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ARCHAEOLOGY IN THE INFORMATION AGE

The following is a research proposal for a major funding written late in 1992 following an open invitation from Danish National Research Foundation. The bid, which was for a fairly large amount of money, was unsuccessful. The proposal was a joint venture between six people (named above) representing six institutions, but I on the whole wrote the text of the proposal during a sabbatical period in the autumn of 92. The proposal has previously been published in Kark Nyhedsbrev 1993, Nr. 1, where you may also find various reviews of the proposal.
Torsten Madsen 1-10-2003

1 SUMMARY

A fundamental problem in archaeology today is the rapidly growing masses of primary data. It is increasingly difficult for archaeologists to cope with the accumulating information on all levels of research. The problem is worsened by a segmented methodology rooted in traditions of the preceding century, and tuned to the use of pen and paper.

A way to improve the situation can be found in the context of modern information technology. There we find the means to cope with the multitude and complexity of data, and the means to create an integrated methodology. A computerisation of existing methods, however, will not solve the problem. Archaeology has to re-evaluate its methods and the structure of its data. Only then can a full exploitation of the potentials of information technology be achieved.

The project falls in two interrelated parts. One is a set of archaeological projects aimed at the redefinition and refinement of archaeological methodology. The objective of the other part is to develop and test implementations of archaeological methodology using information technology. The archaeological projects will relate to various topics and various periods within archaeology. Their main purpose is to bring together archaeologists in a mutual effort to break new ways of dealing with archaeological research. The information technology part of the project has a specified set of objectives to be achieved within the fields of excavation recording and analysis, regional studies, electronic dissemination of information and creation of an integrated work environment.

The two parts of the project will be in close co-operation. The archaeological part will define and apply the research methods. The development part will outline what the realities and possibilities of information technology are, and implement the methods.

2 RESEARCH PLAN

2.1 Need for the proposed research

2.1.1 «The fundamental problem of Danish archaeology in the 1990's»

The above heading stems from *Strategiplan 1993-97* (plan of strategy) by The Research Council for the Humanities. It heads a chapter recommending Danish archaeology to *Danmarks Grundforskningsfond*. We would like to cite a few paragraphs from this recommendation (in our translation) raising a very pertinent problem:

> Rescue excavations take up probably 90% of the research time of archaeological museums. Processing and analysis of materials, taking up most of the research time in other disciplines within the humanities, are seldom carried out due to a lack of resources. This state of affairs is in direct contradiction with national interests, which are to secure the sources of the National History, whether these sources belong to an archive or a museum.
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> The effort should be concentrated on investigations of a size and nature that will make them important foundations in the source base. It must be a clear strategic task to secure the quality and preservation of important sources for future research. The outlined problem must be considered the most urgent in Danish archaeology today and many years ahead. -------
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> Thanks to its long tradition and good legislation Danish archaeology has, seen in a European context, a uniquely diverse source material, and it has in later years been the foundation of Ph.D. theses of several American and English researchers. Thus an international obligation to secure an optimal source base lies with us as well.

It is true that large quantities of source material pile up in the museums without being prepared, analysed and made available for research. This is indeed a serious situation, not least because of the quality and potentials of the material. We do not, however, entirely agree that the solution is merely to allocate large funding to produce more printed publications. This would be an attempt to remedy the situation by removing the symptoms rather than the causes. One should not forget that publications in archaeology appear as never before. It is in fact increasingly difficult for researchers to cope with the growing mass of printed information.

The problem outlined by the Research Council has its roots deep in the traditions of Danish archaeology. The crux of the matter is the way we carry out archaeological research - the *archaeological methodology*. We believe it is possible to reduce the problem drastically if archaeology restructures its methodology to fit present day conditions. An important part of the restructuring is to take full advantage of today's possibilities of efficient information handling.

Apart from the obvious need for a conversion to modern *Information Technology* (hereafter IT), the major problem with the current methodology is its segmentation. Every type of task has its own work procedures aimed at summing up information in written statements. Others may take up these statements as a starting point for further research, or they may leave them unused in the archives.

A good example is excavation. Traditionally, archaeology views them as technical activities not directly associated with the formulation of culture-historical syntheses. Even if this view is outdated today, an excavation is still considered an activity, which is an end in itself. It is formally closed when all finds and documentation are in the museum archives. The excavator only is obliged to deliver the recordings in a proper form. (S)he is not expected to analyse the finds, to append culture-historical syntheses of the excavation to the files, or to publish the excavation, however important it may be.

Many excavations are published, but most of them belong to the category of minor "interesting finds". Intentions to publish the larger excavations are always there, but they are often hard to realise. The excavator may during the excavation and immediately after have a very good mental model of its structure. This model tends to vanish over the years, and to others such a model has of course never existed. When you have to work from the formal recordings exclusively, especially those of others, it is very difficult to form an idea of the complete structure of what was excavated, and it is a hideous task to create meaningful patterns by cross linking the multitude of information written down in endless lists. This is an important reason why so many publication plans are beached.

Formal printed publication of excavations is a bottleneck problem in Danish archaeology today, as it is only through these publications, that the knowledge embedded in the excavation results can be disseminated. This problem is partly due to the large number of excavations currently taking place. It is also, and fundamentally, due to segmentation in the methodology leading to a difficult transformation from one type of representation (recording lists) to another (narrative syntheses).

2.1.2 Needs for a new methodology

Danish archaeology (and archaeology as a whole) needs to restructure and renew its methodology. We should replace the current segmented methodology with an integrated methodology, where we view the total process from excavation to publication as a unity without intermediate "ends". That is, throughout the process the data should always be on a form that makes them directly usable in the next step, and indeed even if there is a logical sequence of steps in the process, these should be able to run parallel in time as far as possible. An integrated methodology as this can only be achieved if it is based on modern IT.

The need to use modern IT as an indispensable part of new methods geared to cope with the growing amount and complexity of data raises some fundamental problems. Archaeology has to realise that the computer is not just a new kind of typewriter that makes life a little easier for the archaeologist. The "transition" from the typewriter to the computer is in no way comparable to the transition from the pen to the typewriter. We must realise the ultimate conditions of accepting IT based solutions: information *not* kept and treated electronically is lost information. The implication is that data enter the computer once, and remain there for good. Output to a printed medium is always *ad hoc* and never meant to constitute a documentation of data.[1]

In the following we will elaborate on some of the problems associated with the traditional methodology, and the corresponding need for changes. It is feasible to divide the archaeological domain into three areas, traditionally viewed as separate entities. We will term these three areas *Data Procurement*, *Data Analysis* and *Data Dissemination*:

- *Data Procurement*: There are several areas of data procurement within archaeology. The most important and most troublesome of these is excavation. Data deriving from modern excavations are often too comprehensive and complicated for researchers to record and treat efficiently with current standard "notepad" based methods. Attempts to use computer recording has so far been of little help to solve the problem of complexity. The reason is that the systems established tend to mimic the "notepad" approach to data rather than dealing with complexity from a multidimensional, relational point of view.

[1] This "provocative" statement should be seen from the point of view of an integrated computer based methodology, and what it says is that we cannot sit between two chairs. Seen from the point of view of the individual researcher who has to familiarise himself with a research area or take part in the general level of synthesising, printed information is certainly not obsolete, and probably never will be.

There is a major need for a computer based data recording and handling system for archaeological excavations. The system must be based on an in-depth archaeological analysis of the structure of excavation data; it must be flexible to cope with different levels of particularity in field recordings; and it must have a global well-defined file structure that secures portability and re-use of data from applications other than those defined within the recording system itself.

There is a further need to improve many of the recording methods used in the field. This is not just a question of applying new field technology - many excavation-units do so anyway to save money. Rather it is a question of reassessing traditional methods of recording to evaluate if they optimally document the complexity of data. Again, we have to realise that the "tyranny of pen and paper" has a decisive role in the way we do things.

- *Data Analysis*: We normally meet a high level of complexity in the processing and analysis of data, whether excavation data, data from regional studies, or studies of artefact groups. The versatility of the data is not easy to represent in the analyses, and the results often become a number of static representations that are far from satisfactory, considering the variability of the data in multiple dimensions.

  There is an obvious need in archaeology to improve the analytical methods, and this applies to all areas of archaeology. It is true that many sophisticated analytical methods exist in archaeology. An example is multivariate statistics that have gone through an amazing development in recent years. Yet, the multitude and diversity of analytical methods in archaeology, many of which are loans from other disciplines, often lead to badly implemented methods. There is a clear need for a better understanding, implementation, and use of many methods.

  During analysis of large data-sets from excavations we face various problems: stratigraphic analyses; distribution of artefact categories across features and/or stratigraphic levels; comparison of artefact distributions; phasing based on stratigraphy and artefact content of features; combination and incorporation of available information into a site model; etc. Although the principles of doing all this are quite simple, the magnitude of the task when it comes to "real world" data from large excavations can be insurmountable. Many excavations remain unpublished due to this problem. One of the more notorious 'dead' sites in Denmark is the Late Mesolithic - Early Neolithic settlement site Muldbjerg in Aamosen on Zealand.

  Within regional studies we find major problems associated with the handling of map data. There are technical problems acquiring relevant base maps, but above all there are problems with formal analyses of artefact and site distributions. Although regional studies are a major topic in Danish archaeology surprisingly little happen to enhance and formalise the analysis of the geographical component. Despite books and papers especially in Anglo-Saxon and Anglo-American literature addressing this issue, there is currently no formal set of methods in use to compare and evaluate artefact and site distributions on the regional level. Nor are there any established methods for comparing archaeological distributions with various types of mapped “background” information (environmental, topographical, etc.). A reason for this lack is that many of the potential methods are so complicated and time consuming to carry out using pen and paper that they have had no chance to become established within the traditional methodology.

