AARGnews
The newsletter of the Aerial Archaeology Research Group

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Edited by Rog Palmer
rog.palmer@ntlworld.com

[Cover photograph. Flying back from AARG, Dublin. 27 September 2014]
Editorial

AARG in Dublin
A good meeting with some interesting papers and posters in perhaps the noisiest city in which AARG has yet convened. Sessions included papers on the local area (in which it was good to see Gill Barrett back at AARG), on moving from aerial data to knowledge, and new trends or ideas. The debate session (detail) didn’t arouse much debate but that may have been because the speakers were too polite and didn’t shake the tree enough to upset those who think that recording maximum detail is an aim in itself. Good weather for the field trip helped us enjoy the tourist attraction of Newgrange and a stroll over the Hill of Tara.

Capital cities may be vibrant and relatively easy to get to but in Dublin it was difficult – or impossible – to find a quiet pub in which to chat to those people we only see once a year. Not that I’m really complaining. Dublin also marked the last time that an Archaeolandscapes Europe plenary meeting was coordinated to take place in conjunction with AARG. Archaeolandscapes Europe ends its five-year funding in September 2015, although there are attempts to ensure that it has an afterlife (see ArchaeoLandscapes International – coming soon!, p46). It will be interesting to see whether the demise of Archaeolandscapes Europe and these sequentially-timed meetings affects numbers attending AARG in 2015. Some good news concerning the 2015 meeting is that AARG is committing further funding to assist student attendance. The first notices about AARG 2015 are elsewhere in this issue.

To see or not to see – is that a question?
One of the good things about AARG is that we are a small group, currently with about 120 paid-up and honorary members of whom perhaps half go to AARG meetings. So most of us know many of the others. Because of this, and because of the way I am, writing the editorials for AARGnews seems sometimes like chatting to friends. OK, sometimes I shout at you and sometimes, as in this section, I just want to think out loud – in this case about eyesight.

Those of us who look at aerial images need good eyesight which, at a basic level, can be deduced by simple tests of stereo perception and colour vision. Such tests are usually taken by those applying to become photo interpreters, although I don’t recall taking any in the relatively-informal days when I joined RCHME’s Air Photo Unit. At that time I was 23, but in recent years – possibly after my official retirement age if I had had a real job – my eyesight has deteriorated to the extent that I have decided to stop interpreting photos for commercial work. This is also why I now sit near the front at AARG – so that I can see the slides, not (necessarily) to frighten speakers.

The deterioration of my eyesight is not too bad but I consider it has become sufficiently poor for me to stop interpreting APs for the purpose of making maps on which other people will rely. Part of the reason for making this decision is because I know that I would get really annoyed with anyone else who could see this poorly but was still trying to interpret images. Eyes, like the rest of our bits, degenerate with age and my own situation started me wondering if organisations that employ interpreters make any periodic checks on their eyesight during what could be a 40+ year employment. Or maybe this is taken into account by ‘promoting’ them away from interpretation and side-lining them into management. We may pass the tests

¹ rog.palmer@ntlworld.com
at the beginning of our career but are there – or should there be – any further checks as time goes on? To some extent we are self-judging the situation through regular or periodic eye tests and – for those who need them – use of spectacles to correct some changes, but I wonder if anyone with a job would be brave enough to admit that they can no longer see to the standard required for ‘best practice’.

But ‘the standard required’? Is there such a thing or does it come down to what feels right for each individual? Half an hour searching the web came up with no useful guidance for PIs other than a preference for stereo vision, although that seems not to come into modern ‘image analyst’ jobs which require familiarity with computers, image enhancement and GIS. So we are left with the basic colour vision requirement and stereoscopy – both of which can be tested – and beyond that I suppose we have to rely on discussion of photographs with other people and arguing about who sees what where. This may show up differences in perception but it remains up to the individual(s) to do anything about it and, as we know, we will all see slightly different versions of the same image.

If a question emerges from the above, it is to ask whether it may be necessary to make periodic checks on the vision of full-time interpreters and, if so, just how that can be done to any degree of effectiveness? Obviously this would need something beyond the stereo and colour tests – but what, and how may it be done? Or do we rely on each individual to be honest about when they feel that they are no longer up to the job?

**Arnold Baker**

Arnold Baker, one of AARG’s Honorary Members, died on 19 September 2014, age 98. What follows is based on memory from when I worked for RCHME before 1973 and Arnold was one of the private fliers whose material I worked with. In those days he used to turn up late in the summer with a brief case (a special ER brief case with combination locks suggesting that perhaps he worked somewhere secret) full of rolls of 5-inch film from the F24 camera he used. His summer holidays were spent photographing from a Tiger Moth over the West Midlands of England and the way things worked then was that RCHME provided the film and a set of prints in exchange for copies for the library. Arnold’s photographs were a primary source for one of the first (and forgotten) mapping projects in Warwickshire (Webster and Hobley 1964) and later were used by the Wroxeter Hinterland Project to provide information on the Roman town and on features in the 30x40 km around it (eg Buteux, *et al* 2000). In 1992, Arnold completed his external PhD at Southampton University titled *Air Archaeology in the Valley of the River Severn*. It remains unpublished but a copy is at NMRC, Swindon which is one of the places where Arnold’s aerial photographs may be seen.

Arnold didn’t attend any AARG meetings but was made an Honorary Member sometime in the past (do we keep a record of such things?). He had a sense of fun that would have fitted in well with AARG. The fun aspect was evidenced by his occasional air-to-air shots of RAF basic training aircraft that, he told me, had been sent up to shoo his Tiger Moth, which had no radio, out of restricted flying areas. He would play dog fights with these and send copies of the photographs, usually taken from behind a tightly-turning aircraft, to the RAF base to show that he had ‘shot them down’.

Copies of his photographs, usually contact prints from 5x5-inch negatives, are held at NMRC, Swindon, and possibly also by archaeology offices of the counties over which he flew.


**AARG 2015 in Santiago**

Our first announcement of AARG 2015 and a call for papers is elsewhere in this issue. The committee met in Santiago de Compostela towards the end of February and were pleased with the progress made and venues chosen by the local organiser, César Parcero-Oubiña, and his student team. Santiago is an interesting place to have a meeting and we hope that many of you will be there in September to sample the good local food and enjoy the company. But beware, AARG pilgrims going there may be plagued by mishaps (see page 46).

**This issue and thoughts thereon**

Much of the content of this issue derives from AARG 2014 and students’ contributions that were taking uses of aerial images in new directions and investigating new techniques and methods through which to exploit them. The paper by Heather Papworth (p10) is based on the presentation that won the prize for the best student/young researcher contribution in 2014 (more information on page 9). There are occasional negative comments about the amount of technical stuff that we have at AARG and, yes, sometimes there has been a lot. But we all use technical stuff, be it lenses in stereoscopes, sensors in cameras, or the range of programs that help us locate and organise photographs, match images to maps, create and geolocate 3D models, analyse ALS data and finally to visualise features on a topographical model in ways that may help us understand the past. In my opinion, technical stuff is far easier to talk about than archaeological results and makes me wonder if any of AARG’s members are capable of giving a presentation that ignores the ways and means through which the results of a landscape study were achieved but simply, here are the results and this is what they tell us about the past. Sometimes, and especially in a 20-minute presentation, we can skip the traditional talk-flow and get directly to the point. It reminds me of someone at a (non-AARG) conference years ago who rambled on for 15 minutes thanking everyone involved and was then told by the session chairman, “Five minutes, Gavin.”

Fonts rear their sometimes ugly heads in this issue too. Usually I convert everything to Times Roman 12pt because I find it easier to read (on screen and on paper), but the current Word default seems to be Calibri or Arial 11pt which I know that some of you seem to prefer – or perhaps are too idle to change? So I’ve left contributions more or less set in the fonts that the authors used – not through laziness, but to see if any word of your preference filters back to me. It may depend how you view the text, as serif is said to be easier on paper while sans-serif is recommended for on-screen reading. Or perhaps they are all much the same once the eye-brain has tuned into the current page.

And happy 50th issueday to *AARGnews*. 
Chair(man)'s Piece

Rachel Opitz

Tradition holds that in their first piece for AARGnews an incoming Chair begins by thanking their predecessors in the post. This is a tradition I am happy to follow, and foremost I wish to thank my immediate predecessors, Oscar and Wlodek and Dave, for their continued informal leadership. Indeed, I get the sense that once you serve as chair (and then as vice-chair according to another tradition) you graduate into a sort of post-committee emeritus position wherein you continue to advise and guide the AARG community. By this calculation my future commitment to AARG, official and post-hoc, stretches at least to 2025, and likely longer than that. Balanced with the thought of my own long future in AARG, and reflections on a good deal of continuity among the membership and the formal and informal leadership, is the distinct sense of coming in at a moment of transition.

AARG's membership is actively discussing the group's role in a future ArcLand, alliances with groups like the EAC, EarSEL and ISAP, and the relative merits of remaining a small, research focused group of specialist practitioners, or becoming a larger, more diverse group, with an outward facing agenda of promoting our specialism and influencing broader debates, in teaching, research priorities, and policy at various levels. This moment of transmutation, coinciding broadly with the beginning of my term as chair, has prompted a certain amount of discussion about identity of AARG as a group, and of aerial archaeology as a (sub-)discipline. What does it mean to be an aerial archaeologist, someone who does aerial archaeology, now?

Considering these heady questions while attending the final ArcLand conference in Frankfurt, I heard Grzegorz Kiarzszy of Szczecin University give a paper, on the whole one which I enjoyed. In it he casually stated something along the lines of that everyone knows how to look at an aerial photograph because they are ubiquitous, citing google maps as an example of the pervasive aerial perspective in our society. My initial reaction, before returning to listening to the paper, was that if Rog was present he would likely have taken issue with the idea that anyone can read an aerial photo, and the implication that no special skills or practices are needed. And this having just come from a committee meeting in which we had a sidebar discussion on training schools, recruiting teachers for them, and just who could be entrusted with the task of teaching the high art of air photo reading and interpretation.

Who then can be relied upon to read the archaeological record in the landscape captured in an aerial image? Is the aerial image so embedded in our lives that their reading is intuitive, and anyone can do it? My own answer is that this is a bit like some types of modern art. Anyone, including your five year old child if you have one, can splatter paint across the canvas. But to do so with reflection and intentionality, with seriousness or earnestness, and to care enough about doing so to do it for a living and call it art and try and get it into galleries where you can show it to other people - that's something else entirely. It's not the act of putting paint on the canvas, but the motivations and reflections behind the act. So yes, anyone can read and interpret an aerial photo, but it's a smaller group who will tell you that this is what they do, that it is an activity worth recognizing in its own right as part of the larger conversation called archaeology, and that there are specific ways of doing it that represent intellectual traditions and modes of practice. This smaller group, those who are doing it intentionally, bring to bear a host of influences, methods, background, and reflections, coupled with a consciousness of doing something that is meaningful and perhaps even important.

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1 aargchair@gmail.com
Going into 2015, AARG is embarking on a set of initiatives to promote aerial archaeology beyond the aforementioned small group. The first of these is the 'Flying Circus' which aims to get community groups started using aerial imagery to explore and understand their own landscapes. This initiative will be piloted (pun intended) by Rog Palmer, beginning with workshops in the UK, and to be followed by workshops in Europe, co-organized with AARG members from the relevant local communities. A second initiative, headed by Oscar Aldred, is a series of conversations with individuals who have been particularly influential in the development of the discipline. These semi-structured interviews will be recorded and published, the beginnings of writing a history and anthropology of the recent past of our community, and a means not only of reflection internally as a group, but of articulating the role of the aerial perspective to a broader audience. Finally, there is the commitment, as voted by the membership at the 2014 conference in Dublin, to work to continue ArcLand, maintaining aerial archaeology as a pillar of the community interested in the prospection of archaeological landscapes.

