Remote Sensing for Archaeological Heritage Management

Edited by David C Cowley

Remote sensing is one of the main foundations of archaeological data, underpinning knowledge and understanding of the historic environment. The volume, arising from a symposium organised by the Europae Archaeologiae Consilium (EAC) and the Aerial Archaeology Research Group (AARG), provides up to date expert statements on the methodologies, achievements and potential of remote sensing with a particular focus on archaeological heritage management. Well-established approaches and techniques are set alongside new technologies and data-sources, with discussion covering relative merits and applicability, and the need for integrated approaches to understanding and managing the landscape. Discussions cover aerial photography, both modern and historic, LiDAR, satellite imagery, multi-and hyper-spectral data, sonar and geophysical survey, addressing both terrestrial and maritime contexts. Case studies drawn from the contrasting landscapes of Europe illustrate best practice and innovative projects.

EAC Occasional Paper No. 5

Occasional Publication of the Aerial Archaeology Research Group No. 3

ISBN 978-963-9911-20-8

Royal Commission on the Ancient and Historical Monuments of Scotland

ARCHAEOLINGUA

EAC Occasional Paper No. 5 **Remote Sensing for Archaeological Heritage Management** Edited by David C Cowley

EAC Occasional Paper No. 5

Remote Sensing for Archaeological Heritage Management

Edited by David C Cowley

Royal Commission on the Ancient and Historical Monuments of Scotland

EAC Occasional Paper No. 5

Occasional Publication of the Aerial Archaeology Research Group No. 3

Remote Sensing for Archaeological Heritage Management

EAC Occasional Paper No. 5

Occasional Publication of the Aerial Archaeology Research Group No. 3

Remote Sensing for Archaeological Heritage Management

Proceedings of the 11th EAC Heritage Management Symposium, Reykjavík, Iceland, 25-27 March 2010

Edited by David C Cowley

EAC Occasional Paper No. 5

Occasional Publication of the Aerial Archaeology Research Group No. 3

Remote Sensing for Archaeological Heritage Management

Edited by David C Cowley

Published by:
Europae Archaeologia Consilium (EAC), Association Internationale sans But Lucratif (AISBL), Siège social
Koning Albert II-laan 19
P.O. Box 10
1210 Brussel
Belgium

Avenue Roi Albert II 19
Boîte 10
1210 Bruxelles
Belgique

www.e-a-c.org

In association with:
Aerial Archaeology Research Group

ISBN 978-963-9911-20-8

Brought to publication by Archaeolingua, Hungary
Managing editor: Elizabeth Jerem
Copy editing by Dorottya Domanovszky
Layout and cover design by Gergely Hős
Printed by Aduprint Printing and Publishing Ltd, Hungary
Distribution by Archaeolingua, Hungary

Cover image:
Airborne Laser Scan (LiDAR) of a forested area before and after filtering
(St. Anna in der Wüste, Austria). © *Michael Doneus and Klaus Löcker, LBI-ARCHPRO, Vienna*

Contents

3 | 'Total Archaeology' to reduce the need for Rescue Archaeology: The BREBEMI Project (Italy)

Stefano Campana

Abstract: In Italy there is growing debate about the methods that can or should be adopted within the fields of preventive and rescue archaeology in the face of major infrastructure projects. Greater immediacy has been added by the potential (but not yet fully realised) impact of new domestic legislation dealing with procedures to be adopted to assess the potential archaeological implications of development projects. This contribution describes the methods brought to bear in advance of a major motorway development in Northern Italy, along with some of the insights gained from new approaches, both in drawing information from existing sources and from the deployment of a wide range of survey and investigation methods in the field. It is clear, however, that conflicts remain between 'traditional' approaches and the new opportunities presented by looking afresh at maximising gains and minimising losses in the course of such developments.

Introduction

My mentor, the late professor Riccardo Francovich, started collecting data on the landscape of Tuscany in the early 1970s, mainly through a systematic programme of field-walking survey and archaeological excavation, along with the collection of information from written sources and the examination of historical aerial photographs (Francovich 2006). After about 30 years of work within the Tuscan landscape it became clear that, despite the huge database of information assembled by that time (about 25,000 individual items), a large amount of essential evidence remained effectively undetectable, with the result it was impossible to answer important archaeological questions within the confines of this methodological approach (Campana & Francovich 2009).

There were at least three contributory factors. Firstly, the nature of the landscape itself, with its clay soils, large areas of forestry, intensive agricultural exploitation and distinctive morphological patterns. Secondly, the peculiarity of the material culture, constantly changing over time and with related difficulties caused by post-depositional processes. And last but not least the definition and range of the evidence in terms of artefacts but also ecofacts and environmental factors. It is important to emphasise here that the main aim of the University's research is to write a historical narrative in which the emphasis is on the interpretation of archaeological sites in relation to their surrounding landscapes. In pursuit of this we have moved progressively from a 'thematic' approach to a more 'global' consideration of historical processes and interpretation. In essence this has meant switching from a site-based approach to a landscape perspective: in the study of castles, for instance, this has brought into play the consideration of related field systems, communication routes, production centres and cemeteries as well as geomorphology, palaeo-environmental factors and archaeo-zoology etc. A central tenet of our research has been the need to view the context as a *system* developing over time rather than as something that can be related, as in so many earlier approaches, to specific themes, time-periods or site types such as castles, Roman villas, oppida and so on. We feel that this broader perspective on the past will enable us to describe historical patterns in a more complex, balanced and representative way.

