The S. Anna Mapping Project by the Leiden ArcLand Field School

Johanna Stöger

From 2010 to 2015 the Faculty of Archaeology of the University of Leiden participated in the Pan-European ArchaeoLandscape programme (ArcLand), with great enthusiasm and success. The ArcLand Project brought together 35 universities, various museums, and heritage bodies drawn from 24 European countries. The project was funded by the European Union within the framework of the Culture Programme 2007–2013. The objective of ArcLand was to promote the better usage of aerial survey techniques and other forms of remote sensing throughout Europe. The programme's ultimate aim was to foster understanding, improve conservation, and enhance public enjoyment of the shared landscape and archaeological heritage of the countries of the European Union.[1]

Within the larger framework of ArcLand, the Leiden team (John Bintliff, Hans Kamermans and Hanna Stöger) organised eight international technical field schools at five different archaeological sites in the Mediterranean, including the Akragas project in Sicily in 2013.[2] All of the Leiden field schools provided excellent training opportunities both for students of archaeology, and for professionals in the field of heritage protection and local cultural resource management. The training programmes were firmly rooted in Leiden's long-standing experience in Mediterranean landscape studies and the available expertise in computer applications in archaeology. The training activities focussed on the exchange of expertise and the transfer of knowledge.[3]

The Leiden field schools offered first-hand experience in digital recording and remote sensing to about 90 students. These field schools attracted participants from a range of European countries including Cyprus, Estonia, Germany, Greece, Hungary, Italy, the Netherlands, and Poland. The participants were able to attain proficiency in recording methods and gained experience in remote sensing techniques, the use of which can be applied to many archaeological sites and time scales. The Leiden field schools also created opportunities to incorporate expert knowledge offered by partner institutions within the network of ArcLand (e.g. IMS-Forth, Crete) and external expertise (Ken Kvamme, University of Arkansas, and TU Delft, The Netherlands). The majority of the field schools consisted of two parts: part I took place in Leiden, where teaching focussed on methodologies and theories. Part II was focussed on supervised practical work fully embedded in on-going archaeological research conducted by Leiden staff members at key sites in Italy and Greece. These complementary parts allowed participants to deepen their knowledge and to apply their acquired skills to the archaeological field.

The Leiden training program promoted non-destructive methods for the retrieval of archaeological data, and contributed to the enhancement and exchange of knowledge within the field of archaeology and heritage. This emerged from

1. Musson et al. 2013, 514.
2. I am indebted to Hans Kamermans, John Bintliff and Eric Dullaart. The ArcLand fieldschools would not have been possible without their continuous support.
3. Stöger – Kamermans 2015, 114–116.

the application and sharing of international skills in the use of varied forms of remote sensing, including digital ground-based recording, geophysics, and aerial photography.

Key projects and expert knowledge

The first Leiden technical field school took place in 2011 in Boeotia, Greece. It was hosted by the Boeotia Survey Project directed by John Bintliff. The project's research area comprised ancient cities, rural settlements, and isolated architectural remains; in its diversity the landscape offered an ideal training environment for intensive recording using a total station and dGPS (differential Global Positioning System). In the following year, the 2012 Leiden field school travelled to Italy. The specific aim was to learn from the challenges presented by both the densely packed standing architecture of ancient cities and the dispersed single rural sites. After a thorough introduction in Leiden (part I), part II of the training took place in Italy. Ostia, the harbour-town of ancient Rome (the study of Roman Urban neighbourhoods, Hanna Stöger), and the rural Samnite sanctuary and its surroundings of San Giovanni in Galdo, Molise (Landscapes of Early Roman Colonisation (LERC, project director Tesse Stek), offered excellent environments for participants to acquire experience in digital recording methods of urban and rural architectural structures.