Looking at the set of new activities, we have an effort to bring aerial archaeology to a broader public and make it part of how people engage with their own past and present landscapes; a project to record the reflections and memories of individuals who - intentionally or otherwise - have played an important role in the formation of aerial archaeology as a practice and influenced the community; and a commitment to sustaining and defining the future direction of ArcLand as a network for the practice of prospection of archaeological landscapes (prospection to co-create archaeological landscapes). In these, I see a group that thinks aerial archaeology is a thing - a distinct practice in its own right, with a disciplinary past, a perspective on today's landscapes that might, in spite of its ubiquitous availability, be missed or made into background, without someone actively promoting it, and a voice that should be heard in broader conversations on landscape and the environment - the places and scapes in which we live. This brings me to the word intentionality, which I will suggest as an overarching theme for AARG in 2015. Many valuable and productive trends, avenues of research, forms of practice, and topics of shared interest emerge naturally from conversations among the membership, the interests of individuals, and the happy creative chaos of the annual meeting, and take on a life of their own pushing AARG in new and unexpected directions. This is an essential part of being an active community of research and practice, but we can also, from time to time, reflect on our identity and situation, and without knowing fully where it will lead, take our next deliberate steps.
* FIRST CALL FOR PAPERS *

International Aerial Archaeology Conference
AARG 2015
SANTIAGO DE COMPOSTELA

Wednesday 9th to Friday 11th September 2015

Organised by: The Aerial Archaeology Research Group and
The Incipit-Instituto de Ciencias del Patrimonio, Santiago de Compostela

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Papers (20 minutes) and posters (A0) are invited on the themes of:

★ visual / textual communication
★ mis-interpretations and disappointments
★ lost arts & lost practices / new arts & new practices
★ stories through aerial photography (narratives based on completed research)
★ hidden landscapes
★ measuring change in the landscape

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All conference paper and poster offers to: Rachel Opitz,
CAST, 304 JBHT, University of Arkansas, Fayetteville, AR 72701, USA
Email: aarg.chair@gmail.com

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Wednesday 9th September and Thursday 10th September - Paper and Poster Sessions
Debate Session; Local Session; Idiosyncrasies Session (Invited Papers)
Themed Sessions (Open Call for Papers)
Poster Session (Open Call for Posters)

Friday 11th September - Field Trips
Full-Day Field trip to Castrolandin Iron Age site and The Rock Art Archaeological Park in Campo Lameiro, Pontevedra
Half-Day Field Trip: Tour of Historic Santiago de Compostela

Closing date for all proposals (with title and abstract) is the 1st June 2015.
STUDENT/YOUNG RESEARCHERS SCHOLARSHIPS FOR AARG 2015. These scholarships are intended to support bona fide students and young researchers who are interested in aerial archaeology and wish to attend the conference. There is no application form. Please provide the following information in an emailed headed with “Student/Young Researcher Scholarship”: Your interests in archaeology and aerial archaeology; place of study; the name and contact details of a supervisor or employer (email) who can provide a reference; why you would benefit from attending the conference; and an estimate of travel costs to attend. Furthermore, you should also be willing to provide a poster, or for exceptional work provide an abstract for a paper (20 mins) under one of the conference session themes listed above.

Applications should be addressed to Rachel Opitz at aargchair@gmail.com. In addition, there will be a competition for the best Student/Young researcher poster or paper, judged by the Chairman and Vice-Chairman. The prize will be a free 2016 conference package (registration fee, dinner and field trip). All entries for the competition must apply for the Student/Young Researchers Scholarships to be eligible. The closing date for applications is the 1st June 2015.

More information may be found at
the Aerial Archaeology Research Group website: http://www.univie.ac.at/aarg/
or the conference website: http://aarg2015.incipit.csic.es/inicio
Assessing Archive Stereo-Aerial Photographs for Reconstructing Archaeological Earthworks

Heather Papworth¹,², Andy Ford², Kate Welham² and David Thackray³

²Bournemouth University, ³ICOMOS-UK

Introduction
At the 2014 AARG Annual Conference held in Dublin, Ireland, I introduced my PhD research to the group. I had been, and still am, investigating ways to analyse the data extracted from archive stereo-aerial photographs (or ‘SAPs’ as I like to call them) to discover whether it is possible to reconstruct earthwork features. When I say ‘reconstruct’ what I really mean is the ability to discern metrics that describe the length, width and depth/height of the objects identifiable in aerial photographs.

When I introduced my work, I set the scene as to why earthworks are so important, using the UK as an example. They enrich our lives by providing a familiar landscape and a sense of place to UK residents; a tangible record of the way in which our ancestors sought to adapt the world around them. Today, we may appreciate them by exploring the landscapes in which these features reside, enjoying them as a place to exercise, to learn in or to relax amongst. And a large number of us do just that, with not only UK residents but foreign tourists visiting such sites each in our countryside each year and contributing an estimated £26 billion annually to the UK economy (El Beyrouty and Tessler 2013). It is sad when the economic impact of earthworks has to be calculated and speaks more to those who would seek to remove them than their intangible worth as a historical remnant that is so important to the quality of our modern day lives.

According to Darvill and Fulton (1998) the estimated rate of archaeological site loss within the UK is quoted as being one site per day since 1945 out of an estimated total of ~600,000. In over 70 years, this means that we have lost at least 25,000 sites, which is likely to rise given the ever increasing efficiency of mechanised industry and the effects of climate change.

So what does this mean for us as the researchers and custodians of earthworks? Well, if we had all of the resources we would ever need to ensure these features are recorded before they are damaged and destroyed, then we would not have to worry about finding a way to retrospectively achieve this feat. Despite national and international heritage conservation bodies advocating the production of as full a record as is practicable prior to archaeological site loss (Bassegoda-Nonell et al. 1964; Council of Europe 1992; ICOMOS General Assembly 1996), or ‘preservation by record’, in practice this is impossible given the finite resources with which we have at our disposal. It is therefore likely that information about the form and function of earthworks may have to be obtained in another way, if possible. This is where my research on archive SAPs comes in.

¹ hpapworth@bournemouth.ac.uk
To mitigate for earthwork loss using non-invasive survey techniques, the research question I asked was “how well can the topography of these sites be reconstructed from archived (old) photography using digital (new) photogrammetry”?

Field Site Selection

To test the suitability of SAPs to reconstruct earthworks a pilot study site was required that contained both subtle and pronounced features that were well preserved and stable, which would indicate the possibility of reconstructing earthworks of variable size. To investigate the effects of change (should time allow!) an area of the site had to be threatened by an erosive force. Finally, coverage of the area with archive SAPs devoid of cloud cover and with suitable stereo-overlap was vital, as was a range of imagery for each decade from the 1940s onwards. Fortuitously, Flowers Barrow near Lulworth in Dorset, as shown in Figure 1, ticked all of these boxes. The Iron Age hillfort is situated on Defence Estates land and is only accessible to the public on weekends and during major school holidays and thus footfall is limited. The site is not actively targeted by the Army’s Gunnery School, located at Lulworth, although there are a couple of large craters close to the ramparts, indicating a small number of narrow misses! Perhaps the most famous feature of Flowers Barrow is that an estimated third of the site, consisting of the southern ramparts, have been lost to the sea as the hillfort is perched atop chalk cliffs that form Worbarrow Bay. A condition assessment completed by Wessex Archaeology (2001) identified the hillfort and its environs as being in good condition and, coupled with access permission from Defence Estates, all of the requirements were met for the pilot study. Figure 2 illustrates some of the earthworks found within the hillfort.

A transferability study was required to ensure that any observations from analysis of the Flowers Barrow data were achievable elsewhere. Again, the second site had to contain earthworks of varying sizes to assess the ability of archive SAPs to detect smaller features and photography had to be available across the site with sufficient stereo-overlap, lack of cloud cover and for a number of epochs dating back to the 1940s. Eggardon Hillfort, situated to the east of Bridport in Dorset, as shown in Figure 1, met all of the criteria whilst also uniquely illustrating the effects of ploughing. A parish boundary, in the form of a fence, separates the hillfort into two halves, the southern of which is owned by the National Trust, facilitating its preservation. The northern half is in private ownership and has, in the past, been sporadically ploughed, which has removed all but the most subtle surface expression of the earthworks here. Figure 2 illustrates the earthworks found with and surrounding the hillfort.

Figure 1: Maps highlighting the location of Eggardon Hillfort (left) and Flowers Barrow hillfort (right) within the UK.
SAP Digitisation and Photogrammetric Processing

The SAPs used by this research were obtained from two sources: the National Monuments Record (NMR) in Swindon, UK, and from Dorset County Council. SAPs from the NMR were scanned from negatives using a photogrammetric scanner at a resolution of 2400 dots-per-inch (dpi), providing ground-sample distances (GSDs) as low as 0.072m. The GSDs for each SAP epoch are listed in Table 1. The photographs obtained from Dorset County Council were in print format and scanned using a consumer grade desktop scanner. These GSDs obtained for these data, namely the 1972 and 1997 epochs of the Eggardon case study, are also provided in Table 1. At this stage, it is worth reiterating the work undertaken by Sevara (2013), who also presented his research during the AARG 2014 conference on the influence scanning technologies have on creating DSMs from archival imagery.

The software used for processing the archive SAPs was BAE Systems SocetGXP®. After trials with Leica Photogrammetry Suite (LPS) had produced poor digital surface models (DSMs) and the processing times to obtain these were many hours long, experimentation with SocetGXP® with the help of the Geomatics Department at UCL proved to be hugely successful! The DSMs output from the software using the Automatic Terrain Extraction algorithm (ATE) produced much smoother terrain and the longest processing time was under 2 hours, rather than the ~24 hours required by LPS. At this stage it is worth noting that, although Structure-from-Motion (SfM) software was considered, namely Agisoft’s PhotoScan, it was disregarded for its lack of optimisation for use with traditional, high resolution vertical stereo-aerial photographs. Instead, SfM is designed for use with lower-resolution photographs that are taken with a suggested overlap of +80% forward and 60% side (AgiSoft LLC 2014). As SAPs are usually captured with an overlap of 60% in the forward direction and a 20-30% overlap between image strips, it can be seen that there is an offset between SfM requirements and that of traditional photogrammetry. Whilst it is possible to obtain a DSM from SfM using archive SAPs, any metric information extracted from them should be examined carefully.
As archive SAPs tend to lack camera calibration certificates containing data relating to interior orientation data (i.e. focal length of the lens, lens distortion parameters, measurements for the fiducial marks) and exterior orientation information (i.e. GNSS camera positions at the time of exposure and the associated rotation measures describing the attitude of the camera at this time) a large number of ground control points (GCPs) have to be collected to account for this missing information. A useful introduction to the basics of photogrammetry is provided by Mitchell (2007), who explains the principles and mathematics behind the technique in an accessible manner, illustrating the chapter with pertinent diagrams. As shown in Figure 3 the GCP distribution across both sites was extensive, with as many gathered close to the point of interest as possible, which in this case was each hillfort. The most challenging site was

Figure 3: Location map showing the distribution of ground control points for (a.) Flowers Barrow and (b.) Eggardon Hillfort (Papworth 2014). (© Crown Copyright/database right 2014. An Ordnance Survey/EDINA supplied service).
Flowers Barrow because of its location on a live firing range and the restricted access to the area surrounding the hillfort. Whilst a large number of GCPs were recorded using a Leica Viva global navigation satellite system (GNSS or, perhaps more simply, a differential global navigation system a.k.a. dGPS), many of the GCPs situated to the north of the hillfort within the fields and the farm area were extracted from 1:1000 scale Ordnance Survey MasterMap data, accessed via the Edina Digimap service (digimap.edinia.ac.uk), and a 2m photogrammetric DSM downloaded from the Landmap portal (since closed due to government funding cuts, but now available via the National Earth Observation Data Centre for NERC investigators). Fortunately, the fields and roads surrounding Eggardon hillfort were accessible and these features were used to access areas where GCPs could be measured, which included field boundaries and road markings.

As each GCP recorded with the Viva GNSS is stored with data quality information, it was possible to input this into SocetGXP®, although with an extra 20cm added to the x/y values to account for any potential offset in the observer (being me!) identifying the GCP within the imagery. Ideally, when a set of photographs and the GCPs are input into SocetGXP® and the final triangulation is calculated, the overall root mean square error (RMSE – a global measure of the accuracy with which the software has calculated the solution for the relationship between the SAPs and the GCPs) should be less than 2.2 pixels (the value obtained by BAE Systems technical staff using 1972 photography of Flowers Barrow scanned from prints using a desktop scanner). However, this value could not be obtained with the 1945 dataset from Flowers Barrow, and was limited to 8.333 pixels, although the 1948 photography from Eggardon was a more satisfactory 3.198 pixels!

