

TRADITION MEETS INNOVATION IN ANALYTICAL EARTHWORK SURVEY

Dave Went MClfA (762) and Olaf Bayer MClfA (9135), Historic England

The term ‘non-intrusive archaeology’ covers a lot of ground nowadays. In Historic England’s Archaeological Investigation Team (AIT) we use it as a shorthand for three principal approaches: aerial investigation, geophysical investigation and analytical earthwork survey. Technical developments in the aerial and geophysical approaches are fairly frequent and sometimes game-changing (eg, ground penetrating radar and extensive LiDAR coverage). By comparison, the practice of analytical earthwork survey, especially use of the time-honoured ‘hachure’ (an elongated triangle depicting the intensity and direction of slopes) can seem a little dated.

Historic England’s Landscape Archaeology Team still carries out closely observed earthwork surveys in this, the longest tradition of non-intrusive investigation, following in the footsteps of our notable predecessors, including the 20th-century Royal Commissions on the Historical Monuments of England, Scotland and Wales, and the surveyors of small-scale earthwork plans that adorn early Ordnance Survey maps.

The common aim of earthwork survey is to produce two-dimensional plans from three-dimensional patterns of slopes, teasing archaeological/anthropogenic features away from the underlying natural topography, and interrogating the relationships between individual features to support an interpretation of their sequence and purpose. The tools have evolved over many years – from prismatic compasses, tapes, plane tables and alidades to total stations and Global Navigation Satellite Systems – but the approach remains much the same: the close observation of earthworks recorded as tops, bottoms and breaks in slope. Since, with care, perfectly good results can be achieved using any of the above, earthwork survey falls easily within the grasp of professional researchers and community groups alike.

Large quadcopter drones, with a variety of sensors, are now a routine part of the archaeological surveyor’s toolkit, as here in Derbyshire. Credit: Historic England

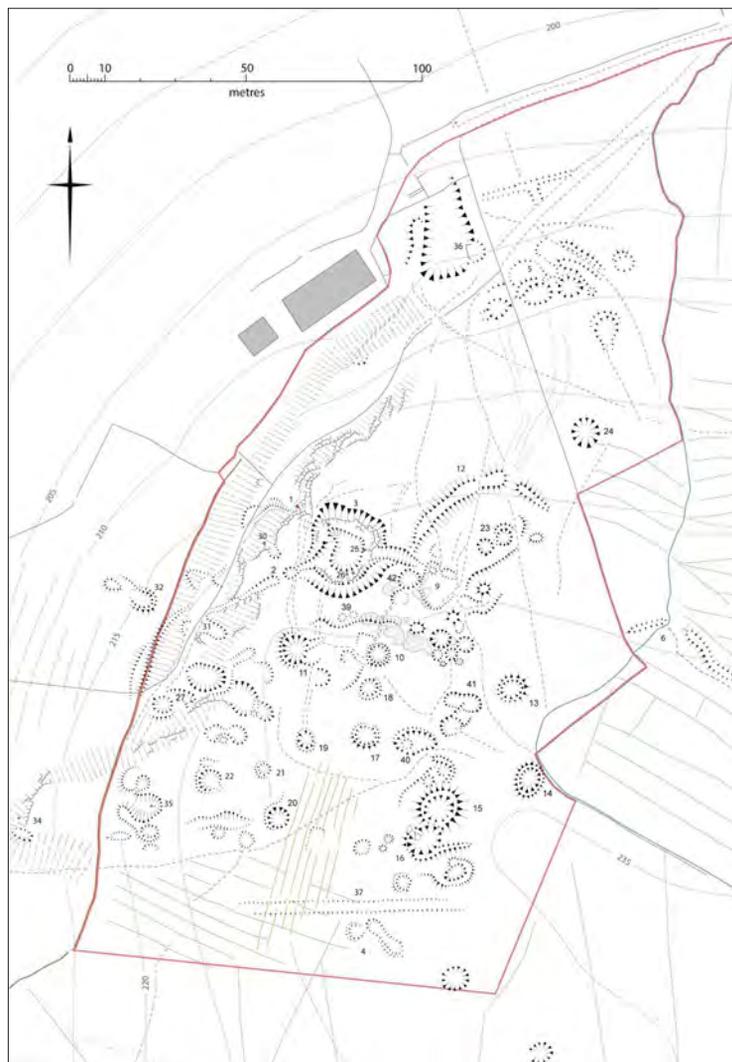


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Drone-acquired digital surface model of the Ashnott lead mine, Lancs, and the interpretation plan drawn from the DEM, checked and refined by observation and additional recording on the ground. Credit: Historic England