  Analyses of artefacts include a wide variety of methods. Typology is just one example, though a notable one, with a serious need for renewal. For years now we have maintained that the typological method is an analytical decomposition of the items at hand, and a subsequent definition of types based on selected attributes from this decomposition. Increasingly, however, researchers have begun to avoid types or talk about polythetic types, which are not types in the accepted formal sense. The reason is that typologies are rigid, monothetic and one-dimensional, whereas the reality to which they are applied is variable, polythetic and multidimensional. The problems have increasingly become clear, but no acceptable alternatives have so far been established although the issue is much debated, and many interesting papers exist.

- *Data Dissemination*: It is a growing problem that the traditional printed publication often presents data in a way that makes them difficult to access for further study. Increasingly we find extensive information condensed into tables and lists. The information is valuable in the sense that it displays the data used by the author. The problem, however, is that the data are not directly informative when read. Researchers wishing to use the data often must record them in electronic form from the publication or ultimately from the primary sources to make them available for their own analyses. Unnecessary

resources are used today on re-recording. Often publications appear as “black boxes”. Data used are displayed all right, but an active control of conclusions or contributions with alternative interpretations based on these data are often out of the question because the work effort demanded is prohibitively high. The consequence is more often than not a "take it or leave it" attitude towards the conclusions of the publication. A further result of this development is that research increasingly become based on a discussion of what others have said about data, rather than on the data itself.

There is a further problem with the traditional printed publication. A book is a physical entity in itself, and any search system for information (e.g. indexes) is limited by its boundaries. To seek information on a specific issue means searching a number of books - there is nothing new to this. As the number of books grows, however, the search for information becomes increasingly tedious, and researchers become more and more restricted and specialised in their topics and in their outlook. Abstract publications help of course, but far from enough, nor are on- line bibliographies, etc. sufficient. The situation is worsened by the fact that archaeological publications are now very numerous and expensive. Only three institutions in Denmark can afford to have a reasonably complete collection of relevant literature that allows a straight forward physical library search, and ordering through the main national libraries may sometimes mean weeks or months of delay.

The problems we currently face with traditional publications lead to a strong need for an investigation into, and a development of new forms of inexpensive and easily searchable publications of data based on electronic media. The expensive printed books could then be reserved for argued discussions and syntheses.

2.2 Purpose of the research project

The purpose of the project is to improve the way archaeologists carry out research, or in other words to improve archaeological methodology.

We can formulate this purpose in a number of statements:

- Substitute a segmented methodology with an integrated methodology;
- Improve specific archaeological methods within various research areas;
- Improve the efficiency with which archaeological data are analysed and disseminated;
- Democratise archaeological knowledge[2] - meaning: make archaeological information available to more people faster, easier and cheaper;
- Create a framework that encourage pluralism;
- Establish an integrated IT based work environment for archaeology;
- Create the necessary knowledge and tools to manage archaeological information as digitally stored data in an integrated environment.
- Lead archaeology into the information age;

What particular areas within archaeology to improve, what aspects of these areas to change, and the nature of the solutions to seek we will outline in chapter 2.3 and 2.4.

2.3 Delimiting the research area

To delimit the research area we will impose two points of view . One is entirely archaeological: where within the domain of archaeology do we wish to concentrate our efforts of a renewal of archaeological methodology. The other is IT based: what issues should be addressed to establish an integrated IT based work environment for archaeology.

The primary choices are archaeological, naturally, but given the overall purpose every choice has an IT counterpart.

We single out four topics of research using the following headings: *handling of excavation data*, *regional studies*, *integrated archaeological workbench*, *and dissemination of archaeological information.*

- *Handling of excavation data*: The archaeological issues we want to address here are: the structure of excavation data; data recording principles; methods of post excavation analysis of excavated data. Within the IT sphere this implies: creation of an object-oriented relational database system reflecting the structure of excavation data; establishing a recording system directly from the field to the database; creating applications that will perform the specified post excavation analyses.

[2] Paul Reilly & Sebastian Rahtz: Introduction: archaeology and the information age. In Paul Reilly & Sebastian Rahtz (eds.) *Archaeology and the Information Age. A global pespective*. Routledge, London. 1992 p. 18 ff.

- *Regional studies*: The archaeological issues are: the structure of regional data; relating regional (archaeological) data to other types of geographically defined data (environmental, topographical, historical, etc.); comparing and interpreting distribution patterns. Within the IT sphere this implies: creation of a relational database system reflecting the structure of regional data; implementation of a geographical information system (hereafter GIS); development of archaeological defined analytical applications in the GIS.
- *Integrated archaeological workbench*: The variety of analytical methods that may be applied to archaeological data on the one hand, and the physical dispersion of data on the other calls for integration. In the archaeological sphere we need to deal with basic methods for an analytical approach to data. Within the IT sphere we need, apart from implementing various methods, to create a basic common (communication) structure of all implemented applications to secure that data can be implicitly passed between applications. Further we need to concern ourselves with the introduction of distributed data and distributed processing solutions.
- *Dissemination of archaeological information*: This topic addresses the dissemination of archaeological information in general. However, we will concentrate on the publication of archaeological excavations. Within the IT sphere this implies: the structuring and implementation of publication data on electronic media and experiments with a distributed knowledge-base system.

In the following chapter these four research topics are further described. Problems relating to them are discussed and projected solutions are outlined.

2.4 Description of research topics

2.4.1 Handling of excavation data

One of the characteristics of excavation data is their heterogeneity. The reasons for this are obvious: any historical event is unique; site formation processes are locally conditioned; excavations are carried out with different objectives and with different backgrounds; recording standards on excavations can vary drastically. Nevertheless it is generally agreed that excavation data constitute a common pool from which archaeological knowledge can be inferred. The reason is that excavation data on the conceptual level can be transformed into a homogeneous representation.

Excavation documentation is viewed as a recording of layers (often viewed as forming a hierarchy of entities (e.g. context, feature and structure) objects and inter/intra relations between these described by text, photos and drawings. A recent analysis[3], however, has shown that *layer* and *objects* are insufficient entities to give a proper presentation of excavation data in a formal representation. A further (interpretative) entity, called a *construct*, is necessary to avoid ambiguity.

The main problem with the current usage is that interpretations of layers are tied to these as attributes (whether through a "typology of layers" (e.g. postholes, pits, middens, floors, etc.), or directly through a field of interpretation. The basic idea of the *construct* is to separate interpretation from description, and to create a flexible structure that will allow for even complex interpretations of recorded data (*layers*, *objects* and their interrelations), cross linked with these, but yet with an independent existence. The construct may from one point of view be seen as an object-oriented construction that allows the archaeologist to build an interpretative model with inheritance and polymorphism between the data types of the model.

From the point of a Database Management System the structure of archaeological information is truly complex. Not only are there "many to many" relations among all three entities (*layers*, *objects*, *constructs*) individually, and within each entity internally, but *layers* and *objects* are also related to other types of entities: *drawings*, *photos* and possibly *three dimensional positioning* (one may also choose to view the latter as an attribute of *layers* and *objects*). This gives a further set of "many to many" relation tables, and so does relations between *photos* and *drawings*, and *drawings* internally.

To our knowledge a data base structure that fully represents the complexity of excavation data, has not yet been set up. Most of the systems that we are familiar with have only single flat file or hierarchical file representations of excavation data. Only a few try to handle some of the complexity using relational structures.

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[3] Jens Andresen & Torsten Madsen: Data Structures for Excavation Recording. A Case of complex Information Management. In Carsten U. Larsen (ed.) *Sites and Monuments. National Archaeological Records*. Nationalmuseet, København 1992 pp. 49-70.

One problem is to set up a data base structure simulating the full complexity of excavation data, create input routines to this structure, and generate standardised reports from the system. Quite another problem is to create applications that will make even complex analyses of the data a matter of routine.

There are two different yet interrelated ways to approach analyses of excavation data. Both must carefully be evaluated in an archaeological context and implemented in an IT context for a full use of the data. The one takes as its starting point the internal structuring of the three basic entities. The other takes the drawings and the three dimensional positioning of layers and objects as its point of departure.

Applications dealing with the structure of data can be of different kind and purpose. Examples are: applications that construct Harris Matrix representations of stratigraphy; applications that investigate object distributions across layers and constructs; applications that let the user build up an interpretative model of the excavation using the *construct* entity.

Applications based on the drawings and the three dimensional positioning of layers and objects have many features in common with a GIS (mentioned further in the next chapter). The idea is that the drawings in a digitised form constitute the main interface to the excavation. Thus it should be possible to move around in the excavation (on the screen) zooming on features, letting more detailed plans (if available) replace general plans, and turning from horizontal to vertical views where appropriate (with sections, etc.). It should also at any time be possible to query the database for all types of information relating to what is viewed on the screen (which objects were found in a grave, which photos show the grave, etc.). It should be possible to select objects from the database using various criteria and map them superimposed on the drawings. Further, it should be possible to view an interpretation model created in the construct realm as colour markings of layers and objects on the drawings. This type of application obviously results in a very interactive way of analysing excavation data, and it constitutes a qualitative leap in the methods of analysis compared to what is available today[4].

The traditional methodology of excavation documentation has three phases that are considered to be reasonably independent: recording, analysis and report writing. In the field, the excavation is recorded through notes, list of items, drawings and photos. These recordings then become historical documents (never to be changed) brought home for further analysis. Based on the documents and the analyses a report is finally written. This report becomes the “final” truth of the excavation, and it closes the case of the excavation forever (no information concerning the excavation enters the archive after the final report has been delivered - new information means a new case).

In a new methodology, the concept of historical information, never to be changed, poses a special problem. We cannot maintain the definition we have now, where we can point to a set of physical papers and claim these to be the historical documents. In an IT based methodology there will be a beginning of recording but not a naturally defined end, nor any naturally defined stages in the process. As data enters the system, analyses can begin and they can influence further recordings or even influence recordings already made, by pointing out that they must be in error. The point where information becomes “historical” is thus floating. It has to be carefully defined, and forcefully implemented through “locks” in the system.

