DIGITAL DATA : THE FUTURE FOR ORDNANCE SURVEY

M SOWTON
ORDNANCE SURVEY
ROMSEY ROAD, MAYBUSH, SOUTHAMPTON, SO9 4DH

ABSTRACT

Ordnance Survey has been producing digital data at large scales (1:1250, 1:2500 and 1:10 000) since the late 1960's. Progress since then and the major factors affecting the development of digital mapping in Great Britain are described.

A number of issues are coming to a conclusion with the implementation of a pilot database, based on the successful study project and prototype trial which ran from 1985 until 1987. The paper explains the uses which will be made of topologically structured data for automated map production, customer designed maps and specialised datasets for various purposes.

The OS large scale digitising programme now includes blocks being digitised by the Utilities (water, gas, electricity and telephone). New data specifications and quality control procedures have been introduced to ensure acceptable data standards are achieved.

With the increased number of digital maps available increased capacity to revise the digital data is needed. Recent projects have confirmed that a field office can function satisfactorily without record maps.

INTRODUCTION

The Ordnance Survey of Great Britain (OS) is a Government Department with responsibility for the provision of topographic information in forms which customers require and can be economically supplied.

The original surveys of OS in 1790 concentrated on mapping at one inch to one mile, and later six inches to one mile, but modern mapping has been concerned with much larger scales. Today the official map coverage of Great Britain is as follows:

1:1250	54 600	km^2 sheets - urban areas
1:2500	164 600	1 km^2 sheets - developed rural areas
1:10 000	10 200	5 km x 5 km sheets - full cover derived from the above scales except in mountain and moorland areas
1:25 000	1 374	10 km x 20 km sheets
1:50 000	204	40 km x 40 km sheets (nominal size)
1:250 000	9	sheets
1:625 000	2	sheets

Not all these sheets have been digitised, but at present large scale digital data exists for:

1:1250	35 210 sheets (65% coverage)
1:2500	19 135 sheets (12% coverage)

Although various survey techniques have been used over the years to create these maps they are now kept up-to-date by predominantly graphic survey methods supported by instrumental survey and some photogrammetry. The up-to-date survey of an area is held in a local field office as an inked plot on a plastic field document known as the Master Survey Drawing (MSD). This method has proved to be extremely cost effective and digital revision methods have been designed to maintain this process as well as incorporate output from field instruments and photogrammetry.

Only in the last 2 - 3 years has interest in digital data caused OS to reconsider the nature of digital data as a product in its own right, and not purely as a technique of map production. Nonetheless the bulk of OS revenue is realised from the sale of large scale graphic products and royalties paid for copying and other use of these maps. Digital data is increasing in importance as a product, but for some years it is likely to be a lower revenue earner than graphics.

Graphic products are sold in 3 main forms. Firstly as printed copies which as time passes, become more and more out of date until a new edition is produced. Secondly as enlargements from 35mm microfilm output known as SIM (Survey Information on Microfilm). And thirdly as direct copies from the MSD produced in the survey office known as SUSI (Sale of Unpublished Survey Information). This allows the customer to have access to up-to-date mapping but has limitations regarding presentation. These services or improvements of them have to be maintained from the digital data as part of a fully viable digital process.

With this background in mind it is perhaps best to consider the development of the large scale digital processes at OS in 4 separate periods before finally taking a brief look at the future prospects.

Origins of OS digital mapping	1968 - 1972
Digitising Progress	1973 - 1982
Recent Past	1983 - 1987
Current Events	1988 - 1989

ORIGINS OF DIGITAL MAPPING AT OS

In the late 1960s a study of the possibilities of using digital techniques was carried out. At this time computer processes for automating engineering and architectural drawing processes were emerging, and it was considered that similar techniques could be adapted to the process of large scale map production.

Two approaches were studied. Initially production of digital data directly from photogrammetric plotting machines was investigated, but eventually the development of digital procedures centred on the digitising of existing maps. These early investigations concentrated on the reproduction of the original map to the same standards of accuracy and quality.

The reasons behind the adoption of digital processes were based on the benefits which were considered would arise in the automated reproduction of the maps and the derivation of smaller scale maps. The early data was collected as a series of strings captured in a sequence decided by the digitising operator. Each feature was assigned a feature code and a serial number, but the extent of each feature was determined more by digitising convenience than any other consideration. Data for each map was held in separate files on magnetic tape which started with a map header followed by the map data.

