The Use of Global Positioning System Technology to Record and Interpret Archaeological Sites and Landscapes

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Abstract

This paper describes and discusses the use of differential Global Positioning System (GPS) equipment for the survey and recording of archaeological sites and landscapes within the Exmoor National Park, an upland area in southwest England. The technique facilitates the production of earthwork plans, site management information, contour maps and digital terrain models (DTM), all surveyed to the Ordnance Survey (OS) National Grid. The digital data obtained can then be used in the GIS (Geographic Information System) operated by Exmoor National Park Authority (ENPA).

1 Introduction

1.1 The Exmoor archaeological survey project

The Exeter Office of the Royal Commission on the Historical Monuments of England (RCHME) instigated two major upland archaeological survey projects in 1993. The aim of these projects was to record the archaeology contained within the former Royal Forest of Dartmoor and the Exmoor National Park. This paper is concerned with the development of a survey methodology designed to cope with the rigours of the complex topographic and archaeological landscapes of Exmoor.

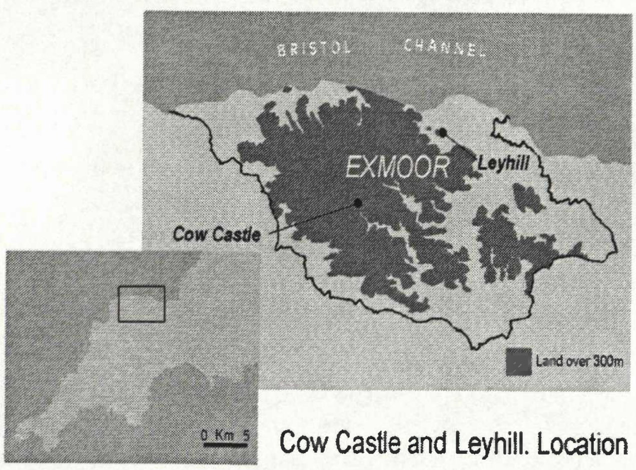

Figure 1. Exmoor National Park and sites mentioned in text

The Exmoor National Park covers approximately 700 km^2 of diverse landscape type in the southwest of England (see Fig. 1). The landscape ranges from bleak high moorland such as the Chains, which rise to over 400m OD, to the deep wooded valleys of the Barle and Exe rivers. The Exmoor coast offers high cliffs, coastal heath and a foreshore environment, whilst the Brendon Hills to the east are mainly enclosed and improved (Binding 1995).

1.2 Exmoor's archaeology

The range of archaeology encountered is similarly diverse (Grinsell 1970). Prehistoric sites are largely confined to the unenclosed moorland. The earliest field remains consist of stone monuments: stone settings and stone circles, which tend to be elusive and vulnerable to damage. These monuments are undated, but probably belong to the later Neolithic and earlier Bronze Age periods. Bronze Age burial cairns are often substantial monuments, situated in prominent positions on the ridge tops of the dissected upland plateaux. On the coastal fringes, these cairns command splendid views over the Bristol Channel to the Welsh coast. Smaller cairns are often associated with fragmentary field systems and house platforms. The later prehistoric period is represented by earthwork enclosures and hillforts (see Fig. 2). Castle earthworks and several deserted medieval settlement sites with associated field systems are some of the earliest documented sites. Post medieval sites encompass a wide range of industrial, agricultural and recreational activities.

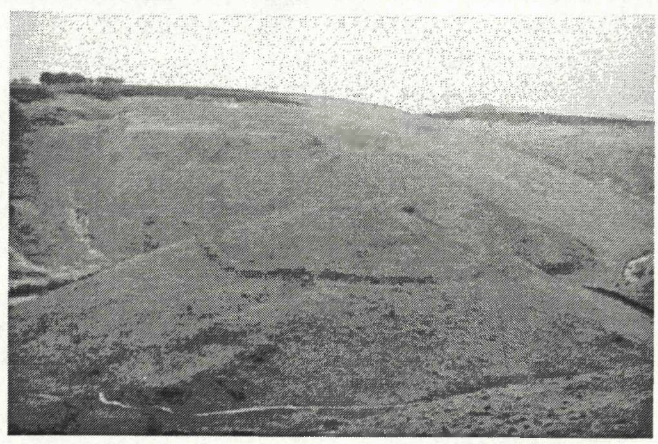

Figure 2. Cow Castle: Iron Age hillfort in Barle Valley, Exmoor.