Over the past decade LAP&T, the Laboratory of Landscape Archaeology and Remote Sensing established by Riccardo Francovich at the University of Siena, has focused particular attention on issues of archaeological visibility, principally by developing a more integrated approach to instrumentation and operational strategies in archaeological prospection (Campana 2009). Today the University's archaeological maps contain features that would previously have been 'invisible' to field-walking survey and other traditional research methods (Figure 3.1). While the one-time gaps are thus being filled to one extent or another we have come to realise that our 'total archaeology' approach has not yet addressed a challenge that has for some time lain before our very eyes, that of preventive and rescue archaeology.

Rescue archaeology in Italy is synonymous with rescue *excavation*, giving rise to a vast number of small-scale 'test' excavations (Guzzo 2000; Guermandi 2001; Ricci 1996, 2006). It is only in the last five years that the scenario has begun to change to any significant extent, thanks mainly to the work of a few individual archaeologists and the establishment of two ministerial commissions, one of which has drafted a new domestic law on 'preventive archaeology', obliging the initiators of every public construction project, whether for buildings or for infrastructure developments, to commission and

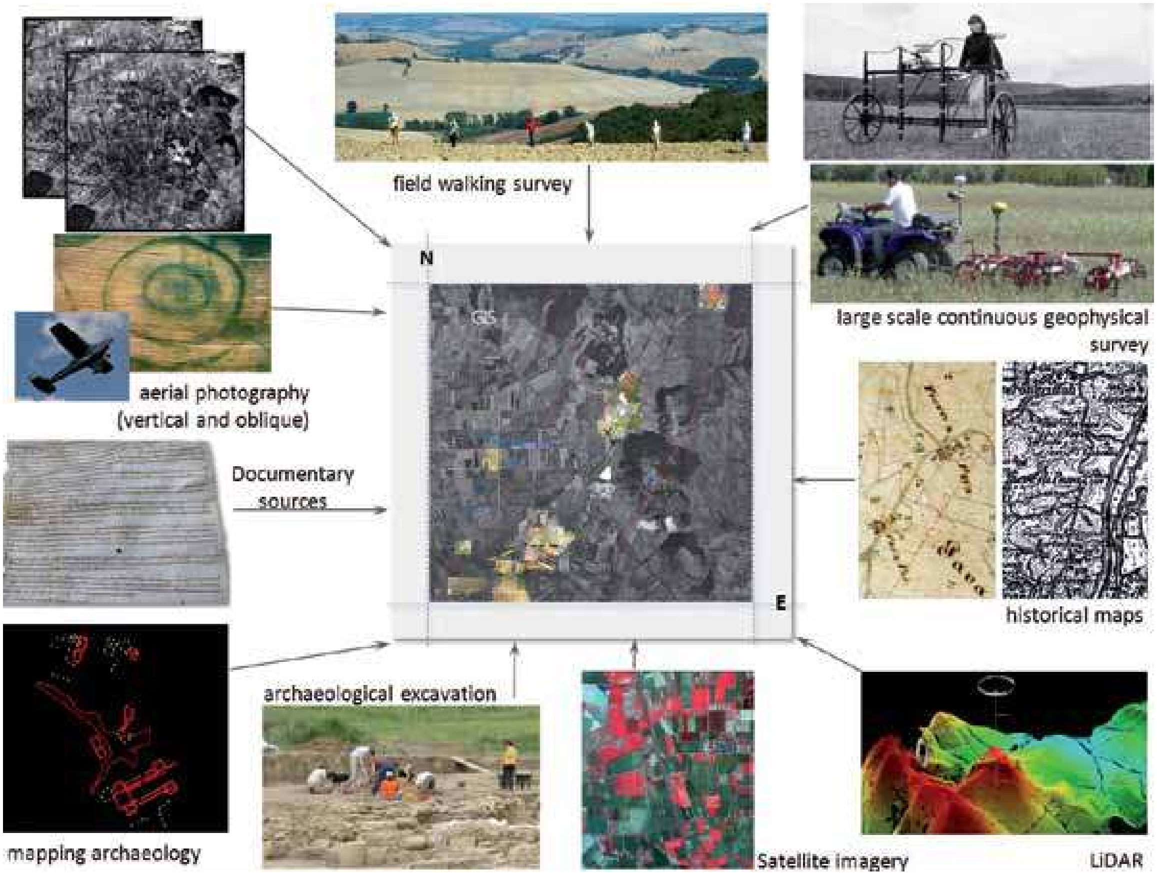

Figure 3.1: The 'total archaeology' approach, based on the integration of a variety of research methods matched against the physical and palaeo-ecological characteristics of the context and the nature of the material culture likely to be encountered.

present a report setting out an 'archaeological impact assessment' (Carandini 2008). Compiling this kind of report involves three main steps:

- The collection of all known data from the archaeological literature and from historical cartography, along with place-name and palaeo-morphological studies.
- The analysis of vertical aerial photo evidence (without, unfortunately, any reference to oblique photography from exploratory aerial survey) and, when possible or potentially useful, the collection and analysis of LiDAR data. In some cases there is a requirement for more intensive work on particular areas through such methods as geophysical prospection or small-scale test excavation.
- The mapping of 'archaeological risk', followed by targeted test excavation or in some cases larger scale investigation through mechanical stripping of the surface deposits.

The example presented in this paper formed part of the so-called BREBEMI project in northern Italy, BREBEMI being the acronym for a motorway construction project linking the cities of **BRE**scia, **BE**rgamo and **MI**lano over a total distance of approximately 100km. The project was initiated before the new law on rescue archaeology came into force and in this case the Archaeological Superintendency of Lombardy, armed with virtually unlimited power within its own region, required the motorway contractors to carry out 'excavation by surface stripping' over the *whole* of the area affected by the motorway construction. Naturally, this approach made nonsense of the contractor's financial and logistical planning, increasing the total cost of the project by a completely unrealistic amount. The construction company therefore called on the writer and his colleagues at the University of Siena to act as consultants in the design of an alternative approach that might be acceptable to the Superintendency.