Feature codes were attached to the data in order to identify what each represented on the ground, and later to allow features to be suppressed in derived map production.

The digitising was blind, checked on a plot and corrected off-line, and this process was repeated until an acceptable result had been achieved.

DIGITISING PROGRESS 1973 - 1982

The processes described above continued to be refined with the introduction of more efficient data specifications and storage, interactive screens and improvements in techniques, but the basic concepts remained unchanged.

With only few customers for the data and conscious of the need to create a cost effective use for it, OS experimented to a greater degree on map production processes and the creation of derived maps from the digital data, rather than investigations into using it as a product in its own right. Despite all the effort expended, it was not possible to achieve 100% facsimile reproduction of the large scale maps because the available plotters could not cope with ornate symbolisation, a problem exacerbated by a data structure which did not support polygons. As a result much of the ornamentation had to be added by hand to a plot of the digital data. This partially accounts for the lack of success in deriving 1:10 000 scale maps from the larger scale data. Other contributing factors were an inappropriate data structure for computer generalisation, and a traditional specification on which 1:25 000 derived production depended.

Despite limited achievement during this period digital mapping was stimulated by the report of the Review Committee of OS, known as the Serpel Committee which firmly endorsed the policy of converting the large scale maps into digital data. Its recommendations were a great

support for the continuation of the digital programme.

As a result the potential of digital map data was investigated by a growing number of users, and in some areas trials of data were set up in collaboration with OS. The most significant of these trials which became known as the Dudley Project, was really two separate projects, one developing out of early structured data experiments and a second using the digital maps as a basis for an information exchange and record system for the Public Utilities. Both these trials were highly significant in the development of digital map use. In practice, the Utility project has had most impact because it focussed attention on the importance of using a common digital map base for the recording of Utility plant records and the need for such data to be provided as quickly as possible. The structured data project was more significant in terms of spatial analysis and the benefit which could accrue from such use, but unfortunately was overshadowed by the Utility project where the maps were only used as a background to the Utility plant records. The structured data project was undoubtedly the precursor of GIS in Great Britain, but was probably too advanced for the state of the art at that time.

OS had to design digital conversion and revision policies without having a definite user requirement. Clearly it was not sensible to produce data which no-one wanted and equally doubtful to maintain existing data which no-one had bought. However, it was decided to continue with digital conversion, a system to revise digital data based on existing graphic survey methods which became known as DFUS (Digital Field Update System) was being developed, and digital photogrammetry was revived.

In 1982 a House of Lords Select Committee on Science and Technology studied the subjects of Remote Sensing and Digital Mapping. Their recommendations included further support for digital mapping and the acceleration of the OS Digitising Programme.

Thus by the end of 1982 there appeared to be a growing interest in the digital map data itself which was available for about 25% of the urban areas. The need for digital mapping had been established through the Review Committee of OS, the Select Committee of the House of Lords and OS had itself held seminars to establish the needs of users. Nonetheless it was still largely an interest expressed by potential users rather than a commitment to purchase data and there were few indications about where it would be most worthwhile to produce the additional data. The ability to update the data and processes to derive smaller scale maps were being investigated and emphasis was increasing on ways to accelerate the digital conversion.

RECENT PAST 1983 - 1987

This was the most active period in the development of digital mapping in Great Britain. After the Government response to the report of the House of Lords Select Committee the OS made representations to the Treasury for

additional funds to accelerate the digitising of the large scale maps. These funds were used to employ outside contractors on the digitising process.

Up to 1985 the digital data was stored in serial file form in a tape databank, but it was becoming clear that some improvement was essential. The opportunity was taken to launch a study into the requirements for digital data by both customers and the OS itself together with a review of the techniques of storage, handling and management. The study team carrying out this project produced its report in December 1987, having implemented a prototype database based on relational technology using a small Briton Lee database machine.

While the database study proceeded the improvement of DFUS and the investigations to integrate digital data from photogrammetry and instrumental survey continued and for operational reasons the tape databank was replaced by magnetic disc storage but still in serial file form.

