

THE DEVELOPMENT OF AN AUTOMATED MAPPING SYSTEM
FOR THE ELECTRICITY DISTRIBUTION SYSTEM IN THE
SOUTH WESTERN ELECTRICITY BOARD

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ABSTRACT

The Electricity Supply Boards of the United Kingdom are required by statute contained in the Electric Lighting (Clauses) Act 1899 to maintain records of underground mains and services. The South Western Electricity Board had by 1981 accumulated 19,000 record maps of urban and rural networks based upon Ordnance Survey map background and normally held on translucent material for reproduction. The maintenance of this stock of records in this form is a significant manual task comprising updating and replacement of the ageing archive. In 1981 consideration was given to the transfer of these records and the associated map backgrounds to digital form to eliminate this task and to establish an associated data base for design and general facilities management concerned with the Board's assets. The paper describes the project trial which was undertaken to evaluate this possibility and which formed the basis for an investment appraisal which subsequently led to a Board-wide installation of computer graphics equipment to provide an automated mapping and facilities management system by the early 1990's.

INTRODUCTION

The South Western Electricity Board supplies the south west peninsula of the United Kingdom from Bristol to Lands End. The area, some 14,400 square kilometres, contains more than one million electricity consumers supplied from 28,000kms of overhead network in the rural areas and from 16,200kms of underground cables in the urban areas. The Board's general management is based at

its Headquarters in Bristol and four regional managed units are located at Bristol, Taunton, Exeter and Redruth in Cornwall. There are also subsidiary offices at Bath, Weston-Super-Mare, Barnstaple, Torquay, Plymouth and Bodmin.

The statutory requirement to maintain records of the distribution system has been met by the creation of 19,000 record maps, made up of 11,000 records at 1:2500 scale in rural areas, and 8,000 urban records at 1:500 scale or larger.

The average life span of such records held on translucent, often diazo, material is of the order of 20 to 30 years. As time passes the film can darken or be damaged by handling or alteration, which affects legibility when such records are copied. In 1981 it was assessed that 10,000 record maps required replacement. Records showed that the rate of replacement of urban records at 1:500 scale was 13 maps per draughtsman per year and that with the then employed numbers of draughtsmen the replacement task was increasing rather than diminishing. Even if the numbers of staff were increased to overcome the backlog it was evident that there would be an ongoing residual replacement task requiring 30 draughtsmen.

The introduction of a computer-based map record system could break this cycle and it was envisaged that if the appropriate data base concerned with the electrical attributes of the distribution system could be associated with the records, a facilities management system could be provided.

Whilst such concepts were clear, the costs, timescale of achievement of the transfer, impact upon staff and other issues could not be assessed. It was decided, therefore, that it would be proper to establish a working trial to develop procedures and practices, and to evaluate the productivity gains that computer graphic systems could offer. In due course a full investment appraisal would be made. Fortunately some years before, a limited trial of computer graphics equipment had been undertaken in the Board's Plymouth Office and although that system was crude by comparison to equipment available in 1981 it did mean that there was some working experience of such

systems amongst the Board's engineering and computer staff. The project trial was begun in the Board's Somerset Office at Taunton in the Autumn of 1981.

The Somerset Trial Project

Following a review by the Board's computer staff of computer graphics equipment available in 1981 a turnkey contract was signed with Intergraph (Great Britain) Ltd to supply a DEC PDP 11/23 processor, two LSI monochrome workstations, a pen plotter and associated equipment. A project team of distribution engineers, computer staff and operators was established and supervised by a small senior management team. The Project Team was given terms of reference which were:

"to become fully conversant with the equipment; to establish standard working practices within mapping systems, system diagrams and a data management retrieval system; to seek to demonstrate the productivity gains; to monitor all work undertaken and to report in such a manner that senior management might consider the wisdom of further investment."

The central processor was installed in an air-conditioned room but the workstations were installed in the drawing office so that staff would become accustomed to such equipment since this marked the introduction of computing equipment into locations where working practices had varied little over many years.

The operators, chosen on the basis of their aptitude and interest in such development, were trained initially by the equipment suppliers but much of their ability was as a result of a self-learning process. Computer support staff also received specialised system support training from Intergraph.

The area of project study chosen was Glastonbury in Somerset. This town had a mixture of urban and rural networks and was fairly typical of those encountered in the south west. No Ordnance Survey (O.S.) digital mapping was available for the area but this was not seen as a disadvantage since it was envisaged that there would be times in the future when SWEB staff would undertake limited map digitising tasks. The project area was covered by 109 records at 1:500 scale and 15 at 1:2500 scale. The scope of the project was established as:

- the attainment of operator efficiency; storage, retrieval and use of digitised data.
- the establishment of standards for symbols, text, line weights.
- the creation of file registers and access systems.
- the creation of new records.
- the establishment of protocol and procedures surrounding the computer system in terms of back-up to files, system recovery and security.
- the establishment of an engineering data base associated with the map record of the distribution system.
- the application of computer graphics to other drawing office tasks concerned with schematic diagrams.
- the production of standard 'in house' user manuals of procedures which could be the basis for training other operators if the project was launched Board-wide.