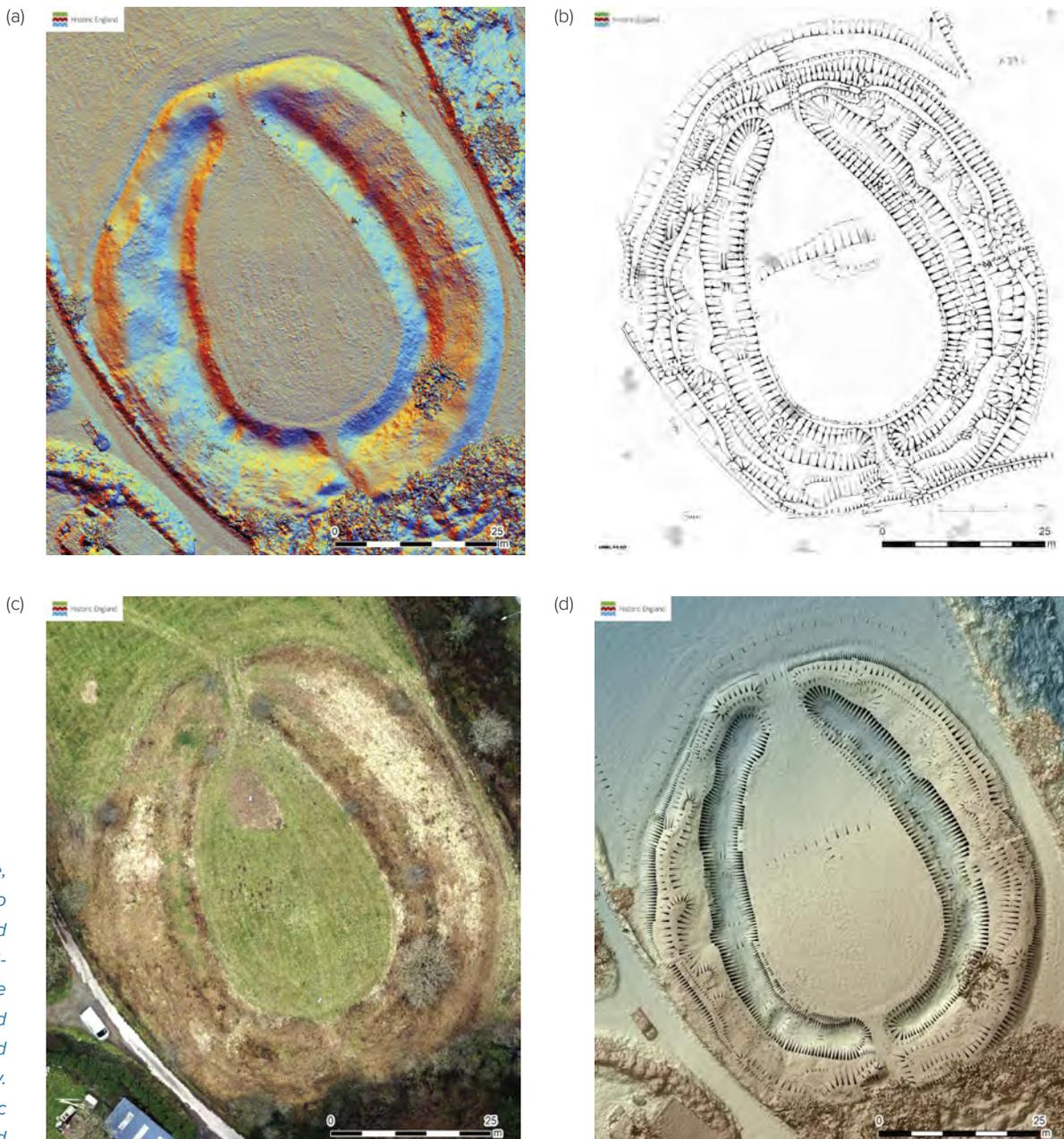


Field survey has long incorporated information from aerial photographs, but the emergence of Digital Elevation Models (DEMs), derived from a variety of aerial sources at relevant levels of resolution, has opened up a whole new range of possibilities. We started commissioning LiDAR from light aircraft around 2008, and extended this to contracted drone services early in the following decade. By 2015 we were making close comparisons between drone-flown terrain models (then using photogrammetric processes) and earthwork surveys created by more traditional means. The potential, explored through early forays such as shown here at Ashnott lead mine in the Forest of Bowland, Lancashire, was obvious. With these models we could visualise the site from almost any angle, revisit the site virtually while reviewing the survey data, add detailed contours and other setting information, and perhaps (as at Ashnott) attempt initial interpretation and mapping from the model before further refinement on the ground. More recently we have acquired our own drones for capturing high-specification photogrammetry and LiDAR, and the production of localised terrain models has now become a routine aspect of our fieldwork, complementing our ground survey skills and adding fresh dimensions to the portrayal of the results. A

