DIGITAL MAPPING AT ORDNANCE SURVEY

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ABSTRACT

Ordnance Survey (OS) has been digitising its basic scales mapping (1:1250, 1:2500, 1:10 000) on a production basis since 1973. The main purpose for digitising was originally seen to be threefold: to automate large scale map drawing, to facilitate the production of derived maps at 1:10 000 and 1:25 000 scale, and to make digital data available to users as an alternative to printed maps. Cost savings in map production and increased flexibility for users were the motivating factors. The achievements and the digital system developed at OS are briefly described. OS is now undertaking a series of major investigations to improve production methods and introduce new data specifications, taking account of new technology and changing user needs . These investigations will also look at the introduction of digital techniques into those functions of the Department which are still "conventionally based".

INTRODUCTION

This paper is mainly about the large scale aspects of digital data requirements. This is not intended to suggest that data derived from small scale maps or surveys is of any less importance, but is a consquence of OS digitising priorities to meet the needs of users. However a short section deals with the smaller scales where development has been separate from the basic (large) scales.

Brief mention is made in this paper of systems being developed for the speeding up of data capture, updating digital data and the integration of digital data obtained by map digitising, photogrammetry and instrumental survey. These subjects are more fully described in D W Proctor's paper "The Capture of Survey Data" which is to be presented at this Conference.

THE STARTING POINT

The development of the digital map programme at OS and the current state of play cannot be fully understood without an appreciation of what OS had achieved and was doing by traditional methods before the introduction of digital techniques.

In the early 1970s, OS was entering the final stages of a post-war resurvey programme for mapping at scales of 1:1250, 1:2500 and 1:10 000 - the basic mapping scales for Great Britain. Important factors in considering fundamental changes of direction were:

- A well organised and very efficient method of graphical survey had developed. Whether for first time survey or revision a high proportion of detail was surveyed directly on to a Master Survey Drawing (MSD) by the surveyor. The MSD was either the result of high order survey control work, usually with detail from photogrammetry, or a copy of the previously published map on a stable plastic base.

- The mapping was maintained by a system of continuous revision. The survey archive was in the field surveyors' offices on MSDs and not at HQ in fair drawn map form. Methods were devised for transferring this unpublished up to date survey to customers.

- The basic scales maps at 1:1250 and 1:2500 were generalised and redrawn to produce 1:10 000 derived maps. The degree of generalisation and the drawing specification were such that these maps could be further reduced photographically to produce a 1:25 000 series of maps.

- A 1:50 000 (then 1 inch to 1 mile) series of maps was in production. Though deriving some of its detail from the larger scales, special surveys were carried out for this product. The reason for these surveys was that the revision cycles for 1:50 000 maps were generally more frequent than for the basic scales, and full derivation from the larger scales was not practical.

HISTORY OF DIGITAL DEVELOPMENT AT THE OS

After several years of research and development work, OS set up a digital production flowline for the basic scale maps in the early 1970s. The first published (printed) sheets came off this flowline in 1974.

This early development was directed towards automation of the map drawing process. The MSD was digitised by draughtsmen instead of being scribed and the "fair drawing" was produced by a flat-bed plotter. For a combination of technical and cost reasons not all the production processes were automated, so the maps were completed by draughtsmen using traditional techniques.

Digital methods were introduced for a number of expected benefits:

- To reduce the costs of map drawing. The rapidly rising cost of skilled labour and the falling cost of automation was a major consideration.

- The cost of revision which also involves much redrawing would be reduced.

- There would eventually be savings in derived mapping costs if generalisation and redrawing could be automated.

- In the longer term, accuracy would be more easily preserved. Redrawing destroys some of the accuracy, and ultimately resurvey becomes necessary. Again, potential savings were significant.

- Digital data could be supplied to users instead of the printed map, giving them greater flexibility to meet their mapping needs and other advantages.

In the early 1970s OS concentrated on the development of cost effective digitising and automated map drawing methods which were capable of matching the accuracy and quality of existing maps. At that time, the use of digitising tablets and plotters in a production environment was new and the rules and practices required to make the best of this technology were being established as the flowline evolved. OS being at the forefront of this work found that software could not be bought in and it had to be written in-house.