As a direct outcome of the House of Lords Select Committee, in 1985 the Government set up a Committee of Enquiry into GIS under the chairmanship of Lord Chorley. The enquiry added considerably to the already growing pressure on OS to increase the output of digital map data, and within its recommendations were important proposals for OS to collaborate with its major customers in funding and acceleration of the digital conversion programme. Subsequent high level negotiations with the Utilities led to an agreement whereby customers for digital data in areas not yet digitised would let contracts for digitising within the framework of an OS controlled programme. This digitising would be carried out to a reduced feature code specification known as OS 1988, and a quality control procedure based on statistical sampling was introduced. Data which met the specification would be accepted into the National Topographic Database, kept up-to-date by OS, and sold to other customers to the mutual benefit of OS and the customer letting the contract. Thus, completion of the digitising programme became a realisable objective for the near future.

In this period a trial was started to investigate the possibility of using digital data to support a field survey office, which did not hold any map graphics, but which could satisfy its needs for all survey drawings directly from the digital data. The trial area was established in Milton Keynes where collaboration between the OS Agent, the Development Corporation, local customers and the OS field office tested the concept of a "map-less" field office. In addition to this primary aim Project 88, as it was called, was expected among other things to investigate the practical and economic limitations of supplying a wide range of high quality graphic products directly to the public from the field office. The equipment for the trial, which was a variation of the standard DFUS, was installed in July 1987 and the system was worked up in parallel to the conventional revision methods so that by the launch date in

January 1988 all the MSDs for the trial area could be destroyed.

At the end of 1987 the team carrying out the database study reported favourably about the introduction of structured data with predictions of cost savings in the production of graphic maps, and also produced an implementation plan for a pilot project to test their conclusions. The study concluded that significant benefits would accrue from:

- a completely digital large scale map archive
- topologically structured data
- the addition of management, quality and process data to the topographic data

and that as a result of these changes in data specification, there would be additional benefits if database management were to replace file management, and more on-line communications were to be introduced. The implementation plan for the Pilot Topographic Database, as it was called, contained 3 main elements:

- to develop a fully automated map production system which would eliminate all manual intervention

- to create a pilot area to test the conclusions of the database study

- to carry out Marketing and R&D projects to examine the implications which would arise from the full implementation of a data management system based on the conclusions of the database study.

CURRENT EVENTS 1988 - 1989

The early part of 1988 was one of consolidation, the implementation plan for the Pilot Topographic Database was accepted, Project 88 was launched, the feature code specification OS 1988 and the quality control procedures were finally agreed, agreement was reached with British Telecom and other Utilities over the terms on which they would digitise areas where digital mapping could not be produced in time by OS, and contracts for the supply of digital update by OS at various levels of change were arranged with a number of customers. The possibility of a completely digital large scale operation which was cost effective was beginning to emerge.

Project 88

The outcome of this project has been the acceptance of the financial and technical advantages of using a field system to maintain the digital data. The ability to discard the graphic survey records (MSDs) and rely completely upon the digital data to furnish the day to day needs for field documents has improved efficiency, increased output and reduced the cost of the equipment. Authority has been given to deploy 12 additional field update systems currently based on SUN workstations and a number of offices are being converted to "map-less" working.

A fundamental addition to the OS product range was also possible with Project 88. In the past customers could buy SUSI or SIM as the most up-to-date survey information, but with up-to-date digital data it was possible to provide customers with high quality graphics to a variety of specifications, scale and sheet layout directly from the field office.

Instrumental Surveying and Photogrammetry

While Project 88 concentrated on the main issue of how to automate a very economic, but low order of survey, other projects have concentrated on how to merge data from higher accuracy survey methods into the data. Techniques to integrate the coordinates of points fixed by Instrumental

Survey into the database have been developed. Data recorded by survey instruments is now coded and incorporated directly into the digital archive, immediately after capture.

Similarly with photogrammetry, as a result of developing new techniques there is now less movement of detail at the field completion stage and most digital data from photogrammetry goes into the database unaltered.

The ability to assign quality codes to each of these data sources to show that it is better than data originating from cartographic digitising or graphic survey is being developed as part of the Topographic Information System (TIS). (See later)

Pilot Topographic Database

The Pilot Topographic Database has now been publicly launched, although not all areas of the pilot can go live before April 1989. The original intention to select one area was not possible and a compromise has been adopted to create a database covering more than one area where different aspects of the project can be tested.

The main considerations in the pilot project are:

- Relational database management for the topographic data with improvements in data handling and storage of information related to the data.