good example of this is shown at Castilly Henge, Cornwall, where a detailed (HE Level 3) earthwork survey was accompanied by drone-derived orthophotography and DEM visualisations.

Scrutiny of the digital imagery at Castilly was no match for the experienced human eye on the ground when it came to defining and understanding slight earthwork features and the subtle relationships between them. This distinction has recurred time and again throughout our more recent hybrid survey projects and is likely to remain true despite continuous improvements in sensors and processing software.

In 2023 the authors brought together a range of drone-users from the public, commercial and academic arms of the sector at the Nottingham ClfA conference to discuss present and future uses of the technology. The range of applications was impressive then, and has no doubt grown since. Bob Johnson spoke about Sheffield University's experience of the educational value of combining drone modelling with more tradition groundwork. Chris Casswell from Reclaim Heritage CIC demonstrated the value of high-resolution Digital Terrain Models (DTMs) for charting intricate First World War trench systems in dense woodland to assist a



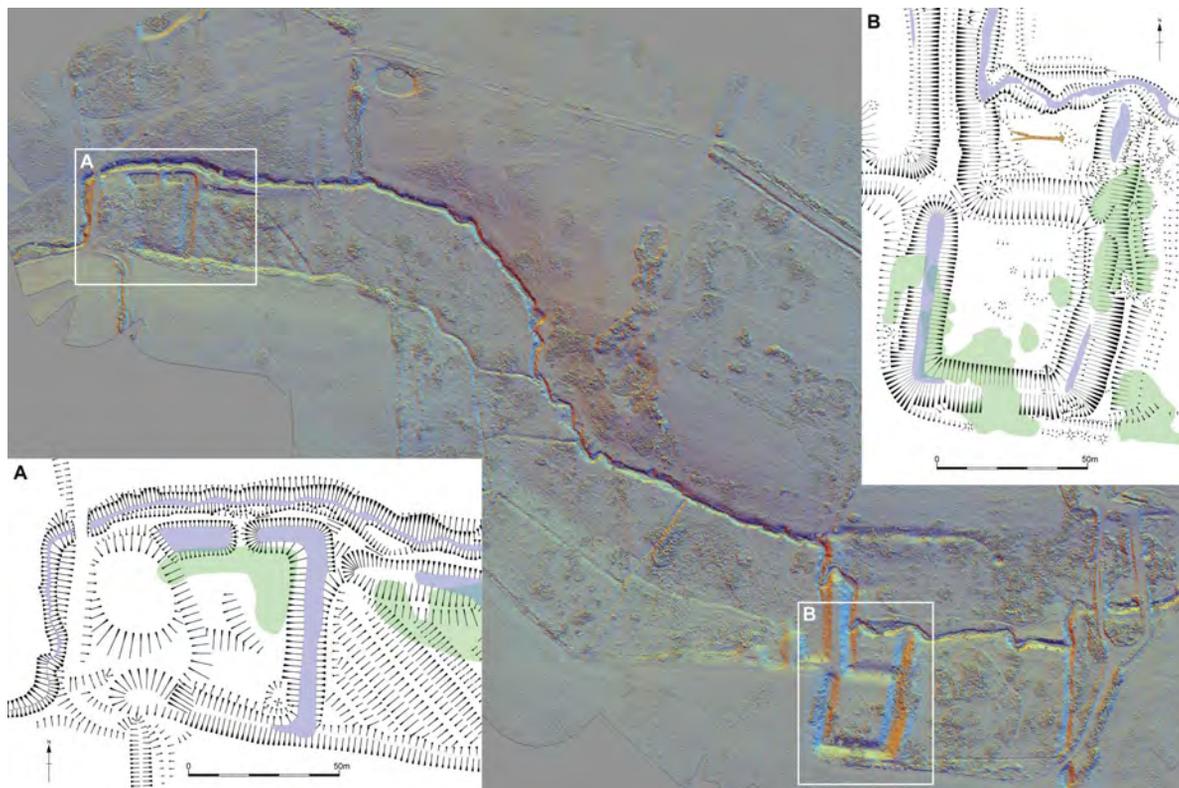
Castilly Henge, Cornwall. (a) photo orthomosaic; (b) field drawing; (c) 16-direction hillshade DEM, (d) hachured plan with coloured DEM underlay. Credit: Historic England