After triangulation, the next step was the production of terrain data using ATE. The ground sample distance (GSD) for output was 1m, which may appear to be relatively low (especially as we wished to try and identify smaller earthworks using the data), but follows the precedent set by 1m GSD airborne laser scan data (ALS or LiDAR), so common to England, Wales and around the world. Such 1m GSD ALS DSM had been obtained for Flowers Barrow from the Environment Agency and thus the decision was made to interpolate all DSMs, including those from the SAPs and terrestrial laser scanning (TLS – explained in the following section), using a 1m GSD. I should, however, point out that I will not be comparing the LiDAR data here but comparisons can be found in Papworth (2014). The raw point data produced by ATE in SocetGXP® was exported from the software and imported into ArcMap for interpolation using ‘Natural Neighbour’, the reasons for which will be described below. When each of the ALS, TLS and SAP DSMs from all epochs and for each field site were finally layers in ArcMap, the fun of comparing and contrasting the data began! The resultant SAP DSMs from each field site are shown in Figure 4.

**Quantitative Data Quality Assessment**

To assess the capabilities of archive SAPs to reconstruct earthworks, digital surface models (DSMs) had to be extracted from the photographs and validated against an independent, more accurate dataset. This reference data was a DSM created for both sites using a Leica C10 terrestrial laser scanner (TLS) to gather point-cloud information, similar to that of LiDAR, and subsequently and Leica Cyclone to clean and unify the point cloud data. The TLS points were exported from Cyclone in ‘*.xyz’ format, imported into ArcMap and interpolated using the ‘Natural Neighbour’ interpolator. This algorithm is stated by Maune et al. (2007) to work well with both regular and irregularly-spaced point cloud datasets and is not prone to
introducing artifacts into the data. Subsequently, all of the data from the TLS, EA LiDAR and SAP point clouds were interpolated to 1m DSMs using the ‘Natural Neighbour’ option and its default settings in ArcMap.

\[ \text{Figure 4: DSMs produced using SocetGXP® for both field sites.} \]

The next stage of the comparison was to subtract one of the SAP DSMs from the TLS DSM to produce a DSM of Difference (DoD). In this way it was possible to identify where the major differences lay between the elevation, slope and aspect values of the SAP DSM and those of the TLS DSM, as shown in Figure 5. Within the DoDs, shown in the third column of Figure 5, there appears to be little difference in the elevation and slope results, as indicated by the ubiquitous green colour. This is not the case for the aspect DoD, in which there is a large multi-coloured patch present, predominantly situated within the southern half of the hillfort. This is indicative of a region where large differences between the TLS and SAP aspect values are located, which appears to be severe. In the example from Figure 5, this difference is likely to be caused by a number of factors, some of which may be attributable to noise in the data, but also to vegetation and topographic expression. This section of the hillfort is covered by tufts of grass that can be lengthy (~15cm) in places and, because it has not been ploughed
(unlike the smooth northern half, which appears to be predominantly green in colour), the ground surface has retained its natural and anthropogenic form. As the TLS will record these features in more detail than is available from the DSMs extracted from aerial photography, there will inevitably be large differences in aspect values between the datasets.

Differences were also clarified using a tool known as ‘Cluster and Outlier Analysis (Anselin Moran’s I)’ in ArcMap, which creates a diagram showing the magnitude of differences between two DSMs, whether high (red) and low (dark blue) values are significant at the 0.05 level or not significant at all. It also highlights points that have either a large positive difference (orange) when compared to surrounding points or a large negative difference (light blue) compared to surrounding locations. This analysis was repeated for each of the SAP epochs that are shown in Table 1, including the root mean square error (RMSE) illustrating the global accuracy of the SAP DSMs in comparison with the TLS.

This procedure was also repeated by converting each elevation DSM, both SAP and TLS data, into the first order derivatives of slope and aspect. The reasons for this were to enhance any noise or errors within the elevation values that will propagate into any products derived from a DSM and be enhanced by this process, which can thus help to identify ‘problem areas’. Subsequently, SAP slope data was subtracted from TLS slope data to create a slope DoD and SAP aspect data was subtracted from TLS aspect data to create an aspect DoD, the process for which is shown in Figure 5. ‘Cluster and Outlier Analysis (Anselin Moran’s I)’ was performed on each of these DoDs, again helping to identify the autocorrelation of residual errors across the site between the validation data (the TLS) and each SAP epoch.
Histograms of residual values between the TLS and SAP datasets were examined as they are useful for distinguishing the spread of residual values (see Figure 6): if there were a perfect match between the SAP and TLS datasets, all of the residual values would all be zero. Unfortunately, this is rarely likely to be the case and thus an indicator of whether there is a good match between these data is a highly spiked (leptokurtic) peak that is not skewed. It was also a useful exercise to examine the histograms of elevation, slope and aspect values, shown in Figure 6, as the difference in their shape is also indicative of the differences between a baseline dataset, such as the TLS, and other DSMs.

Scatter plots were also employed to identify whether a linear relationship existed between the SAP and TLS DSMs, as shown in Figure 6. This process plots the elevation values of one dataset against another and can reveal how similar or different these data are. Again, it would be hoped that there is a positive, linear relationship, or correlation, between the two to illustrate their similarity, which was generally observed across all of the datasets.
Archaeological Assessment

Whilst it is important to understand the metric performance of a dataset from which archaeological information is extracted, it is just as important to assess its ability to provide data of use to archaeologists! To assess whether the SAP DSMs were fit-for-purpose, breakline and profile data were extracted from each epoch and compared to existing surveys conducted by the Royal Commission for Historical Monuments of England (RCHME). The RCHME hachure plans are the only survey data for both Eggardon and Flowers Barrow, produced in the 1950s and 1970s respectively. If both sites had disappeared prior to being recorded, these plans would be the only records available. Thus they were taken to be the baseline requirement for archaeological survey and an indicator of whether data from the SAP DSMs were capable of providing similar information.

To ensure that the profiles from the SAP DSMs and TLS were extracted from the correct location, the RCHME hachure plans for each field site were georeferenced using AutoCAD and imported into ArcMap. From here, point data could be generated along the profile line, as
indicated in the hachure map, which was subsequently extracted to provide data for the Viva GNSS. By using the stakeout function in the Viva software, it was possible to locate the RCHME profile line in the field and re-measure this with the Viva, not only to identify the area of interest but to create another comparative dataset against which to test the SAP DSMs. The profiles from Flowers Barrow and Eggardon Hillfort are shown in Figure 7.

Results and Discussion
Table 1 illustrates the global quality of the SAP DSMs in comparison with the TLS DSMs and highlights which of the SAP datasets generated the most accurate results. Within the Flowers Barrow site, the 1982 SAP DSM was more comparable to the TLS data than the ALS data gathered in 2009. As stated previously, all of the SAP datasets were obtained from the National Monuments Record (NMR) in Swindon, UK, and were scanned from negatives using a photogrammetric scanner at a resolution of 2400dpi. For the Eggardon site the most recent SAP dataset, namely the 2010 digital imagery acquired from GetMapping Ltd., generated the DSM most similar to that of the TLS, followed closely by the Ordnance Survey photography from the 1980s. With the exception of the 1972 and 1997 SAP images that were scanned from prints using a desktop scanner, also at a resolution of 2400dpi, the remainder were obtained from the NMR in the same way as the Flowers Barrow SAPs.

This indicates that, unsurprisingly, the newer imagery will perform favourably as compared to the older photography, which is to be expected as camera and film technology continued to improve and still does, although modern aerial cameras now employ digital capture methods.
It is interesting that the 1982 OS photographs out-performed those from the 2009 digital imagery, however, which were produced using an UltraCamX digital camera. Upon reflection of this issue, the potential cause of this disparity is the data provided by GetMapping, which was taken from the lower-resolution red, green, blue imagery rather than the panchromatic sensors. The details as to how the imagery had been processed prior to obtaining it for this study were also unavailable. As can be seen in Table 1 the GSD of the digital photography is lower than that of the 1982 dataset, which may also explain the results observed.

Whilst a very limited number of cluster analyses (Figure 5), histograms and scatter plots (Figure 6) are shown, they highlight the differences that can be identified using such techniques. For example, the cluster analysis in Figure 5 illustrating the results from slope analysis shows a long, linear series of red travelling across Eggardon Hillfort from the north-west to the south-east. This indicates a statistically significant high value, whereby the TLS slope is much greater than the SAP DSM slope value. The reason for this result is due to the fence line that runs across the hillfort in this location which has not been reconstructed in the SAP DSM but is contained within the TLS DSM as it was not filtered out during processing.

The linear scatter plot, shown in Figure 6, highlights the similarity between the TLS and the Flowers Barrow 1982 SAP DSM elevation values. A small number of outliers that deviate from the linear scatter can be seen around an elevation of ~150m, although the predominant impression is one of agreement between the two datasets. If there was absolute agreement then the line of scatters points would be very thin whilst indicators of dissimilarity are a much thicker line, lack of linearity, especially if the gradient tends to zero, and an excessive number of outliers.

Figure 6 illustrates the large disparities between the TLS aspect histogram and that of the 2010 and 1948 SAP DSMs from Eggardon Hillfort. By examining these data it is evident that the 1948 dataset in no way resembles that of the other two examples. In this instance, this result can be used to identify datasets that are not suitable for further analysis or that may require re-evaluation and processing within the photogrammetry software.

The profiles taken across the ramparts at Flowers Barrow and Eggardon Hillfort, shown in Figure 7, help to illustrate how well each of the SAP DSMs perform when compared with the RCHME survey, TLS and GNSS data. As highlighted by the results from quantitative analysis it is the newer imagery that produce profiles more representative of the banks and ditches. However, it is interesting to note just how similar the RCHME and GNSS profiles are to one another, demonstrating the excellent results that can be obtained using traditional techniques.

**Conclusion**

Overall the method for extracting DSMs from archive SAPs is a successful one and shows promise for future investigation. Whilst in general newer SAPs will produce more accurate DSMs, this is not always necessarily the case as demonstrated by the comparison between the 2009 digital imagery and that of the black and white (B&W) 1982 analogue photography from the Flowers Barrow case study. In this instance it can also be noted that B&W photography is superior when creating DSMs in comparison with colour data, which is related to the lower resolution of this digital dataset and the processing methods used to combine the three colour channels prior to supplying the photography.
It is also interesting that the quality of DSM results from SAPs varies between both sites, indicating that any further sites would have to be considered and verified independently. This intimates that a leap of faith may be required when choosing to undertake SAP processing, although there are a number of considerations which may help to assess the likelihood of success. Photographs taken with larger format cameras produce better results than those from smaller-format systems, the results of which can be seen in the difference between the DSMs created with the 1940s SAPs compared to the remainder of the SAP epochs, which were taken with large-format cameras. As an example from my research, the 1940s SAPs were captured using 5x5 inch format film with an 8-inch focal length lens whilst the 1980s SAP format was a more expansive 9x9 inch with either a 6- or 12-inch focal length lens. Whilst the 5x5 inch format may be considered to be either medium or large, the 1980s formats are almost double the size and contain more textural data.

The base-to-height ratio of the photography should be as close to 1:6 as possible, which ensures sufficient parallax in the imagery to generate the stereo-effect. It is also advisable to avoid imagery that contains excessive tip, tilt or crabbing.

The use of first-order derivatives in assessing the quality of SAP DSMs compliments the statistics derived from elevation DSMs by enhancing the noise and outliers in the dataset, making any differences in the quality of a DSM more obvious.

As regards the reconstruction of earthworks, it has been shown that larger features can be reconstructed using this method. However, the investigation into the ability to achieve the same results for smaller earthworks is ongoing, although it can be stated that digitising these features can be undertaken more accurately in 2-dimensions from the orthophotography. I just hope that the success of this method does not provide an excuse for destroying earthworks altogether…

References


Exploiting the Obsession of Detail:  
the Benefits of Developing Aerial Archaeology

Olivia Mavrinac

Introduction

Aerial archaeology has increasingly become a more indispensable tool, as it now allows the archaeologist an affordable platform to accomplish tasks that seemed impossible only a few years ago. Applications now range from using image radar (SIR-A) to detect subsurface valleys underneath dunes of sand in the Eastern Sahara (McCaughey et al., 1982), to the discovery of vast water management systems under tropical forests in Angkor with data from a NASA Space Shuttle (Moore et al., 2007), and to investigate ancient settlement mounds in the Middle East without excavation (Menze et al., 2006).  

The new and ever growing possibilities of earth observations and spatial technologies have gained popularity for several reasons; i) the improvement of spectral and spatial resolution of satellite sensors; ii) the availability of user-friendly software and routines for data processing and analysis; iii) the interests of archaeologists to study the dynamics of human frequentation in relation to environmental changes (Lasaponara and Masini, 2011; 1995). However, a new perspective has not accompanied the increasing interest in remote sensing on data processing, reflection, and interpretation.