Background: landscape, research design and project team

The motorway will be constructed through the typical landscape of the Po Valley, with its extremely flat morphology and sand-and-gravel soils, heavily affected by intensive arable cultivation involving the systematic use of heavy-grade tractors and deep ploughing over at least the last sixty years. The area also has substantial concentrations of industrial and related residential development (Figure 3.2).

For the first time in Italy the influence of the new law gave an opportunity to make systematic and innovative use of a range of non-invasive techniques to minimise the risk of archaeological damage in advance of large-scale motorway construction. The project design (Figure 3.3) thus envisaged the systematic collection of historical and geographical data and interpretations from documentary sources,

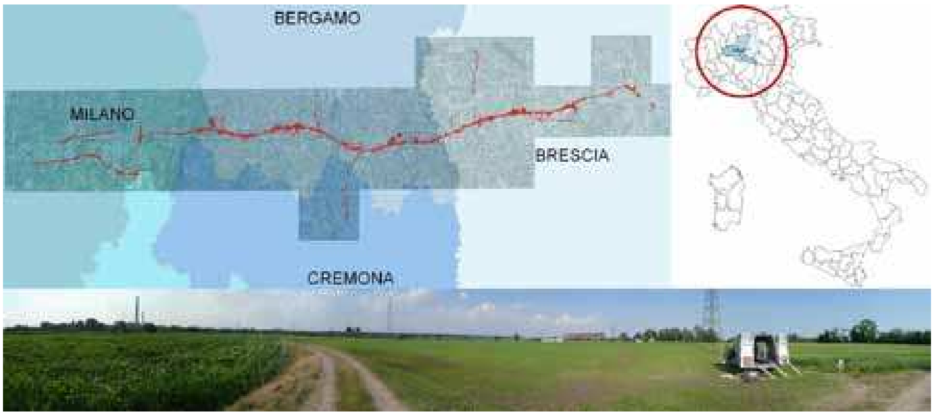

Figure 3.2: General view of the motorway path and overview of the landscape pattern.

along with geomorphological studies, the analysis of vertical historical aerial photographs and the initiation of oblique aerial survey and LiDAR acquisition along the whole of the motorway corridor, in some cases including a substantial buffer zone on either side. Also included was the systematic collection of geophysical data, both magnetic and geo-electrical, across large and contiguous areas of between 200 and 750 hectares respectively, building on an approach successfully tested in Italy, France and above all the UK (Campana & Piro 2009; Dabas 2009; Powlesland 2006, 2009). Systematic test excavations were also planned to verify anomalies identified by any or all of these techniques and independently, the regional Superintendency designed a pattern of random test trenches amounting to a 5% sample of the motorway corridor.

A GIS environment was designed to manage and integrate the collected data at all stages of the project, from data acquisition in the field to interpretation and field checking, so as to assess any significant trends in the collected data and to develop archaeological models. The aim of the project was to reduce the degree of uncertainty about the presence (or *potential* presence) of archaeological remains by identifying areas that ought *not* to be subjected to disturbance by the construction works in the light of the demonstrated presence of either surface or sub-surface archaeological remains.

The Laboratory of Landscape Archaeology and Remote Sensing already had experience in using each of these survey methods but saw the BREBEMI project as an extraordinary opportunity to add its weight to an important culture-change in the theory and practice of preventive and rescue archaeology in Italy. A decision was therefore taken to involve some of the most highly skilled and specialized companies, institutes and research workers from across Europe. The Laboratory used Archeolandscapes Tech and Survey Enterprise (ATS), a spin-off company of the University of Siena, to act as project coordinator and to manage the following activities:

- Aerial survey, in collaboration Klaus Leidorf, of Luftbilddocumentazion from Germany, and Chris Musson from the UK.
- Interpretation and mapping of information from vertical aerial photographs, by the Laboratory's own staff.
- LiDAR processing and interpretation in collaboration with Prof. Dominic Powlesland of the Landscape Research Centre and University of Leeds in the UK.

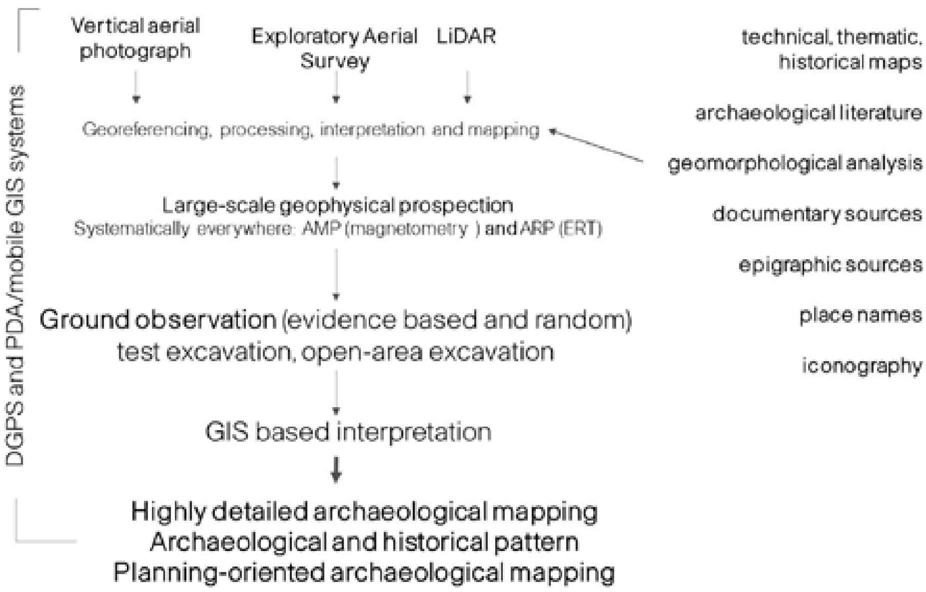

Figure 3.3: Flowchart of information and activities within the BREBEMI project.