In 1973, the Development Unit entered into discussions with the potential users of digital data (actual users were then few in number) about their longer term needs. It was appreciated that the potential of digital data was not only in the drawing of user-defined maps, but also in the computer solution of planning and land management problems. It was further evident that applications of this sort required a different data specification from that being used at OS. With funding from the Department of the Environment (DOE) a Restructuring and User Languages project was initiated. Restructuring was concerned with the reformatting of the data into links and nodes by software, and the User Languages dealt with the recognition of objects such as land parcels, roads and railways, also by software. The "Dudley 400 Project" produced data by Restructuring and User Language "Land" to form land parcels for the Metropolitan Borough of Dudley. Although worthwhile experience was gained during the project it did not result in a production method. The existing digital data could not be changed without a costly interactive stage which defeated the intention of the project to reformat the data by software.

In 1975 the OS Development Unit (forerunner of the current R&D divisions) began to investigate the production of derived maps from basic scale data. The flowline for digital map production was well established and sufficient large scale data had been captured to permit the investigation of this stage in the digital development programme. Maps at 1:10 000 were produced successfully although the drawing specification had to be modified to achieve this. Subsequently, it was demonstrated that this saved about 50% of the conventional drawing costs. However, major difficulties began to emerge when 1:25 000 mapping was attempted. The specification changes for 1:10 000 scale eliminated most of the generalisation that had previously taken place at that scale making the photographic reduction to 1:25 000 no longer possible. Therefore, the 1:25 000 scale map had to be produced independently and the generalisation was thus shifted from one scale to another. One 1:25 000 scale sheet was published and several more are in the final stages of production, but the generalisation problems have not been satisfactorily solved. This is particularly so in urban areas where the generalisation processes have not coped satisfactorily with the large amounts of detail originally captured at 1:1250 scale. Taking the two derived scales together, digital production has proved to be more expensive than conventional: the increased costs of 1:25 000 production swallowed up the savings achieved at 1:10 000 scale. Furthermore the quality of the 1:25 000 digital maps is inferior to the conventional product, particularly in urban areas. Production of digital maps at both scales will be discontinued until better generalisation methods are developed.

During the first 10 years of digital production at the OS, digitising remained a Headquarters task for draughtsmen, concerning only the final part of a survey and data collection system. Revision information was dealt with in much the same way as an initial digitising task. However it was seen that the next logical step was to increase the use of digital techniques to create a system in which revision surveys and resurveys could produce digital data directly. Not only does this make good management sense, eliminating the need to digitise work surveyed in the field, but it also enables new digital data to be transferred to the customers more rapidly. OS R&D devised a digital field update system which has been tested by a pilot production project in the West Midlands. Major investigations are in hand to develop digital photogrammetric capture techniques, incorporate instrumental detail survey into the digital archive and to introduce raster data capture systems into the initial digitising processes. These projects are described in D W Proctor's paper to which reference has already been made.

The OS is very much aware of the need to introduce faster methods to create a digital archive from the published maps. Investigations and experiments are in hand to test the feasibility introducing scanning methods into the data capture process. However this technology is difficult to apply to the MSD on which the surveyor has drawn new detail and deleted features which no longer exist. The surveyor draws in ink and line weights and density do not exactly match the original graphic. It is the essential nature of the MSD - as a working drawing - which makes it difficult to use as an input to the scanning process. OS now have to test the cost effectiveness of scanning high quality originals and adding surveyed work interactively. We also need to confirm that this combination of methods produces a satisfactory revision document.

CURRENT PRODUCTION

Until 1984 digital map data for the OS digital databank was produced entirely within the Cartographic Divisions using digitising tables and interactive edit stations. As a result of initiatives by the House of Lords Select

Committee on Science and Technology a submission was made for more financial support to accelerate the production of digital data. Agreement has been given to an expanded production programme which should result in all 1:1250 urban mapping being digitised by the mid-1990s and the conversion of the remaining basic scale mapping to digital form soon after the turn of the century. While this is not as early as many users would wish, the availability of digital topographic data may be brought forward by new techniques and developments in data capture and coding. A major benefit of this programme has been the involvement of others with digitising work; an increasing number of map sheets are being digitised by an ever expanding number of contractors. This is fostering an increase in the private sector capacity, and an expanding awareness and expertise in digital mapping techniques both for exploitation and in data capture.