Previous archaeological surveys of the Exmoor landscape have either been monument based (Grinsell 1969; Quinnell and Dunn 1992), or have focused on a specific area for management purposes (McDonnell 1985). The

RCHME Exmoor survey project is designed to consider the archaeology of all periods for the whole of the Exmoor National Park, both to improve the locational and textual record for known sites, and to reconnoitre for new sites. This targeted reconnaissance is based on air photograph inspection, map work, local knowledge and experience (Wilson-North and Sainsbury 1994; Exmoor National Park Authority 1995).

2 GPS and its use in archaeological survey

2.1 Principles of GPS survey

Only the basic principles of GPS survey are set out here, further details are given in Hern 1989. The method of working will, to some extent, depend on the type of equipment and software being used. The RCHME Exeter Office has had access to differential GPS survey equipment since 1995. The equipment in use is Leica single frequency System 200 (SR 261 GPS sensor and CR 233 controller). This equipment utilises the American Department of Defence navigational satellites. These are 24 NAVSTAR satellites, which orbit the earth at an altitude of 10,900 nautical miles, constantly transmitting radio signals. Triangulation from these satellites is the basis of the system. To triangulate, GPS measures distance using the travel time of a radio message. Readings from a minimum of four satellites are required to give a position. Depending on the type of equipment used, the position given can be accurate to within, say 50-100m (*navigation solution*), this is the type of solution given by hand held equipment for walkers. Working in differential mode, as described below, allows measurements to be taken on a feature centimetres apart.

2.2 Differential GPS survey

Differential GPS equipment is required for precise land survey. Two sets of equipment are used. One GPS receiver (the *reference* station) is set up over a point with known GPS coordinates (WGS 84). This records radio signals transmitted from the satellites throughout a survey session. On East Exmoor, two permanent reference stations have been established, both in secure sites owned by the ENPA. The second set of equipment (the *rover*) is taken to the survey area, which can be up to 10km from the reference station. The rover is set up for a specified amount of time to *initialise*, then the operator is free to walk where he chooses to record either fixed survey points, or the archaeological detail (see Fig. 3). A set of data thus recorded is known as a *kinematic chain* (see Fig. 4). OS triangulation pillars or other co-ordinated points also need to be incorporated into the survey data set if the survey is to be related to the OS National Grid.

The survey data is processed using Leica's SKI GPS processing software. The data collected from the rover is processed in relation to the reference station, a known, fixed point. The survey data is now in the form of WGS84 co-ordinates, expressed as either latitude/longitude or Cartesian co-ordinates (see Fig. 4). A further transformation program allows the conversion of this data to the OS National Grid (OSGB36). The resulting ASCII file is then processed using Trimmap integrated survey-processing software, to resolve feature codes, and plotted or further enhanced in AutoCAD and CorelDraw.