Perhaps it is wise to slow down in our desperate attempts at getting closer, being more precise, and collecting information quicker, and instead take a look at the value of information that is being generated? To what purpose are we producing surveys, are they defined well enough? To what purpose are we producing and storing high-resolution images and information – are we doing it because it is useful, or just because we are able to do it? Do we hope to cover everything? (Lecture by Dave Cowley, 2014 AARG, 10/25). These are some of the main points that were made during the debate at the 2014 AARG conference in Dublin.

Many interesting points were raised during the debate, however in this paper I will focus on three themes; theoretical problems underlying field survey, the obsession with high-resolution imagery, and the possible threat of using ‘predictive mapping’ or auto/semi-auto mapping. I will draw on experiences from fieldwork in the Qa’ Shubayqa in eastern Jordan, to show how some of these issues can affect our understanding of the archaeological record and our reconstruction of past societies.

Field Survey and Theory

The argument that “different methods, different practises, produce entirely different landscapes” (Mlekuž, 2012, p. 91), is especially significant when examining field surveys, due to the delicate matter of collecting surface finds, determining appropriate areas to investigate, the scope and the goals for the survey. Therefore there are several questions that beg to be addressed; how easy do we find it to generalise or are we instinctively drawn into detail? And how clearly do we define the purpose(s) of survey? (Lecture by Dave Cowley, 2014 AARG, 10/25) It is well understood that “any survey process is a balance between the level of detail that can be achieved, the extensiveness of coverage, the

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1 oliviamavrinac@gmail.com
2 Point made by Rog Palmer in his abstract from the AARG 2014 conference.
available data and the tools applied to analysis”\(^3\). Furthermore it is important to use appropriate survey techniques, based upon character, scale, and extent, and geomorphological background (Keay et al., 2014; 290).

30 years ago, it was emphasised that the basic purpose for surface surveys was to select sites for excavation, rather than providing the solution to research problems (Dunnell and Dancey, 1983, p. 268). However, field survey can now provide the archaeologist with more than just sites for excavation. It now produces tremendous amount of invaluable data “from diverse non-invasive remote sensing sources [that] can support a scalable and modular approach to archaeological surveys” (Lasaponara and Masini, 2011; p. 2000). Gordon Willey states,

_Settlements reflect the natural environment, the level of technology on which the builders operated, and the various institutions of social interaction and control which culture maintained. Because settlement patterns are, to a large extent, directly shaped by widely held cultural needs, they offer a strategic point for the functional interpretation of archaeological cultures (1953, p. 1)._

Therefore, it is not enough just to document the structures which are found, but also to use that information to look further and try to decode the formation of sites and their landscapes. We need to clearly define the purpose of the survey if we wish to say more than just ‘there were people here’?

Adams and his team (2010) described their goal well in their first season report on the Barqā landscape survey, it is clear and achievable. Their wish is to understand the “underlying questions (…) [in the Faynān region] about the organization, scale and intensity of production of copper during the third millennium BC” (Adams et al., 2010, p. 95). Here the information learned during the survey, is used with the previously known information on the area, providing them with further knowledge on the production of copper. Their range of detail on the specific period and production, are compared to the general idea of the copper production in Faynān region.

**High Resolution Data**

High resolution images are increasingly available and provide the archaeological user with great detail. The high resolution advantages apply both to map aesthetics and to the raw remote sensing data. This has raised questions as to whether or not the maps and information are used to the fullest, and if an obsession for getting as close as possible has made us ‘blind’ to the actual goal of unravelling the past.

“The finer resolution, the closer and more detailed the representation is to its ground state” (Wheatley and Gillings, 2002, p. 46), but “some parts of the scene is identifiable at all resolutions, whilst others only become apparent with increased detail” (Beck, 2004, p. 54). Is there a tendency to become obsessed with detail, if high resolution imagers can be obtained, but not per se necessary? “Experienced interpreters would admit that the information they derive is heavily biased towards their expectations and knowledge, with the risk of missing or dismissing features” (Bennett et al., 2014, p. 899). There are now many

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\(^3\) Point made by Rog Palmer in his abstract from the AARG 2014 conference.
ways of extracting useful information from high resolution imagery which include, among others multispectral analysis, image classification, pattern recognition, and photogrammetry (De Laet and Lambers, 2009).

Ciminale, Gallo, Lasaponara & Masini (2009; 148) shows results from examination of high resolution aerial photographs. They constructed a palaeohydrographic map that enabled them to have a better understanding for the “relationship between each site and the environment around it” when used with other archaeological information. Nevertheless, they inform the reader with nothing more than a enumeration of the discovery, only briefly mentioning that “this pattern suggests that the external ditches probably were aimed not only at defence but also at delimiting areas for corrals and livestock pasturing” (Ciminale et al., 2009, p. 154).

Predictive Modelling

Many of the issues that came to light in the early years of computer manipulation of aerial images, such as the misunderstanding and misinterpretation of the raw data have been under constant critique, resolving in perhaps a more conscious usage and interpretation of the data. However, with new tools and techniques new questions naturally arise. The idea of automatic/semi-auto mapping is a new and interesting concept which can analyse airborne and satellite data (Bennett et al., 2014). It has “been built to predict where people in the past chose to settle, to hunt, to bury the dead, to create or discard objects in particular locations” (McEwan, 2012, p. 527). The concept is that, it is possible to feed a GIS program with enough information that it can detect structures automatically. However, there is great suspicion with this technique because critics deem that “computers simply do not have the ability of the human eye and mind to detect patterns that might denote traces of past human activity and separate them from geological and recent disturbances” (Parcak, 2009, pp. 110–111).

The technique has been adopted from environmental science techniques, however “the fundamental goal of machine learning is to generalize beyond the examples in the training set” (Domingos, 2012, p. 2), which means that it uses information that it already knows to predict site distribution automatically. This is useful because it will generate a general ‘show’ of the results, while it ensures that features with the set of criteria will be detected. Furthermore, it can be used on large datasets and, due to the systematic nature of the program, it will not miss anything within the selected criteria (Bennett et al., 2014, p. 899).

The “manual and semi-automated methods for feature detection is hampered by the fact that the two methods results in different products and therefore cannot easily be compared” (Bennett et al., 2014, p. 899). Moreover, since the archaeological sites are not just a concentration of material culture, and will only represent a fraction of the human experience (Kvamme, 2012, 337), it seems insufficient that a computer should be able to filter and rationalise a mass of visual information (Bennett et al., 2014, p. 899). It has been emphasised that the inconclusive nature of the results, are not appropriate for dealing with archaeological remains (Bennett et al., 2014). This does not mean of course that it should be completely dismissed, but should be used with care and understanding.
Case Study: Surveying the Qa’ Shubayqa

The eastern Jordanian *badia* comprises a semi-arid zone between potential agricultural land and true desert, on the lower slopes of the ancient volcanic peak of Jabal Druze (Figure 1) (Betts, 1999, p. 25; Betts et al., 2013, p. 1).

Archaeologists have known the area for many decades, but only recently has the interest really thrived (Maher et al., 2012; Richter and Maher, 2013; Rollefson et al., 2013). The area has been seen as a frontier and also a deserted area, a “risk-prone environment” (Fleming, 2005, p. 12). We aim to prove all three assumptions wrong.

The survey of the Qa’ Shubayqa, started in 2012, and identified the Islamic village of Khirbit Shubayqa which showed that the areas was not ‘deserted’ and that there was no reason to believe that the land was merely a ‘shelter’.

The first season focused on exploring the area to get an idea of how many remains were actually there (for more information (Mavrinac, 2013)). The season ended on the east side of the Qa’, where the second season began.

The targeted features were initially recorded within a 100 x 100 grid overlaid onto the aerial photographic maps. Using these grid-squares the survey team walked in transects within each square, documenting every human-made feature. Along with forms provided by the Jordanian Department of Antiquities, special project specific survey forms were filled out. When possible, surface finds (ceramics and lithics) were collected to estimate the date of structures or lithic scatters. Depending on the type and size of the associated feature, a 3 – 10 minute pickup was done. A handheld GPS was used to record coordinates and elevations of each documented feature.

The task of the survey is to see how “the harra has been occupied and how these are represented” (Mavrinac, 2013, p. 6) through initial survey data from the Qa’ Shubayqa, two different methods were used for this, however this will be discussed later on. During the 2013 survey a rescue excavation was carried out of a looted cairn, where several arrowheads were found and dated to the early Neolithic. This discovery resulted in further interest in dating the many cairns and walls covering the area. Additionally several desert kites, burial cairn concentrations, and long walls were observed. Investigation showed that some walls seemed to end at other structures and others were of unusual construction. In places we found areas that simply were too complex to disentangle from the aerial maps alone. The large structures are easy to detect on the high resolution maps, such as desert kites, animal pens and tent clearings, because of their size and recognizable shape. But separating cairns

Figure 1: Map of survey area generated from Google Earth.
from basalt rubble and hut structures from stone circles, is far more difficult. Therefore surveys are still taking place, while mapping of the area is slowly coming along.

Discussion

The survey of the Qa’ Shubayqa is still in its early phase and different approaches are still being tested. Therefore the survey is a very good project to look at the theoretical background, how high resolution imagery has changed or improved the work methods, and how predictive mapping could perhaps fill gaps in our investigation.

To dwell on the first issue, the survey done in the Qa’ Shubayqa has had a very clear theoretical focus. The purpose is to dismiss our modern perception of the desert being a deserted and frontier place, a place where no plants grow and no water flows. We see clear evidence of occupation in the harra, with everything from structural remains to lithic scatters dating from the Epi-Palaeolithic to the modern Bedouins. The 2013 survey focused on areas which were near the edges of the Qa’, where the team would walk 1 kilometre, recording every human made formation from tent clearings to lithic scatter, then turn around recording in a parallel transect. These surveys were carried out in different areas around the Qa’, to the north, south, west and briefly to the east. This gave an idea of the distribution and date range of features in the area, even though our dating is based on surface finds. This really supported our perception that the harra is not marginal and deserted, however it does not say anything more than there were people there. This is what we are trying to get beyond.

The survey 2014 focused on specific formations on the eastern side of the Qa’. Areas were selected in grids from the map, and the team went to decode some of the unusual locations. This approach was very different to that of preceding season because we now used the maps to navigate rather than surveying ‘blindly’ and later check the photos. However, we can question the approach, because is it really efficient to use it when considering the vast evidence in the area? We need to be critical of ourselves and reflect on the methods we have used, and how this might have something to do with what we are finding or not finding. Since the original question of whether this area was occupied and to what extent, has been answered with still more conviction, the survey needs a new purpose if we wish to go beyond documenting that there were people here. If remembering Gordon Willey, the settlements reflect the social interaction and to a large extent the cultural needs, it is therefore about time to incorporate different techniques and explore the opportunities beyond field survey. So the time and energy can be used on solving questions, rather than simply generating more information.

During the 2014 season, the project acquired high resolution imagery, allowing for a much closer view compared to the previous images generated from Google Earth. Along with high degree of detail, came overwhelming confusion because it was now much easier to detect the large areas, however it showed how dense and complex the areas really were. New problems obviously arose, such as distinguishing the different ‘rubble’ formations. It became almost impossible to separate cairns from the basalt piles (Figure 2+3), human
Figure 2: Cairn taken during 2014 survey season.

Figure 3: Aerial photograph of the eastern part of the Qa’ Shubayqa, showing cairns, piles of rubble, walls and animal pens.
made or bedrock formations. It is sadly true to say that the project is not using the high resolution images to their fullest potential, but this is something we have to remedy in the future. The range of detail that is wanted for the region is not possible to obtain from the images at this point. However, using different colours and contrasts helps a great deal, but this is of course old news. To understand the distribution and cluster of structures and periods, the wish is to map the entire area, or most of it. For this an accessible and swift method should be found, this will be discussed later.

With the acquiring of the high resolution images, there seems to be a power forcing you to zoom in as much as possible. You feel the urgent need to trace the sites precisely and rethink the structure a thousand times before labelling them. This is very time consuming, and is it in the end useful for us to do this? There will, as has been emphasised earlier, always be a heavy bias towards the interpretation known types of sites. This is clear when describing structures in the field as well as in the office. What can we use so detailed information for? Is it really worth spending time recording it? Rog Palmer illustrates, that the detailed drawing of every cobble that made up a stretch of a Roman road, perhaps was not the best way to spend archaeological time and money (Palmer, in prep.). On the other hand, he states that “until we have the context and range of ‘sites’ recorded from the air our knowledge and understanding of the past is based on a few scattered excavations suspended over a map of nothingness” (Palmer, in prep.). There seems to be a balance between recording everything, but at a level where it does not become obsession, but rather to prove a point or stress a hypotheses. I strongly believe that structures that are important in shape and size should be drawn up, but cairns, pits, funky looking stone formation, and looted areas can simply be shown by dots. “Like the pornographic photograph, detail and clarity of reproduction bring fascinations, a sense of being in on the act” (Shanks and Tilley, 1992, p. 80), we might be fascinated to obtain great detail, but we should consider why we do it, instead of if we are able to do it.