- Processing and interpretation of magnetic data, again in collaboration with Prof. Powlesland.
- The collection and interpretation of geo-electrical and magnetic data, by SoIng (Italy)
- GIS and topographical survey, integrated archaeological data interpretation, selective ground observation and test excavation, by ATS.
- The collection of information from historical and geographical documentary sources was carried out by the University of Bergamo under the direction of Prof. J. Schiavini, as were place-name and geomorphological studies.

The geophysical prospection (Figure 3.4) involved the use of magnetic and geoelectrical instruments (respectively ARP and AMP, Automatic Resistivity Profiling™ and Automatic Magnetic Profiling™) developed by Geocarta, a French spin-off company of CNRS, the National Centre for Scientific Research. Geocarta, under the scientific direction of Michel Dabas, also exercised quality control over the collected data and remained on call to provide general assistance throughout the whole process from fieldwork to data processing and interpretation (Dabas 2009). The initial collection of the data was undertaken by SoIng of Livorno, an official partner of Geocarta with long-standing experience in geophysical survey for environmental projects.

Altogether, the project management involved the co-ordination of a team of about 25 research workers from Tuscany, Northern Italy, France, Germany and the UK, carrying out a wide variety of inter-linked work in a very short period – about 4 months or 80 working days.

Results

Bearing in mind the large size and peculiar shape of the survey area this paper will concentrate for the most part on a sample area which is representative of the landscape as a whole in terms of known archaeological data, geomorphological complexity, the availability of geophysical and other survey data and ground observation. This sample, measuring about 20km in linear extent, lies between Caravaggio and Urago d'Oglio, roughly bounded by the Rivers Oglio and Serio. The research work itself can be divided into two main steps: the collection of existing knowledge, and the survey work in the field.

The first step involved the collection and entry into a GIS environment of all the available information about a 2km-wide buffer zone centred on the motorway corridor, from archaeological sites and finds to geomorphology and the evidence of existing aerial photographs etc. This involved the collection of the following information and material (Figure 3.5):

- Place-name registers and historical maps, including historical cadastral maps and the national maps of the Istituto Geografico Militare (University of Bergamo – Centre for Territorial Studies (CST).
- The Archaeological Map of Lombardy, with related updates (University of Bergamo – CST).
- Maps of springs, palaeo-river channels, fluvial ridges and fluvial terraces (University of Bergamo – CST).
- The interpretation and mapping of information from historical and contemporary vertical aerial photographs, principally the GAI series of 1954 and the CGR series of 2007 (LAP&T and the University of Bergamo – CST).
- New aerial prospection and aerial photography along the motorway route in the spring and summer of 2009 (ATS in collaboration with Klaus Leidorf from Germany and Chris Musson from the UK).
- The capture, processing and interpretation of LiDAR data (collection and initial processing by CGR of Parma, further analysis and interpretation by ATS in collaboration with Prof. Dominic Powlesland in the UK).

The collection and mapping of the sites published in the Archaeological Map of Lombardy (Poggiani Keller 1992), with subsequent and updates, produced evidence of 118 already-known archaeological sites within the 2km-wide buffer zone, representing a density of about 2.38 sites per square kilometre, a relatively high figure in comparison with the national average. Even so, this obviously constituted only the tip of the

Figure 3.4: Geophysical instruments used during the survey. *Left* – the Automatic Magnetic Profiler *(AMP © Geocarta)*, capable of recording up to 20ha/day. *Right* – the Automatic Resistivity Profiler *(ARP© Geocarta)*, capable of recording up to 4ha/day. To increase productivity within the project two ARP instruments were often used simultaneously.

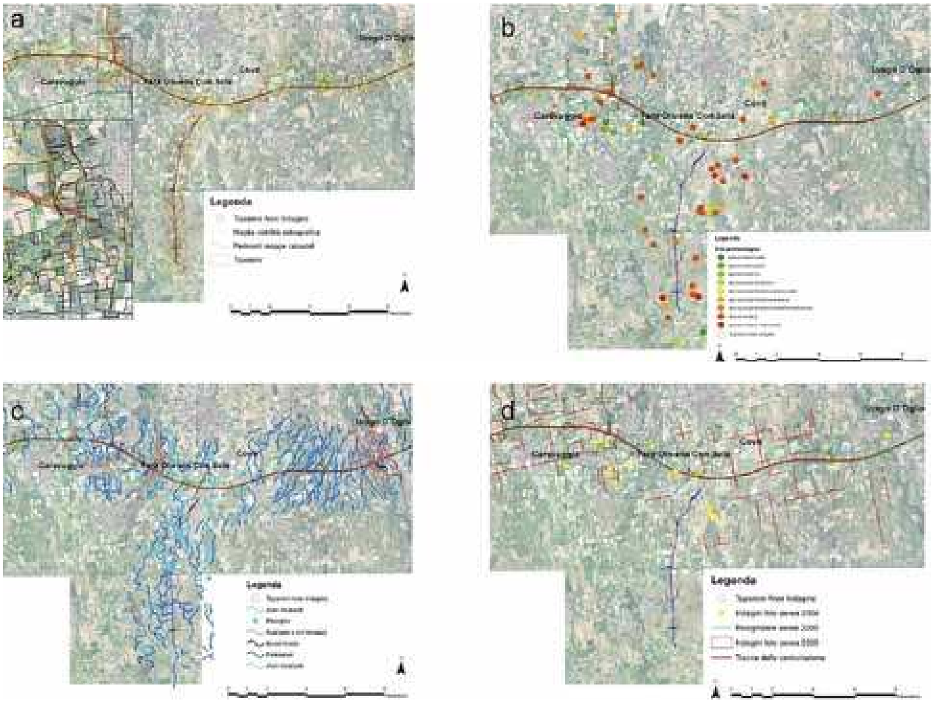

Figure 3.5: Mapped evidence for part of the survey area. *Top left* – historical cadastral map recording 3650 potentially relevant place-names and 154km of field boundaries within the 1km-wide motorway buffer zone. *Top right* – distribution of known sites and related archaeological evidence (118 in all, including 50 within the sample area). *Bottom left* – springs, palaeo-channels, fluvial ridges and fluvial terraces, clearly showing the hydro-geological volatility of the area. *Bottom right* – distribution map of features detected through exploratory aerial survey and oblique aerial photography.