- Structured data with object building and attribute attachment.

- Increased production efficiency with the eventual establishment of a Topographic Information System.

Relational Database Management

In the earlier study a relational database was identified as the most efficient way in which structured data could be stored together with the associated objects and attributes. A software relational database management system was tested on a standard computer where it was found it be very slow, and a much larger computer would be necessary to give a

realistic performance. Tests on a specialist database machine from Britton Lee showed this type of machine to be more suitable for small amounts of data.

Government procedures for the purchase of computers is slow and although OS could have called for tenders on a given operational requirement, this would have delayed the start of the pilot project. It was eventually agreed that OS should purchase a larger Britton Lee for the pilot project and seek competitive tenders for suitable computer equipment before the implementation of the full system if the outcome of the project endorsed relational database management with structured data as the best way forward. A Britton Lee IDM 700 model 140 was obtained for the pilot project.

Structured Data

The bulk of OS digital data remains much the same as that described earlier. The structured data is produced from

this by digitising some additional information, mainly polygon points, creating a link and node structure by software with some interactive editing and building objects of the polygon type also by software, using the polygon points which can then be discarded. The attributes of these polygons can then be used to fill areas with symbols, other ornamentation or colour. The topological relationships thus identified are explicitly stored in the database along with attributes deduced from the original data. Positioned text, previously used for cartographic purposes is now being attached to the points, links, nodes and objects to which it actually belongs as an attribute.

Topographic Information System

Although the full details of the TIS have not yet been developed, the concept is simple. Management data will be held as relationships or attributes in the database associated with the topographic data, allowing information about production control, revision status, data quality, history (date of survey or demolition), rates of development, attributes defining treatment of data at other scales etc to be recorded for objects or features within the database.

It is anticipated that the Topographic Database will be linked with other databases associated with the graphic maps such as the Map Information Database and the Digital Marketing Database to create a comprehensive central system for topographic information, that is, the TIS.

The Pilot Project Area

In order to test one of the main benefits identified in the earlier study, it has been decided that all new editions since the start of the project will become part of the pilot database project. This will demonstrate the cost advantages which are expected from the production of new editions directly from the structured data. This decision means that

a number of isolated maps all over the country will be created in structured data to test this map production process.

Three areas have been selected to test other applications. Most important is a block of data covering Tameside Metropolitan Borough in Greater Manchester where the Borough is committed to a trial of GIS and is also prepared to produce maps from the data for OS customers. Of slightly less importance is a small block of maps wanted for a pilot trial of GIS for the City of Birmingham, which together with a larger block also in Birmingham, makes up the second area. The combined block could be used to extend the pilot GIS if successful, but is needed to prove that an OS map agent can use the digital data and produce graphics for customers in his own premises. Finally, there will be a block of mapping covering the Project 88 area in Milton Keynes where it will be possible to test the relationship between the structured data and the Project 88 operation.

It is anticipated that the structured data produced in these 3 areas, together with the structured data for new editions will allow OS to evaluate the advantages arising from it, and the use of a relational database in a production environment. The significant customer linked advantages which need to be tested are:

- The use of structured data outside OS.
- The ability to produce graphic products directly from the data.
- The creation of additional digital products.
- The production of microfilm output.
- The handling of digital data by agents.

Graphic Products from the Data

For some time it has been recognised that digital data will only be a valuable asset for OS if it can be harnessed to produce not only a range of digital products, but also a range of graphic products similar to the current range of printed paper maps and copies of the surveyors drawings like SUSI and SIM.

It was realised that this could only be done by eliminating manual cartographic processes, by substituting software processes to create similar effects, and by modifying the map specification within acceptable limits. A flowline has been created so that in future, all new editions will be produced in this way. This process has become known as AMP (Automated Map Production) and its success depends on structured data, some additional feature codes and a high quality electrostatic plotter. It has at last been demonstrated that digital production of maps is cheaper than could possibly be achieved by conventional manual methods. As an extension of this process it is possible to carry out a variety of manipulations on the data:

- Altering the sheet layout.
- Changing scale.

- Suppressing detail.
- Adding symbols.
- Adding colours.