When the right questions have been asked and the right amount of detail has been applied, the next step would be to optimize the method. The goal at Shubayqa is to map the area, as accurate and quickly as possible, so we can get down to the interpretation and understanding of the past civilization in the harra. Predictive mapping would seem to be the answer to our prayers – the medicine we have been craving. It can detect the structures we want it to, and do it systematically. The problems that can occur are different. Mapping an area within an urban settlement is very different compared to a desert area, especially because obviously it will confuse modern structures with archaeological ones. The only really visible modern standing structures in the harra are the wells and the few houses, which have been built for the agriculturalists. They are very easy to separate from the archaeological standing structures, so this is not a problem. Furthermore, because of the desert’s quiet nature, there is not too much modern disturbance other than a few wells, roads and houses. So the visible archaeological structures, are fairly easy to detect from the air.

At Shubayqa the main interest is to understand the prehistoric history of the landscape, but in doing so, we believe that closing our eyes for the other archaeology would mean that we would never really understand the landscape. The periods reflect a way of using the landscape that we can use for our investigation, as well as simply trying to understand the landscape as a whole. Mapping the Qa’ Shubayqa’s large structures and walls, would take time, but is not impossible. The real problem is the cairns, this would really
take time – and for what use, as was discussed above. Even if we decided simply to place a dot or a letter for the cairns, we still need to detect them, this is where the use of the program would really be interesting. However “the truth of the matter is that regardless of the level of sophistication, a single detection algorithm could never adequately account for the range of feature types” (Bennett et al., 2014, p. 901), and I think we would miss the point of mapping the area in the first place. We do this to look at interesting areas, to see abnormalities or generalities and this creates our understanding. As we know people are not predicable or logical. We lose the power to ask questions, stupid questions sometimes, because the interpretation can now be done simply with the touch of a button. The past civilization would never had been able to view the area from the air, so if we do not constantly keep our minds focused on the ground, we will make assumptions which are just too ‘up in the air’. I do not believe that predictive models can be used, as it is now, for anything else than pointing to structures we already know. Auto/semi-mapping seems to be producing inconsequential information, which in the end will have to be checked and corrected. In due time though, I believe that it will be shaped and customized to archaeology, as so many other methods have.

Landscape archaeology as a theoretical discipline is relatively new, and our abilities are ever growing and changing. Luckily we are not reluctant to ask many questions, and there seems to be a much broader acceptance of the idea that we cannot do everything and there are pros and cons to everything we do with landscape. Every time we decide to include something, we decide to exclude something else. Landscapes can be everything, and can accomplish anything, but I cannot (Figure 4).

Figure 4: Photo taken during 2014 survey season, me as a scale in front of a possibly hut structure.
Conclusion
We have come far in our understanding and reflection of our work, but perhaps what has mainly increased is our attention towards the results we are generating. The theoretical background is essential for generating a good field season with results that can be used for unravelling the past, as was seen with Shubayqa. We generate much more useful information when a clear goal has been made. As is the case for Shubayqa, questions must be modified with the increasing data. The high resolution images allow us to go more into detail and see the landscape in a different way. However, we still need to be very aware of the interpretations that we make, so they are still grounded. We must acknowledge the limitations and pitfalls that can occur when so much can be seen. Some things just need to be observed and investigated by foot. Predictive mapping cannot be used for projects like the Qa’ Shubayqa at this time, because the questions we ask are out of the programs league. Archaeology is about people, and therefore general theoretical and analytical methods, will always have to be revised and modified.

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A workflow for (Semi) automatic extraction of roads and paths in forested areas from Airborne Laser Scan data

Willem. F. Vletter1

In this article, I would like to present my PhD project and the first results achieved as shown at the AARG conference in Dublin in 2014. The PhD project was carried out at the Vienna Institute of Archaeological Science at the University of Vienna. It is part of the Initiative College ArchroPro in which the Ludwig Boltzmann Institute is also involved. The title of the PhD is Reconstruction of prehistoric and historic road and path networks in forested areas through the application of Airborne Laser Scanning. For this project we formulated two main aims. The first one, and most important, is the development of methodology for the use of Airborne Laser Scan (ALS) data for historical road networks research. The second one is the reconstruction of road networks in two case study areas. The reason to work with two case studies is that the methodology should be applicable in forested areas of different landscapes. In other words, it should not depend on specific morphology, vegetation or regional road and path type. Therefore the ALS data of one research area will serve to develop the methodology and the second to prove the validity of its application in a different landscape.

The first research area is the Leitha Hills, about 40 kilometers southeast of Vienna. It is an area of 190 km² of mixed trees, mainly oak and beech, on a limestone soil. The highest point is 484 meters above sea level. The difference in altitude between this peak and the lowest point at the foot of the hills is about 250 meters. The ALS data from the Leitha area will be used to develop the methodology. The second area is the Veluwe area. It is a mainly forested area in the center of the Netherlands on a push moraine with sandy soils and extends over an area of about 1000 km². The forest is a mix of deciduous and coniferous trees. The highest point here is 110 meters above sea level; the lowest point is almost at sea level. Both study areas have a time depth from the Neolithic till now.

Before discussing the methodology and the first results, I would like to address the issue of why we think it is worthwhile to investigate historical roads and paths. Historical roads and maps can provide important insights about the landscape and its use in the past both on local and regional scales. If we compare, for example, roads and paths on historical maps of different periods, it becomes clear that road patterns have changed over a relative short period as have the uses related to them.2 This should make us aware that landscape could be quite dynamic in historic periods and probably even in prehistoric times. The same accounts for the effect of erosion and other natural decay processes in the landscape on archaeological features.3 These two facts should make us cautious when we draw conclusions about landscape in the past based on the features that are still visible or detectable.4 Despite the importance of roads and paths for getting insights of historical

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1 willem.vletter@univie.ac.at Vienna Institute of Archaeological Science, Univ. of Vienna, A-1190 Vienna, Franz-Klein Gasse 1, Austria +43-1-4277-404 75
2 Aston, M. Interpreting the landscape. Landscape Archaeology in local studies. Fig. 23 (1985).
landscapes, in a lot of countries there is a lack of knowledge regarding historical roads and paths.\textsuperscript{5}

Unfortunately, few remains of roads and paths are left in the landscape due to human intervention or natural processes. Normally they are best preserved in forested areas or in heathland. This is the reason to concentrate on these kinds of areas. ALS has proved very valuable in the research of archaeological features in forested areas. Indeed, is the only technique which can be applied in such areas, as it can detect `through’ the leaves of the trees. Also, it can be applied on a large scale, which is needed if you want to do research on regional or interregional basis. Moreover, is very suited for historical roads research as they can extend over a many kilometers.

In the second place ALS data can be used to visualize very subtle linear features. This high level of detail is of course essential to trace historical roads and paths, features which often can’t be seen by the naked eye in the field. An example is given by a road in a wet heathland area on the Veluwe in figure 1. On the image of elaborated ALS data a straight line is visible running from Southwest to Northeast. This road is a Koningsweg (’Kings Road). This kind of road was built by Willem III at the end of the 18th century for mainly hunting purposes, like his monarchial colleagues abroad. On a normal air photo you are not able see it. In the field, we could only find it with the elaborated ALS image in our hand. Even on the map of the late 19\textsuperscript{th} century it is barely drawn and certainly not as a continuous road. This not only demonstrates the power of ALS, but could also provide information of the historical map. On the one hand one could, for example, discuss the significance of roads and maps on the historical maps. On the other hand, it maybe tells us more about the use of this road. As mentioned, they were straight lines through the landscape. In other words, the morphology and the wetness of the landscape were not considered when they were built. It might have been that for these reasons they were not viable. Moreover, their intended function was not to connect villages to each other or a village with its surrounding fields. Maybe only limited use of the road was allowed.

The methodology proposed has four main steps. The first step uses a technique which enables the (semi) automatic extraction of roads from ALS data in forested areas. In the chronological model, the second step, the relative and absolute dating of roads and paths, is carried out. This is based on historical sources and physical characteristics of the found roads and paths. As only parts of networks survive over time, the third step will serve to predict where unknown road and paths would have been, taking into account the networks found and their morphology. In the final step, the spatio-temporal visualization of roads networks will be investigated, with a focus on their development. As mentioned before, after development of the methodology in the Leitha Hills, it will be applied in the second research area to test its validity.

In this paper I will deal with the automatic extraction step and give description of the research carried out and the results achieved. A more extensive paper on the topic has been already published.\textsuperscript{6}

\textsuperscript{5} Gutormsen, G.S. Transregional Historical Roads in Local Landscapes: Via Egnatia in Macedonian Greece, in Die Erde 138 1, Special Issue: Mediterranean Landscapes, p. 98 (2007).

ALS data can be visualized in a way that a huge amount of linear features, and thus possible roads and paths, are visible. Instead of manual mapping, which takes a lot of time I tried to find a way to (semi) automatically extract them. For this, I compared four workflows on quality, time and costs. The workflows are shown in table 1.

Figure 1. In the left upper corner the Koningsweg is shown in red on an air photo. In the right upper corner, the same road visualized with openness based on ALS data. In the left lower a historical military map from 1850. In the right lower is a geographical map in which purple stands for heathland. The water bodies in blue gives an indication of the wetness of the area.

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Table 1. The four workflows tested in this paper. For each workflow the data format, the (possible) pre-processing step, the visualisation technique used and extraction software are listed.7

The first workflow is based on the concept of break lines. A break line is the intersection of two smooth surfaces, each surface interpolating the point on either side. You can, for example, imagine that where a road or path lies deeper in the surface, that there is a break in the surface. For the break line concept the software package STREX was developed by Technical University of Vienna, which operates in DOS. It has 3 command lines. The structure line extraction tries to connect points from the point cloud that are situated at the same height and have the same orientation and creates small structure lines. The break line finder has the objective to connect these structure lines and create break lines. The final command line is a refinement step in which the results can be improved. All three command lines contain parameters which can be adjusted; like, for example, the maximum angle and the length of the structure lines. In order to optimize the results, the software has been run a lot of times with different parameter sets. The outcome of the break line concept is shown in figure 2. As can be seen in this figure, STREX is able to detect subtle features as roads or small paths. However, there is a lot of noise, unwanted directions may be followed and also of double lines created for single linear features.

Figure 2. The visualization of openness shown in two directions. In left picture the positive openness in red has larger values than the negative openness in white. In the right picture it is the other way. The pictures also show that negative openness is not the inverse of positive openness.

In the second and third workflow I applied the concept of openness to visualize the linear features. The reason for choosing openness as a visualization technique is that, from earlier research regarding visualization of ALS data of Leitha, it was considered best. In general it can be stated that openness is well suited for the visualization of long linear subtle features like road and paths. Openness is defined as parameters expressing dominance or enclosure to visualize topographic character, or as an angular measure of the relation between surface relief and

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horizontal distance. Openness measures the mean of the dominance of enclosure of a certain point in normally eight horizontal directions. The angle with surface expresses the level of openness. We can say that positive openness is above surface and negative is below. L is the distance of how far is measured from a certain point. Looking at the angles in figure 2 it shows that if a point lays higher that its surroundings that the positive openness is higher and the negative openness is lower and vice versa. It also proves that negative openness is not the inverse of positive.

The following step in the second workflow was the extraction of the visualized linear features with the software package Feature Analyst, which can be plugged in ArcGIS and also Erdas Imagine. It can be used for different kind of imagery, like maps and satellite images. I used it also for historical maps and it works quite well. The most important step is probably the creation of the training set. Then the parameters have to be set. Once the software is run, the results can be improved or adjusted by using certain tools, like smoothing for lines. The final product is a model, which expresses all the steps you selected. Once you have created a model, based, for example, on a single tile, it can be run over the remaining tiles using batch processing.

The results of the combination of openness and feature analyst are quite good, although some parts are missing (figure 3). Compared with the break line concept of workflow one, it has far more less noise, less double lines, and less odd orientation.