Further, it has to be realised that an IT based recording system will remain dynamic. Even if a report is printed at one point, this does not mean that the recordings may not continuously change as a result of analysis. It is within the interpretative *construct* entity that changes can occur as long as somebody is working with the excavation. Indeed the content of the *construct* part may vary with the archaeologist working with the excavation. Thus we have to be able to work with parallel “user owned” *construct* parts of the recording. One of these, of course, will be “official” - owned by the excavating institution. Individual archaeologists working with the excavation will own the others. Mostly they will be copies of the official version with added or changed information.

An important area for development accompanying a new IT based excavation-recording system is the field recording procedures. It is obviously not satisfactory to continue with paper based recording in the field, and a subsequent data entry phase. Thus the practice of carrying through a new system has to be given careful consideration, and experimentation.

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[4]A system developed by Dominic Powlesland already holds this feature. Unfortunately Dominic Powlesland's system has not the needed flexibility and openness in its database parts, nor the open architecture needed to allow independent applications to interface it. Everything is programmed from scratch in one huge program. We hope very much to be able to attach Dominic Powlesland to the project.

A system as advanced as the one we plan to create - we call it RAU (Registreringssystem for Arkæologiske Udgravninger) - must be tested thoroughly using the most complex source material available. Otherwise we risk creating an academic system that will not work properly in practice. As a test case controlled by the project we have decided to use the important and highly complex excavations from the old town of Ribe. Testing will be performed on already existing materials as well as on future excavations. Of the existing excavations especially one - "Posthusudgravningen" - is of interest. Here, within barely 80 m^2, more than 75.000 artefacts were recorded, and more than 500 separate layers were identified. Throughout the excavation recording was very detailed, resulting in one of the best-documented excavations in Denmark, but consequently also one of the most difficult excavations to analyse. This makes it the perfect test case for our project. The more so as the excavation together with other excavations in Ribe has evoked major national and international interest that will make the primary material a target of analyses and reinterpretation after the publication of the excavations. Only a system of the type we plan here will freely allow this.

Apart from testing the system in Ribe, members of the archaeological research group (see chapter 2.5) are expected to contribute significantly to the design of the functionality of RAU, as well as to use and evaluate it within their projects. We plan to urge Ph.D. students and research fellows to incorporate these aspects into their research. Further we intend to make arrangements with other archaeological units in Denmark and abroad to use the system as soon as it is reasonably operational. In this way we can gain a number of independent opinions on its functionality.

2.4.2 Regional studies

Regional studies are not a new development in Danish archaeology. One needs only to look back at the works of Sophus Müller at the beginning and Therkel Mathiassen in the middle of this century. An important *Siedlungsarchäologie* tradition also evolved in post-war Germany influencing Denmark. However, the *New Archaeology* in America and the *subsistence archaeology* tradition from England brought a renewed and very strong interest for regional studies in the 1970's.

In a sequence of annual symposia in Odense organised by Henrik Thrane, many of the varied elements to enter the new era of regional studies were discussed. Especially the interdisciplinary approach, now so important, was in focus, and discussions of base map elements and analyses of location determinants were also established. Since then relatively little has happened within these fields of study so central to formal regional studies. This is so, even though perfect base maps with a variety of natural and cultural information occasionally have appeared[5], and analyses of location determinants have been attempted[6]. As stated in chapter 2.1.2 the main reason seems to be that the work involved in making good base maps is immense, and the procedures for making relevant analyses of distribution patterns and location determinants are rather unclear to many archaeologists, as well as tedious to carry out given the traditional methodology.

In the same period results achieved by historical geographers in Sweden were introduced to Danish Archaeology, primarily at Moesgård. The methods and theory of historical geography have since influenced Danish Iron Age - Viking Age archaeology.[7]

It is true that a better methodology of working with data from regional studies is needed. This new methodology must be based on GIS, but it is important to realise that GIS is only a vehicle not the method itself. A GIS consists fundamentally of a relational database containing a variety of information, all being characterised by the property of a geographic position. Apart from the archaeological information the database may contain all kinds of topographical, environmental or cultural information. For each set of data in the database, a map layer is prepared displaying a geographic representation of the information. These map layers can be displayed overlaying each other in any combination on the screen or in hard copy. Two main functions can be performed within a GIS. One is querying the database for its content related to any point, area or distance from point or area on the map, or for any selection of information you like to have displayed on the map. The other is performing logical operations between map layers resulting in new map layers, or any desired computation on the data in a map layer.

Although a good GIS comes with all standard functions needed, it is a major task to set it up and customise it for a particular use. Clearly it will take up a great deal of the initial resources of the project to set

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[5] e.g. Svend Aage Knudsen: *Landskab og oldtid. Atlas over Søllerød og Lyngby-Taarbæk kommuner*. 1982

[6] e.g. Torsten Madsen: Settlement Systems of Early Agricultural Societies in East Jutland, Denmark: A Regional Study of Change. *Journal of Anthropological Archaeology* 1, 1982: 197-236

[7] e.g. Charlotte Fabech & Jytte Ringtved (eds.) *Samfundsorganisation og Regional Variation. Norden i Romersk Jernalder og Folkevandringstid*. Jysk Arkæologisk Selskabs Skrifter XXVII 1991.

the system up and make it run, to get data into the system, and to prepare map layers. It will also take time to teach archaeologists to operate a system properly. Dutch archaeology has been through this process in a small test area of Holland, parts of American archaeology as well, and British archaeology is currently in the middle of it. Danish archaeology has no experiences yet (apart from a few experiments with a small PC-system called IDRISI).

Beyond this phase, however, lies the area of proper use in regional studies in archaeology[8]. A GIS as installed is best suited for administrative purposes. To use it in a research context implies that proper analyses and methods of use are developed. To archaeologists a GIS will be a totally new experience. The type of analyses it will be possible to perform on spatial data lies beyond what has been practical available to archaeologists, even if the principles of the analyses are often simple. Archaeology thus has to find its way into a proper use of GIS as a research tool. Useful analyses have to be developed and an integrated approach to regional studies in archaeology has to be defined.

One way a GIS may be used in archaeological research is as an EDA for spatial data (Exploratory Data Analysis). Through its ability to combine data from various map layers, and display them together with selected data from an archaeological site database, the discovery of spatial patterns is facilitated. Merely by viewing a distribution of sites one might be able to realise spatial relationships or other patterns that might exist.

By sheer computational power, otherwise impossible analyses become possible. A good example of this is "view shed analysis". On the basis of a computer representation of a landscape, known as a Digital Terrain Model, a view shed includes those areas that are visible from a specified point on the landscape. A view shed may in many cases be important in the evaluation of specific site locations.

From basic environmental or topographical data in the GIS, new data of importance to the evaluation of site distributions may be derived. Thus the Digital Terrain Model (itself derived from elevation data) can be employed to determine such terrain features as ground steepness (slope), direction of ground facing (aspect), or even drainage courses through algorithms that consider interrelationships between adjacent or nearby elevations in the matrix.

Location analyses are of major importance to most regional studies, and it is an obvious area to develop further using GIS. Site locations may be analysed in terms of distances to coast, water courses, water sheds, bog areas, ancient road systems, etc.; in terms of placement on specific soil classes, slope categories, etc.; or in terms of a quantitative expression of the surroundings of a site.

A GIS may also be used for analysis of artefact distribution patterns, whether on an inter-site or intra-site scale. Its ability to perform map algebra (adding, subtracting, etc. maps) together with the possibility of implementing spatial statistics gives it a great potential in this area.

GIS may also be used for spatial modelling. From the observed location of a number of sites a model for the ideal location of a site type may be constructed. This model may naturally provide considerable insight into the settlement location strategy, but it may also be used as a "prospecting" tool for further site discoveries. By comparing the model with the whole map area, a map may be drawn showing the optimal areas for location of the specific site type.

A final topic to mention is the simulation of spatial processes. By preparing map layers of finds each representing a time interval (time slicing), the possibility of studying dynamic aspects of spatial distributions arises. The problems associated with this type of analysis, however, are numerous, and archaeology is currently in a very preliminary state regarding formal analysis of this nature.

Setting up the system is thus only a preliminary step to the real task within the project: to develop analyses and methods as part of an improved methodology for regional studies. Elements may be found residing with other archaeologists working with GIS, and elements may be found within the discipline of cultural geography. Yet, a major task lies ahead for us to develop methods and not least have these methods incorporated into an integrated approach to regional studies.

To test the use of the GIS we will set up (named GISA for Geographical Information System for Archaeology) and the research methods developed we have decided to use Ribe County. From 1981 to 1986 20 researchers joined efforts in a "settlement history" research of the Ribe Area. The researchers covered many periods (archaeological and historical) and represented many disciplines including natural sciences.

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[8]Kenneth L. Kvamme: Geographic Information Systems and archaeology. In Gary Lock & Jonathan Moffet (eds.) *Computer Applications and Quantitative Methods in Archaeology 1991*. BAR International Series S577 1992. pp. 77-84

The results will be published in two volumes (600 pages) in 1993. It will be the first in Denmark to be published *in extenso* since Thekel Mathiassens *Nordvestsjællands Oldtidsbebyggelse* in 1959. This project has established a very detailed source material readily available for test purposes.

Digital environmental, and topographical data are not yet generally available in Denmark. By coincidence, Ribe County is currently the only area with a full set of digitised topics, including terrain curves and aerial photographs. In a GIS context this is really worth a fortune, as the cost of digitising data is quite high.

Apart from a systematic testing on the Ribe area, it is our intention to emphasise regional studies within the archaeological research group (see chapter 2.5). The current methodology within regional studies is very informal and intuitive. GIS provides us with a set of opportunities to develop a more systematic and formalised methodology, but to achieve this it is imperative that archaeologists sit down and work through the problems and state what exactly they want. Thus it is our objective that quite a significant number of the Ph.D. students and research fellows should have projects within the realm of regional studies, and that they should be the driving force in creating the archaeological demands for a new methodology within this field.

2.4.3 Integrated archaeological workbench

As a result of the project, archaeological excavations should be recorded at various museums using the system developed. A major question is, how do we share the information recorded in this way among the archaeologists in Denmark? Further, the project will develop a number of applications analysing various types of data, but others will develop even more applications, mostly in other countries. How can we make the most out of such a variety of applications given one single work environment?

