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Computers and the evolution of archaeological organisations

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13.1. Introduction

When looking at strategic management for an organisation one of the crucial stages in formulating decisions is the recognition of change factors in the external environment and the impact that these may have: impact on the organisation's goals, on organisational practice, and importantly on the organisation's structures and staff roles. Technological change and development has become an increasingly important player on the strategic management stage in the past decade, with computer technology at the forefront (e.g. Andrews 1991).

The purpose of this paper is to investigate the relationship between archaeological organisations and computer technology from a management perspective. What effect does the introduction, maintenance and continued development of computer systems have on archaeological organisations and, as importantly, what effect do those organisations have on the introduction and usage of computer technology? This latter point is, we believe, of crucial importance to our discipline. It can be argued that the nature and form of organisations, the prevalent organisational culture, and the organisational environment will influence the nature of computer technology employed, and ultimately its success. The last point is based around a school of thought in management circles termed contingency theory, which sees organisational design and structure influenced by organisational environment (e.g. Lawrence and Lorsch 1967). However, discussions of computer applications in archaeology mostly concentrate around standards, specific applications or particular philosophies, and where reference is made to organisations they are frequently given as a sterile background rather than as a fundamental factor in the applications (e.g. Carver 1985, Reilly 1985, Reilly and Rahtz 1992, Richards 1985).

For many management theorists, technology has a crucial influence on organisational design, and is one of the most important factors to be taken into account in the structuring and effective management of an organisation (see, for example, Butler 1986, pp. 42–64, Quinn 1991, Mintzberg 1991). Similarly from a strategic management perspective, technology and technological change are important factors in the assessment of organisational change (e.g. Johnson and Scholes 1989). It is argued elsewhere that archaeologists need to become more familiar with management theory (Cooper 1993) but the general lesson to be drawn from the relevant management literature is that technological change is likely to influence archaeological organisations and their structures, and the roles of archaeological professionals, very widely. Therefore, although the decision to introduce or to develop computer technology may seem relatively simple, the reality is that its impact is likely to be far-reaching.

Given the above, this paper has been designed to explore computers and archaeology very much from an organisational perspective. It is based on the experience of using computers in the Archaeological Service of Hereford and Worcester County Council over the past five years, during which time the service has moved from word processing, using four low-powered computers, to the intensive use of 12 machines with software as diverse as computer-aided design, GIS applications, desk-top publishing, databases and project management software. Although part of a much larger organisation (the County Council), the Archaeological Service is generally able to operate autonomously on a day-to-day basis, and thus has the perspective of a much smaller unit.

13.2. The County Archaeological Service

The County Archaeological Service comprises two wings. The advisory (curatorial) side, with four permanent members of staff, holds the county Sites and Monuments Record (SMR), monitors planning applications, and gives advice to the County Council, nine district councils, and a multitude of developers, landowners and other organisations and individuals. The field (contracting) wing presently comprises twenty fixed term contract staff who undertake a range of archaeological fieldwork including rescue excavation, landscape survey, building recording, and site evaluation. It also offers services including illustration and design, environmental analysis, and finds analysis. Funding for the field wing is derived entirely from external sources and turnover comprised *c.* £400,000 in 1992/93. While the curator-contractor split is achieved through the use of a "Chinese wall", there is inevitably a cross-over between the two wings in the area of computer technology where compatibility between and a common understanding of hardware, software and data are essential to ensure rapid information transfer between the two sides.

13.3. Computer development at the Service

The main development of the Service's computer systems has taken place over the past five years. Prior to 1988 computer usage was limited to word processing, which was mostly done by specialist typists.

In 1988 the Service commenced a large-scale urban excavation in central Worcester — the Deansway Archaeology Project. This led to a significant increase in the

funding of the Service at a time of rapidly falling hardware and software prices and increased availability of more sophisticated computer systems.

These two factors led to the rapid introduction and development of a CAD-based system for storage and manipulation of the site drawings (*e.g.* Templeton 1990), and a database system for storage of various other site-related data (Huggett 1989a, 1989b). At the same time, given the deliberately high-profile nature of the excavations, a desktop publishing package was used to provide information sheets, captions for on-site displays, and other publicity material.