iceberg in terms of the potential number of sites within the survey area. Recent studies in Tuscany, Lazio and Puglia (Campana 2009; Guaitoli 1997) have suggested that, in the absence of systematic survey projects, the 'published' archaeology as represented in the archives of the Archaeological Superintendency, represents no more than 1% to 5% of the 'real' archaeological potential. If applied to the BREBEMI motorway this would suggest the possibility of between 2,000 and 12,000 archaeological points of interest within the buffer zone!

The first stages of the analytical work went some way towards confirming this suspicion. For instance, the new aerial survey and the analysis of the historical aerial-photographs added another 76 'sites' of various kinds, substantially enriching the landscape picture and in some cases providing very detailed information about the sites concerned. An equally important contribution from the aerial-photo studies lay, as expected, in the reconstruction of the centuriation grid, knowledge of which is essential to the better understanding of the landscape and settlement patterns of the Roman and later periods.

In some cases, for example at a location close to Bariano (Figure 3.6), oblique aerial photography produced really striking results, bringing to light very detailed evidence of post holes, graves, round barrows and other previously unknown archaeological features but at the same time allowing the motorway construction company to take protective measures so as to avoid major logistical problems and significant waste of money during the eventual construction works.

The project also involved the capture 150 square km of LiDAR data at a resolution of 4 points per square metre, covering the full length of the motorway corridor along with the 1km buffer zone on either side. As noted earlier, the morphology of the area is to all intents and purposes completely flat and the land-use devoted for

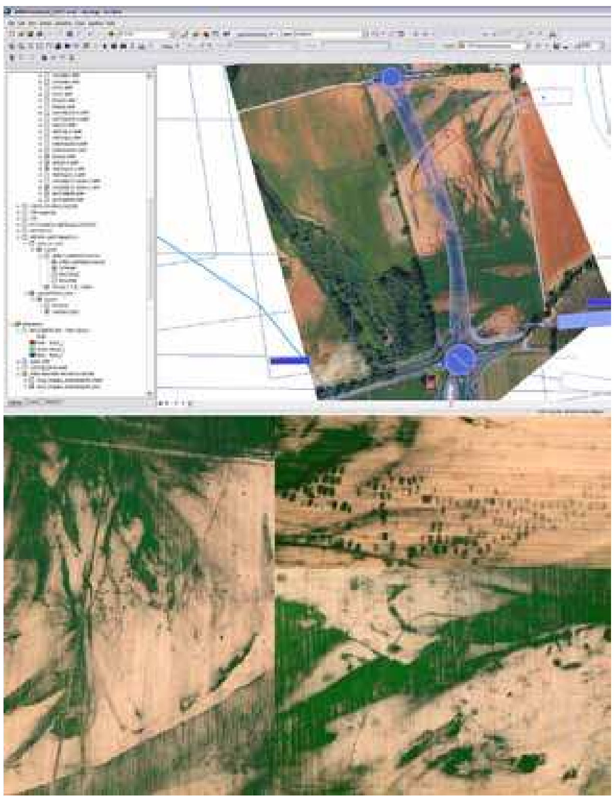

Figure 3.6: Newly discovered cropmark sites near Bariano
Top – the relationship between site and the motorway.
Bottom left – archaeological features associated with ancient road systems, the centuriation pattern, large round barrows and graves. *Right* – details of the cemeteries and settlement evidence including a ditch, post holes and probable sunken floored buildings.

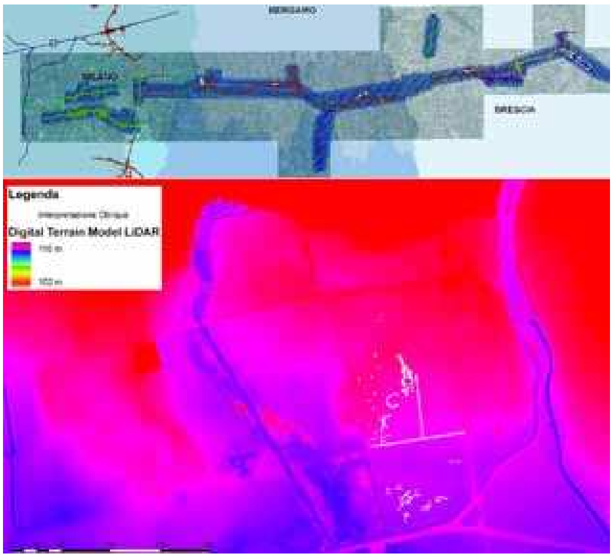

Figure 3.7: LiDAR survey. *Top* – data acquisition pattern for the project as a whole. *Bottom* – overlay on LiDAR data of features detected through aerial survey in the Bariano area (white). There is a clear correspondence between the aerial evidence and a terrace bordered on the east and west by two shallow valleys.

the most part to intensive cereal and maize production. The collection of LiDAR data was essentially aimed at identifying barely perceptible ridges, elevated areas and depressions, many of them perhaps related to former watercourses. The first stage of data processing, to create a basic digital terrain model, was carried out by CGR of Parma, the survey company that undertook the initial data capture. The second step involved collaboration between ATS and Prof. Dominic Powlesland in the UK, using his own visualization software, LidarViewer. This allowed the identification of 509 potentially significant features, consisting of 173 depressions, mainly interpretable as palaeo-river channels on the basis of their size, continuity and sinuous shape, along with 336 ridges or 'elevated' areas, at least some of them interpretable as fluvial ridges.