In 2013, Leiden was able to organise two ArcLand field schools. The first one was hosted by the Akragas Research Project directed by Natascha Sojc in Agrigento, Sicily.[4] The area of an extra-urban sanctuary held a different set of challenges for the Leiden field school (a detailed description follows in the sections below). Furthermore, the Akragas project offered the opportunity to invite experts in geophysical prospection. From the University of Arkansas, Ken and JoAnn Kvamme joined the Akragas team for a short period of intensive geophysical work.[5] The second field school, which took place in 2013, was hosted once again by the Boeotia Survey Project in Greece. The enigmatic site of ancient Hyettos was the focus of research. The Boeotia field school brought expertise from the ArcLand network to the project, when colleagues from IMS-Forth Crete joined the Leiden team. The field schools of 2014 and 2015 were focussed on Ostia and Greece. The 2015 Ostia field school allowed the Leiden team to co-operate once more with experts in geophysical prospection.[6] Also in this case, the participating students gained first-hand experience in a range of tools for non-destructive methods in remote sensing, including GPR (ground-penetrating radar, Till Sonnemann and Dominique Ngan-Tillard) and low-altitude aerial photography directed by Till Sonnemann.[7]

Mapping S. Anna: the Leiden ArcLand field school hosted by the Akragas project

In 2013, the Leiden ArcLand team was invited by the director of the Akragas project, Natascha Sojc, to organise a technical field school at the site of S. Anna in Agrigento. As the research project was in its early phase,[8] the field school was entrusted with carrying out an initial digital recording of the site to delimit the extent of the research area (fig. 1), and to create a digital elevation model (DEM). The team was supplied with a survey brief stating the specific tasks to be carried out during the field school. Therefore, while not losing sight of the educational goals of the field school, the Akragas project also required the field school to develop a professional attitude to a number of surveying responsibilities. The Akragas project requested the ArcLand field school to perform the following tasks:

- To establish a set of permanent reference points for use during the next fieldwork seasons;
- To set up a local coordinate system to support the geophysical survey, the surface finds survey, excavations, as well as future geo-referencing;
- To collect geo-referenced location data for the creation of a Digital Elevation Model (DEM) with the intent to represent the research area within the confines of the fence/road delimiting the field of S. Anna;

4. See Sojc 2016, 269–274.
5. See the contribution by Ken Kvamme in this volume.
6. Till Sonnemann from Leiden and Dominique Ngan-Tillard from the TU-Delft.
7. For preliminary results see Sonnemann – Stöger – Ngan-Tillard 2015.
8. See Fiorentini 1969, 63-80 for preceding investigations in the area of S. Anna.

- To establish an overlay on top of the Digital Elevation Model to display the survey results;
- To create a profile of a transect of the hill slope of the S. Anna terrain;
- To deliver a written report before the new fieldwork season commences.

The ArcLand field school team of 2013 consisted of seven students and two supervisors, Eric Dullaart and Hanna Stöger. The participants were undergraduate and graduate students from the University of Leiden eager to develop their skills in total station work, dGPS positioning, and geophysical prospection. The ArcLand digital recording project took place over the course of five days, from May 27th to 31st, 2013. In addition, the field school inspired one of the participants (Iris Kramer) to write her BA thesis in the field of computer applications in archaeology, using the digital dataset collected at S. Anna by the field school.[9]

The Akragas project's recording specifics: establishing a geo-referenced recording system

The field school's first task was to establish two permanent reference points at the site of S. Anna. These points were set up to function as fixed 'benchmarks' with the purpose to integrate subsequent survey and excavation data. These permanent reference points also helped to geo-reference a local coordinate system, which was also devised by the field school team. In consultation with geodetic specialist Eric Dullaart, the Gauss-Boaga Fuso Est (or Monte Mario zone 2) was selected as the map projection for this project.[10] The following description may serve as a guide to best practices when carrying out initial mapping tasks before archaeological fieldwork can commence.