Overlapping with this project, the English Heritage-funded Herefordshire Valleys Survey — a survey of the alluvium covered river gravels in Herefordshire — took the opportunity to explore the development and use of linked CAD and database software to store, manipulate and display SMR and survey data. While the system used was by no means a GIS, the linking of CAD and a database allowed the plotting of site distributions in a relatively painless way. It has also guided the path which the Service has followed towards a full-scale GIS implementation, this development taking place in association with the commercial sector. The Herefordshire Valleys Survey also used ground-modelling software to demonstrate the potential for the visualisation of buried landscapes on the basis of borehole information. The application included the display of the results of phosphate and magnetic susceptibility analysis, which could be compared visually (Dinn and Roseff 1992).

The Service is currently undertaking two major survey projects. The first of these, the Marches Uplands Survey, concentrates on the upland areas of the Central Marches bordering on Wales. The second focuses on the urban areas of Herefordshire, Worcestershire and Shropshire. Both projects are being run in collaboration with Shropshire County Council and the Royal Commission on the Historical Monuments of England and funded by English Heritage. The Central Marches Historic Towns Survey is seen as a pilot study for other extensive urban surveys in England (English Heritage 1992, p. 8). Both projects involve the assimilation of large quantities of map data, and the combination of archaeological records from two Sites and Monuments Records with data from other published and unpublished sources. Efficient computer systems for handling this data are essential, and the two projects are collaborating in the implementation of a geographical information system (Arc/CAD, based on AutoCAD and Arc/INFO) to store and manipulate data and to present information. This development will in turn influence the eventual nature of the County Sites and Monuments Record.

The other main area of software usage has been that of the administration of the Service, with packages including Superproject, SuperCalc, and inevitably the use of a word-processing package (currently WordStar 7).

13.4. Characterising the Service's internal environment

It is clear both from management literature and from our own direct experience that the introduction and development of computer systems within an organisation will be strongly influenced by the nature of the organisation's internal environment. We should make it clear that we are *not* referring here to the function of archaeological organisations, but to the organisational structures employed, and perhaps most significantly to the prevalent "culture" of the organisation.

The structure and culture of an archaeological organisation such as ours is likely to develop in reaction to a variety of factors in play in its external environment, and while we would not argue that our organisation is representative it seems likely that these same factors will affect other archaeological organisations to a greater or lesser degree.

13.4.1. Projects and project funding

Perhaps one of the most significant external factors is that of archaeological projects and "project funding" for the majority of archaeological fieldwork undertaken in Britain. This leads to many organisations being partially or totally dependent upon external income for their work, and also to the creation of project teams working on tightly controlled programmes of work, over defined spans of time. For the organisation as a whole, development can be seen to be driven through the combination of a series of discrete projects.

13.4.2. Fixed-term contracts

A recent survey by the Institute of Field Archaeologists (Bell *et al.* 1993) indicated that a high percentage of its members were employed on short fixed-term contracts. Clearly this reflects the nature of project funding, but it is an important contributing factor towards the culture of the archaeological organisation, and will have a direct impact both upon training and upon the development and maintenance of expertise.

13.4.3. Motivation and culture

The internal culture of many archaeological organisations is strongly affected by the nature of the staff themselves. In the case of archaeological organisations many professionals can be characterised as well qualified, dedicated, flexible, innovative and highly motivated — this, despite a background of relatively poor remuneration, restricted career opportunity, and in many cases job insecurity.

13.4.4. Matrix structures and team-based organisation

Resulting from the above three factors, archaeological field organisations are increasingly altering their structures from simple hierarchical organisations to those more akin to matrix structures (Kolodny 1981). The latter comprise "teams" built on the basis of expertise, which may come together for specific long-term activities such as projects, intermittent activities such as working parties on recording methodologies, or even for "one-offs".

This combination of factors, reflecting projects, employment constraints, motivation, culture and structures, leads to a recognisable internal culture described in management terms as an "Athena Culture" (Handy 1985), char-

acterised by highly motivated staff forming non-hierarchical teams resting on an expert power authority system, and we believe that such a prevalent organisational culture will have strong implications for introduction and development of computer systems.

13.5. Computers and their impact

Having identified the above significant factors in relation to the archaeological internal environment it is proposed in this section to describe a series of phenomena experienced in the Service which have either led to organisational problems or have highlighted existing organisational problems. The following section will then turn to some suggested general approaches and solutions to the identified problems.

13.5.1. Staff and computer technology

Our experience is that there is a great enthusiasm amongst staff to be involved in new archaeological developments especially in relation to computer technology. There is little doubt that the development and implementation of computer hardware and software to support archaeological research is an important contributor to motivation of staff, and we would go as far as to say that in a time of rapid technological change the failure to adopt new systems will have a far-reaching impact on the organisation, with the potential for staff to become disillusioned. The potential conflict between the desire to remain innovative and financial constraints is one possible stress factor that needs to be recognised.

