network hasn't been able to reproduce with precision because of the great patrimonial affectation produced between XVI and XIX centuries.

In front of these lacks, we have turned to the information of historical cartography managed by a GIS. Fortunately the area within the city walls was developed on a coastal hill, which from the 15 m over the sea level, climbed progressively up to 80 m. This fact determined the roman town-planning making an urban network with great architectonic structures of retaining slope of hill and, by the other hand, an orientation of *kardines* and *cloacae* which made easy the evacuation of faecal and pluvial water to the harbour bay. A lot of these elements lasted in time, further the abandon of Later Antiquity. So, the urban roman structures were well used from medieval times on, as rural paths, the old *viae* – or as elements of farming division into plots – walls of *insulae* or embankment. Later, the medieval farming division into plots determined the form of town-planning of XIX century. Therefore, and in spite of the centuries passed, it's possible to detect the roman town-planning by means of historical cartography. The clearest example is that the nineteenth-century streets maintain the same orientation as the *kardines* of the end of I BC century.

## 2.2. CONTRIBUTIONS OF GIS

For this methodology of researching we have chosen the “*Plan of the portion of terrain which is between the high Precinct of square of Tarragona and its Harbour*”, edited the year 1800 by Antonio López Sopeña. This is a document made before the appearance of facts which produced the biggest affectation in historical heritage of Tarragona: the great urban quarries and the town-planning expansion of the middle of XIX century. Moreover the chosen plan is a reliable document, which recently has been analyzed from the topographic point of view and historical evolution of the town (Gabriel, 2001).

For our self-interest the plan is useful for the definition of the urban zone within the city walls of old *Tarraco* (Fig. 1, areas 2 and 3). This part of roman town was abandoned from IV century on, when *Tarraco* recovered the urban duality characteristic from republican times: a high part on the hill and a great harbour suburb outside the city in relation with its harbour and the surrounding land (Macias, 2000b). This look remained until XIX century so that the residential area within the city walls of roman town was, between IV century and middle of XIX century, a rustic zone where the urban division into plots was continuously transformed by farming activity.

From the conceptual and technical point of view we faced up the doubt that, instead of the centuries, we had to prove that the farming occupation of this area hadn't been enough to hide the urban roman traces, the most important one would have been useful in farming division into plots or road network which join, in 1800, the high part of town with the harbour zone.

The analysis of the central part of plan shows the pre-eminence of three ways: the one of the *Piramide*, the one of the *Mig* and the *Caputxins* (Fig. 2).

The most oriental one is already known in a plan of 1641 and the other ones were documented graphically from 1769 on (cfr. Aresté, 1982). These three ways are coincident with three of the *kardine* of the town. Even the most oriental one is a reminiscence of the *kardo maximus* of the town and it has been, during modern and contemporary times, the city's main area for the communication between the high part and the harbour.

With regard to the cross-axis, the historical cartography also shows coincidences with the layout of roman *decumani* and this is useful for us to restore the *forma Tarraconis in areas* affected by the quarries of XIX century (Fig. 1). The most obvious case is the republican *decumanus* identified under the high imperial theatre of town and that, according to the cartography of 1800 and the archaeological funerary remains of the suburbs, allows us to interpret the hypothetic presence of a new roman gate of the walls, from where it must situate one of the outlying ways which created a little necropolis previous to the amphitheatre of II century AD (Fig. 4). This way would become a structure of terraces of a little hill which wasn't likely urbanized.

By the other hand, we also see farming traces – edges of farmer – of XIX century that coincide approximately with the cross-axis of the *insulae* which measured 35 m of width per 70 m of length (Fig. 3).

This is due to the great slope of the roman town (around the 7% of median), so that there would be a difference of theoretical height around 5,3 m between the axis of the two adjacent *decumani*. So, in some parts of town northern front of each *insula* would be about 5 m over the southern one. The inside architectonic distribution of each *insula* might correct this slope. This fact would have required the construction of terrace and retaining walls which, according to the datum given by GIS, would have an architectonic structure suitable to be edges of farming division into plots.

The conclusion is that the datum obtained from the application of a GIS complement the experiments of reconstruction of old urban aspect. This new source of traces allows us to corroborate the previous interpretations and, at the same time, includes the urban areas which are object of an irreversible affectation of their heritage in the interpretative proposals.