The information currently available shows a clear tendency for known archaeological 'sites' to occupy fluvial ridges and other 'elevated' areas within the plain. This is not to imply that these 366 raised areas correspond to a similar number of archaeological sites, only that these areas have a higher potential for the recovery of traces of past human activity. For instance, overlaying the LiDAR data on the aerial survey results for the area illustrated in Figure 3.6 shows that there is a clear correspondence between the features detected from the air and a terrace or ridge bordered on either side by two shallow depressions or 'valleys' (Figure 3.7). An alternative interpretation would see the aerial photographic features at Bariano as potentially continuing across the *whole* of the fields concerned but only being *visible* as cropmarks on the thinner and potentially drier soil of the ridges compared with the deeper and less responsive soil in the flanking depressions.

There can be no clear rule of interpretation about such situations but there are many other instances within the survey area where there is a clear relationship between topographical features in the LiDAR data and known or suspected archaeological sites established through documentary, place-name and cartographic research or through geophysical prospection or aerial-photo studies. With all due caution it is fair to stress the importance of carefully analysed LiDAR data, even in apparently 'unpromising' situations, in the process of archaeological prospection and indeed within the archaeological process as a whole.

Turning now to the second part of the process, and in particular the collection of geophysical measurements and related ground observation, both parties to the project, BREBEMI and the Superintendency, demanded a high level of reliability in the interpretation of the geophysical data. This is what prompted LAP&T and ATS to involve Geocarta in the systematic collection of ARP (magnetic) and AMP (geo-electrical) data on a field-by-field basis across the whole length of the project area. A total of 217 hectares of magnetic data and 215 hectares of geo-electrical data was collected, processed and interpreted (Figure 3.8). Ground observation of the first 150 hectares has been carried out through more than 200 test excavations, to a linear extent of about 5,220m (2.6 hectares) of 'targeted' interventions and a further 5,000m (2.2 hectares) of random excavations. Before looking at the results it is worth making some general comments on the kind of high-speed geophysical prospection involved in this case.

Figure 3.8: Geophysical prospection: quantification of detected features.

MAGNETIC ANOMALIES – AMP® METHOD ARCHAEOLOGICAL AND PALAEO-GEOMORPHOLOGICAL FEATURES	
Type of feature	Number
Road system	31
Field system	355
Centuriation	46
Ditch	33
Palaeochannel	204
Generic structure	90
Fence	1
Dipole Cluster	1389
Generic dipole	1770
Generic metal feature	151
Not id.	70
Generic alignment	449
Palaeo-morphology	444
Generic atrophic feature	25
Noise	142
Agricultural pattern	79
Grave	18
TOTAL	5297

ELECTRICAL ANOMALIES – ARP® METHOD ARCHAEOLOGICAL AND PALAEO-GEOMORPHOLOGICAL FEATURES	
Type of feature	Number
Road system	23
Field system	36
Palaeochannel	264
Generic alignment	152
Generic structure	15
Not id.	219
Centuriation	5
High conductivity	124
Low conductivity	13
Generic atrophic feature	35
Noise	2
Palaeo-morphology	454
Channel	8
Agricultural pattern	26
TOTAL	1376