As stated above, the starting point for the geo-referenced recording system for the area of S. Anna was the setting up of two permanent reference points using the dGPS. Linked to these two fixed reference points, eight 'temporary' local reference points were positioned along the x and y axis of the local grid, using the Total Station (TS) (fig. 2). For every

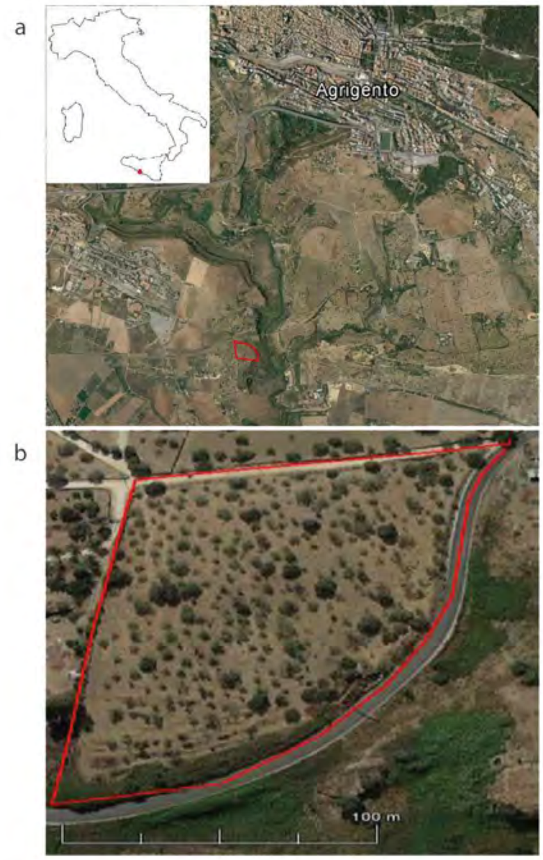

Fig. 1. Satellite image of Agrigento (modern Akragas) with the study area marked in red (source Kramer 2014, based on Google Earth 20-04-2014).

'temporary' local reference point, the location was marked by means of a plastic rod, inserted into the ground at the specific location measured in by the TS. In addition, the exact coordinates of these positions were recorded using the dGPS. The positions of the reference points relative to the other reference points were then measured again using the Total Station. By combining the dGPS and TS readings, the team was able to optimise the accuracy of the positioning, and thus assured the reliability of the reference points. Starting from the local reference points along the x and y axis, a local coordinate grid was created, delineating squares of 20 x 20 meters across the research area. These squares, marked by wooden stakes, both demarcated and visualized the local coordinate grid (fig. 3). Once set up, the grid facilitated the subsequent surface finds survey and the geophysical survey, both of which were conducted in the field of

