GIS Analysis of Roman Transport Routes, Seville Province, Spain

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ABSTRACT

Urban Connectivity in Iron-Age and Roman Southern Spain is an AHRB project based at Southampton University aiming to analyze changing social, economic and geographical relationships between towns and nucleated settlements in southern Spain between the Iron-Age and Roman periods from c.500 BC to AD 500. The work presented is an interim report on an aspect of that project: the use of a GIS to locate, record and analyze probable transport infrastructure within the region. This is with particular reference to the Roman and pre-Roman road system and the river Guadalquivir which provides a transit 'spine' traversing the entire study area. Evidence for location takes a variety of forms from the textual (classical texts, itineraries) and material (milestones, geophysics) to the geographical (digitized aerial photos, topography and hydrology). How to record such a disparate array of data in a manner which is complete, comprehensible and comparable is a further element of research. The approach currently undertaken is to generate a series of node graphs corresponding to provisional routes and then establish correlations between them. Having established these theoretical pathways, there will be further investigation into ways in which, in such a necessarily probabalistic field of inquiry, levels of certainty can be linked directly to the epistemic root of an assertion (e.g. that there existed an established route between locations X and Y). Thereafter it will also be necessary to find ways of representing different certainties, and indeed, varying types of certainty. These issues form the basis for a brief discussion at the end of the paper.

1. BACKGROUND

The Roman province of Baetica is of signal importance in comprehending the origins and development of Roman hegemony with an unbroken record of transition from the Republican to the Late Imperial period. Roughly coextensive with the modern Autonomous Region of Andalucia, Spain, it was a key exporter of olive oil, grain, metals and garum, and an integral part of the Roman 'world economy'. Despite this high level of commerce, the natural topography of the area is essentially Atlantic-facing and bounded by the Sierra Nevada and Sierra Morena mountain ranges to the North, East and South. These natural restrictions on interaction with neighbouring regions make it an ideal case study for inter-urban relations between towns during the Roman period. Urban Connectivity in Iron-Age and Roman Southern Spain, an AHRB-funded project based at Southampton University aims to collate and synthesize a wide variety of data in order to better understand the changing social and economic relationships between urban and rural settlements within the province from its pre-Roman Iron Age cultures through to late antiquity (c. 500 BC to AD 500). By recontextualizing these locations within their broader social, political and physical 'ecosystem' it should be possible to make greater use of a large body of detailed investigations which have hitherto been studied independently of one another.

This paper is based on a sub-project focusing on the primary transport routes between settlements located in the modern province of Seville, along with parts of Huelva, Cordoba and Cadiz. As the economic hub of the region, the area has a transport network that predates, but was greatly expanded by, Roman administration. Use of the Guadalquivir, which served as an important link to the outside world and a vital conduit for internal traffic, is the other major focus of the investigation, along with its erstwhile Atlantic estuary and major tributaries. Part of the challenge comes in modelling the interface between terrestrial and water-borne modes of transport, which a recent study has shown to be extremely difficult (Rahn, this volume). Source materials range from the textual (classical texts, itineraries) and material (milestones, geophysics) to the geographical (digitized aerial photographs, topography, hydrography). Despite this volume of data, our picture of regional inter-urban communication, and its commensurate social, political and economic dimensions, is not clear. Thus the research intends to utilize spatial analysis to evaluate better the relationship between historically and archaeologically recorded infrastructure.

Whilst it should be made clear at the outset that the work does not suppose non- (or non-direct) communication between settlements where no transport route is recorded, the presence of such a route is taken as an indicator of stronger links between the settlements than might otherwise be the case. Predicated upon this assumption is the view that analysis of the transport infrastructure (natural and artificial) may, when used in conjunction with other indicators, provide insight into the civic structure of the region. The research will therefore have two primary outputs. The first is the location, recording and analysis of the transport vectors of the region in a form allowing for easy integration with like data and which provides the capability of 'back-referencing' the results of the study to the sources which provide their underlying justification. The second output will be a critical analysis of the tools and methodologies used as some of them will undoubtedly prove to be less successful than anticipated. This is not a criticism of the tools and techniques currently available, merely an acknowledgement that GIS-analysis of archaeological data is, in a number of ways, still a technology in its infancy. The final results, as part of the wider research agenda, should contribute to a better understanding of the ways in which

Iron-Age communities were integrated into the Roman Empire and social hierarchies within the Roman provinces were articulated. The purpose of presenting a paper at this 'innovation' session is to raise a number of issues which the work has encountered to date with the hope of provoking a wider discussion of them.