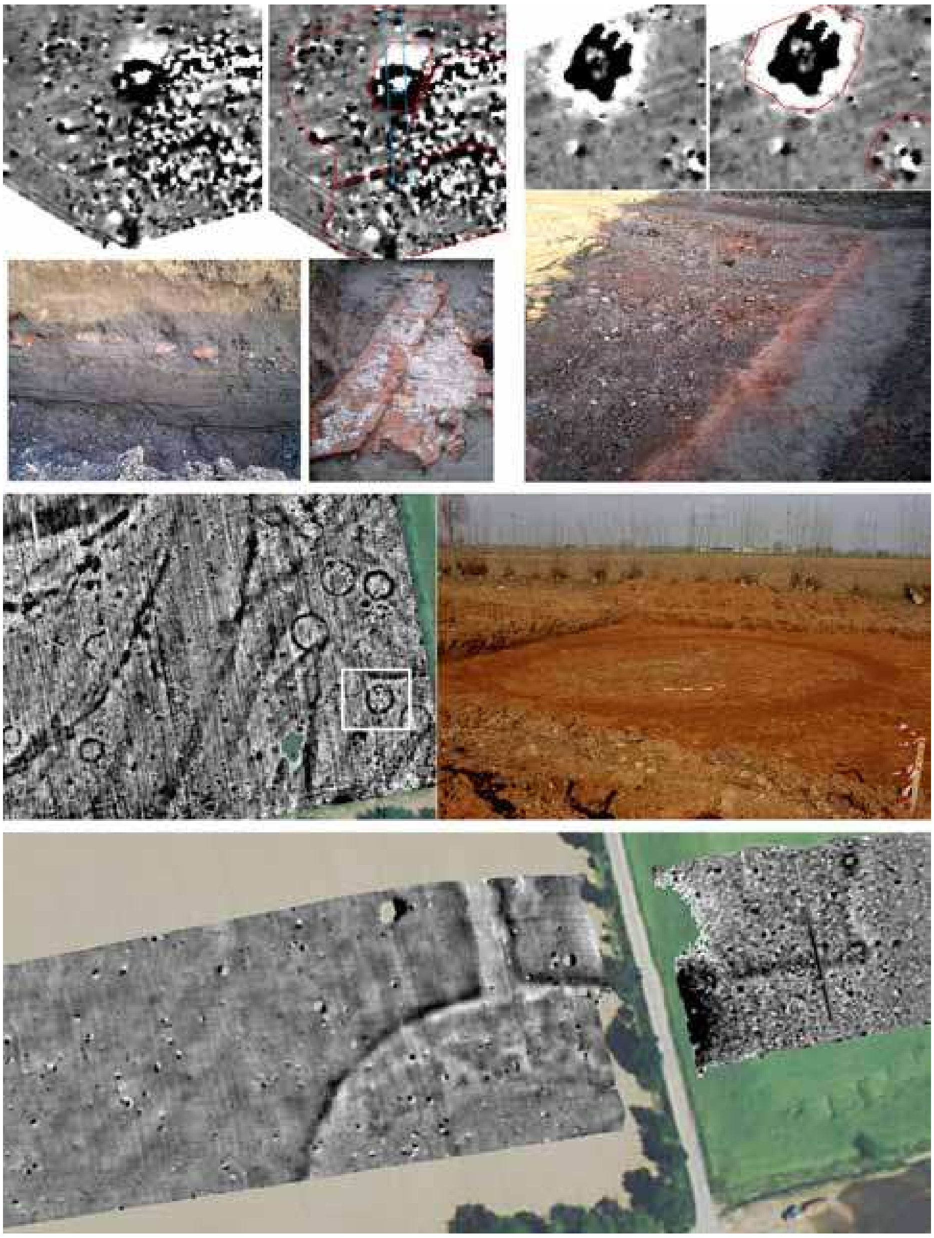

Figure 3.9: Extracts from the magnetic map, with related interpretation and ground-observation by excavation.
Top left – a structure related to water management.
Top right – a feature that was expected to be (and was) a kiln.
Centre – circular features with numerous parallels throughout Europe as (Bronze Age) round barrows, with ground-observation confirming this interpretation.
Bottom – a feature of a size and shape that finds parallels within Italy and elsewhere as a medieval mound or motte; the site still awaits verification by excavation.

- High-speed prospection instruments demand high-speed processing and (more problematically) high-speed archaeological interpretation and mapping.
- The process of archaeological interpretation was more difficult in this case because of the peculiar shape of the survey area, a strip 100–150m wide along the full 100km length of the motorway.
- The prospection instruments for the most part performed extremely well but the use of a prototype instrument for collecting the magnetic data appears to have introduced a certain amount of noise into the dataset.
- This background noise, along with the physical and cultural peculiarity of the survey area, in particular the low magnetic contrast and perhaps other factors not yet identified, resulted in the identification of a large number of dipole clusters that were difficult to interpret, reducing the perceived reliability of the geophysical results.

Despite these problems we remain convinced that the systematic high-speed collection of geo-electrical and magnetic data is theoretically correct within such projects. In practice, however, there were too many occasions in this particular physical and cultural context where the magnetic data did not materially help archaeological interpretation.

Even allowing for these problems the geophysical prospection allowed the identification of a large range of both positive and negative evidence for the presence or likely absence of buried archaeological features, as shown in Figures 3.8 and 3.9. Despite the problems encountered it should be emphasised that the interpretation of the geophysical data in most cases achieved a higher level of interpretative reliability *when combined with* information from other datasets such as those derived from documentary sources, cartographical studies, aerial photography and LiDAR prospection. In the most favourable cases it is undoubtedly possible to achieve a full and detailed interpretation of the survey data. Despite degrees of uncertainty in other instances it is certainly possible to construct a reasonably reliable map of archaeological risk and potential which can then be subjected to ground-observation by test excavation or more substantial stratigraphical investigation in advance of the construction of the motorway.

Conclusions

Over a period of no more than four months of multi-faceted investigation it proved possible to collect and interpret a vast amount of data, greatly enriching our understanding of this particular stretch of landscape. The collected evidence and its interpretation also helped the motorway contractor to plan in advance for archaeological work which might otherwise have necessitated delays and extra expenditure during the construction work through the discovery of unforeseen archaeological sites and deposits.

The first 438 hectares of geophysical prospection and ground-observation have shown up some critical comparisons with the 'excavation by surface stripping' prospection system adopted by the regional Superintendency. In this context it is important to stress that while geophysical prospection and interpretation improve in reliability every year it is not possible to say the same for the method of rescue investigation adopted by the Superintendency, using mechanical stripping rather than prior survey and targeted stratigraphic excavation. Another key point is that it is not possible to verify the results of the excavation work initiated by the Superintendency – every archaeologist knows that excavation destroys the evidence upon which it relies, especially if it is not carried out within a suitable methodological framework. By contrast it is entirely possible – and desirable – to use stratigraphic excavation to verify and interpret potential archaeological features recorded initially through geophysical or other forms of non-invasive prospection.

There is a clear contrast here between the approach of LAP&T and ATS within the BREBEMI project compared with the traditional approach advocated by the regional Superintendency. Fortunately an 'outside' assessment of the relative merits of the two approaches, based on depositions in writing and in person by both parties, was made by the Technical and Scientific Committee for Italian Archaeology, consisting of leading academics along with the General Director of the Superintendency at national level. After a detailed analysis of the two approaches the Committee was unanimous in its conclusion that the strategy proposed by LAP&T and ATS, and the survey and ground-observation work subsequently undertaken, represented the most advanced approach to this kind of preventive archaeology so far attempted in Italy and that this case study should represent an example for future projects of infrastructure and building development.