9. Kramer 2014, unpublished BA thesis, submitted at the University of Leiden.
10. Mugnier 2005, 889-290.

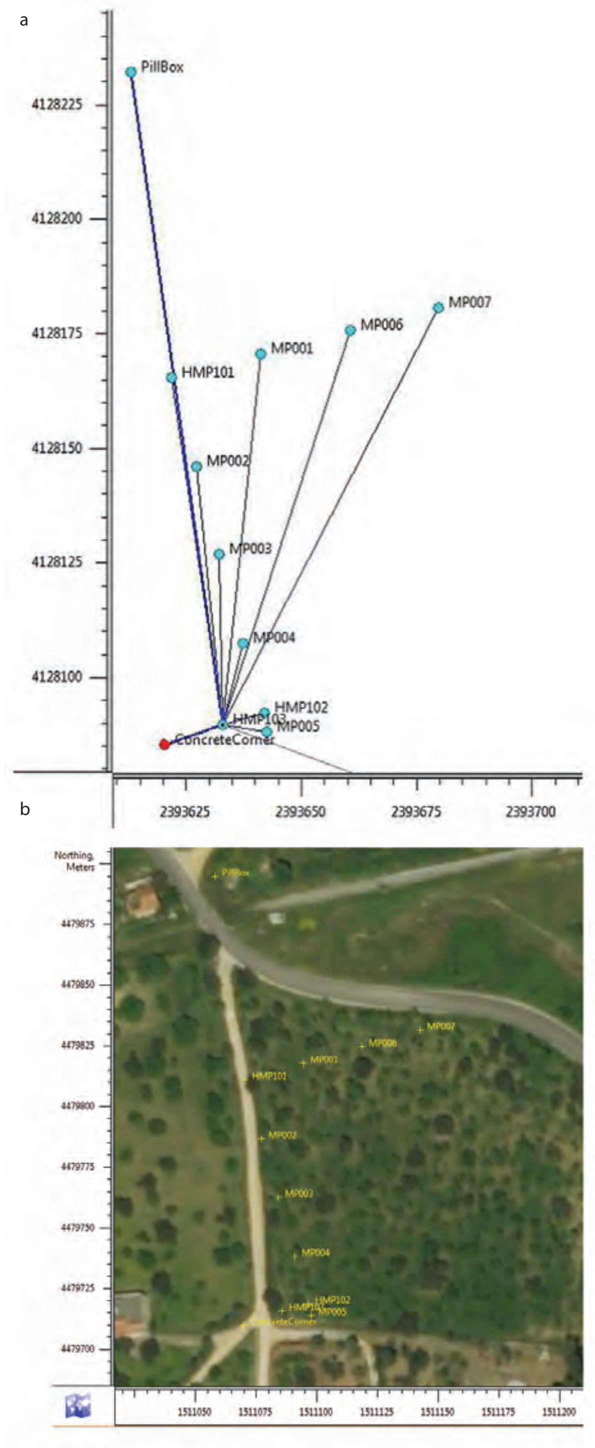

Fig. 2. Permanent Reference Points (Concrete Corner and Pill box) and all reference points along the x and y axes upon which the local reference grid was based.

S. Anna. These surveys began immediately once the area had been geo-referenced and mapped.

The purpose of the local coordinate grid was to create a comprehensive and manageable recording system adjusted to the local situation. When setting it up, the local grid was specifically adapted to fit the sloping terrain, to cope with obstructions presented by almond and olive trees, and to account for the roads which enclose the area. To avoid well-known but frequently recurring mapping problems, and to create a useful system, three major considerations had to be followed:

1) The coordinates within the area should not move into negative values. This prevents mistakes due to forgetting the minus sign, and assures compatibility with other survey data.

2) The values for the x and y axes should not be interchangeable and should therefore be chosen in a way as to avoid overlaps between the co-ordinate ranges.

3) The grid should be aligned to the survey area in the most practical way.

The first requirements of avoiding negative values was met by placing the grid system's point of origin (0; 0) outside the field itself, and to create a local point of origin by giving it values which move into the hundreds. The local point of origin (200; 500) was chosen to avoid a potential confusion of the x and y values. To fulfil the third condition, the origin of the local system (200; 500) was positioned in the north-western corner of the field of S. Anna. This specific alignment was chosen to make use of the only flat part of the field. Moreover it ensured that the local co-ordinates did not run into negative values beyond the x or y axes due to the shape of the field. However, this implies that the local system was set up in the opposite direction to the actual northings. Since such a controversial positioning may cause problems in interpreting the grid system, it needs to be clearly documented and displayed in great detail on presentation maps (fig. 3).

Since the field school had agreed to submit a written report, the positions of all reference points were entered into a catalogue as x, y, and z coordinates (Gauss-Boaga Fuso Est and local). The first part of the catalogue lists the permanent reference points. It provides a description of each reference point, photographs of the specific location, a digital map, and the coordinates. The second part contains the temporary reference points. Finally, the third part consists of a map of the local coordinate system giving the position of the permanent, the local, and all reference points forming the 20 x 20 m local grid. Each permanent reference point has a separate recording sheet; hence every point can stand alone, while further reference points can be added to the catalogue as required. The temporary reference points have been entered in a table; subsequent fieldwork seasons can easily recover the exact position of the local coordinate system.