13.5.2. Osmosis of computer applications between projects

The link between organisational environments and the introduction of computer systems was evident in the case of the Deansway Project, and in the subsequent projects carried out by the Service. Projects often provide the stimulus and the resources for rapid development of computer systems, but while the project funding has allowed the rapid development of software, hardware and expertise on specific projects, it has to a great extent been funded by and limited to these projects alone, while the rest of the Service looked on.

While the enthusiasm of staff for technological advancement is in many respects a strength for an organisation, it can also cause problems within the organisation where unplanned osmosis of applications takes place. Where a particular computer package or computer-based approach was specifically and deliberately introduced onto some projects run by the Service, its wider applicability was quickly recognised by other staff who expressed strong desires to apply it to their own work, even where this was unplanned and unresourced. This desire may also be compounded by certain project staff feeling "left out" of computer developments. This phenomenon often leads to informal arrangements being made between staff to train others, and this in turn may lead to increased pressure to widen the use of an application.

13.5.3. Expertise and roles

The initial introduction on the Deansway project was achieved with the aid of a full-time computer post, held by Jeremy Huggett. His roles and responsibilities included implementation of packages, writing of user-friendly front-ends to, for example, AutoCAD, and (especially important) the training of staff and trouble-shooting. However, once the fieldwork element of the project was nearing completion and the software and hardware configurations were being used effectively by the project, the nature of project funding led to the computer post being lost. Responsibility for continued usage of the systems and for development was spread between the remaining members of the project team and in a more general way to other staff.

This highlights the problem of driving the development of computer systems through a project-based structure. The effect of this is that one project (and one group of staff) leaps ahead of others, and the potential exists to effectively marginalise the other projects. Avoiding this problem, through allowing the application to spread, will have a significant impact on resourcing. However, if the location of relevant expertise is tied to the original project, the danger of losing the accumulated user experience at the end of a project is always present.

13.5.4. Career paths and training

As noted above, the introduction of new software and hardware is likely either through choice or through osmosis to influence other members of the organisation. These may feel that they are being marginalised from new developments, or may find their own areas of responsibility or skills under threat from a previously unrecognised direction. All staff within the Service are increasingly expected to use computers as part of their work, but the degrees of training given, and the degrees of access to the more sophisticated software packages, are very uneven.

Probably the most clear example of this in the organisation at Hereford and Worcester is the use of computer aided design packages and the role of illustrators. On the Deansway project, while the design and implementation of the system was the task of the project's computer officer, usage of the system fell to other team members and specifically to the project illustrator, the reason being that its main role was to help in the rapid production of site plans. The use of CAD was then successfully transferred to other projects such as the Herefordshire Valleys, Marches Uplands and Central Marches Urban surveys. Over the past five years, there has been a noticeable trend towards the illustrators becoming the resident experts on the CAD system, including modification of the front-end. The implication is now that the Service illustrators must be capable computer users, with skills in CAD in particular, although the use of desk-top publishing has also necessitated this movement. This shift has been gradual, and one could argue almost subversive, in that it is not possible to identify one corporate decision where this was formally recognised and the implications fully thought through. However it would be possible to argue with hindsight that the proposed path was implied from the very first CAD purchasing decision.

The result of one project's decision has not only affected the organisational direction, with consequent resourcing implications, but has radically altered the nature of archaeological illustration as practised in the Service. Given the nature of computer usage and EC guidelines on computer usage, it is necessary to spread the computer usage amongst the three illustrators employed by the service and it is not possible therefore to limit the impact of this change to one specialist illustrator.