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## FIGURES

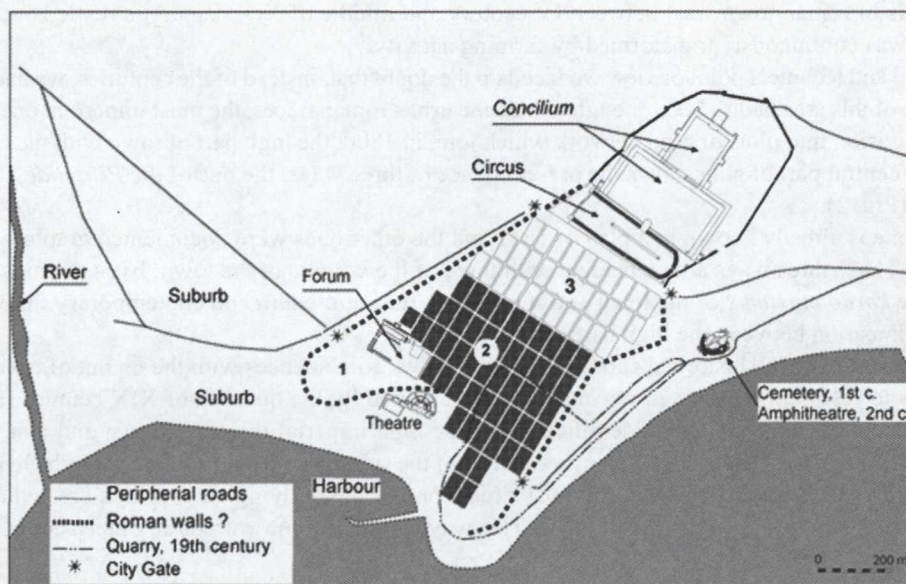


Fig. 1 – Hypothetic plan of town of *Tarraco* at beginning of II AD century according to archaeological datum (Macias, 2000) and contributions of GIS.

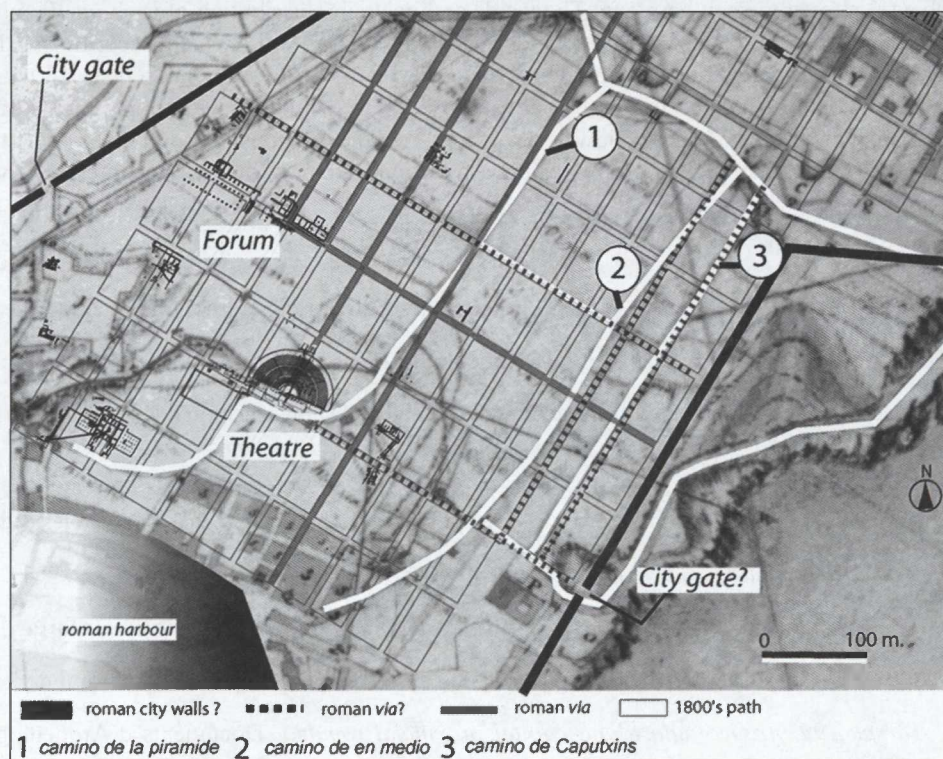


Fig. 2 – Central part of the plan of López Sopeña (1800) related to the reconstruction of Roman division into plots.

