

## AutoCAD — 'The Beast of Bolsover' (a sequel to 'Into Battle with AutoCAD')

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### 34.1. Introduction

This paper draws upon the work that the Central Archaeology Service (CAS) carried out on two English Heritage sites, Battle Abbey and Bolsover Castle, during the summer of 1992. The two six-week projects, whilst both involving building recording using AutoCAD and photogrammetric digitally generated data, were set up for totally disparate reasons. At Battle the archaeological work, including two planned seasons of excavation, is part of an integrated project which will see the currently roofless Courthouse brought into active use again. The Bolsover Castle project was to enable a specification to be drawn up to complete the recording of the standing walls as part of a programme of consolidation to the Terrace Range. For both projects raw digital photogrammetric data was supplied to an on-site CAD station, verified by hand, digitised on site, and re-plotted. In both cases, most of the base data was collected by the use of photogrammetry, and then imported into AutoCAD format for verification and further enhancement. The methodology relied on the production of digital elevations from the plotting of the metric photographs which were taken as part of the photogrammetric process. This methodology was varied at Bolsover Castle in order to provide control data.

The final part of the paper will try to indicate some of the pitfalls encountered, and to suggest some solutions to these problems. Areas where developments are necessary and worthwhile will be indicated.

### 34.2. Battle Abbey

The first site selected in this paper to demonstrate the AutoCAD and photogrammetric methodology is the Courthouse Building adjacent to the Gatehouse at Battle Abbey. The project is to explore the development of the building, both above and below ground. The building will then be refurbished and brought back into use by English Heritage's Historic Properties Group as the ticket office and entrance to the site. The work in 1992 consisted of the verification and enhancement of the digital data that was captured by photogrammetry for all the elevations of the building. This work will be followed up by excavation within the building in 1993, and within the demolished monastic southern range in 1994. The integration of the digital building recording archive within the data recovered from the excavation of the deposits is described below.

The work at Battle Abbey is part of an integrated process, which will have an end result of bringing back the building into a roofed state with as much of the historic fabric and integrity of the building retained. The building as currently seen is a hybrid which contains elements from sev-

eral phases of monastic life, followed by post-Dissolution use as the Town Courthouse. The original function of the building was the monastic almonry, and it was a twin-ranged building. The northern range is represented by the current Courthouse, and the second range, now demolished, lies to the south. It is likely that the first masonry monastic building was constructed in the 12th century, and that it was much modified during its monastic life. It survived through to the late 18th century as the Courthouse, when the roof collapsed and it then became ruinous.

### 34.3. Bolsover Castle

The second site selected in this paper is the Terrace Range at Bolsover Castle, which was set up as a project to try to obtain some facts and figures relating to the time taken to enhance digital photogrammetric data, prior to commissioning further extensive recording work on the building prior to consolidation.

### 34.4. Software and hardware selection

The hardware and software selected for use on site was:

- 25MHz 80386 and maths co-processor
- 4Mb RAM
- 120Mb hard disk
- 14" VGA colour monitor
- AutoCAD version 10

The reason for this choice of equipment and software was basically expediency, as the hardware was already available, an AutoCAD version 10 licence existed, and the operators were familiar with the use of AutoCAD. It should be remembered that when the projects were being planned AutoCAD version 12 was not yet released, and problems had been experienced with version 11, including under-performance to the specification.

### 34.5. Methodology

The methodology involved the generation of unverified colour plots in A3 format on the plotter, and the use of an A3 permatrace overlay to permit the necessary changes and additional information to be recorded on site. The A3 format was chosen because it was the best compromise of a reasonable area of wall to be recorded, 5m. x 5m. at a scale of 1:20, and sufficient safety precautions, given that the staff had to work on scaffolding platforms up to 25m. above ground level. After the corrections to the basic photogrammetric plot were noted, additional information, such as stone typology, stone decay and architectural features, were noted on the permatrace overlay. The information on the permatrace overlay was then digitised on site and the record