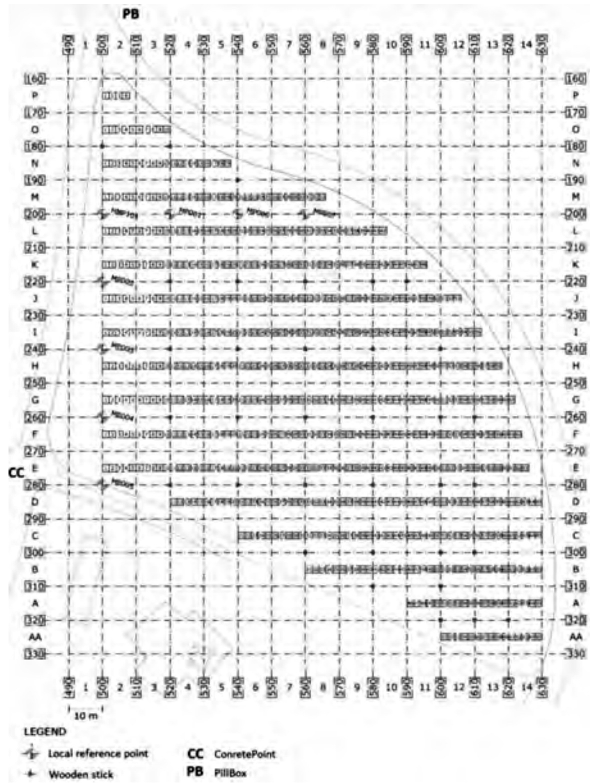

Fig. 3. Local reference grid set up in the field of S. Anna (map produced by Annalize Rheeder).

Towards a Digital Elevation Model – the dGPS elevation survey

The survey brief supplied by the director of the Akragas project included the request for a Digital Elevation Model (DEM) for the field of S. Anna. Ideally one would opt to create a DEM from the highest resolution images possible, resorting to LiDAR data or other means of topographic recording using drones or other devices for low altitude recording. Since the 2013 field school was neither equipped with drones, nor were LiDAR data available, the field school team had to use the equipment at hand. Therefore, as part of the digital recording tasks, as many dGPS readings as possible given the terrain were taken at short distances across the S. Anna field to create a DEM. A Digital Elevation Model (DEM) is the most widely used term for models of the earth's surface.[11] The main purpose of creating an elevation model for S. Anna was to better understand the topography of the area under study. The created DEM helped to visualize the recorded terrain and enabled us to distinguish between flat and sloping areas that might have affected motives for land use in the past. The detailed topographic information provided by the DEM was used to support other

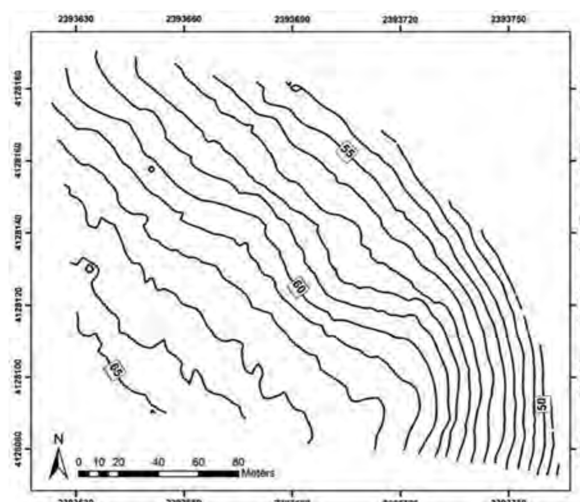

Fig. 4. Contour line map of the area of S. Anna (from Kramer 2014, 14 fig. 3).