An attempt to answer these two questions leads to the concept of the integrated archaeological workbench. The answer to the first question is «by way of distributed shared databases and distributed data processing». The answer to the second question is «to design a basic data communication structure for the applications».

Distributed databases and distributed data processing as such are naturally nothing we have to develop. It is something everybody is talking about and waiting for. A major precondition has recently become available in Denmark - the ISDN system, an intelligent and fast telephone based digital network facility. We take it for granted that it will only be a few years now before distributed databases and distributed data processing become generally available, and we would like to bring it into archaeology as soon as possible.

The prospect is that you should be able to sit at location x working with an excavation recorded at location y. You search the database at y, but if you add information to your own version of the *construct* table, or if you create new tables out of searches at y, all this will happen at location x. Seen from your application (screen) you are working with one database, but actually the database is physically split in two or perhaps more parts with no need for you yourself to be aware of it.

The design of a basic data communication structure for applications is an idea developed (by Jens Andresen, Moesgård and Nick Ryan, Canterbury) to improve the integration of applications. Given an operating system supporting dynamic data interchange using a message handling method (like Microsoft Windows), and given object oriented software development, it is possible to add an object to the basic set of objects in the development tool kit containing all the necessary methods for an implicit data exchange between applications. If this object is included and used in applications by various developers it will make it easy subsequently to make these applications communicate and exchange data. Much of the design and basic work for a prototype of the object has already taken place[9].

The advantage of the system is that any application based on this object will, if running, immediately react when it receives data that it recognises, and do with these data what it is programmed to. Thus a program designed to produce Harris matrixes, will then display the matrix, if series of stratigraphical relations are dispatched from an application that has, say, made a database query for stratigraphical information.

The concept of integration is vital to what we intend with the project. Throughout we want data to flow as fast, as efficiently and with as little “manual” help as possible. Only in this way, we believe, can we overcome the problems with data indigestion that archaeology is facing. We must improve and tune our methods to be able to cope with the growing amounts of information.

[9]Most of the activities associated with the creation of an integrated workbench are placed late in the project. We are, however, aware that the full design of a basic data communication structure for applications has to be forwarded to an early stage of the project.

The objective to create an integrated work environment from procurement to dissemination of data naturally leads to the question of the analytical methods to be used in the integrated environment. Part of the work of the archaeological research group will have to address this issue, and it is our objective that some of the Ph.D. students and research fellows should have projects within this realm.

2.4.43 Dissemination of archaeological information

Printed publications constitute a reduction of complexity to simplicity. The art of publishing an archaeological excavation is essentially to reduce the complex cross-linked information to a perceptible set of parallel narrations (description of structures, description of stratigraphy, description of objects, etc.). Often the outcome is not satisfying: too much information is left out, and too much is presented in an impenetrable manner.

Archaeological data have a very complex multivariate structure - or hyper structure. A printed book cannot maintain this hyper structure, but an electronic medium can. In changing to electronic publications we should try to take advantage of this, and instead of reproducing the printed book electronically, we should aim at publishing the total complex structure.

Experiments with the production of electronic publications are placed at a rather late state in the project (see chapter 2.5). The reason for this is twofold: Firstly and most importantly we need to have some properly structured excavation data electronically recorded before we can make any attempts. Thus we have to get RAU up and running with a set of excavation data. Secondly we would like to see the IT development move a little further before we begin.

When we come to this part of the project we will face many problems that we currently have no means to fathom. One such problem is «how are we going to secure the readability of the published data?». Publishing on CD-ROM's is presently an attractive possibility, but for how long can we expect the current line of CD-ROM's to be generally readable? We are in a sphere where technological changes may outdate standards very quickly, and archaeological publications are not just meant to be read when they appear. They are also to be read a hundred years from now.

This problem could imply that a national body of some sort should be given the full ownership of electronic publications and the responsibility to maintain their existence in usable form despite technological changes. Although this is not a problem the project has a responsibility to solve, we have to consider its consequences [10]. The question also opens for a debate of whether electronic publications of excavation data in the long run should be aimed at network dispersal rather than CD-ROM's or their future equivalents.

Another question is «what structure/format should the data have when published?». As excavation data represent a hyper structure and will be kept as such in RAU, some form of hypermedia publication is imperative. There have been promising experiments with publication of archaeological excavations using HyperCard stacks for the Macintosh[11]. Our project definitely has to look into these perspectives, as well as doing some prototype experiments of our own. It does, however, currently appear doubtful to us, that the publication of data should take place in this type of format. The problem obviously is that it may bind the publication to a particular program (perhaps even to a particular version) based on a particular operating system on a particular processor type. The chances are high that this will make the publication obsolete even faster than the technological changes mentioned above, and it may not be a straightforward case to republish the data, as the code structuring the stacks may have to be rewritten.

A better solution perhaps would be for data and the program that presents the data to be kept as separate entities. This will make it possible to transfer data to new hardware platforms, to new data standards, etc. with relatively little effort. At the same time it will make it possible independently to develop, and change the program displaying the information. Data for hyper- structures are currently published using a mark-up language defining the structure of the data[12] . A benefit of this solution is that it is possible to design a “publication generator” that can transfer all the basic data from RAU to the publication automatically, and

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[10]The solution could simply be, and may well be that the responsiblity of DKC (*Dansk Kulturhistorisk Centralregister*) is extended to cover this aspect as well.

[11] E.B. Banning: Hypermedia and archaeological publication. The Wadi Ziqlab project. In Jens Andresen, Torsten Madsen & Irwin Scollar (eds.) *CAA93. Computer Apllications and Quantitative Methods in Archaeology*. Aarhus University Press 1993

[12] e.g. Neel Smith: An experiment in electronic exchange and publication of archaeological field data. In Gary Lock & Jonathan Moffet (eds.) *Computer Applications an Quantitative Methods in Archaeology 1991*. Bar International Series S 577 1992 pp. 49-57.

yet retain the structure of the data. The solution will however not be without drawbacks either. Firstly it is not possible to get the fancy sort of hypermedia publication with "buttons" in graphics, etc. available in HyperCard. A hypertext solution only is available with the ability to show graphics as a result of a pressed "button". Secondly, if the data are distributed in a mark-up format then the end user has to generate the hypertext version using a program distributed and maintained especially for this purpose.

A major point in doing electronic publications of excavations is that we can publish the complete complex structure and not just a one-dimensional description of the structure. However, if we end up disseminating information primarily through networks, then it certainly would be advantageous if we could operate more freely across publications, and perhaps could include comments to the publications from various sources. That is essentially if we could operate across the whole library instead of across the publication.

What we are aiming at here is the possibility of having an integration of information in various heterogeneous databases across a network. The possibility of integrating heterogeneous information (structured publications, notes, comments, illustrations, etc.) entered into the system, lies with the concept of metaknowledge. Metaknowledge in this connection is a knowledge of which items in a collection are dealing with the same issue(s). In a normal library the Dewey decimal system constitutes the metaknowledge system, but it is awkward in the sense that it has a purely one-dimensional way of dividing the books.

What we need is freedom of association, and we may here point to systems currently being developed like MIRAS (Midlands Information Retrieval and Access System)[13], which is a metadata system that enables users to explore and create knowledge linkages, based upon their own views of relationships between concepts and materials. In other words the users create the metaknowledge by using the system. No rigid one dimensional classification system is imposed on the information.

2.4.5 A note on hardware and software strategy

Concerning the hardware part, our ambition has to be fitted to a rather low-level budget situation. Should the project be realised, the developed software has a potential market of about 50 archaeological institutions in Denmark alone, all of which use PC equipment exclusively. It is unlikely that they can ever afford to go beyond main-stream products aimed at the mass-market. This limitation is not likely to impose restrictions to the processing of textual data (= symbolic representations), but graphical data, especially in raster form, do currently pose a problem that we have to consider.

Yet, we may foresee a drop in hardware prices at a rate of about 20-40% *pro anno* relative to performance, and a performance increase at a rate of about 100% *pro anno* relative to price. From these figures it follows that in a 7 year perspective a computer bought at the beginning of the project will cost 10-20% at the end, or that a computer over 60 times as fast can be bought for the same amount of money. We may thus conclude that "time is on our side" and that the estimated development in price/performance ratio may eliminate our concerns of the processing and storage of visual information.

As for the software strategy we currently lack sufficient knowledge. Yet, it is our impression that even professionals in the area can hardly have a 7+ years perspective. Given the hardware platform we can point at three competing major operating systems: UNIX, OS/2 and Windows NT.

With these options the UNIX-family is no doubt the current serious bet for a production environment. OS/2 is not a multi-user operating system and the number of development tools for OS/2 is quite limited at present. Windows NT is not even on the market yet, however promising the prospects of it sounds. On the other hand, Windows as we know it would suffice as an environment in the development phase, and seen in the 7+ years perspective - with an eye to what has happened so far - Windows NT may turn out to be not an alternative but a necessity.

Because the software developed has to be distributed to a number of units with generally low budgets, we have to limit the number of commercial products which have to be owned by the individual units. This means that much code has to be written from scratch. To keep the written code as independent as possible of operating system (and even hardware platform), the code should be based on the C++ language. At least that seems to be the foundation of any serious software production at the moment, and there is no reason to depart from mainstream.

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[13]Personal communication from Clive Ruggles. The system has been developed at the University of Leicester and Loughborough University of Technology, and is currently being implemented as part of a project named "An Integrated Computer Environment for the Management of Student-Centered Learning across the Curriculum in Higher Education".