In the third workflow, again openness was used but this time combined with Ecognition software. Ecognition is powerful software but it takes time a lot of time to know it thoroughly and to exploit its full capacities. Nevertheless, in a short period I managed to create a simple model, which involved segmentation, a classification based on pixel values and a merging step. The result was exported as a linear feature. As with Feature Analyst it is possible to carry out batch processing.

If we compare the results of work flow 2 with work flow 3 (Figure 3), it is clear that Ecognition may detect more subtle features, but they are less straight and there is more noise and the lines are more interrupted. The results in Ecognition can probable be improved by using image statistics in the classification step. However, this required more investment in knowledge of Ecognition which, unfortunately, was not possible at the time of the research.

Intensity was tested in the fourth workflow, calculating as intensity the amplitude multiplied by the Eco width of the laser pulse. With intensity, far fewer linear features can be visualized. This may probably be improved by calibration, but I suspect that the differences in the backscattering signal between a small path and its surroundings are still too small to be detected. This consideration, combined with difficulty to carry out a calibration on the short term lead to the decision to not further investigate the possibilities. So if we compare the quality of the workflows, openness combined with feature analyst performed best (Figure 3).

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Figure 3. The same SW hill shaded ALS image of the Leitha Hills is used to show results from different workflows. In the left upper corner the visualization of break lines (workflow 1). In right upper corner the results of openness and Ecognition combination (workflow 3). In the left lower corner the results of the combination openness and Feature Analyst (workflow 2). In the right lower corner the positive openness image used (kernel size 5).\textsuperscript{13}

\textsuperscript{13} Vletter, W. (Semi) automatic extraction from Airborne Laser Scan data of roads and paths in forested areas in SPIE proceedings Second International Conference on Remote Sensing and Geoinformation of the Environment (2014).
Also, the processing time for a tile of 1 square kilometer for all the four workflows was calculated. The intensity option delivered a processing time of around 10 minutes. The processing time for the second and third workflow was similar about 15 minutes. The break line option of workflow 1 took at least 5 times more time than the workflows with openness.

Looking at the costs, we can tell that the STREX software for break line extraction is not for free on the market. However, the goal is to integrate STREX in OPALS, which is free for PhD students. Feature Analyst has 10 days free license. This is sufficient if you want built model. Especially, if you first study the manual. Often the company (Overwatch) is also willing to extend the free license. Ecognition is on the contrary quite costly. However, there is place for negotiation and for scientific purposes there is a discount. Taking into account the results, processing time and costs workflow 2 clearly is the best option for the moment.

In the end, this workflow was applied to the whole of 180 square kilometers area of the Leitha hills. It resulted that in less than two days, 300.000 linear features with a total length of 12000 km were extracted (see figure 4). Looking at them in detail, a first estimation leads to the conclusion that more than 80 % are segments of a road or a path. The applied workflow has resulted in a huge time gain.

Figure 4. The result of the automatic extraction of linear features in the Leitha hills with workflow 2, which combines Openness with Feature analysts. In less than two days, 300.000 linear features with a total length of 12000 km were extracted of which more than 80% is estimated as being a road or a path segment.
For the sake of clarity I would like to stress that automatic extraction is by no means interpretation. Nevertheless, it creates circumstances that allow more time to be spent on interpretation, which is often an issue with remote sensed data. The actual interpretation in this project will be dealt with during the (relative) dating in the chronological model of the methodology, where historical resources and the physical properties are taken into account.

Further, the networks in figure 4 are not complete. This is due to two main causes. On the one hand, for different reasons the software applications didn’t manage to capture all the linear features. On the other hand, sometimes parts of road or paths networks didn’t survive the wheel of time. The issues which come along with completing a network, both manually and automatically, are dealt with in a next paper. This also accounts also for the other steps of the methodology for reconstruction of prehistoric and historic road and path networks in forested areas through the application of Airborne Laser Scanning.
Seeing, thinking, walking: a report on the LiDAR visualization and interpretation workshop 2014, Esslingen, Germany

Mikolaj Kostyrko¹

Between 8th and 11th of July 2014 I took a part in the LiDAR visualization and interpretation workshop which was organized by an ArcLand partner, the State Office for Cultural Heritage Baden-Württemberg, and held in the picturesque city of Esslingen, Germany. The training school was addressed to students of archaeology as well as young professionals who were, or are, planning to work with LiDAR derivatives.

As the workshops were focused on visualization and interpretation of LiDAR-derived data, the first step was to gain a theoretical background on how this information is being gathered and post-processed. Initial presentations were by Simon Crutchley (English Heritage), Žiga Kokalj (Research Center of the Slovenian Academy of Science) and Ralf Hesse (State Office for Cultural Heritage, Baden-Württemberg). These dealt with collecting LiDAR data, processing it into derivatives, how the quality influences our perception and, through that, also our interpretation of archeological features. Some case studies from around Europe were presented. Our attention was focused to one problem: that we cannot rely only on using one method of visualization LiDAR-derivatives. As there is no one algorithm that would be suitable for all kinds of terrain or for indicating all archeological features, a combination of these must be used². Later, in a practical session, we had a chance to experiment with data to investigate which visualizations, in our opinions, were most suitable for a high and low relief area. Some of them are good for giving an overview of the shape of the landscape, others tend to flatten it out but indicate small features. From my perspective (which was not far from the others), the overall topography of a high relief area was best seen using either multiple Shaded Relief Models (SRM) or Sky View Factor (SVF), whereas for a low relief area I found only the first to suit the purpose. For the visualization of the relief of both areas in order to indicate archeological features I would use Negative and Positive Openness or a SVF (which indicated small morphological features as well as gave a ‘feeling’ of topography). Trend Removal blurred the relief in this condition, but was the best, in my opinion, for investigating a low relief area. Negative and Positive Openness, also gave good results but comparable to SVF and SRM.

The visualization that we discussed were computed either by using an open source LiDAR Visualization Toolbox (LiVT)³ or by freeware Relief Visualization Toolbox (RVT)⁴. At the first glance RVT seemed to be easier to use than LiVT by being more automatized and

¹ mkostyrko@gmail.com
² Presentation by Ralf Hesse, Žiga Kokalj and Simon Crutchley, where pros and cons of each visualization are shortly reviewed and where literature on the subject can be accessed at: https://www.academia.edu/7630931/Lidar_visualisation_and_interpretation_workshop_in_Esslingen_8-11_July_2014 (accessed 07.08.2014)
³ Which can be downloaded at: http://sourceforge.net/projects/livt/
A short introduction of the usage of LiVT and visualisations that can be computed by it can be found here: https://www.academia.edu/4610472/Visualisation_of_high-resolution_DEM_with_the_Lidar_Visualisation_Toolbox_LiVT
⁴ A short introduction and the standalone of RVT can be accessed at: http://iaps.zrc-sazu.si/en/svf/
as it uses as an input file a DTM in a popular raster Tagged Image File Format (TIFF) format. It computations consume a large amount of virtual memory, therefore it would be most convenient to perform the visualization on small parts of landscape at one time.

During the workshop, Žiga Kokalj suggested also viewing the data by combining different visualizations together and by manipulating their transparency. In this way, we could use SRM, SVR and Slope together or by using any other combination that proves to be effective.

Fig. 1. Working in groups provided us with lots of discussion on the interpretations of LiDAR-derivatives.

We learned that software differences among other things could be summarized as follows:

As SVF algorithm provided in RVT is susceptible to any shifts in data, i.e. in the sections where two LiDAR flights overlapped. Due to that, an option of Remove noise was added, which gives the software an opportunity to search through pixels within a user-defined radius depending on the level of noise to be removed.

LiVT uses a different file format, Band Interleaved by Line (BIL). Relatively recently Ralf Hesse, the author of LiVT, added a new algorithm to it, a Multiscale Integral Invariants\(^5\) (MSII). MSII and Local Relief Model are two visualization algorithms that, in my experience, proved effective in defining archeological features in relatively flat areas.

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On the third day we were taken on a field trip to investigate the features we had been seeing on LiDAR-derivatives. This gave us a chance to confront our assumptions and interpretations with the reality, which in the future will help in further interpretation of similar data. One of the sites that we visited was especially striking: an enclosure that had been easy to distinguish on a computer screen was not visible in the field for an inexperienced surveyor. This truly shows the potential of LiDAR technique in archaeology.

Our last day was mainly focused on group work and further interpretation of LiDAR-derivatives as well as discussing our ideas with other participants.

I am glad I had a chance to participate in this workshop as it gave me opportunity not only to gain further insight on how LiDAR-derived data can be visualized and interpreted but also to meet people from all over Europe who are also interested in using this remote sensing technique in their studies.
Notes on “Sensing the Past — New Approaches to European Landscapes”

Rachel Opitz

No research was conducted as part of the ArcLand Project, and certainly none was presented at the final meeting in Frankfurt, “Sensing the Past — New Approaches to European Landscapes” which took place from the 24-26 February 2015. There was, however, a good deal of content created and this content was presented and will clearly be put to use as individual projects move forward. ArcLand’s official aims include the creation a self-sustaining network to support the use of aerial survey and remote sensing across Europe, to promote understanding, conservation and public enjoyment of the landscape and heritage of countries and communities across the EU, through sharing of skills, opportunities and resources. Its activities, over the course of the five year project, centered on communication with various constituencies, skills exchanges and knowledge transfer, exploiting shared resources such as the air photo archives, and supporting the development of tools and guidance. The concrete results of these activities have included software, a traveling exhibition, whitepapers (in production) and a number of projects using aerial archaeology and remote sensing to study and explain past-in-present landscapes across Europe. Beyond this, some shared methods and more general ideas of good practice have emerged from the project, and these results of a collective direction were evident. Techniques and, importantly, approaches to landscape that were not so long ago the purview primarily of Anglo-tradition archaeologists are now de facto standard practices for archaeologists engaged in the ArcLand network in both research and management contexts at institutions across the EU. Whether this de-regionalization of research practices is a good thing™ is up for debate.

Looking back on the meeting, I feel I can pick out a few strands that emerged from five years of work within the ArcLand network. The papers and posters themselves highlighted themes of remote sensing techniques to tell the landscape story, remote sensing and prospection to help improve the practice of CRM, and actively thinking more spatially about what we do and the particularities of the aerial perspective. Talks by Edel Bhreathnach, Darja Grossman, Kevin Barton, Hanna Stoger & Hans Kamermans and Anthony Corns, Rob Shaw & Gary Devlin offered an interesting variety of perspectives on teaching and public communication using remote sensing and prospection data. This collection of papers raised questions of how we can use teaching to highlight the importance of remote sensing for landscape understanding, effectively using a distant view to bring people closer to a place with which they may feel intimately familiar. Presentations by Dave Cowley, Michael Doneus, Grzegorz Kierszys and Stefano Campana, K. Saito & B. Frezza urged us to push beyond the data capture stage and focus on interpretation and extracting meaning from the data (or gaps in data) accumulated through our collective projects. More broadly, I saw an increasing orientation toward the public and a community outside either research or heritage management for its own sake. I likewise saw strong bridges between an older and younger generation of archaeologists. This is perhaps one of the most valuable outcomes of the network, as a new generation of archaeological professionals and researchers try and find their feet, and form their own

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1 aargchair@gmail.com
professional identities and agendas. Interesting as well was the presence of a single land owner (perhaps there should have been more!) which to me reflects the growing now-orientation and outward looking attitude of the collective project, and a sense that we have responsibilities and a voice outside of the archaeological community or the relatively narrow if more public facing confines of heritage landscape management. There is a strong continued interest in archives. If anything, ArcLand clearly demonstrated to scale of this still unresolved problem. The question of how we might secure and begin to use the archives is tied up inextricably with a growing interest in the historic landscape / historic environment across Europe, and the conviction that the archives provide a valuable window on the transformation of the landscape over the past 80 years, including vast shifts in population distribution, the introduction and evolution of mechanized agriculture (deep ploughing to no-till) and changes in woodland and scrub distribution as policies and fuel sources shift. The archives - how to make them accessible and ensure the survival of the information within them - present one of the greatest challenges for our community - and this was clear in unofficial discussions at Frankfurt, as it has been elsewhere.

While the meeting presented results and outcomes, it was also clear that much remained to be done. Much of what was presented was described as work in progress, ongoing efforts at one stage or another of completion. The main outcome of ArcLand then, visible at the Frankfurt meeting, is not the finished content of individual partner’s projects or working groups, but a real and active network, evidenced by the number of side meetings to start or continue joint projects, set up exchanges for students, or discuss shared interests. There was, if I may give a personal perspective, a palpable sense of unfinished business for what was ostensibly a wrapping up meeting - less 'what was done' and more 'what we are doing'.
ArchaeoLandscapes International – coming soon!