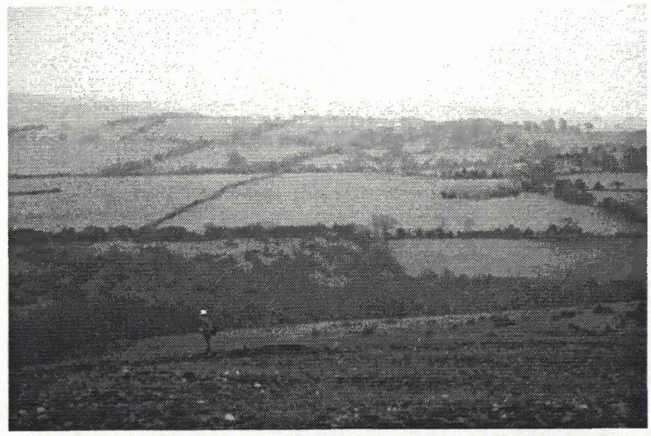

Figure 3. GPS survey on Exmoor

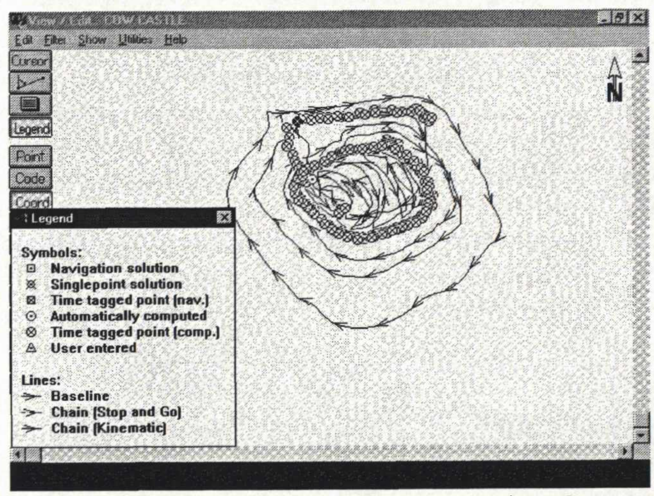

Figure 4. Cow Castle: kinematic survey points shown in Leica's SKI GPS processing software

2.3 Advantages and problems of GPS survey

This method of working has several advantages over traditional EDM survey. The most obvious is that it allows the operator to walk wherever he needs, there is no longer any need for intervisibility between survey stations. A team of two people can thus concentrate on finding and recording the archaeological features. A second major advance is that the co-ordinates obtained are absolute, there is no need for laborious traversing to obtain OS control. This is particularly beneficial in upland areas, where OS map detail is sparse. GPS thus allows sites and landscapes to be tackled in a way that was hitherto prohibitive in terms of fieldwork time. The whole of the archaeological landscape including, for example, extensive areas of extractive industrial remains, can be recorded in some detail. The continuous recording of 3-D kinematic points facilitates the production of DTMs and contour plans, either of individual sites or detailed topographic features.

GPS receivers will not function properly close to trees or buildings, where the satellite constellation is blocked. The kinematic technique has proved to be particularly suited to areas with unrestricted, open horizons, such as moorlands and inter-tidal or coastal landscapes (Riley 1995). The reference station must be in a secure position, as it will be left unattended for the duration of the survey session.

3 Archaeological sites and landscapes

3.1 Introduction

One of the key aims of the RCHME's Exmoor archaeological survey project is to provide a record of Exmoor's archaeology at 1:2500 scale. Within the project there is scope for the larger scale survey of discrete sites or areas of particular regional or national importance. The project also allows the archaeology of Exmoor to be considered in a wider, landscape-based context. The use of GPS technology has aided all types of survey work undertaken within the project.

3.2 Large scale survey of archaeological sites using GPS

A large-scale survey of the univallate hillfort known as Cow Castle was undertaken early in 1997, at the request of the ENPA. The survey was part funded by the ENPA within their Monument Management Scheme, which is itself jointly funded with English Heritage. The site also comes under the remit of the RCHME's Exmoor archaeological survey project. Cow Castle lies on an isolated, conical hill in the Barle Valley (see Fig. 2). The aim of the survey was to record the earthworks in detail, and to produce information to aid the management, presentation and interpretation of the site, which is close to a popular riverside footpath.