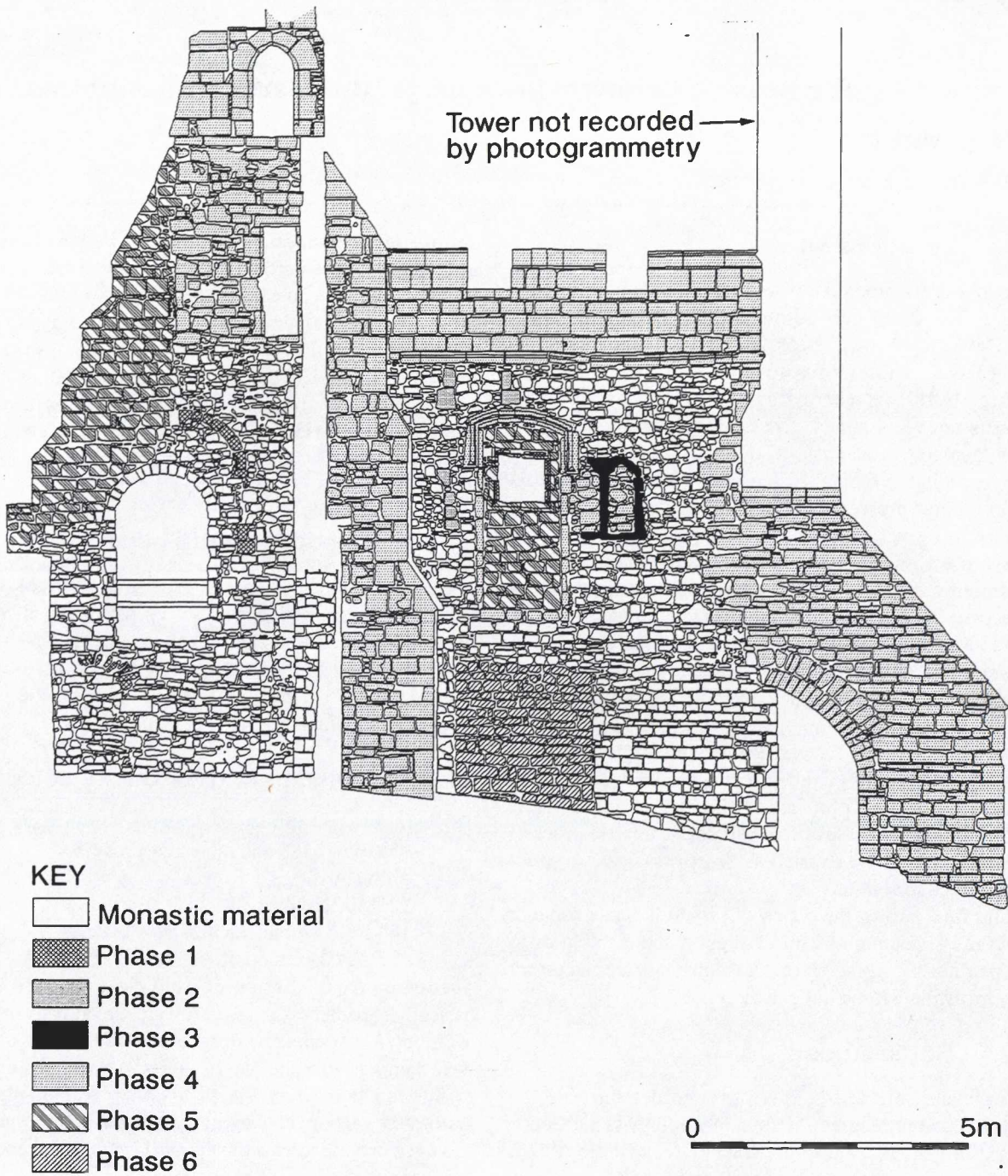


Figure 34.1: Battle Abbey: a typical photogrammetric plot with manual enhancements.

was updated and enhanced by using AutoCAD's layering system. In the post-fieldwork stages this enhancement of the information was taken further by the identification of the various architectural units and phases of construction. A typical plot is shown in Fig. 34.1.