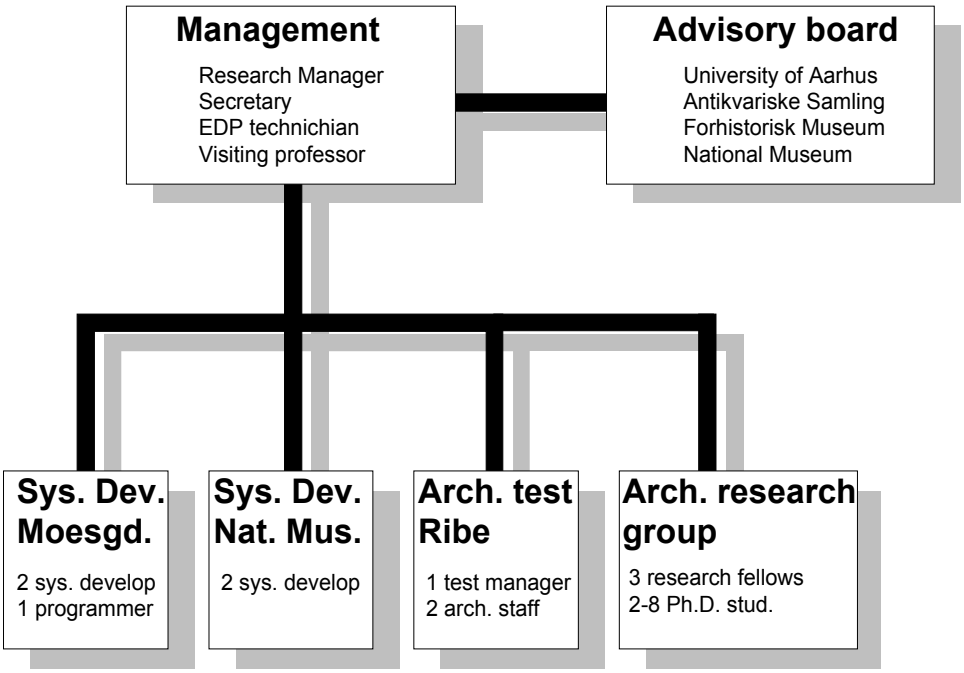
A note concerning the GIS system should also be added. There are several commercial GIS systems available on the market. They are however, quite expensive, and therefore not well suited for the low cost market of Danish Museums. In England ARC/INFO has been made available to archaeology at a relative low cost thanks to a central funded initiative. A comparable solution could be attempted here. Holland on the other hand has opted for GRASS. This is a mega-system developed for the American Defence Ministry, and it is hence in the public domain. It was initially introduced into archaeology through Arkansas Archaeological Survey, and from here it came to Holland. It is a very advanced system, and it is still being developed, but being a public domain system means that you have the responsibility yourself to make it run. The pro and cons of the two alternative directions to take, should carefully be contemplated before a decision is made.

2.5 Organisation and work Programme

As four different institutions are involved in this project it is necessary to consider the organisational aspects. It is obvious from the papers received from *Grundforskningsfonden* that all responsibility for decisions has to be allocated to a research manager. Other models more familiar to the humanities would have been possible, but we will abide with the one given. To ensure the co-operation of all four institutions, however, we would like to establish an advisory board for the research manager consisting of one person elected by each institution.

Within the project we will operate with a management unit and four work units. The management unit will, apart from the research manager, consist of a secretary, and a technician taking care of all the EDP equipment of the project. Also the visiting professor will be directly associated with the management unit.

Of the four work units two will be IT units, and two will be archaeological. All units will be placed in a flat structure directly below the management. Each group will have one person who is responsible for its activities. Further a person in one of the IT development groups will be given responsibility to co-ordinate inter-group work where required. Graphically the organisation plan takes the form seen below.



The work programme operates with three locations: Moesgård south of Århus, Ribe and the National Museum in Copenhagen. In the following the four work groups at the three locations are outlined in more detail

The system development group at Moesgård consists of two system developers and a programmer. Their main responsibilities will be system development within the topics *handling of excavation data*, *dissemination of archaeological information*, and *the integrated archaeological workbench*.

The system development group at the National Museum consists of two system developers. Their main responsibilities will be system development within the topics *regional studies* and *the integrated*

archaeological workbench. The group will work in close collaboration with the documentation department of the National Museum, and of course with the system development group at Moesgård.

The archaeological test group at Ribe consists of one archaeologist employed all through the project and a number of archaeologists and students employed for various periods of time according to the needs as they arise. The Ribe group performs the testing of the systems developed. Within the topic *handling of excavation data* it also plays an active part in the development of the field recording systems. The Ribe group will be closely associated with the museum - Den Antikvariske Samling - in Ribe, from where the major part of the data used for testing will come. It should be noted that it is not part of the plans to finance and carry out excavations. To test field recordings, the Ribe group, however, has to take part in some of the excavations conducted by the museum.

The archaeological research group at Moesgård in a sense constitutes the core of the project. It will consist of three research fellows and a number of Ph.D. students (2-8 varying with time).

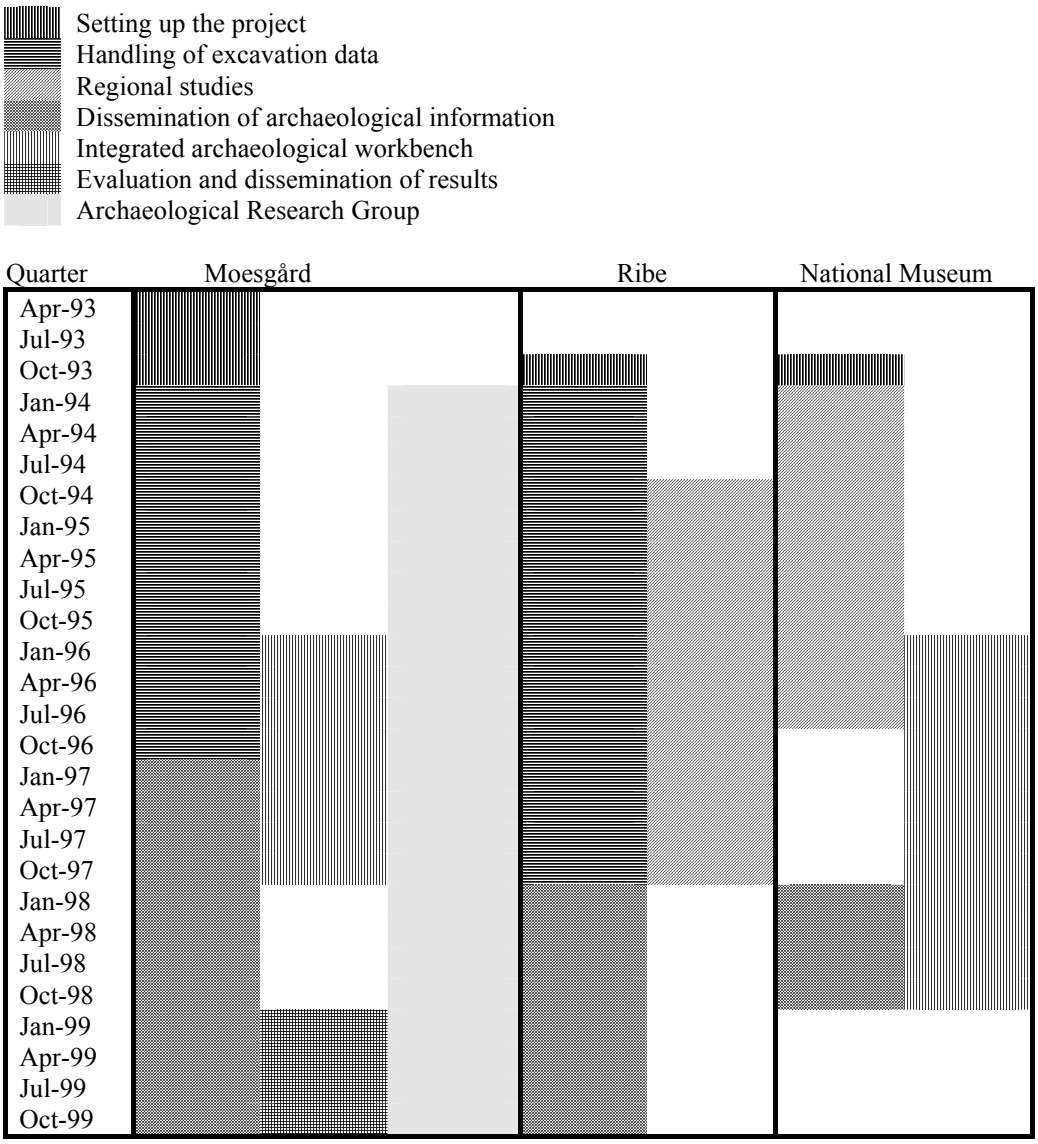
The research fellowships three scholars yearly will be announced giving details of what kind of research activities is expected to take place, and how they should relate to the overall purpose of the project. Appointment will be based on formal applications giving details of the projects proposed. The duration of each post (1-3 years) will also be decided based on the evaluation of the project and communication with the applicant. The purpose of these research fellowships is to bring into the project a number of researchers with a background from various research institutions and make them contribute to the archaeological foundation of a new methodology. Two of the fellowships - one after the other - have to be three-year postings, and with these fellowships follow a special obligation to organise a number of national seminars on archaeological methodology and as to act as Ph.D. supervisor.

It is our objective that the individual projects within the research group, apart from their methodological component, should reflect key research areas of Danish archaeology. Thus for example it is obvious that within the regional studies an emphasis will be placed on the first millennia AD. This is due to the many important settlement archaeological investigations carried out in recent years within this period. It is also due to the new research initiative on “Farms and Villages” from the Research Council for the Humanities, which will allocate significant resources into this area, and thus make it a profitable area of co-operation. Thus it is imperative to us to have the methodological development embedded in Danish main stream archaeology.

The Ph.D. students will have a normal three year study, planned in close association with the Department of Archaeology, University of Aarhus, where they will be formally signed on. As with the research fellows their projects have to relate to the main purpose of the project. Further details are given in chapter 5.1.

A work programme is included in appendix A. The time schedule of the individual tasks is outlined in some detail giving an idea of the planning. Should the project be realised, a detailed work plan, indicating persons, etc. will of course be established.