2. METHODOLOGY

The first stage was the initial process of identifying, collating and storing data from a variety of different sources in order to establish an organised corpus of material with which to work. This is not the first study of Roman roads in the region, and in fact a number of books have been written on the subject (esp. Sillières, 1990; Corzo-Sánchez, 1992) which take into account a very broad range of information, both historical and archaeological, and provide strong foundations for further research. These were used to provide reference to the archaeology and aided the identification of primary sources. The textual and epigraphic evidence includes Pliny the Elder, Strabo, Ptolemy, the Antonine Itineraries, the Vicarello Goblets, and the Ravenna Cosmography/Peutinger Table, while archaeological sources include bridges, *miliarii* and aerial photography. As the nature of this data is extremely heterogeneous, a database was developed to record references to the smallest unit considered – a presumed pathway between two locations. The presumption in each case is that a given source asserts (or at least implies) the existence of such a pathway (rather than, say, its non-existence), but a notes field allows for non-binary data. The simple database structure, implemented in Microsoft Access, was designed for maximum fitness-of-purpose and contains just two tables. The first records relevant locations (essentially possible nodes on a transport route) with any correspondent data. The second is a record of transport links (of whatever nature) and notes which sources do (and do not) refer to it. The result provides an overview of all documented connections between locations and, more importantly, enables 'backwards' referencing to the sources that record them.

Having stored abstract references to the primary objects of the investigation, the next task was to compare them to a model of the 'real world'. The operative word here is *model* rather than *real*. A GIS enables the graphical representation of complex spatial data which may (or may not) have a bearing on the existence of the transport routes, but in any case provides the context in which those routes are to be understood. Collating data was once again the first step. In this case the principal information included the boundary of the study area, topography, hydrography, orthorectified digitized aerial photography[1], all known site locations, and a number of possible transport vector schemes[2]. These were all introduced into an ESRI ArcGIS 8.0 geodatabase and fully georeferenced using a common projection. The combination of all this information enabled a far clearer overview of the locations' physical relationship to one another, as well as the potential barriers between them. It also made clear the considerable differences between interpretations of the transport network described by the secondary sources.

Having introduced the data into the system, the hypothesized vectors were compared with the aerial photos to try and establish whether clear traces of them could be identified within the landscape. Initial results seemed promising with roads and field-markings providing extensive linear features with low curvature, oblique-angled bends, and apparently linking key locations. It was therefore a disappointment to discover that the most promising candidates were in fact oil pipelines! This nevertheless allowed the conclusion to be drawn that surface traces of the roads will be at most fragmentary, and in all likelihood entirely absent, entailing a different kind of approach. It was decided to abandon a feature-led methodology in favour of a network analysis based primarily on historical and epigraphic sources.

Network analysis uses the concept of arc-and-node graphs to represent the abstract 'proximity' of a set of objects. In other words it uses our conception of space in order to represent non-spatial relationships between them. The approach has previously been used in the region on an extremely broad level (Thomas 1999), and the results of that investigation will be used to guide the future direction of the current one. For the purposes of this study it is postulated that a recorded transport route between points A and B indicates a closer social/economic proximity than that between identical points A' and B' that do not have such a route. A further assumption is that multiple referencing of such a route suggests its increased importance (i.e. we would expect more references to highway than a byway). The data collected in the database is to be used to generate a series of node graphs representing epistemic units, i.e. statements from primary sources that vectors ran between two or more locations. Once these have been generated, common locations are to be identified and an aggregate super-graph created displaying the relative closeness, betweenness and degree centrality of towns (with respect to their common communication routes) and hence level of importance within that network. Whilst interesting in itself, the primary importance of this knowledge comes from comparing it both with spatial and geographical factors, such as real distance and cost-distance, and with other network-analysed characteristics such as epigraphy, ceramics and size/status. In this way the research will both contribute to and draw from the greater body of work of the UCIARSS Project.

1 **Principally from the Mapa digital de Andalucía 1:100.000, Sevilla: Consejería de Obras Públicas y Transportes.**

2 **Archaeological data, where not input by myself was provided by the UCIARSS, University of Southampton.**

3. CHALLENGES

Turning now to some of the issues raised by the work to date, a brief comparison of the results of previous studies (Figures 1 & 2) will serve to demonstrate the difficulties encountered when using their results. The problem here is *not* that the two maps differ – in fact the discrepancy highlights important information, namely that the road system is by no means certain. The issue is that the maps do not make this clear to the user shown individually, or indicate the evidence on which the theoretical road system is based. Although the authors go to great lengths to explain and qualify their respective views, this information is lost when presented in map form as the visual nature of cartography tends to reify its subject. Archaeologists work with probabilities rather than facts however, and so the challenge is to represent this clearly. That is to say, maps often combine a wide variety of data (often of debatable validity) which is masked by uniform presentation. The issue is an extremely broad one and worth breaking down into (at least) three constituent parts:

1) Epistemic reversibility – A GIS ties argument and presentation together. Currently however, they are mostly used to generate maps for use within paper-based publications, which results in a vast loss of information to the end user. How can we enable and encourage the use and dissemination of GISs *contra* 'flat' maps within archaeological publications? What ramifications does that have in terms of e.g. viewing software, standards, user training, and so forth? How can end users be permitted to 'play' with the data?
2) Certainty – How can we best illustrate the 'probabilistic' nature of archaeology and hence avoid collapsing into the kind of 'concrete' models implied by traditional cartography? How can types of certainty be distinguished from degrees of certainty?
3) Variety – How can we represent a disparate array of data in a manner which is complete, comprehensible and comparable? Is it possible, or even sensible, to combine abstract spaces with geographical ones?