### 34.5.1. Time and motion study

The project at Bolsover Castle was designed to try to indicate the optimum scale that gives the best compromise between speed and the need for detail. In addition to this component, the recorders undertook a time-and-motion study to determine the average time taken for each scale

used, and thus to estimate the time necessary to complete the planned recording. The following operations were timed:

- generation of the plot
- verification and enhancement of the plot
- digitisation of the overlay

The following details were recorded:

- weather conditions
- percentage of added detail
- verification
- recorder

The scales used for plotting were 1:10, 1:20 and 1:50, and selected areas were recorded at all the scales to enable com-

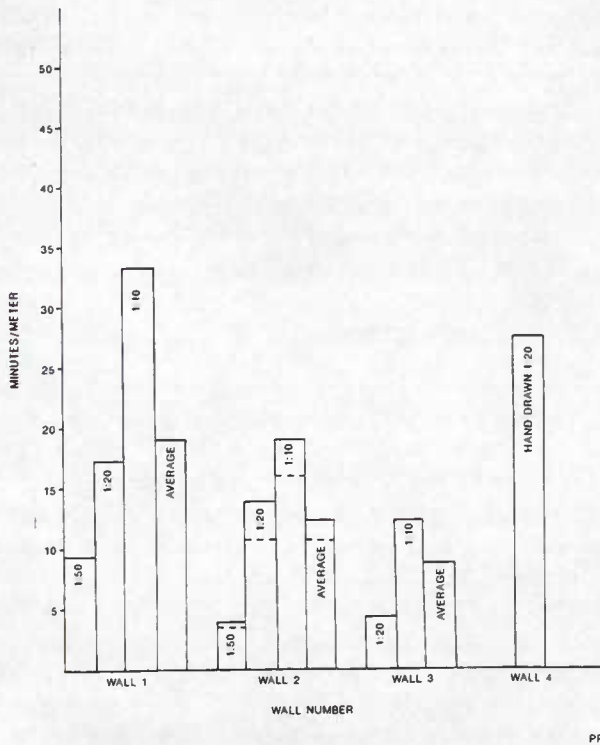


Figure 34.2: Bar chart showing the times necessary for each of the scales, and the average (all in minutes/m<sup>2</sup>) for each of the walls surveyed.

parisons to be made. In addition to the digitally generated data, some areas were recorded totally by hand and then digitised to provide a base level against which the digital recording could be measured. A final area was recorded using EDM, with the data downloaded into AutoCAD. Unfortunately, inclement weather prevented the complete recording of the area by hand for this comparison.

The five recorders had a wide range of experience of building recording and the use of computers and CAD. These factors were also included in the calculations when analysing the data. To attempt to see what the learning curve is on a project like this, the recorders in the later phases of the project went back and re-recorded areas which they had recorded in the earlier phases of the project.

### 34.5.2. Access

By far the majority of the work was carried out from a fixed scaffold, but two other forms of access were also chosen for comparative purposes. These were an alloy access tower, and a self-powered hydraulic access platform. Both have their positive and negative aspects, but it is considered that the use of a fixed scaffold is the most efficient when all factors are taken into account.

### 34.5.3. Analysis of results

Unfortunately there is not space in this paper to discuss all the factors which have emerged from the data collection, but a few points will be mentioned. There is a wide variation in the amount of manual enhancement necessary after

the photogrammetric plot has been produced. Some areas require only *c.* 10% enhancement. Other areas, such as the base of the internal walls, where encrustations are so prevalent that the photogrammetry is almost useless, require *c.* 90% of the detail to be added by hand. It might be thought that the amount of time required would have increased by a factor of 9, but it is likely to be more than this because of the difficulty of actually seeing the outline of the stones through the encrustations. Such variations in recording time have occurred frequently at Bolsover Castle, where chemical attack by airborne pollutants from nearby coal fields and heavy industry has been going on for 150 years.