A summary of the work plan is given on the following page



3 BUDGET

The budget on the following page gives a survey of the total project, and hence it works with coarse categories only. We find it unreasonable at the current level of planning to enter into further details as these may change as a result of our own planning, negotiations with institutions to house the project, *Grundforskningsfonden*, and other parties that will become involved in a detail planning.
We hope that the level of detail is sufficient for an evaluation of the project. Further, we hope that our planning has not resulted in a level of ambition beyond what *Grundforskningsfonden* is willing to support. We are of course open to discussions of changes that may lower the need for resources in the project.

	1993	1994	1995	1996	1997	1998	1999
Management & common facilities							
Research manager	200.000	400.000	400.000	400.000	400.000	400.000	400.000
Project secretary	100.000	200.000	200.000	200.000	200.000	200.000	200.000
EDP-technician	50.000	200.000	200.000	200.000	200.000	200.000	200.000
Visiting Professor		370.000	370.000	370.000	370.000	370.000	370.000
Office expenses	30.000	60.000	60.000	60.000	60.000	60.000	60.000
Library expenses	20.000	40.000	40.000	40.000	40.000	40.000	40.000
Board expenses	20.000	40.000	40.000	40.000	40.000	40.000	40.000
Establishment	100.000						
travel expences	50.000	200.000	200.000	200.000	200.000	200.000	100.000
"hands on" seminars (staff incl)							1.500.000
"House rental" - Moesgård	1.500.000						
Management total	*2.070.000*	*1.510.000*	*1.510.000*	*1.510.000*	*1.510.000*	*1.510.000*	*2.910.000*
Moesgård							
2 system developers	222.000	740.000	740.000	740.000	740.000	740.000	740.000
1 programmer	60.000	200.000	200.000	200.000	200.000	200.000	200.000
Establisment (EDP)	300.000						
Running costs (EDP)		150.000	150.000	150.000	150.000	150.000	150.000
Moesgård total	*582.000*	*1.090.000*	*1.090.000*	*1.090.000*	*1.090.000*	*1.090.000*	*1.090.000*
Ribe							
Pilot project manager		370.000	370.000	370.000	370.000	370.000	370.000
2 archaeological staff members		400.000	400.000	400.000	400.000	400.000	
Establisment (EDP)	200.000						
Running costs (EDP)		100.000	100.000	100.000	100.000	100.000	100.000
Ribe total	*200.000*	*870.000*	*870.000*	*870.000*	*870.000*	*870.000*	*470.000*
National Museum							
2 system developers		740.000	740.000	740.000	740.000	740.000	
Establisment (EDP)	200.000						
Running costs (EDP)		100.000	100.000	100.000	100.000	100.000	40.000
National museum total	*200.000*	*840.000*	*840.000*	*840.000*	*840.000*	*840.000*	*40.000*
Archaeology groups (Moesgård)							
3 research fellows		1.110.000	1.110.000	1.110.000	1.110.000	1.110.000	1.110.000
Overhead (research fellows)		300.000	300.000	300.000	300.000	300.000	300.000
Ph.D. students		420.000	840.000	1.260.000	1.260.000	840.000	420.000
Overhead (Ph.D. students)		200.000	400.000	600.000	600.000	400.000	200.000
National seminars		60.000	60.000	60.000	60.000	60.000	60.000
International Symposia					300.000		
Establisment		150.000					
Archaeology groups total		*2.240.000*	*2.710.000*	*3.330.000*	*3.630.000*	*2.710.000*	*2.090.000*
Project total	**3.052.000**	**6.550.000**	**7.020.000**	**7.640.000**	**7.940.000**	**7.020.000**	**6.600.000**

Notes for the budget:

1. The project of course has access to the library at Moesgård and the State Library. However, specialised literature is needed, making major library investments imperative.
2. Expenses associated with the advisory board from the participating institutions are singled out.
3. Travel expenses noted here are meant to cover the whole project. The money is intended to cover staff participation in foreign conferences and symposia, as well as covering expenses of educational courses for staff members.
4. There is a special housing problem at Moesgård. At one point in the project 15-20 peoplehaveto be accommodated here. All available office space at Moesgård is already taken up. There is, however, an area that can provide ample space following a minor rebuilding. The idea is that the project pays this rebuilding and this then constitute the rental. As for space in Ribe and at the National Museum, this poses a minor problem.

4 QUALIFICATIONS

There are two domains of qualifications needed to carry through the proposed project. One is an in depth knowledge of archaeological methodology with special reference to: *handling of excavation data*, *regional studies* and *dissemination of archaeological data*. The other is a detailed knowledge of the possibilities of modern IT.
The six individuals proposing this research project are the following:

- *Niels H Andersen*: one of the most experienced excavation organisers in Denmark. He organises and heads the rescue excavation programme at Moesgård, and at the same time carries out a research excavation programme on southern Fyn. His excavation of the 9 Ha large Neolithic causewayed enclosure of Sarup is among the largest ever in Denmark. As part of the research project on Fyn he is also deeply involved with regional studies. He uses computers extensively throughout his work.
- *Stig Jensen*: a very experienced excavator and organiser of excavations. His qualifications are especially prominent on the matter of dealing with complex stratigraphies. His excavations in the town of Ribe are continuously cited for their eminent control of the deeply stratified deposits. He is also experienced within regional studies. Thus he has organised a major study of Ribe Amt, due to be published next year.
- *Hans Krongaard Kristensen*: an experienced excavator within medieval archaeology. Among other things he has carried out excavations in the complex deposits of old Viborg; he participated in project Middelalderbyen, where large amounts of information were processed; and he take part in the Nordic work group for the investigations of the derelict city of Kungahälla in Sweden.
- *Carsten U. Larsen*: In addition to his archaeological degree he has a formal basic education in computer science. As head of the documentation department of the National Museum he has acquired a major knowledge of the use of IT in archaeology and other museum disciplines. An extensive set of international relations and participation in many international conferences has furthered this knowledge. Together with Torsten Madsen he organised and headed a project on "Information Technology within Culture-historical Museums" supported by the Research Council for the Humanities.
- *Torsten Madsen*: an experienced excavator with numerous excavations on mainly Neolithic sites. He has also experience with regional studies, where he has organised and carried one out in eastern Jutland. He has acquired a major knowledge of the use of IT in archaeology: thus he headed a joint venture development project on far distance teaching with University of Aarhus, Aarhus Technical School, and IBM Denmark as partners of the project; Together with Carsten U. Larsen he organised and headed a project on "Information Technology within Culture-historical Museums" supported by the Research Council for the Humanities; He has worked extensively within international organisations dealing with IT in archaeology, and among other things organised the largest symposium ever on the subject (CAA92 - march 92 in Århus).
- *Ulf Näsman*: as one of the leaders of the excavations of the settlement fort Eketorp, Öland, he has long experience in leading and publishing complicated settlement excavations. He is very experienced within regional studies, originally from the settlement archaeology of Öland, but later primarily through work on the theoretical level. Thus he has worked to introduce in Danish archaeology the methods and theories of landscape studies developed by Swedish historical geographers. He has a major insight into publication problems, based on many years as editor of the *Nordic Archaeological Abstracts*. Further he is at present chairman of a group investigating problems of information and documentation within the humanities. The group has been set down by DANDOK, a governmental body for scientific and technical information and documentation.

It has been decided to point to Torsten Madsen as research manager.
All six members of the group - all senior researchers within archaeology - are fully qualified within the archaeological domain. Within the IT domain the qualifications rest with two persons, and only one have a formal education within the field. Although their qualifications are based on a very long and devoted preoccupation with IT issues in archaeology, it is obvious that professional support from computer scientists is needed should the project be realised.

In practice this means that the IT work groups placed on Moesgård and the National Museum (see 2.5) should preferably be constituted on a permanent basis throughout the project and should include fully educated computer scientists. These could be recruited in Denmark, but they could also, depending on

practicalities, be recruited abroad among a number of computer scientists, known to us and already heavily engaged in archaeological projects.

The project is based on the co-operation of four institutions: Department of Archaeology, University of Aarhus; Forhistorisk Museum, Moesgård; Den Antikvariske Samling, Ribe; Documentation Department, National Museum. Together these four institutions represent a full cross section of Danish archaeology (university, national museum, specialised museum and regional museum). This is very important as the project does not aim at research topics that are of interest to a small group of archaeologists or institutions only. It addresses fundamental issues in archaeology, and is hence of importance to all archaeologists and all archaeological institutions in Denmark.

Further, the project incorporates the only two institutions in Denmark that currently have an in depth expertise on the use of IT in archaeology (Department of Archaeology, University of Aarhus and Documentation Department of National Museum).

The major part of the activities of the project will be placed at Moesgård. The main reason for this is that Moesgård houses the largest university department in Danish archaeology with 9 senior researchers and currently 8 junior researchers and Ph.D. Students, and has the largest (face to face),probably most inspiring and active archaeological research environment in Denmark with more than 20 researchers within archaeology (and a little less in social anthropology).

5 PERSPECTIVES

5.1 Educational programme

Archaeology has a relatively high number of Ph.D. students compared to its size within the humanities. In later years Moesgård has continuously had 5-7 Ph.D. students, and it produces about two degrees every year (in Copenhagen somewhat less). The current possibilities of receiving a grant to become a Ph.D. student are not sufficient, however, to accommodate all those who apply. There is need for a more extended Ph.D. programme.

Seen from the point of the present research proposal there is also a marked need for a planned Ph.D. programme with a range of topics relating to the main purpose of the project. The reason is that the most efficient way to make the results of the project count is to bring up a new generation of researchers within the reign of the project. It becomes even more important if one considers that the project is not primarily going to produce empirical data, but rather to create attitudes towards the proper way of doing archaeological research.

Setting up a good Ph.D. programme will be fairly easy, given the nature of the issue, but there are a number of considerations to take into account. One is that there will be a limited number of qualified students among whom to pick. Archaeology does not produce all that many students on an annual basis, and we do not want to undermine the traditional avenues to a Ph.D. study in archaeology. The reason is partly that it may be difficult to reinstall these avenues, once they have been left to others, and partly that the project should not block the path for students with Ph.D. projects of a nature that do not fit into our project. Thus the Ph.D. programmes we set up should run parallel to other possibilities and respect these.