13.5.5. Public relations "value"

The nature of archaeologists, in terms of their openness to new developments and their overall commitment, often leads to great emphasis being placed on computer technology as a tool of public relations and marketing (Cooper and Mundy 1991). Whether through the production of high-quality reports and displays, or the more complex systems such as GIS, there is no doubt that the usage of computers can help promote archaeology to other professionals as a serious discipline. The Archaeological Service has for example taken development plans on disk and returned information on depth of archaeological deposits in the same form. The advantages of this type of work are often difficult to calculate, but are certainly significant. However, the danger always exists that we will overstretch our internal abilities on the basis of guarantees from the companies providing the software and hardware. Ultimately the lesson is that rarely can a system be introduced in the time suggested by computer suppliers, rarely will the system be without bugs and development problems, and on at least some occasions the system will not do what the suppliers say it will. At the other end of the scale is the possibility that the system will fail entirely — one has only to look at the recent horror stories emerging from at least two health authorities to recognise the very real possibility of this occurring. While the pressures exist therefore to implement new complex systems in archaeology, the need for resident expertise, support and flexibility in resourcing to overcome unforeseen difficulties is very important and has to be recognised both by the employing organisation and by the sponsor — especially where this is an organisation such as English Heritage. The temptation to overplay the computer system and underplay the problems of its implementation during negotiation for a project is great and must be avoided.

13.6. Implications and observations

Going on from the above, it is possible to make a series of observations regarding our experiences on the relationship between computers and our archaeological organisation which may be of wider relevance:

13.6.1. Understand the implications of the external environment on the organisational internal environment

Decisions made with regard to computer technology must make full reference to the external environment in which the organisation rests. While each archaeological organisation will face a different environment, common themes may include unpredictable levels of external funding, the requirements and wishes of external organisations including funding bodies, relatively small staff numbers, short fixed-term contracts and staff turnover, and relatively low levels of remuneration. Each of these may lead to problems in ensuring a corporate strategy in relation to computers, and indeed may limit the expertise available to implement and run computer systems.

13.6.2. Technology is a crucial consideration in the strategy process

The lesson to be drawn here is that the decision anywhere in the organisation to implement new software or hardware, or indeed to put existing systems to new uses, is likely to have organisation-wide implications, even where this does not appear initially to be the case. As such therefore, there is a need for those implications to be carefully explored from an organisation-wide perspective, and the decision to be made from that perspective. This may in fact lead to the non-implementation of systems, not because their application is flawed, but because the implications are on investigation far-reaching and would cause unmanageable problems elsewhere in the organisation. Hand in hand with this consideration is the organisation's ability either to buffer the introduction or to provide the support mechanisms to identify and deal with other outcomes.

13.6.3. Fully integrate project strategy into organisational strategy

In terms of strategic planning, it is also noticeable that if decisions to implement new software and hardware are taken at a project level, there is a potential that specific projects and/or staff begin to influence or even to drive the computing strategy of the organisation as a whole, even where this may not be to the overall benefit of that organisation. The organisation must evolve mechanisms which define its strategy over and above the project level, but must also allow this to be influenced by project initiatives where these are shown to be beneficial. The organisational strategy must be robust enough not to be thrown off course by large projects or strong-willed project officers. It is of critical importance that the organisational computing strategy is developed in the context of the needs and aims of the organisation as a whole, and not considered in isolation.

13.6.4. Think through the implications of implementation and development of computer systems.

It is crucial to understand that if a project develops new software and hardware configurations, it is necessary from a strategic management perspective to ensure that the understanding exist to assess the "real cost" of implementation. However, while the costs may appear straightforward, given the potential for osmosis and taking account of motivation, training and career development factors, the reality is that the strategy should include the cost from an organisation-wide perspective, and where it is not possible to buffer developments there will be a significant increase in the overall cost to the organisation. Similarly, if the expertise is vested in the staff of one project alone, then it is impor-

tant to recognise that this expertise is likely to be drawn on by other areas of the organisation, leading to a significant diminution to the resourcing of the initial project.

13.6.5. Deal with the potential for osmosis — turn informal into formal

It is argued above that given the nature of the organisational culture in archaeology osmosis has a high potential to occur, driven by high motivation, the team-based nature of the organisation, and the wish to develop career paths. We would recommend that decisions to implement new software and hardware should involve members of staff not involved with the target project, as the effect of the introduction, if successful, is very likely to influence the organisation as a whole eventually, even if the initial impact is more project-based.

The use of some form of co-ordinating body to investigate implementation of new systems or applications is much to be recommended, especially in an organisation which is based around specialist groups, either in terms of skills or in terms of applications (i.e. projects). It is crucial that this body includes a spread of members from across the organisation, representing the various functional and specialist areas of that organisation. While this may appear to be unnecessary in some cases, the underlying purpose is to ensure that all the hidden implications of decisions are explored and that actions are taken to ensure no unpredicted outcomes of decisions in one area of the organisation are felt. The body should also ensure that no informal osmosis takes place, by formalising and resourcing it. Such co-ordinating bodies also have advantages in terms of their ability to consider training and communication.