Dave Cowley\(^1\) (ArchaeoLandscapes Europe), Rachel Opitz\(^2\) (AARG), Axel Posluschny (ArchaeoLandscapes Europe), Armin Schmidt (ISAP)

In September 2015 ArchaeoLandscapes International (ArcLand) will be launched, developing from the highly successful EU funded project ‘ArchaeoLandscapes Europe’. While planning is still ongoing, this note will give AARG members some insights on the developments.

The story so far - ArchaeoLandscapes Europe (http://www.arcland.eu/)
The ArchaeoLandscapes Europe project was born out of a desire to promote the application of remote sensing techniques, both ground-based and airborne, for archaeological landscape studies. Because these techniques underpin the creation of knowledge about the past and its material remains across a variety of domains, raising awareness of their potential and facilitating the broader adoption of their use was seen by the project’s instigators as vital. Beyond their importance in research and heritage management contexts, the results of archaeological remote sensing can have a dramatic impact in illustrating to the general public, policy makers and government representatives the character and importance of heritage sites and of the evolving landscapes within which they lie. Recognising this, the project has emphasised communication and education activities bringing archaeological remote sensing to a variety of communities and groups, supporting fuller understanding and appreciation of past-in-present landscapes.

A central aim of the ArchaeoLandscapes Europe project has been to address regional imbalances in the application of remote sensing and to improve conditions for the regular use of these strikingly successful techniques across Europe as a whole. With 27 core institutional members and 61 associated partners this project is the largest such initiative funded by the EU, and has resulted in the creation of a strong network engaged in knowledge-exchange, content creation, and education activities that promote archaeological remote sensing. During the last four and a half years, six training schools and 22 technical workshops have been organised, hosting a total of 572 students and young professionals. Some 54 ArcLand grants have enabled their beneficiaries to attend these educational events or an ArcLand related conference. Thirteen internships in ArcLand partner institutions have allowed young archaeologists to learn new skills and gain experience in a working environment. To date seven larger publications have been supported through the ArcLand Project and consequently are badged with the project logo. The travelling exhibition "Traces of the Past", previously hosted in various places in Ireland and in the USA, will be shown in Germany, Slovenia, Denmark, Spain and other countries in the coming months. These activities, as well as many smaller events, press and media work, and active conference participation have generated a high level of visibility for ArcLand in the scientific and archaeological communities. These activities have also highlighted ArcLand to the broader public and have strengthened the network, creating fertile ground for ArchaeoLandscapes International and its future work (see http://www.arcland.eu/images/articles/PDFs/e6_43.pdf for an interim report on activities).

\(^1\) Dave.Cowley@rcahms.gov.uk
\(^2\) aargchair@gmail.com
From the outset, one of the aims of the ArchaeoLandscapes project has been to ensure the continuation of the network that lies at the heart of this success story beyond the life of the project. To achieve this, discussions between ArchaeoLandscapes Europe, ISAP and AARG began in 2014, resulting in a plan to establish ArchaeoLandscapes International (ArcLand). This new organisation will be dedicated to expanding and sustaining the existing network, and using the network’s collective expertise to develop projects in research, knowledge-exchange, education and outreach.

Looking to the future - ArchaeoLandscapes International (ArcLand)
The vision for ArcLand beyond the end of the EU-funded project in September 2015 reflects its origins and ambitions for subsequent development beyond the borders of Europe. The immediate challenge for the newly created ArcLand organisation is sustaining an active network after the end of the EU’s project funding and to support initial activities, while seeking new sources of funding. To accomplish this, the network has been ‘adopted’ by two well established archaeological societies, AARG and ISAP, who share a common interest in archaeological remote sensing and landscapes. We envisage that ArcLand will promote integrated approaches to prospecting and identify common purpose between AARG and ISAP, and in the future other organisations that may support it, as appropriate.

Reflecting the interests of the ISAP and AARG memberships and those of the current ArchaeoLandscapes Europe network, the central aim of ArcLand is the promotion of non-destructive prospecting methods for archaeological investigations. In particular it:

- considers all methods of remote sensing, aerial archaeology, ground-based geophysical and geochemical prospection and surface survey;
- is concerned with archaeological investigations on all scales, from monuments and sites to landscapes, along with their analysis and interpretation;
- has an international remit in archaeological research and membership;
- is a liaison partner for other organisations and institutions with regards to archaeological prospecting in landscape archaeology;
- promotes the use of archaeological prospecting as a method of archaeological enquiry;
- facilitates education in these methods;
- informs policymakers, government representatives and all parts of the general public about the potential and limitations of archaeological prospecting; and
- supports the development of new equipment, software and methods.

Practical arrangements will remain under discussion for the next few months, but some general principles have already emerged.

- The organisation will again be based on institutional membership; procedures for joining will be established by September; there will be a simple constitution; there will be no subscription fee; external financing will be sought; it relies on the commitment and support from its members.
• It will be administered by a General Management Board (GMB – in the first instance drawn from the current membership), comprising a permanent member from AARG and one from ISAP, with three or four others drawn from the rest of the membership.

• The permanent GMB membership of AARG and ISAP creates a sustainable framework, and reflects the commitment to ongoing material support by these organisations, both through in-kind contributions and in small amounts of seed-funding. Eligibility for other GMB positions will be based on similar in-kind or financial contributions, demonstrated over a certain period.

• Looking for funding to support the network will be a key activity, and a development officer (or a small group of officers) will be responsible for identifying funding opportunities and nascent research, education and outreach projects in the community, and match-making between them. Arrangements for an ArcLand Project Officer are still to be determined, and a person to fulfil this role in the short term on an honorary basis may be sought from AARG and ISAP members.

It is clear that a sustainable network is important for future funding applications, and a programme of ArcLand activities that maintains the visibility of the network after September 2015 will be important. Outcomes from ArchaeoLandscapes Europe, including several publications, will help, and members of both AARG and ISAP may consider badging collaborative or integrative projects as ‘ArcLand’, if appropriate. The continuation of a series of guidelines to best practice, including World War I aerial photographic archives and Airborne Laser Scanning visualisations, is also an aspiration of the future organisation. Such promotion of best practice benefits everyone, and carries weight when published in a defined series with good profile. Members will be encouraged to consider future contributions to the series.

Other possibilities for maintaining the profile and growing the network include website content, conference sessions, workshops/training/exchanges, cross-cutting working groups (e.g. on prospecting in woodlands or community involvement), maintaining publication output and perhaps a newsletter.

**Working together**
The discussions between ArchaeoLandscapes Europe, AARG and ISAP have made it clear that there are strong motivations to create an institutional umbrella organisation for all those working in archaeological prospecting. This organisation should provide a forum to identify challenges that are best addressed at an international community level, add weight and capacity to funding applications, and facilitate and enhance projects carried out by network members. We anticipate that bringing together our two membership-based groups, reflecting different specialist areas of practice, and an integrative shared organisation that looks to the general overarching issues across the whole of archaeological prospecting and remote sensing will benefit the entire community as individual and shared projects are pursued.
Santiago Tales from your Committee

And lo, it came to pass that the Big Chief, Lesser Chief, Scribe, Money Counter and Teller of Tales gathered in the city of Santiago de Compostela to contrive a Great Meeting for Fellows of AARG. This tale shares some of their adventures and may encourage Fellows of AARG to make pilgrimages in September to see the sites of these events.

The Money Counter’s Tale

Point 1. Travel between two points by vehicle may not be the best idea unless you leave plenty of time.
**Reason:** As some trains don’t connect with flight times a car may be used. However, lorries may break down on roads and cause major delays.

**Finding out how:** Stuck on a road between Peterborough and Stansted with gate closing time looming! Airport gate the furthest away to run to.

**Result:** Made it panting on to the plane to find Rog & Oscar grinning at me!

Point 2. Before boarding a plane check your seat number carefully.
**Reason:** You may misread your seat number.

**Finding out:** Having carefully stowed my carry-on and coat under the seat I found I should have been 3 rows further forward.

**Result:** Moved to correct seat and found Rog & Oscar in the seats opposite grinning at me!

Point 3. When booking flights make sure you check all dates carefully.
**Reason:** Arriving at an airport to find your return flight has been booked for the following month is not a good start. Buying another ticket at the airport is very expensive way home!

**Finding out how:** Finding you have a seat with the same number as Rog Palmer’s!

**Result:** Got on the plane at the back so got off early to see Rog & Oscar just ahead of me coming out of the front – grinning at me!

Point 4. When going through Passport Control it is usually quicker to use the e-passport control, if you have one.
**Reason:** The queue is usually shorter.

**Finding out how:** Rog, Sara & I used it.

**Result:** When Oscar came through ordinary passport control there was Rog, Sara & I grinning at him!

Point 5. Advance booking of rail tickets.
**Reason:** Should be easy & faster to collect your tickets – but not always.

**Finding out how:** Web server down so no tickets available.

**Result:** Had to get ticket desk to stamp print-out for train inspector but at least no grinning colleagues to see 4 attempts at trying the machine!

Point 6. Give yourself time to get on a train.
**Reason:** There may be interviewers on the platform asking lots of questions about what you think about train services.
**Finding out how:** Stopped by a very cold interviewer with a survey that took longer than expected.

**Result:** Had to run for the train and tripped over my case while stepping in, twisted a leg of my glasses. Black eye the next day!

**The Big Chief’s Tale**

I’ll share my travel (mis-)adventure. Taking off in Barcelona the plane’s right engine had a close and unfriendly encounter with a large duck during take-off. We came back down quickly, with many bumps and exciting noises. Apparently ducks are not good for airplane engines, and I suspect airplane engines are not good for ducks.


Santiago de Compostela: AARG 2015 venue.

(photoby A. Uzal, www.filmate.es)

![The door left of the tower provides access to the hostel recommended by Cesar and AARG. Off the picture to the right is a much grander door that leads to the conference dinner.](https://en.wikipedia.org/wiki/Santiago_de_Compostela)

The door left of the tower provides access to the hostel recommended by Cesar and AARG. Off the picture to theright is a much grander door that leads to the conference dinner.

See the conference web site for maps and pinned locations: [https://sitios.csic.es/web/aarg2015](https://sitios.csic.es/web/aarg2015)

(photoby Moira Greig)
AARG notices

The Derrick Riley Bursary

The Derrick Riley Bursary still exists. It is £500 a year, usually a single award, but sometimes is split and given to two people.

There should be an application form on the Sheffield Archaeology Department website and a Riley Bursary page on the Sheffield website where potential applicants will be able to find information and download the application form.

Finding the relevant page represents the first challenge, but if you can’t please contact Bob Johnston (r.johnston@sheffield.ac.uk) who administers the bursary.

Please apply for this even though it is not used only for conference attendance. AARG has limited funding and access to the Riley Bursary extends this amount to something more useful. No whinging about lack of money if you don’t apply.

Information for AARGnews contributors

AARGnews is published at six-monthly intervals. Copy for AARGnews 51 needs to be with me by August 5, 2015. Editorial policy (for want of a better word) tends to be that if I am sent interesting contributions they go in unless there’s a danger of an issue overflowing. Vague instructions for contributors are on the AARG website, or use this issue as a guide.

Please do not use any ‘clever’ formatting and avoid footnotes.

Good-quality jpegs are suitable for illustrations. Tiffs are for archives.

And please send us your nominations for future AARG conversations.

Address for contributions: rog.palmer@ntlworld.com
Cropmarks
Harvested by Rog Palmer

Ricoter – Riegl’s UAV
In the last issue we mentioned Riegl’s small laser scanners that were suitable for use in UAVs. Since that date, Riegl have unveiled their own unmanned aerial system that can be fitted with their VUX-1 sensor, their new VQ-880-G scanner for bathymetric surveys or other sensing devices. The carbon fibre UAV is unlikely to be cheap, but it is made to absorb the bangs and bashes these things suffer without (hopefully) damaging the sensor. I couldn’t find any info about payload, duration, etc as the links below do little more than note its existence.