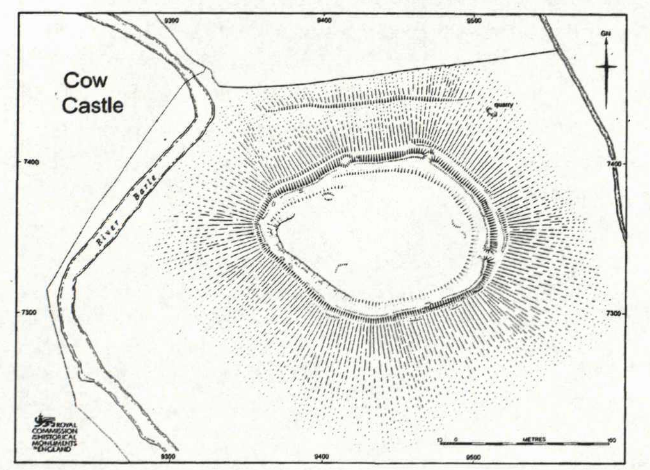

Figure 5. Cow Castle: 1:1000 earthwork survey, RCHME, 1997

The site was surveyed entirely by GPS equipment. An established reference station *c* 6 km from Cow Castle was used. The first stage of the survey was to record the earthworks in detail (see Fig. 5). The position of footpaths, areas of damage and erosion were also surveyed, and the positions of two survey pegs were determined. The second stage was to record enough data to produce a contour plan and DTM of the whole of the hill (see Figs. 6 & 7). This was achieved by walking over the interior of the site, collecting data at a 10 second time interval, on a 10m grid. The hill itself was surveyed by walking a spiral route down and around the hill (see Fig 4). Approximately 2000 points were collected and the fieldwork took two days.

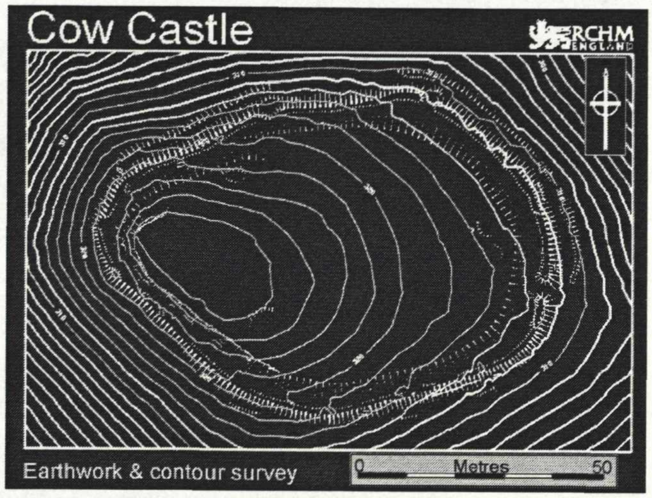

Figure 6. Cow Castle: contour plan

GPS survey is a time effective way of surveying earthwork sites at large scale, particularly if, like Cow Castle, the site is remote. The resolution is accurate enough to take points centimetres apart. The survey of the archaeological detail provides a base for the work required to produce a contour map and DTM (see Figs. 6 & 7). The contour map is particularly effective when the earthworks of the hillfort are superimposed on it (see Fig. 6; earthworks shown on CD-ROM version). The DTM can be observed from different viewpoints, and has proved to be an important tool in the interpretation and visualisation of the site. The CD-ROM version of Figure 7 contains a selection of viewpoints of the DTM. Those from the northwest and east are viewed from a higher altitude, giving an aerial perspective. That from the south has an exaggerated vertical scale and shows the position of the hillfort on the hill in profile. The view from the southwest shows the way the interior of the site falls to the east in a series of terraces which have been utilised for prehistoric habitation sites (Fig. 7).

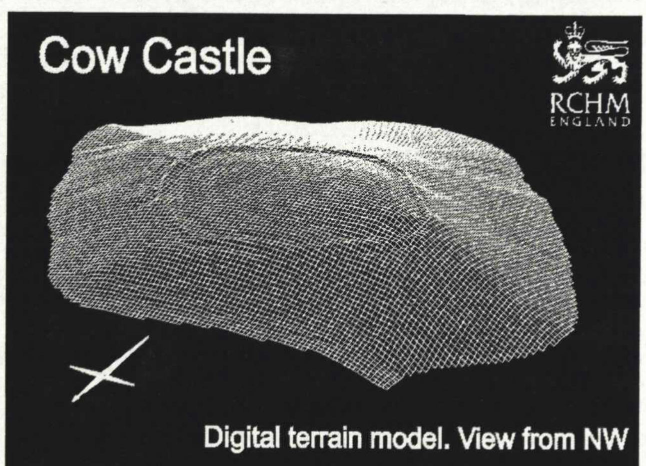

Figure 7. Cow Castle: digital terrain model

This method of digital survey is also an efficient way of dealing with the preparation of drawings for reports. The data is managed in AutoCAD. A number of layers are set up, enabling the production of overlays for the main earthwork drawing, showing the areas of erosion and footpaths, and contours, which are used for the ENPA's ongoing management initiative (Riley 1997).