These questions are certainly not new – all GIS practitioners deal with them on a daily basis at one level or another. Experience suggests that the answers to them are not likely to be simple either, though I do not believe them to be insurmountable. I hope however, that by reiterating them it is possible to contribute to a dialogue of best practice for GIS and its application within archaeology.

REFERENCES

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THOMAS, K. (1999) – 'β-Skeletons: An Application of Network Analysis in the Guadalquivir Valley'. Southampton: University of Southampton

FIGURES

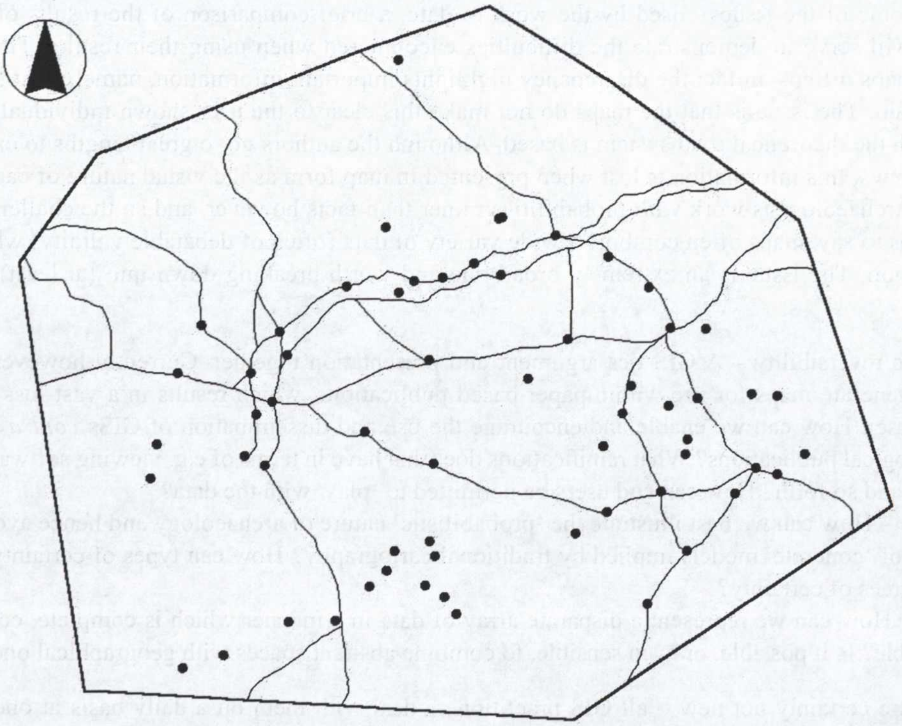

Fig. 1 – Communication routes after Sillières 1990.

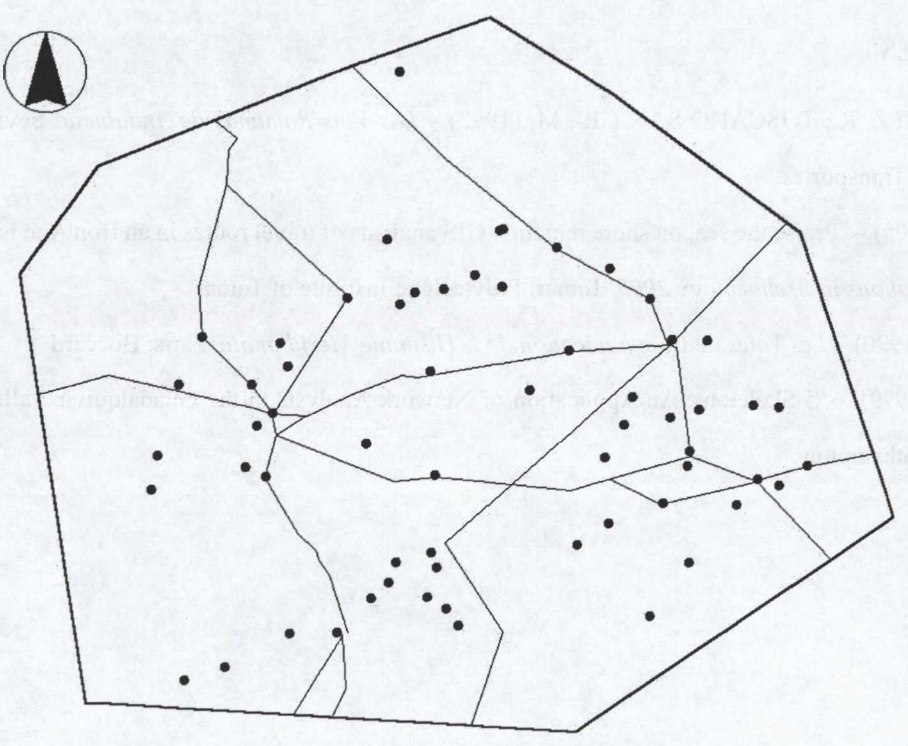

Fig. 2 – Communication routes (schematic) after Corzo-Sánchez 1992.