11. Wheatley – Gillings 2002, 107.

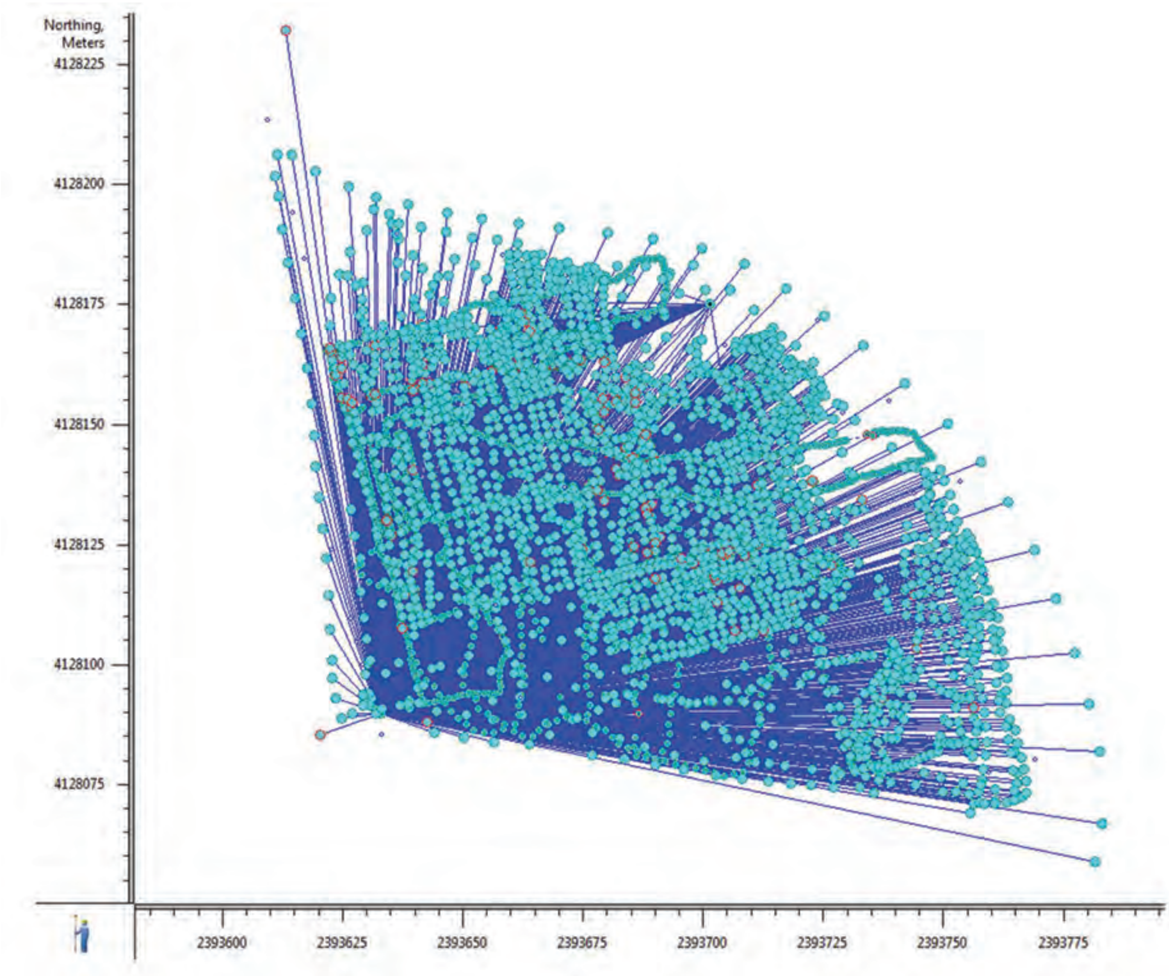

Fig. 5. Dense coverage of dGPS readings taken randomly across the field of S. Anna (data source Eric Dullaart and Hanna Stöger).

archaeological activities carried out in the study area, i.e. to contextualise the results obtained from the geophysical prospection and the archaeological finds' survey.