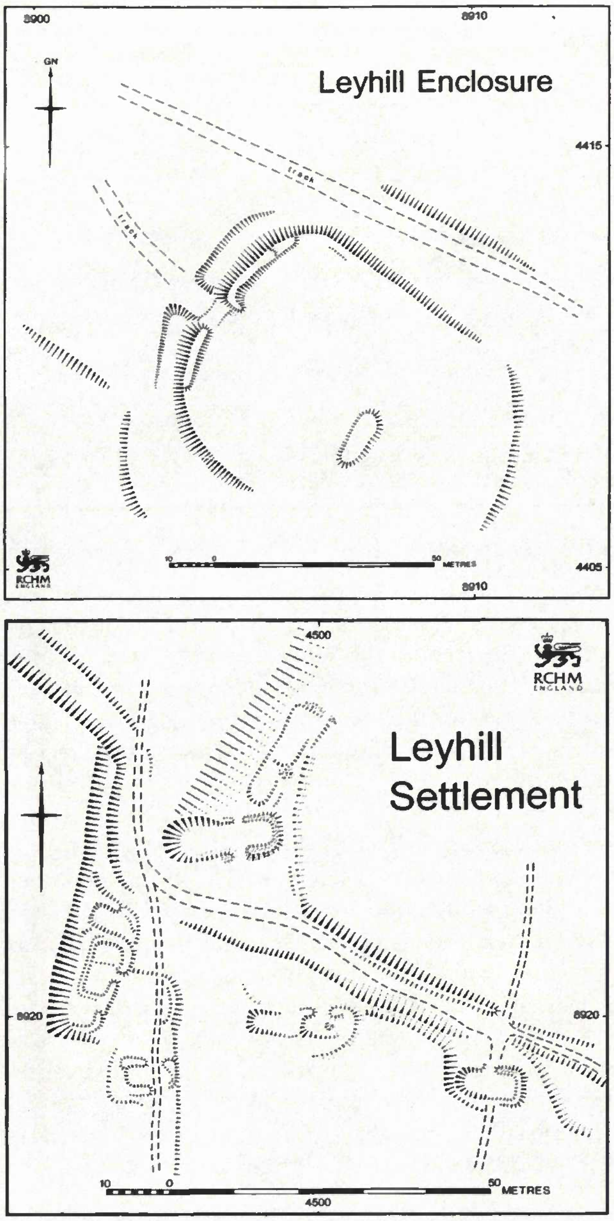

Figure 8. Ley Hill: prehistoric enclosure and deserted medieval field system, 1:500 earthwork plans, RCHME, 1997

3.3 A landscape based approach

At the beginning of the project, the area was divided into two, West Exmoor and East Exmoor. GPS has been available since the start of the East Exmoor area. This has allowed the recording of all the archaeological features on the unenclosed parts of East Exmoor digitally. So far some 50kms^2 have been surveyed in this way, including the block of land surrounding Dunkery Beacon, the highest point on Exmoor. The data is again managed on AutoCAD, in a series of simple layers that relate to the date of the archaeological features. The descriptions of these features are contained in MONARCH at the National Monuments Record Centre; RCHME's text based record.

The margins of the unenclosed land have proved to be some of the most fruitful areas for the discovery of previously unrecorded sites. One such area is on Ley Hill, above Horner Wood (see Fig. 1). The National Trust commissioned a survey of Horner Wood as part of a management plan, and two important earthwork sites were discovered (McDonnell 1994). These sites are an Iron Age enclosure and a deserted medieval settlement. Both sites are located on the edge of woodland and unenclosed moorland. Because of this, locating the sites on the National Grid and surveying the detail is both difficult and time consuming using traditional survey methods. There is very little local OS control, and the nearest OS triangulation pillar is over 3km away, across very difficult terrain.