All of which can be achieved through the medium of the structured data. A customer wishing to have a non-standard product to his own layout, scale and specification can within limits, specify what he needs and have a plot within a short period. This service has become known as CPCD (Customer Plots from Current Data). Both AMP and CPCD depend on the map data being up-to-date to achieve their maximum potential. If this can be done on a regular basis then the current SUSI service would be replaced by an up-to-date high quality graphic output.

Now that all the processes have been perfected AMP is capable of producing standard 1:1250 new editions where digital data exists, giving a result little different from printed new editions on chart paper. A recent breakthrough in the way in which areas are calculated and parcels are numbered has made it possible for 1:2500 new editions to be produced in the same way.

Location of Map Production Facilities

The map production processes described above are very fast. With up-to-date digital data it is clearly not sensible to print maps and store them pending the arrival of a customer. The sales and distribution processes are being reviewed and experiments are in hand to place the map production outlets throughout the country. Using local storage of data or communication links, OS is installing plotters and processors in a survey office, map processors sales agent and a Local Authority to test the viability of a "walk in and buy" map service.

Additional Digital Products

With structured digital data it is possible to create datasets for specialised uses. As part of the pilot database trial, three such datasets will be made available to the public.

- OSBASE: The standard structured digital map data usable as a base for GIS and graphic plot production.

- OSLAND: A product based on OSBASE with all the land and highway parcel polygons closed and referenced. This dataset includes additional feature codes, reference numbers, post codes and postal addresses.

- OSCAR: A dataset related to the road network for use in navigation systems and for solving road related management and maintenance problems. This dataset includes road names and classifications linked to each network segment.

It will be possible for the OSBASE dataset to be delivered to customers indistinguishable from current data, since the advantages inherent in the data for OS map production processes can be suppressed for those users not wishing to exploit the benefits of structured data.

Microfilm Output

It is possible to produce microfilm directly from the existing digital data, but because that data does not include all the details required to draw a complete new edition, microfilm produced in this way is incomplete. However, using structured data in a variation of the AMP flowline it will be possible to produce an up-to-date microfilm as soon as significant change has been recorded.

It is considered that this will remain a standard outlet for up-to-date graphic output for a wide range of customer for some years to come, particularly in areas where change is small and digital production methods by OS agents are not justified.

Enlarged prints from microfilm produced in this way would be indistinguishable from the AMP product and would have the advantage of being frequently updated unlike the current SIM.

FUTURE PROSPECTS

Production of digital data has increased rapidly in recent years. First as a result of the reduction in the feature code specification, secondly by the employment of contractors by OS, and thirdly through data produced by contracts let by the Utilities. This has increased the total amount of digital data and consequently the sales of the data, but has also placed greater emphasis on the requirement to keep the digital data up-to-date and to manage the data.

The results of Project 88 have shown that a cost effective solution for the revision process based upon digital data is possible, and additional equipment will be deployed in step with the requirements to maintain digital mapping in areas of high demand.

If the technical benefits of structured data are proved to be cost effective by a successful outcome of this part of the Pilot Topographic Database project, AMP and CPCD can be introduced as standard map production processes from which significant savings and opportunities to increase sales of large scale graphics should result.

The Pilot Topographic Database is due to report towards the end of 1989. The prime issues will be the use of structured data outside OS and how such data is to be created, manipulated, revised and stored. Whether a relational database is essential for the efficient handling of structured data and the creation of a Topographic Information System will form an important part of the results. Thus the success of current trials of GIS will

have an important bearing on the extension of structured data into other areas.

The introduction of structured data will create problems with the editing process which has not been designed to cope with topological relationships in the data. Investigations are in hand to create an Advanced Edit System to take account of this requirement.

Investigations into the possibility of using attributes rather than feature codes to derive 1:10 000 scale maps from the large scale data appear promising, and will provide additional justification for the introduction of structured data.

A major factor in the future will be the marketing of both the structured data and graphic products produced from it. Part of the Pilot Topographic Database project is concerned with customer requirements and the way they are met. The CPCD option lends itself to a direct output of a plot from digital data to a customer specification directly from the OS Agent, the field update system allows data to be plotted for customers in OS field offices, and AMP would provide up-to-date plots from Headquarters. Added to this are the various ways in which the digital data can be provided to fit different applications.

In areas where digital data exists the production of OS large scale mapping is now entirely digital. The uncertainties which remain should soon be resolved, digital coverage increased, and a digital future for large scale products ensured to the benefit of both customers and OS.