There are various methods to create a DEM, two of which have been already used by other projects for the wider Akragas region. The DEM created for the project directed by Oscar Belvedere relies on digitized contour lines. The contour map serves as a platform to support the GIS created by this project.[12] A contour line map was also produced for the field of S. Anna with line spacing of 10 meters (fig. 4),[13] at a scale of 1:10,000 m.[14] While this method is suitable for mapping a large area, a map based on contour lines is not sufficiently detailed for the small-scale survey conducted at S. Anna. Since contour maps lack detail and accuracy, the positioning data of the dense dGPS survey were used to create a detailed DEM of the field under study (fig. 5). After filtering, a total of 3,578 points were used to create the DEM.

The local reference grid in use and future work

The permanent reference points and the local reference grid established by the ArcLand field

12. Belvedere et al. 2010–2011, 211.
13. Kramer 2014, 14.
14. For a detailed description of the data processing for the DEM of the field of S. Anna see Kramer 2014, 14–17.

school provided the mapping basis for all subsequent archaeological research carried out in the field of S. Anna. In 2013 the research activities included a survey of archaeological finds and geophysical prospection. The former was conducted with the aim of building a statistical overview of the spectrum of finds and the distribution of the various objects across the terrain.[15] The method of survey was an intensive finds' collection sampled in narrow corridors spread over the field. The local grid system helped to facilitate the layout of these survey corridors.[16] The geophysical prospections carried out by Ken and JoAnn Kvamme served to identify areas of intensive past activities and those areas which deserved further investigation. The tasks of the ArcLand field school were completed once the permanent reference points and the local grid system were established, and the dGPS readings were taken. The work was then taken further and expanded by creating a DEM to offer a platform for a geographic information system. This enabled the S. Anna project to combine the 2013 survey results and add all additional archaeological data collected during the following fieldwork seasons (2014–2016).

References

Belvedere et al. 2010–2011
O. Belvedere – A. Burgio – D. Lauro – M. A. Papa, Una rilettura topografica e urbanistica di Agrigento da dati aerofotografici. Metodologie e risultati preliminari, Archeologia Aera 4/5, 2010–2011, 207-214.

Fiorentini 1969
G. Fiorentini, Il santuario extraurbano di Sant'Anna presso Agrigento, CronA 8, 1969, 63–80.

Kramer 2014
I. Kramer, From survey to excavation through extensive data analysis in GIS (unpublished BA thesis. Faculty of Archaeology, University of Leiden 2014).

Mugnier 2005
C. J. Mugnier, Grids & Datums. Italian Republic, Photogrammetric Engineering and Remote Sensing, (August), 2005, 889–890.

Musson et al. 2013
C. Musson – R. Palmer – S. Campana, Flights into the Past. Aerial photography, photo interpretation and mapping for archaeology, Occasional publications of the Aerial Archaeology Research Group 4 (Florence 2013).

Sojc 2016
N. Sojc, Excavation at the suburban sanctuary at S. Anna in Agrigento. Preliminary insights of the 2015 campaign, in: M. C. Parello – M. S. Rizzo (eds.), Paesaggi urbani tardoantichi. Casi a confronto, Atti delle Giornate Gregoriane VIII edizione (29–30 novembre 2014), Bibliotheca Archaeologica 39 (Bari 2016) 269–274.

Sonnemann et al. 2015
T. F. Sonnemann – H. Stöger – D. Ngan-Tillard, Using Technical Expertise at Ostia Antica (Leiden University & TU Delft), ISAP News 44 (October), 2015, 10–12.

Stöger – Kamermans 2015
H. Stöger – H. Kamermans, Making ancient Mediterranean landscapes accessible, in: A. G. Posluschny (ed.), Sensing the Past: contributions from the ArcLand Conference on Remote Sensing for Archaeology (Heidelberg 2015) 114–116.

Wheatley – Gillings 2002
D. Wheatley – M. Gillings, Spatial Technology and Archaeology. The archaeological applications of GIS (London 2002).

15. Sojc 2016, 269–274.
16. See the contribution by Natascha Sojc in this volume.