GPS was used to locate survey pegs on the edge of the prehistoric enclosure, where a clearing in the wood allowed a reasonable array of satellites. The enclosure was then surveyed using an EDM, and the plot was transformed to the National Grid using a conventional program in the Trimmap software. A detailed earthwork plan of the settlement site was then produced (see Fig. 8). The medieval settlement was more complex. Seven buildings survive on the woodland edge, and an associated field system lies both on open, unenclosed land and within the wood itself (see Fig. 9). The settlement was located and surveyed in a similar manner to the enclosure, with survey pegs fixed by GPS, and detail recorded by an EDM to produce a large scale plan of the earthworks (see Fig. 8). The field system was recorded using GPS on open ground. In the wood, the field system was surveyed by traversing with the EDM and pegs were left on the edge of the wood. The pegs were located with GPS in order to relate this survey to the National Grid. This method of working again proved very time efficient. This was particularly important, as there was only a short time window available for survey when both the bracken on the open moorland had died back and the broad-leaved trees had shed their leaves. This survey located two previously unrecorded sites to the National Grid, and enabled them to be placed in their landscape context for the first time (see Fig. 10) (Wilson-North 1997).

Figure 9. Ley Hill: EDM survey of deserted medieval settlement

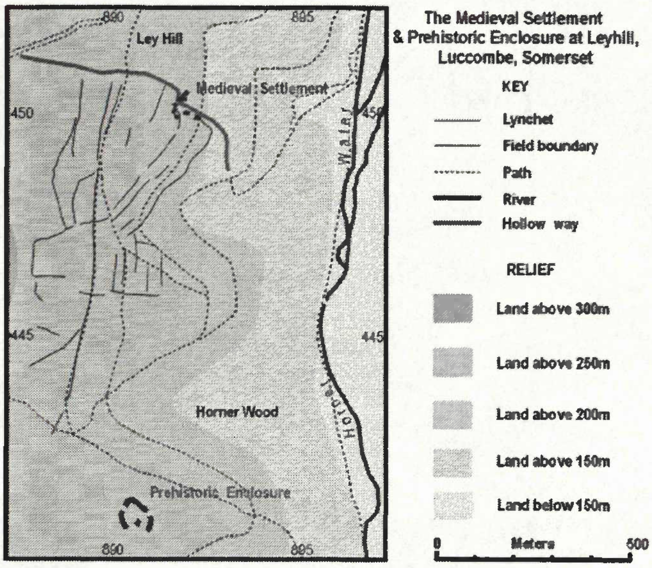

Figure 10. Ley Hill: archaeological landscape

4 The future

The ENPA have a GIS that is used throughout the Authority. MapInfo V4.1 and the Planning System, PACs, are both used. The OS data comprises Landline, OSCAR, 1: 10000 Raster and Address Point. The ENPA have about 200 layers of data on this system, including aerial photographs for the whole of the National Park, taken in 1995, which have been scanned and rectified. Historic maps are currently being input to the system. The RCHME's digital survey data will provide a further layer of information. Digital survey information has been incorporated for two pilot areas from the RCHME survey project. The ability to look at the survey data in conjunction with the aerial photographs aids fieldwork preparation, survey, interpretation and presentation of the survey work. The GIS will be an essential tool in the preparation of the publication of the results of the Exmoor project as a synthetic and interpretative report.

A DTM for the Exmoor National Park is currently being purchased, and the superimposition of 3-D survey data, such as that from Cow Castle, over the DTM, then draped with an aerial photographic image, is planned.

A further site for the raw survey data may be on the Internet, where users could download and manipulate the 3-D co-ordinates for the Cow Castle site in their own Virtual Reality programs.

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Archive arrangements

Site accounts and plans produced for the project area completed to date are available for public consultation through the archive of the RCHME, at the National Monuments Record Centre, Kemble Drive, Swindon.

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