Current digital production from all sources has now reached between 4000 and 5000 sheets per year and is expected to rise to around 7000 sheets a year in 1988.

USER REQUIREMENTS

During the development of digital mapping OS has taken steps to identify the needs of users of digital data. A number of seminars have been held in various parts of the country and a number of OS consultative committees have digital data sub-committees. The most recent user study has been to define the requirement for small scale digital data, while currently the structure and content of new digital databases to replace the existing magnetic tape databank are being investigated.

There is considerable variation in the use of digital data. This varies from relatively simple facsimile map production to highly complex data analysis. The latter will require sophisticated databases and be capable of giving answers to questions relating to not only the map data itself but also to attributes of the data input by the user.

CURRENT PHILOSOPHY

For established users it is essential that data meeting the present specification is available from OS for some years to come. This means that blocks of data must be completed in suitable geographical units and that revision of these units must be maintained until such time as a specification change can be effected without disruption of existing user systems. Notwithstanding this, a number of influences have combined to cause OS to undertake a major study of its digital system and the data it produces.

The current OS digital mapping system has been developed piecemeal with parts of the long established and successful conventional flowlines being tackled independently and at different times. A shortage of resources, both in finance and manpower and affecting both R&D and production areas, have made it necessary to adopt this approach. Additionally, the necessary expertise could only be developed over a period of time. Nobody in 1970 could have designed a system capable of meeting large scale map production, derived mapping, revision, and users' needs for digital map data. However during the past 16 years OS has investigated all of these aspects and, whilst not claiming that all the problems have been identified and satisfactory solutions found, the point has been reached when for technical and practical reasons the whole digital system can be reconsidered.

The system clearly suffers from:

- Lack of an integrated design; matters such as map production, field survey and data storage have been dealt with separately; the problems this causes in computer systems are well known.

- Software that is specific to the map production application. A more flexible design would be achieved if the data was the product with map production becoming just one of the applications.

- Dependence on old ideas and technology concerning hardware, communications, software design and data handling concepts.

- Design based upon the automation of a traditional flowline which was itself organised for a particular product.

The result is a system which is not the most efficient for the collection, storage and maintenance of digital data and one which makes it difficult to adapt to changing technology and to use.

When the results of surveying are in the form of digital data rather than a map a number of constraints are removed. A map imposes limitations on the amount of and the type of data that can be stored and hence transferred to the user. It reduces the accuracy of all survey to a plotting accuracy which depends on the scale of the map. In a digital environment, the height data collected during photogrammetric and instrumental field survey need not be discarded, and this may be of considerable benefit to users. The date of survey, date of change and method of survey of individual features and even coordinated points within those features can be recorded. This has implications for revision and accuracy which previously could only be described in a general way for a whole map sheet and now means that both OS and the users can benefit from more detailed information about the topographic data in itself. The accuracy of a survey need no longer be constrained by the scale of the eventual map sheet; the OS surveyor can use the most appropriate method of data capture taking account of such factors as density of detail and user requirement within local pockets, and knowing that high accuracy work will be preserved for future use. This brings the "scale free" data concept closer to realisation.

At present the main demand for OS topographic data is still in map form and the main requirement for digital data is often no more than a computerised facsimile of a map. It is only recently that a trend has emerged for digital data that is suitable for computer analysis within Geographic Information Systems. It must be stressed that this is only a trend and at present there is little customer pressure on OS to satisfy such a market. However it is accepted that information systems which use topographic data will be the next development in the continuously changing user requirement and OS will have to prepare for this. Its main implication is on the data specification; this must include topological relationships and recognise that mere digitised lines and points are not adequate. Of course, these improvements do not come without cost and the benefits they will bring to users must be carefully assessed and will ultimately be reflected in charges.