13.6.6. Think about the placement of computer expertise

Where computer expertise exists within an organisation, it is important to ensure that it is not tied too closely to one particular project as this will lead either to barriers to sharing expertise around the organisation or will become an open-ended drain on the resources of the particular project. Given the likelihood that developments on one project will affect the organisation as a whole, it is useful to make the computer expertise a specialist function which is "bought in" to projects but which falls out of direct line-management control of the project itself (i.e. a "matrix-type" structure). Such a decision will also encourage an organisation-wide perspective on developments.

We would recognise that particular expertise is likely to grow within individual projects, but where that becomes placed in a post-holder who is committed full-time to that project, then stress is likely to result, and it will be necessary to ensure a mechanism by which this expertise can be shared without causing problems for the project or post-holder.

13.6.7. Think about training and career development needs

There is a clear danger that the full implications of training are not recognised when new systems and applications are being considered. The most likely cause is again the danger of not recognising the implications from an organisation-wide perspective. If you have, for example, three illustrators of which only one is planned to use the new application, the temptation is to train only one person. Experience would suggest, however, that in time it will be necessary to train the others to avoid conflict over career development opportunities, to ensure its eventual application on an organisation-wide level, and to give room for manoeuvre against illness, *etc.* Where the training is provided externally this will have both financial and time implications, but it is important to recognise that even where internal training is possible, the same rule applies.

A further implication is that the introduction of computer technology has the hidden influence of actually drastically changing the nature of a particular job, the skills necessary to undertake that job, and the actual experience of undertaking the job. As well as training therefore, the organisation must recognise this possibility and evolve mechanisms for ensuring that this change is accommodated in a positive fashion. In the Service this has most affected illustration, but elements of the same pressures are also being observed elsewhere in the organisation.

13.6.8. Distinguish between applications and development

It is an important step for any archaeological organisation to decide whether it is to be involved in the development of computer applications as opposed to applying off-the-peg software. In reality of course this distinction can be difficult to make. When does tailoring an existing package such as AutoCAD or dBASE (to take two examples both of which lend themselves to an almost unlimited amount of customisation) to your particular application become research and development rather than implementation? Difficult though this might be, it is of great importance for the organisation to recognise when it is actively undertaking research and development and to ensure that if this is occurring its implications have been fully recognised. The debate is likely to revolve not only on what is an appropriate threshold but also on how an innovative research programme can be implemented within strict financial levels and timescales of many archaeological projects.

13.6.9. Be wary of overplaying the computer applications

While the successful introduction and use of new systems and new applications is often high profile, there is always the danger that problems will occur during the period of implementation and use. Recognise this potential and build in safety mechanisms.

13.7. Conclusions

To the inexperienced, the introduction of a new computer system, new software, or even a new application of existing software appears a relatively straightforward task. Even for those with more experience, the emphasis during the planning stages tends to fall on the suitability and work-

ability of the application itself and the finance for its purchase.

We would argue, however, that the implications of any such decision are likely to be organisation-wide, even where it does not appear to be so, and the planning stages must explore this in detail and take the results of this exploration carefully into account. The decision is likely to touch every member of the organisation, directly or indirectly, it will have wider resource implications that the area it is introduced to and it is likely to affect the structures used by the organisation, the roles of its members and ultimately the career development of all of its members.

We would also suggest that archaeological organisations through both their internal and external environment, will influence the likely success of the introduction or development of any system. The nature of the organisation, its staff, its structures, its funding base and its relationship with the external environment must all be clearly understood within the decision making structures, and the effect of these on the introduction must be fully followed through if the introduction and use of a computer system is to be achieved successfully from an organisation-wide perspective as opposed to a project perspective.

There is, in our experience, the ever present danger that seemingly simple decisions can have a widely-felt impact on the organisation as a whole and vice versa, and by extension on the discipline itself. Of course this recognition goes some way to ensuring that its effects are predicted and accommodated, but it is crucial that discussions of computer technology take full account of the archaeological organisation in order that computers are successfully employed. Indeed, we would encourage wider discussion of the implementation of computer systems in archaeological organisations — not on the basis of the systems themselves, the applications or indeed methodologies employed, but using a management perspective. Such discussions are likely to be of far wider application than the particular organisation involved and therefore of great value to the discipline as a whole. Beware the suggestion that introduction of a machine in the corner of the office is a simple task; the reverberations are likely to be felt long after it is switched on and far wider than the office it is in!

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