One final observation is perhaps in order. The greatest improvement in rescue and preventive archaeology will surely come not from technological development alone but from a more consistent application of the kind of 'total archaeology' and 'global' historical approach advocated at the beginning of this paper. This change of approach is imperative because we need first to understand the local context by working closely with local archaeologists and historians in the attempt to improve our capacity to interpret and test the 'global' dataset assembled from multiple survey techniques. Only then will it be possible to reduce the archaeological risk and maximize the archaeological returns from preventive and rescue archaeology.

Postscript

Sadly, the regional Superintendent Dr Raffaella Poggiani Keller – as is its right within the present organizational structure in Italy – ignored the national Committee's opinion, suspending further work by the consultancy and applying its own 'method of surface stripping' to the rest of the motorway. On the basis of this example it will clearly take time for more advanced methods to attain a widespread application elsewhere. Nevertheless, through the impact of the new law and the example of this and other projects over the past few years the ground has surely been prepared for a culture-change in the official approach to preventive and rescue archaeology within Italy.

Acknowledgments

First of all the author owes a huge debt of gratitude to the late Professor Riccardo Francovich, of the University of Siena, who gave him the cultural background and the intellectual vigour to face a challenge like that of the BREBEMI project. Special thanks are also due to two good friends who have followed and inspired so much of the writer's research work since early in his career, Chris Musson and Dominic Powlesland from the UK; as ever, they helped with constructive criticism and comments throughout all stages of the project.

Sincere thanks are also due to the BREBEMI Company for the great opportunity and trust provided by the president Dr Francesco Bettoni, the general director Prof. Bruno Bottiglieri, the chief of the rescue archaeology bureau Dr Paola Rigobello and the company's chief engineer Dr Lorenzo Foddai. The author is further indebted to the SoIng Company, in particular to Annalisa Morelli, Gianfranco Morelli and Giovanni Bitella, as well as to Iacopo Nicolosi at the Italian National Institute of Geophysics and Vulcanology. Grateful thanks also go to the Geocarta Company and Michel Dabas, as well as to Klaus Leidorf of Luftbilddocumentazion in Germany. All of these friends and colleagues contributed to the successful conduct and management of the field investigations and to the overall outcome of the project.

Special thanks are also due to the team of the Laboratory of Landscape Archaeology and Remote Sensing at the University of Siena and of the spin-off company ATS Enterprise: Cristina Felici, Matteo Sordini, Francesco Pericci, Lorenzo Marasco, Barbara Frezza, Anna Caprasecca and Francesco Brogi.

Finally, heartfelt thanks also go to the president of the Superior Consiluim of Cultural Heritage Prof. Andrea Carandini, to director Prof. Giuseppe Sassetelli and the members of the Scientific Committee for Italian Archaeology, and lastly to the General Director of the Superintendency, Dr Stefano De Caro, for providing the opportunity to discuss our project and for having the courage to present a report which will hopefully see the start of a cultural revolution in Italian archaeology moving from rescue to a real preventive approach.

References

Campana, S. 2009: Archaeological Site Detection and Mapping: some thoughts on differing scales of detail and archaeological 'non-visibility'. In Campana, S. & Piro, S. (eds): *Seeing the Unseen. Geophysics and Landscape Archaeology.* Proceedings of the XVth International Summer School, Taylor & Francis, London, 5–26.

Campana, S. & Francovich, R. 2009: Seeing the Unseen. Buried Archaeological Landscapes. In Campana, S. & Piro S. (eds): *Seeing the Unseen. Geophysics and Landscape Archaeology.* Proceedings of the XVth International Summer School, Taylor & Francis, London, 67–76.

Campana, S. & Piro S. (eds) 2009: *Seeing the Unseen. Geophysics and Landscape Archaeology.* Proceedings of the XVth International Summer School, Taylor & Francis, London.

Carandini, A. 2008: *Archeologia Classica*. Vedere il tempo antico con gli occhi del 2000. Torino.

Dabas, M. 2009: Theory and practice of the new fast electrical imaging system ARP©. In Campana, S. & Piro S. (eds): *Seeing the Unseen. Geophysics and Landscape Archaeology.* Proceedings of the XVth International Summer School, Taylor & Francis, London, 105–26.

Francovich, R. 2006: Archeologia e Territorio. In Detti, T. (ed.): *La terra dei Musei. Paesaggio, arte, storia del paesaggio senese*. Florence, 12–39.

Guzzo, P.G. 2000: Legislazione e tutela. In Francovich, R. & Manacorda, D. (eds): *Dizionario di Archeologia*. Bari, 177–83.

Guaitoli, M. 1997: *Metodologie di catalogazione dei beni archeologici*. Bari.

Guermandi, M.P. 2001: *Rischio Archeologico. Se lo conosci lo eviti, atti del convegno di studi su cartografia archeologica e tutela del territorio*. Ferrara, 24–25 marzo 2000, Firenze.

Poggiani Keller, R. (ed.) 1992: *Carta Archeologica della Lombardia, II. La Provincia di Bergamo*, Vol.1, 2, 3 (Saggi, Schede, Cartografia), Modena.

Powlesland, D. 2006. Redefining past landscapes: 30 years of remote sensing in the Vale of Pickering. In Campana, S. & Forte, M. (eds): *From Space to Place, Proceeding of the 2nd International Conference on Remote Sensing Archaeology*. Rome 4–7 December 2006, Archaeopress, BAR International Series, 197–201.

Powlesland, D. 2009: Why bother? Large scale geomagnetic survey and the quest for 'Real Archaeology'. In Campana, S. & Piro S. (eds): *Seeing the Unseen. Geophysics and Landscape Archaeology*. Proceedings of the XVth International Summer School, Taylor & Francis, London, 167–82.

Ricci, A. 1996: *I mali dell'abbondanza. Considerazioni impolitiche sui beni culturali*. Roma.

Ricci, A. 2006: *Attorno alla nuda pietra. Archeologia e città tra identità e progetto*. Roma.