Fig. 34.2 is a bar chart which shows the times necessary for each of the scales, and the average (all in minutes/m<sup>2</sup>) for each of the walls surveyed. These values were obtained by adding up the time periods taken to enhance the data for each wall, and then dividing by the area surveyed. Thus whatever the variations necessary in the degree of enhancement, these will be taken into account in the averaging process. This exercise seems to confirm that the choice of scale 1:20 (as used for the majority of the work) is the best compromise. The broken line within the bars for wall 2 represents the improvement in times achieved when the wall was surveyed for a second time, indicative of the learning curves of the recorders.

Figs. 34.3 and 34.4 show the average digitising and finishing times in hours/m<sup>2</sup> for different degrees of added detail for 1:20 scale plots on walls 1-3. Finally, Fig. 5 shows spread statistics for individual recorder performance in minutes/m<sup>2</sup> at different scales, with personal averages and team averages for comparison.

## 34.6. Problems

The first problem that was encountered was the combined effects of the hardware and software chosen and the large size of the digitally generated photogrammetric data files.

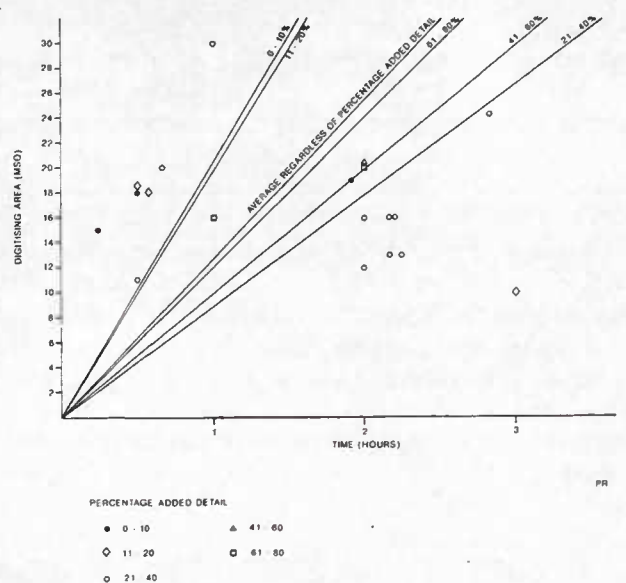


Figure 34.3: Average digitising times in hours/m<sup>2</sup> for different degrees of added detail for 1:20 scale plots on walls 1-3.

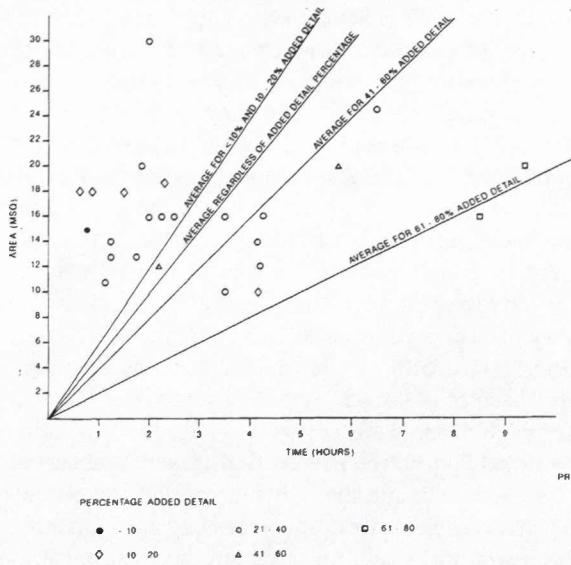


Figure 34.4: Average finishing times in hours/m<sup>2</sup> for different degrees of added detail for 1:20 scale plots on walls 1-3.

The solution would have been to purchase more powerful hardware, together with version 12 of AutoCAD, available in the summer of 1992, but at the time the necessary financial resources were not available, and the project had to be continued with the original hardware and software specified above.

For the 1993 Battle Abbey project resources have become available for the following hardware and software:

- 66MHz 80486 and maths co-processor
- 16Mb RAM
- 1Gb hard disk
- 17" VGA colour monitor
- AutoCAD version 12

With the purchase of this equipment the problems associated with the size of the files has largely disappeared. However, the temporary problem with large files has highlighted another problem — that, despite the data being in digital form, the end product is still seen as being the traditional architectural elevation for use as a hard copy, rather than within a CAD environment. This could be avoided by making sure that the initial specification for the photogrammetric work states that all the different planes within an elevation must be produced as individual drawings.