We believe that the maximum number of Ph.D. students we can allow for per year is two. This means that if we accept that the programme to run for six years, we will start a total of eight Ph.D. students over the first four years of the project.

There is another issue concerning Ph.D. students that we would like to stress right away. In concert with the traditions of the humanities and indeed of archaeology, we do not wish to pre-determine a Ph.D. study to a narrow niche within the research domain of a group of senior researchers. The area within which a Ph.D. study should fall will be stated in advance when the grant is advertised, but we want the students to define and argue their own projects to be added as part of the application for the grant. In return, those chosen will have a high degree of freedom to pursue their goals.

We also have to consider the “teaching” of Danish archaeologists in general. The declared goal, to create a change in the way archaeological research is carried out. This makes it necessary and important that we address the Danish archaeological community throughout the project. One way of doing so is through seminars. We will establish two types of seminars. One will be an annual seminar organised by the archaeological research group. The other will be a tutorial-like seminar that presents actual results of the research project in a “hands-on” manner.

The purpose of the annual seminars is to bring methodological issues into focus of Danish archaeology, and create discussion. They should also sharpen the interest of applying for research fellowships.

The tutorial-like seminars on the other hand are considered more to be a *finale* of the project. They should constitute the main activity of the last year of the project, where most other activities ends. The idea of these seminars is to make Danish archaeology acquainted with the results of the research, as well as giving it some "hands-on" experience with the "products" developed. Further, there should be a certain degree of "midwifery" within that year for institutions wishing to change their practice according to the recommendations coming from the project.

5.2 International co-operation and propagation

The project proposed here is fundamentally international. The research could be carried out in many other countries than Denmark, and various projects around the world do indeed have similar intentions. However, none that we are familiar with are anywhere near in scale and potentials to what can be realised here. The point is of course that if the project is realised it will automatically become of international importance, and draw considerable international interest. Disregarding the national obligations - which we do feel we have - we could easily fill up the majority of the positions in the project with foreigners.

National obligations are, however, not equivalent to national interests, and we certainly intend to open up the project internationally through a number of initiatives. Among these initiatives will be a visiting professor position, international symposia, and formal co-operation with foreign researchers on specific issues, and employment of foreign researchers in positions within the project.

The IT component of the project is by nature the most international. Current co-operation patterns on the use of IT in archaeology are more international than national. We know several highly qualified people in various countries whom we would very much like to see as employees in the system development part of the project. We do not know, however, if this will be realisable. Too many practical obstructions may intervene. It is, however, our firm belief that the system development would benefit from an internationally composed team, and we will do what we can to realise this. Also the archaeological research group (including the Ph.D. programme) may have international members. Although the objectives here demand a primarily national composition, we would rather see good national-international mixed teams than exclusively national teams that are less suitable for the purpose.

The visiting professor position is intended to draw international researchers to the project for up to six months on average. This means that throughout the project it will be possible to invite at least 12 researchers as associates. The persons invited will, with a few possible exceptions, be archaeologists. Some of these will be researchers with a specific IT related knowledge; others will be researchers with a specific archaeological knowledge related to the topics treated in the archaeology group programmes. Decisions on whom to invite and when will be balanced between current needs of the project on the one hand and availability of qualified persons on the other.

It is expected that the visiting professors will join in with the ongoing research, making proposals and contributions to its enhancement. Importantly, they should also give a number of lectures within their fields of expertise, internally to the project members, as well as in public to a wider audience of Danish archaeology.

It is the intention to organise an international symposium approximately half way through the project. This symposium should address archaeological methodology in general and it should primarily be archaeological by nature (suppressing the technical aspects of the IT component). Its objectives should be to call attention to the needs for changes in the archaeological methodology, and to bring the project into international focus. The suppressing of the technical aspects of the IT component should be seen with the annual international CAA conferences that take care of this aspect. We organised CAA92, and we naturally intend to participate every year.

In an earlier paper to *Grundforskningsfonden* we named 44 persons as potential co-operators to the project. These persons have been informed of their inclusion on the list and have received a short summary of the project. Many have answered with enthusiasm, some have not answered, but none have answered negatively, despite our stress that they had to inform us, should they not be interested in participation. We will not repeat the list here with addresses, etc., but for general information the names appear in the table below:

Björn Ambrosiani (S)
Hans Anderson (S)
Daniel Arroyo-Bishop (F)
Grenvill Astill (UK)
E.B. Banning (CND)
Juan A. Barceló (E)
Evert Baudou (S)
Björn E. Berglund (S)
Amilcare Bietti (I)
R.W.Brandt (NL)
Alexander Bursche (PL)
Dan Carlsson (S)
Francois Djindjan (F)
James A. Farley (USA)
Richard Hall (UK)
H.A. Heidinga (NL)
Richard Hodges (UK)
Peter Ihm (D)
L.P. Louwe Koijmans (NL)
Kenneth L. Kvamme (USA)
Gary Lock (UK)
Jens Lüning (D)
Michael Müller-Wille (D)
Bjørn Myhre (N)
Clive Orton (UK)
Kazumasa Ozawa (J)
Dominic Powlesland (UK)
Andrzej Prinke (PL)
Dwight Read (USA)
Paul Reilly (UK)
Julian Richards (UK)
Mats Riddersporre (S)
Clive L.N. Ruggles (UK)
Nick S. Ryan (UK)
Helmuth Schlichterle (D)
Irwin Scollar (D)
Mark B. Shchukin (SNG)
Richard D. Spicer (UK)
Zoran Stancic (Slovenien)
Heiko Steuer (D)
Albertus Voorrips (NL)
Mats Widgren (S)
Andreas Zimmerman (D)
W. Haio Zimmerman (D)

This is the list where we will find persons for *ad hoc* collaborative projects. It is also the list from which we would like to pick some of the visiting professors. It should be stressed, however, that the list is not final. It displays a current selection of persons from all over the world who we know - some very well, others more superficially - and consider highly relevant to our project proposal. A survey of the list will show that special emphasis has been placed on experiences with regional studies and knowledge of the use of IT in archaeology.

Considering *ad hoc* collaborative projects, we certainly expect to be able to set up a number of joint ventures with research groups in other countries. The issues we are dealing with are issues of a general nature attracting considerable attention in other countries. We are thus familiar with several projects of direct relevance to what we are proposing here. If we take projects that have a clear IT aspect we may for instance take the following prominent examples: (ArchéoDATA (France), ARCHIS (Holland), Arkansas Archaeological Survey (USA), Birka Grävningen (Sweden), National Archaeological DataBase (USA), North West Wetlands Survey (England), York Environs Project (England), West Heslerton Project (England). We should, however, stress that we will also seek co-operation with projects not specifically IT based. This can be of particular importance to the archaeological research group, where for instance a co-operation "around the North Sea" may be fruitful in connection with regional studies. Collaboration will consist of exchange of knowledge, and particular solutions to problems where the IT component is concerned.

To further international cooperation we also intend to set up an international consultant grid on the Internet so that those who cannot be present in person in Denmark can still collaborate in the project. One way to do this would be to dedicate a large PC under Windows NT or Unix as an Internet node at Mosegard connected via the Aarhus University LAN but having its own account system and appearing as a separate address on the Internet. A suitable List Server on this node could be incorporated with little further effort. A bulletin board of this type, if properly moderated, is a very fine immediate publication and query centre.

5.3 Importance of research programme

The importance of this project lies with its attempt to redefine the archaeological method. It is not a project aimed at creating new empirical data, and it is not a project primarily aimed at creating an increased or enhanced culture-historical knowledge within a delimited area of archaeology favoured by a few archaeologists.

Empirical data and culture-historical knowledge will of course be created during the project, and it will happen in a directed planned manner, but they will remain by-products so to speak. The intended "products" are: better ways of analysing archaeological data, and better and more efficient ways of handling, disseminating and sharing data within archaeology using modern IT. This is the mission we want to accomplish, and granted its success it will dramatically and irreversibly change many things in archaeology - for the better we believe.

In a few words we can state that the importance of this project is that it tries to *place archaeology in the information age in a controlled manner, where IT solutions to archaeological needs are established from an archaeological frame of reference*.

The people behind the present research proposal are all archaeologists by training and by heart. Their engagement with computers is very differentiated. Common to all, however, is the realisation that merely acquiring computers brings no solutions. We acknowledge that it takes a major effort to take advantage of the IT, an effort we cannot exert individually, and we cannot expect the Research Council for the Humanities to support, since they have other more specialised responsibilities.

When it comes to define the importance of this project there is little to say. What we wish to do is to improve the methodology - the backbone of archaeology - and we do believe this to be the most pertinent problem in the discipline today. As one of the international co-operators commented: «I think your objectives should make you a strong contender for research support as it is right on target with regards to directions that archaeology and computers are going».

We cannot but succeed to some degree, and to be frank we are convinced that we will be able to present a major breakthrough. The question to us is not whether the project is important or not - it is - but more how much leverage it will be able to attain on Danish archaeology. We know that especially an older generation of Danish archaeologist is negative to a project of this type. They accept the computer as an administrative help, but deny that it can be of any consequence to basic issues of archaeological research. In contrast to this, however, we find a rapidly growing number of archaeologists realising what is at stake. Through the network project "Information Technology within Culture-historical Museums" supported by the Research Council for the Humanities we certainly saw this happening. Especially the final seminar organised was met with an overwhelming interest, and there was an immense concern about what the information technological development could mean to archaeology. Fortunately there was also an openness to accept that profound changes should take place.

6 DISSEMINATION OF RESULTS

One of the important outcomes of the project will be a number of "products" in the form of ready to use computer-based solutions to archaeological tasks ranging from excavations through to dissemination of results. These computer-based solutions must be freely available, and they must be adapted to run on hardware platforms available to the museums. It is obvious that these software products are essential to the success of the project, and we have to take great care that they are properly described and documented, and clear instructions in their use are provided.

During the project an annual report describing its activities and progress will be provided, and distributed freely to Danish archaeologists, and all others interested in the project. In producing this annual report we have to find a middle road where clear and concise information is provided, but where a minimum amount of time is taken from the research work.