community survey project. Adam Stanford and Scott Williams from Sumo Survey Services, Joel Goodchild from Archaeological Research Services and Nicholas Crabb from Brighton University each explored the value of multispectral and thermal imagery in isolation and alongside terrain modelling. The recording of this session, available on the ClfA website at <https://www.archaeologists.net/events-training/events/conference/2023>, gives a very useful snapshot of the growing range and potential of drone applications.

The matter that concerned us most at Historic England in 2023, and since, is that the ease and speed with which terrain models can now be generated could draw attention away from the value of closely observed ground survey, or suggest there is no longer a need for such skills to be taught and employed. Mark Bowden and Olaf Bayer spoke about this in Nottingham, emphasising the special value of field

survey to derive nuanced understanding from earthwork remains, and from the personal, immersive experience of their landscape context. In our landscape team we have found this to be entirely true. Simply 'hachuring up' a plan from Environment Agency LiDAR or from a drone-acquired terrain model is no substitute for the investment of time and thought applied through terrestrial survey methods when it comes to the quality and utility of the research.

As with earlier aerial photography, the digital elevation model is a tool to be embraced by landscape archaeologists. Photogrammetric and LiDAR models provide rapid images to suit timely needs, the latter penetrating woodland and dense undergrowth to capture features that it might be impractical to survey on the ground. For the present, however, and in the longer term, it is best used in conjunction with direct observation. This can be 'ground-truthing' to check the



A 16-direction hillshade DTM of a Hertfordshire wood created from drone LiDAR. Hachured plans of two moats – remote sensed (A: left) and directly observed (B: right) – produced to similar but distinct specifications. Credit: Historic England

initial interpretation of features and ascribe finer points of interest (see Casswell's military trenches), or using the terrain model to underscore and inform a full detailed survey, drawing together the best of both approaches.

In these changing times it is important that the means by which earthwork survey plans are created is clearly stated in visual outputs and methodologies. For example, two moated sites at opposite ends of a wood near Cheshunt, Hertfordshire, required contrasting approaches.

The eastern part of the wood was sufficiently open to allow detailed earthwork survey with a total station theodolite (B); the west end, however, was shrouded by an impenetrable thicket, for which drone LiDAR was

the only practical approach (A). To provide comparable plans for interpretation both were similarly hachured, but even after a difficult day hacking through undergrowth to check the LiDAR plot on the ground, the western moat could not be mapped with anything like the same degree of accuracy or insight, and plans with different scales and tone were used to emphasise this difference. Such distinctions become all the more important where various methods of mapping are combined within a single large survey. This may seem to be an obvious statement of archaeological integrity, but in a rapidly evolving field such statements have their place.

Historic England is currently developing a best practice guide for drone-assisted earthwork survey based on the experience of practitioners in this field.

For more information

About how Historic England use airborne remote sensing to discover, research, understand and manage the historic environment, visit <https://historicengland.org.uk/research/methods/airborne-remote-sensing/>. Other guidance on terrestrial earthwork survey can be found at: <https://historicengland.org.uk/advice/technical-advice/recording-heritage/>. Over 7000 research reports from Historic England can be downloaded for free from our website: <https://historicengland.org.uk/research/results/reports/>

Dave Went

Dave is the Landscape Archaeology Principal within Historic England's multidisciplinary Archaeological Investigation Team.



Olaf Bayer

Olaf is a Senior Investigator in Historic England's Landscape Archaeology Team with responsibility for developing standards and guidance in earthwork survey techniques.