Another similar problem which is brought into focus by the use of the modelling capabilities of CAD packages is the need to relate in three dimensions all the elevations of a building. In the past each face of the building has been treated as a separate item, with its own randomly-imposed local grid. Using this system the only common factor is usually height above OD, and a separate survey is necessary to relate one wall face to another. Again the answer lies in the need to specify, at the outset, that the data is intended for three dimensional modelling, and a common grid should be established at the beginning to which all survey stations can be related.

### 34.6.1. Integration of excavation records

There are plans at Battle Abbey to link the AutoCAD building record to the excavated deposits and features. An EDM is to be used to record in three dimensions the interfaces and upper profiles of all the layers. To achieve this the Digital Ground Modelling (DGM) package is to be used in conjunction with AutoCAD. This will enable a comparison to be made between a total digital record of an archaeological site, including standing buildings, and the traditional manual methods of building and site recording.

### 34.7. Conclusion

Looking objectively at the processes involved in the stages of capturing an accurate digital survey database, it is suggested that the beginning and end processes are now correct, but that the middle processes need further research and development. Few workers would suggest that the primary capture of the data should not be by metric survey methods, and similarly few (though perhaps more) would question the creation of a digital survey database resident within a CAD environment. The "filling of the sandwich", however, is currently divided into three repetitive stages all concerned with the same process:

- transference of the photographically captured data into digital data
- the necessary verification of that data
- re-integration of the verified data with the original data.

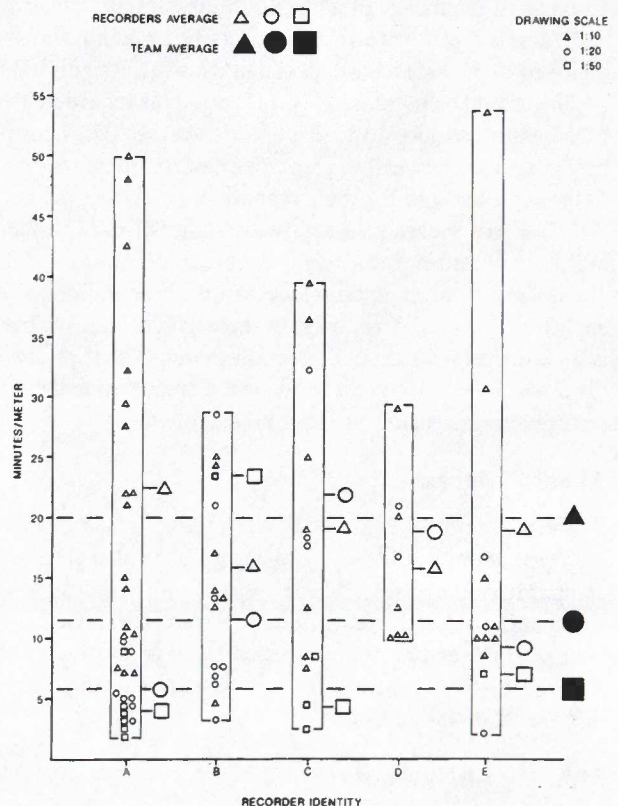


Figure 34.5: Spread statistics for individual recorder performance in minutes/m<sup>2</sup> at different scales, with personal averages and team averages for comparison.

While developments in hardware and software, such as GridPad and reflectorless EDM, will continue to refine the already impressive capabilities of CAD building recording, perhaps there will be no further revolutionary developments here. The real breakthrough must come in the direct digital capture of the primary data (the "filling of the sandwich" mentioned above), replacing the current repetitive manual transcription of images into a digital format.

#### **Acknowledgements**

While English Heritage projects are the subject of this paper, the views expressed are those of the author, and should in no way be taken to be English Heritage's official views.

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