OS believes that its role in the future will be to create and maintain an information system for topographic data, which can be used both to produce maps and to supply digital data to users. It is aware that the user need will change, probably at an accelerating rate, requiring consequent change to data specifications and the method of data supply. Therefore, it must develop a system which is flexible enough to respond to these changes.

THE DATABASE CONCEPT

Modern database methods and their associated concepts place emphasis on the importance of data rather than applications of the data and so offer the flexibility that is needed. A major study is now underway to design and implement a modern topographic database.

As suggested above, the priority for the study is to define the data and its most appropriate structure. The closer the data is to representing topography and associated cultural information, the greater the flexibility and number of applications that will be possible. But there are constraints. Reality is complex and can only be partly represented in a computer at a reasonable cost and the technology available for data capture has limitations. The study is attempting to identify the best data model and then apply the known constraints to produce one that is practical at present. To achieve this demonstrator system is being created within OS R&D, with assistance from contractors.

What is practical is determined by

- the technology available for data capture, storage and transfer
- the value of the data and the system that supports it both to OS and to its customers
- existing commitments concerning products and customers
- organisational matters, such as the number of staff available with particular skills
- the amount of money available.

Consequently, the study encompasses many facets; a systems analysis at OS, an investigation of user requirements and an examination of what is technically possible are all necessary before any decisions can be made.

At the moment OS foresees a database, centralised or distributed, for basic scale data in a number of different specifications. One of these specifications must incorporate topological relationships and other enhancements so that the OS can respond to the changing needs of users. However, the data which has already been produced cannot be discarded or immediately converted to something different. Furthermore, data capture devices and the expertise of the operators cannot be replaced overnight, nor can existing users be expected to suddenly alter their systems, so change must be accomplished over a period and data will continue to be digitised to the existing specification in specified areas for some time to come. The database must therefore be able to store data with two or more specifications and supporting systems must be developed for data capture, revision and supply in either specification. The need to convert existing data to a new specification will eventually arise because of internal and customer pressure, so the necessary conversion techniques must be developed. Conversely, data digitised to the new specification must be made to behave like the old data for certain users.

The database study will have a major impact for the future of OS. Although at present there is little connection between the database for large scales and the smaller scales the study is also investigating the data requirements and the database needed to support the smaller scales.

SMALL SCALES

So far the paper has dealt with the large scale maps and data. The small scale products are no less important and the production of digital data for these scales is not being neglected. In fact database techniques were first investigated at OS using data from some of our smallest scale maps.

A small scale database (1:625 000) was created within OS R&D several years ago as an experiment, using the Route Planning Map, Administrative Areas Map and the General Topographic Map as source material. Not only did this generate experience in the design of databases and appropriate data capture techniques, but it was also used to develop methods for the production of high quality maps from a database which was principally modelled around the needs of a topograhic information system rather than cartographic requirements. A number of products have been made from this database and the data is now being marketed.

It is thought that for some time to come it will be necessary to maintain separate databases for large and small scales, possibly with more than one small scale database. However it will be important to use similar data models and data structures, perhaps with direct links between the databases, particularly where topographic accuracy is being maintained between them. Effort is being concentrated on the creation of a database from our 1:50 000 scale maps, but initially with a reduced data content, and a demonstrator is being created in parallel with the large scale demonstrator. OS is examining 1:50 000 digital data produced by other agencies with a view to using this in the database and has started digitising one 1:50 000 sheet for assessment by potential users.

CONCLUSION

There is little doubt that the future of survey and mapping lies with computer based topographic information systems. And beyond that, by the addition of non-topographic information, systems will be developed into the geographic (or land) information systems which are now much discussed.

It is not now a question of 'if' but of 'when' and 'how' these systems will be introduced. Their development and use will require new concepts and skills from both users and producers of topographic information. These changes are challenging: in the past OS has anticipated user needs for digital mapping and will now continue to lead in this field. Discussion now centres on how quickly systems can be developed; to some extent this will depend on the ability to prove their cost-effectiveness which will demonstrate the benefits of increased user expenditure on these systems.