(Thanks to Nina Heiska)

AirPano
This is a project created by a team of Russian photo enthusiasts focused on taking high-resolution aerial panoramic photographs. Their galleries (video and still) make a good diversion for anyone who enjoys looking at aerial and other pictures. There’s been some clever image manipulation done by the project which may inspire some among us.

http://www.airpano.com/Project-AirPano.php

(Thanks to Irwin Scollar)

Airborne laser scanning
An US-centric summary of ALS, including notes on its use from satellites plus a look ahead to some forthcoming projects. Nothing really new.  http://www.pnas.org/content/111/43/15283.full

Jordan’s ‘big circles’
There have been several reports about this series of 400m diameter circles, possibly built about 200 years ago and of unknown purpose. David Kennedy’s oblique images are in the livescience report below and also can be seen in the project’s archive (http://www.apaame.org/).


Ramses-NG
This is an ultra-high performance detection system, made by the French company ONERA, that uses the full potential of radar/optronics synergy. It may be a bit expensive for archaeology, but the following is taken from a press release:

Some of its uses are aimed at security and defence customers but the press release (perhaps not perfectly translated from French?) suggests that its penetrative abilities may be useful to non-military use. The Ramses-NG system mounts three radar sensors (X-band and UHF L respectively) and offers an unprecedented level of image quality – but you may need to buy a Mystère 20 to fly the kit. Programming, control and data acquisition functions are located in the cabin of the aircraft, with six electronic bays and two dedicated operator stations. The

1 rog.palmer@ntlworld.com
modular and scalable design of the system also allows it to receive any new sensor or industrial model. The plug-and-play system can combine various radar or optical sensors, hyperspectral cameras, or even electronic scanning antennas.

Radar at high frequencies allows fine resolutions and extremely precise image qualities to be obtained, from around ten centimetres to several tens of kilometres. At lower frequencies, they offer significant canopy or underground penetration capacity. In some environments, their detection capabilities are very significant: low-frequency radar thus makes it possible to penetrate at least five meters under sand and four kilometres under ice.

The release claims that the RAMSES system includes:

- High resolution radar for daytime/night time mapping in any weather,
- Complete polarimetry for the classification of objects or environments,
- Interferometry to produce a digital terrain model or detect changes that have occurred since a reference image,
- The ability to detect objects hidden under the canopy or in the ground.

[I can find no useful images of the output of Ramses as the several websites that mention it seem to prefer to show the shiny aeroplane used to fly the kit around.]


[Adapted from the press release, 5 July 2013. Thanks to Paul Bahn]

Eye, brain, belief
A short lecture by Michael Shermer, an American science writer, that he titled Belief but which deals with pattern seeking and the ways in which we do and do not decipher some of these. Of interest to those of us who like to know how and why we perceive things on aerial photographs. http://video.ted.com/talk/podcast/2010/None/MichaelShermer_2010-480p.mp4

The web site offers an audio version but the slides are an essential part of the talk. I needed to click Download before I was able to see the video.

(thanks to Vedrana Glavaš)

More droning on…
Drone uses are becoming more regulated – as in the following article about exemptions in USA. http://geospatial-solutions.com/five-new-faa-commercial-uav-exemptions-what-do-they-mean/

(thanks to Irwin Scollar)

…and on
The above is probably outdated as FAA issued a press release on 15 February 2015 which seems to offer free-for-all commercial use as long as drones weigh less than 2kg, are flown below 500 feet and kept in sight. http://www.faa.gov/news/press_releases/news_story.cfm?newsId=18295
**Drones gone mad?**
Use of ‘drone’ in a project application seems to be the current equivalent of using ‘GIS’ in the 1980s. A recent example seems to have secured funding of 1.7 million Euro and will use a drone in the Amazon to hunt for geoglyphs using ALS. With that amount of money to spend, surely they could run to hiring a proper aircraft that will provide a steady platform with good overlap and a chance of obtaining the best data for processing?


**And for those with drone withdrawal symptoms**
For those few of you who can’t get enough of these things, there is a drone news website. I’m bored with them – they may take aerial photos and may have given us SfM and its benefits but are more relevant to visualisation than to aerial survey. So why do I keep filling *Cropmarks* with news of them?  

http://www.suasnews.com/  

(thanks to Geert Verhoeven)

**Google Earth Pro**
Those of you who are content to use plain straightforward vertical images may be pleased to know that Google are giving free access to their GE Pro version. Among other things, this enables users to save selected screen captures at sizes up to ‘maximum resolution’. On my screen, that equals 4800x2725 pixels and the 4800 stays constant even if I stretch GE across two screens. Download from the link below then register using an email address and the key: GEPFREE.  

http://www.google.co.uk/earth/download/gep/agree.html

**Microsoft’s ICE version 2**
An updated version of the image stitching program was issued in early February 2015 and includes some powerful enhancements (see: http://youtu.be/zhdXLH2GYPa). Download from (http://research.microsoft.com/en-us/um/redmond/projects/ice/)  

(thanks to Geert Verhoeven)

**ALS layer on Geoportal Poland**
To brighten things up after those depressing drones, the new layer of ALS on the Polish Geoportal seems to be of relatively-high resolution and makes a wonderful diversion for a few weeks. The EU really ought to kick the UK government for not having a geoportal (among other kick-worthy things).  

http://mapy.geoportal.gov.pl/imap/?locale=pl&gui=new&sessionID=1677577

(thanks to Lidka Žuk who wishes to thank Greg Kiarszys and ‘all the other boys’)

**Projection of raster data**
A USGS page that provides a reading list of papers dealing with the accuracy of projection of raster data that may be of interest to those of you using Google Earth or similar global image data.  

http://cegis.usgs.gov/projection/  

(thanks to Irwin Scollar)

**STAR**
Is a new open-access and internationally peer-reviewed archaeological journal which stands for Science and Technology of Archaeological Research. Their website notes that STAR
accepts papers utilising any of the array of scientific and computational techniques available to archaeologists, including, but not limited to:

- Archaeological materials science
- Airborne remote sensing, geophysical techniques and imaging
- Artefact conservation and restoration methods
- Biological and biochemical approaches
- Environmental approaches
- Forensic archaeology
- Heritage studies and conservation methods
- Mathematical modelling, computational analyses and virtual reality
- Scientific dating including geochronological approaches
- Spatial analysis and GIS
- Underwater archaeological methods

STAR offers a rapid route to publication with swift, robust peer review, access to the broadest possible archaeological audience and ‘reasonable’ article publication charges of 900 Euro. However, for readers access is currently open and free and there are three articles, not of aerial interest, presently (12 March 2015) available.  www.maneonline.com/star

(thanks to Geert Verhoeven)

Smashing sites
Any of you who want to keep track of damage being done to sites in the Near East and North Africa can befriend the facebook site of EAMENA (careful how I write that) below. This comes from the Endangered Archaeology project being run at Oxford and Leicester with the intention (and I quote from facebook) of ‘…recording endangered archaeology sites…’. Isn’t that almost all of them?

https://www.facebook.com/EAMENAProject/info?tab=page_info

There is also a more measured project description at:  http://www.arch.ox.ac.uk/ea.html

WorldView-3
Samples of new 30cm resolution images have been released and they are pretty good. Recent blurb from European Space Imaging seems to be aimed at rich archaeologists as among the benefits of 30cm is: ‘easier to see non-linear features, like circles and ground markings’. The link below includes some large file samples plus smaller extracts and shapefiles of annual cover for WorldView and other satellites owned by DigitalGlobe.

http://www.euspaceimaging.com/resources?utm_source=European+Space+Imaging+Subscriber+List&utm_campaign=c7217ac3da-30+cm+WorldView-3+Imagery+Products+Now+Available&utm_medium=email&utm_term=0_1a000e8e18-c7217ac3da-71845305#sampledata
Books of interest?

Rog Palmer¹


Yes, it’s old and original copies are somewhat rare, but thanks to the Oriental Institute at the University of Chicago we can all download a free pdf copy. Schmidt’s 1930s aerial photos have been available at the OI website for several years and more recently the OI have been adding scanned books to their website (the miscellaneous publications can be chased via the link below). Useful stuff for anyone working in ‘the orient’ or collectors of old (pdf) books. [http://oi.uchicago.edu/research/publications/misc/flights-over-ancient-cities-iran](http://oi.uchicago.edu/research/publications/misc/flights-over-ancient-cities-iran)

Archaeological monographs from English Heritage

Another goldmine of free books is at the Archaeology Data Service who recently made available past titles by English Heritage as ebooks (see the [English Heritage Publishing catalogue for details](http://archaeologydataservice.ac.uk/archives/view/eh_monographs_2014/index.cfm)) and as PDFs which can be downloaded free from the address below.

Perhaps one day they’ll get around to doing the same with the RCHME volumes.?


MBA enclosures and fields have become ubiquitous in East Anglia since the advent of developer-led investigations and this paper summarises the partial excavation of one of these and identifies other ‘comparable enclosures’ in Norfolk using NMP output. The comparable enclosures are based on similarities in morphology to the Ormesby St Michael enclosure but with considerable flexibility in shape, noting (and illustrating) that MBA enclosures excavated in adjacent Cambridgeshire vary significantly in their morphology. Discussion of field systems laments the usual lack of dating evidence that we have for them but suggests that a lot of those that we would automatically slot into ‘Iron Age-RB’ could be earlier or have earlier origins.


Some results from the Romanian-Hungarian project that examine geomorphological conditions and their effects on the locations of prehistoric and Roman settlement.

¹ rog.palmer@ntlworld.com
A three-language book (Hungarian, Romanian, English) that provides a chronological overview of Transylvania mixing aerial photos (including some anaglyphs) with information from excavations and ground surveys. It’s not a new-new book but has recently been uploaded to Academia from where it can be freely downloaded.

Guides for using drones

The Archaeology Data Service is hosting a two-part guide about using drones for archaeology in Britain (as it only mentions the CAA rules). The first part – suggestions for good practice when undertaking ‘archaeological survey’ with drones had been produced in collaboration with Jisc (whatever that is) and the second part written by Stephen Gray, Bristol University who seems to love metadata. Drone users may find snippets of useful stuff in these free guides but should remember that the rules are rapidly changing (see Cropmarks, this issue).

http://archaeologydataservice.ac.uk/blog/2014/11/archaeological-drones/


Two technical papers that deal with issues relevant to the quality and accuracy of DTM/DSMs produced from UAV images and those from other sources. The first concludes that best accuracy of matches come from features with hard edges [surely no surprise?], the second compares decolourization algorithms and their performance. Both seem focused on a quest to produce highly-accurate digital representations of objects or scenes which seems to suggest a use beyond that of simple visualisation.


An open access publication that has used images from a drone to prepare microtopographic (ie bumpy) maps. The paper goes on a bit but the survey seems to have produced some useful output at 5cm resolution and better of four hilltop sites from planned and controlled survey flights. Cost for this was about $28,000 (kit and software) plus 85 person days.
The Aerial Archaeology Research Group

AARG is a lively and friendly international group of young and old researchers. It provides a forum for the exchange of ideas and experience on archaeology and landscape studies using all forms of remote sensing, especially airborne and satellite based techniques.

AARG is actively involved in promoting the collection, interpretation and application of remote sensing data in fostering research, conservation and public understanding. Its members are among those pushing the boundaries of the collection and analysis of air- and space-borne sensors.

Since its foundation in the early 1980s, AARG has vigorously encouraged discussion and cooperation through its annual conferences, workshops, specialist publications and biannual newsletter, AARGnews.

Membership is open to all who have an interest or practical involvement in aerial archaeology, remote sensing and landscape studies.

AARG is a registered charity: number SC 023162.

**AARG homepage.**  [http://aarg.univie.ac.at/](http://aarg.univie.ac.at/)

**Membership/subscription rates:**

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<thead>
<tr>
<th>Category</th>
<th>Individual</th>
<th>20.00 Euro</th>
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* and applicants residing in Albania, Bulgaria, Croatia, Czech Republic, Hungary, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia, and countries of the former Soviet Union.

Subscription reminders may be sent out on January 1

Methods of payment:

- Standing Order mandate
- Electronic funds transfer
- PayPal
- Sterling or Euro bank notes

Bank details are available on request for direct payment from overseas.

Please contact the Secretary: [aarg.secretary@googlemail.com](mailto:aarg.secretary@googlemail.com)

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**Student scholarships.** AARG has a limited number of student scholarships for attendance at its annual meeting. These are aimed at supporting bona fide students who are interested in aerial archaeology and who wish to attend.

Anyone wishing to apply should write to AARG’s Chairman ([aargchair@gmail.com](mailto:aargchair@gmail.com)) with information about their interests in archaeology and aerial archaeology, as well as their place of study. The annual closing date for applications to the annual AARG conference is 31 May, other meetings for which scholarships may be available will be advertised on an ad hoc basis.