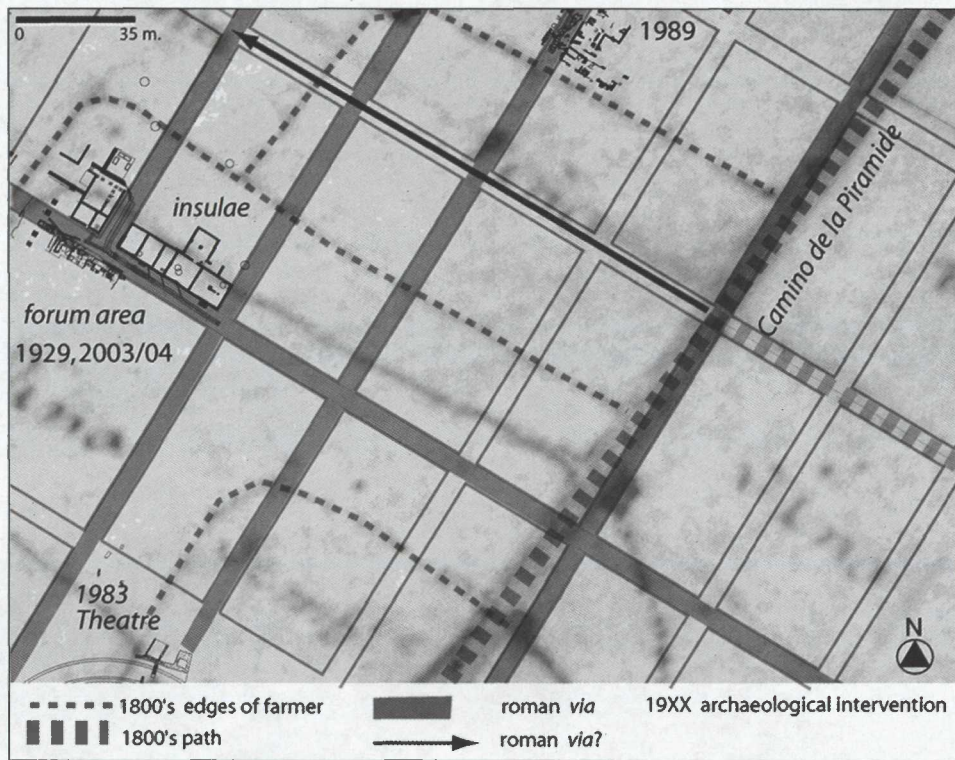


Fig. 3 – Residential area detail.

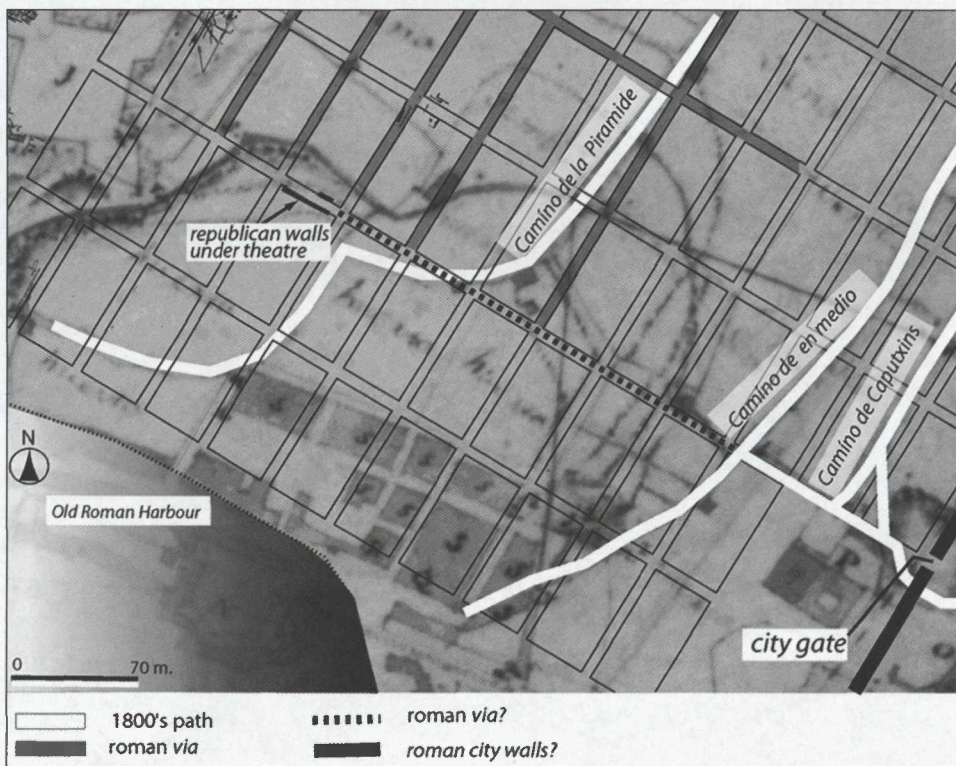


Fig. 4 – Harbour area detail.