Each research area and topic within the project should end with a formal dissemination of the results obtained. This can happen as one of the earlier mentioned software products, as a traditional printed publication, or as some form of electronic publication. The formal evaluation of the result of the project should be based on these "publications", and for each area and topic it should be clearly stated in the planning details of the activities what should be produced, and when.

A very important dissemination of results will also take place through the extensive Ph.D. programme. As can be seen from the planning parts of this research proposal we give this aspect a very high priority with a total of eight Ph.D. students. The main objective with this high priority is the long-term effect it will have on the dissemination of the results of the project, and hence on its importance. By educating a whole group of next generation researchers within the project, we implant the new methodology into future archaeological research.

A final area, where an important dissemination of results will take place, is through an intensive programme of "hands on" educational seminars placed in the final phase of the project. The idea of course is to confront Danish archaeology with the results of the project, and convince them through demonstrations that the project has produced solutions that they simply cannot be without.

7 CONCLUSION

To conclude this proposal for a **basic research** project we would like to stress a few important points.

The step into the information age holds a major challenge to archaeology. The magnitude, diversity and complexity of data in archaeology are staggering, and it is common knowledge that the discipline has a growing problem coping with its data. Many archaeologists also acknowledge that modern Information

Technology holds a promise to help overcoming this problem, but they are all the same beginning to realise that there is no easy way in. If archaeology wishes to take advantage of the machines, archaeology by itself has to find out how to do it. Nobody else can or will.

To us the step into the information age is **the** major challenge to archaeology today. Nothing really compares to it. To take the step properly, archaeology has to reconsider its methods. These were mostly created a hundred years ago, and are of course closely adapted to the technology of pen and paper. A revised methodology has to be closely adapted to the technology of electronic information handling, and this does not happen if the existing paper files are merely computerised.

The change to a new methodology currently takes place piecemeal around the world, and with many mistakes and endless *cul de sacs* due to a lack of understanding of the medium, and a lack of a planned effort. There are projects that have the right bearing and attitude, but they are mostly isolated, and their results have difficulties reaching mainstream archaeology.

The archaeological methodology of the 20th century was for a large part formulated in Scandinavia by the end of the 19th century. This early contribution to the research tradition together with the rich source material in South Scandinavia is the reasons for the prominent position of Danish archaeology today. *Danmarks Grundforskningsfond* provides Danish archaeology with a golden opportunity to make a prominent contribution to the formulation of the archaeological methodology of the 21st century.

The cost of doing planned research in a new methodology is prohibitive for us to do by our own resources. The Research Council for the Humanities of course could manage by laying off most other archaeological activities, but probably will not wish to do so. It would break up their long-term obligations to support individual research projects, and to promote research initiatives into various aspects of history and prehistory. The two most recent examples of such initiatives are concerned with farms and villages in Danish prehistory and into the medieval period, and with Danish shipping. These typical initiatives of the Research Council will help Danish archaeology immensely to exploit the information from the many new investigations into Iron Age villages, as well as the whole new source material from wrecks along our coasts.

Seen from the established system of resource allocation in Danish archaeology the project proposed here has two drawbacks: It is a development project, not a production project (producing empirical data and/or culture-historical syntheses); and its costs are so high that it would upset most other activities.

Seen from the point of view of Danish archaeology and indeed international archaeology it has two benefits: It will help archaeology to better and more efficient ways of working with data; and it will firmly maintain Denmark's position as a major archaeological “power” into the next century.

Finally, we would like to emphasise the role and importance of Moesgård as the hub of this project. It houses the largest archaeological university department in Denmark. It is the largest archaeological “face to face” research milieu in Denmark. It is a very lively, international research institution, with extensive foreign contacts, and with deep-rooted contacts to social anthropology (also situated at Moesgård). Not least, it is a young, progressive research institution wanting to look ahead. The project was initially formulated at a series of meetings among the senior and junior staff including Ph.D. students in the university department. The final decision to promote the project was **unanimous**, and it was decided to refrain from sending in other “competing” suggestions for projects of a more restricted nature. Following the initial formulation, the foundation of the project was then expanded to include the other co-operating institutions.

Quarter	Moesgård	National museum	Ribe
Apr. 93	*Negotiations with the institutions to house the project. *Appointment of research manager. *Establishment of secretariat.		
Jul. 93	*Rebuilding on Moesgård. *Appointment of head system developer. *Appointment of EDP technician. *Planning of the EDP system for the project. *Advertising of Ph.D. grants (two) and research fellowships (three -one of these for three years) within the general realm of excavation processing and regional studies. Posting to take place in Jan 94.		
Oct. 93	*Establishment of EDP system (including ISDN30 connection). *Appointment of one system developer and one programmer.	*Establishment of EDP system (including ISDN30 connection). *Appointment of two system developers.	*Establishment of EDP system (including ISDN30 connection).
Jan. 94	*Design of RAU (recording system for archaeological excavations). *Appointment of first guest professor. (New appointments to follow every half year).	*Installing of GIS system .	*Appointment of test manager.
Apr. 94	*Prototyping of RAU. * Seminar on data types in excavation recording.	*Design of GISA (geographical information system for archaeology).	*Evaluation of RAU prototype.
Jul. 94	*Produktion of RAU. *Advertising of Ph.D. grants (two) and free research fellowships, all within the general realm of excavation processing and regional studies. Posting to take place in Jan 95.	*Establishment of GISA test version for Ribe County.	*Development of field recording methods.
Oct. 94	*Production of RAU (basic version ready by end of year with all applications for updating). *Seminar on data types and data procurement in regional studies.	*"Copies" of the whole GISA system is installed in Århus and Ribe.	*Testing of RAU. *Input of data to GISA.
Jan. 95	*Standard report generation facilities for RAU are established. *Integration of GISA and RAU.	*Development of GISA as a "frontend" to RAU.	*Input of data to RAU. *Input of data to GISA.
Apr. 95	*Development of application modules to RAU *Seminar on analysis of excavation data	*Development of applications to GISA.	*Input of data to RAU. *Input of data to GISA.
Jul. 95	*Development of application modules to RAU *Advertising of Ph.D. grants (two) and free research fellowships within the general realm of excavation processing and regional studies. Posting to take place in Jan 96.	*Development of applications to GISA.	*Development of field recording methods.
Oct. 95	*Development of application modules to RAU *Seminar on the analysis of data distributions in regional studies.	*Development of applications to GISA.	*Testing of RAU. *Evaluation report on RAU
Jan. 96	*Revision of RAU following evaluation report. *RAU available as a full functional system by the end of the year.	*Development of applications to GISA.	*Testing of GISA. *Evaluation report on GISA.

apr. 96	*Development of applications to RAU and GISA. *Experiments with distributed databases and distributed data processing *Seminar on field recording methods in archaeological excavations and surveys.	*Adjustments to GISA following evaluation report *Experiments with distributed databases and distributed data processing.	*Input of data to RAU. *Input of data to GISA.
Jul. 96	*Development of applications to RAU and GISA. *Experiments with distributed databases and distributed data processing. *Advertising of Ph.D. grants (two) and free research fellowships (one will be for three years) within the general realm of publication/ dissemination of archaeological data and artifact analysis. Posting to take place in Jan 97.	*Development of applications to GISA. *Experiments with distributed databases and distributed data processing.	*Development of field recording methods.
Oct. 96	*Final report on RAU. *Seminar on cross disciplinary approaches to regional studies.	Final report on GISA.	*Evaluation and report on field recording methods.
Jan. 97	*Establishment of distributed databases and distributed data processing. *Develoment of electronic publication forms.	*Establishment of distributed databases and distributed data processing.	*Input of data to RAU. *Input of data to GISA.
Apr. 97	*Develoment of electronic publication forms. *Seminar on artifact analysis in archaeology.	* Integrating DKC data into the distributed database and data processing environment.	*Analysis of data in RAU and GISA.
Jul. 97	*Develoment of electronic publication forms. *Advertising of research fellowships within the general realm of publication/ dissemination of archaeological data and artifact analysis. Posting to take place in Jan 98.	* Integrating DKC data into the distributed database and data processing environment.	*Analysis of data in RAU and GISA.
Oct. 97	*Develoment of electronic publication forms. *Seminar on publication practices in archaeology.	* Integrating DKC data into the distributed database and data processing environment.	*Preparation for publication of the Ribe data in RAU and GISA.
Jan. 98	*Development of an archaeological on-line knowledgebase. *Production of Electronic publications	*Development of an archaeological on-line knowledgebase. *Production of Electronic publications	*Preparation for publication of the Ribe data in RAU and GISA.
Apr. 98	*Development of "the integrated archaeological workbench". *Production of Electronic publications *Seminar on integrated research methods in archaeology.	*Development of an archaeological on-line knowledgebase. *Production of Electronic publications	*Preparation for publication of the Ribe data in RAU and GISA
Jul. 98	*Development of "the integrated archaeological workbench". *Production of Electronic publications *Advertising of free research fellowships within the general realm of publication/ dissemination of archaeological data. Posting to take place in Jan 99.	*Evaluation and report writing on the National Museum part of the project	*Preparation for publication of the Ribe data in RAU and GISA
Oct. 98	*Development of "the integrated archaeological workbench". *Production of Electronic publications *Seminar on knowledge dissemination in archaeology	*Report on the National Museum part of the project *Project stop at National Museum	*Electronic publication of Ribes data.
Jan. 99	*Development of "the integrated archaeological workbench". *"Hands on" seminars.		*Electronic publication of Ribes data.

Apr. 99	*Evaluation and report writing on the whole project. *"Hands on" seminars.		*Electronic publication of Ribes data.
Jul. 99	*Evaluation and report writing on the Moesgård part of the project and the whole project. *"Hands on" seminars.		*Evaluation and report writing on the Ribe part of the project
Oct. 99	*Report on the Moesgård part of the project *Report on the the whole project. *"Hands on" seminars. *Project stops		*Report on the Ribe part of the project *Project stops at Ribe