Regular monitoring of the progress of the trial during the following 18 months, together with close liaison between the operators, the project team and senior management ensured that these goals were achieved.

THE RESULTS OF THE TRIAL

Firstly, the study area was hand digitised from O.S. chartpaper originals or enlargements therefrom, and a series of mapping symbol cells and user commands for their manipulation, was established as also were text sizes, line weights and symbology etc. Originally six levels were used, reducing finally to two - road names and remainder. Even during this limited exercise, digitising techniques learned reduced production time per map from 19 to 10 hours.

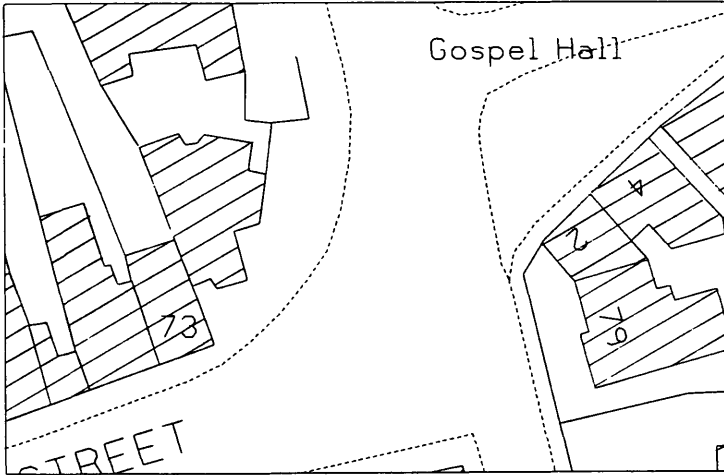


Figure 1 illustrates a section of such a map background within the project area.

BACKGROUND

LEVELS

LV=1	LV=2	LV=3
BN=1	BN=2	BN=3
BFF=1	BFF=2	BFF=3

CELLS

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SLOPES

TEXT

STREET NAMES
HOUSE NO/ NAME
FIELD NO.
LARGE LOCALITY NAMES
OTHER

REFERENCE FILES

BN=1	BN=2	BN=3
BFF=1	BFF=2	BFF=3

Figure 2 shows the menu developed for the operator to use in this process.

Experiments during the trial showed that the use of skeletal background information with limited features of house outlines and very little background data was unsatisfactory from a user point of view. Also, although considerable improvements in output were achieved, it became clear that if the Board were to attempt to create its own mapping base as well as to capture the asset record the task would extend well into the next century.

The next area of development concerned the capture of the digital record of the mains distribution system. Again cells, user commands and menu were established for the mains distribution system including text sizes and line symbology. At the same time procedures were established which associated plant data with spatial referencing thereby producing an interactive database. These enabled the route of the distribution of electricity to be traced from the source to consumers, present analysis of common information, separate levels of voltage and use the record maps at a variety of scales for new construction, maintenance, fault location and so on.

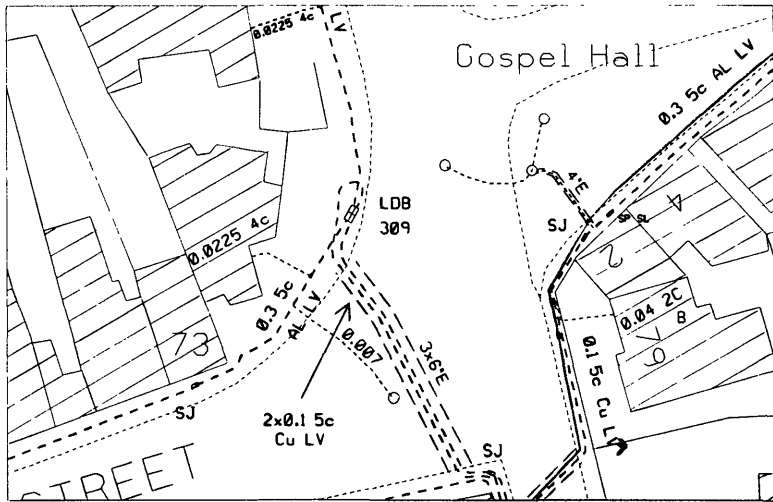


Figure 3 illustrates the product of this work in which the asset record has been superimposed upon the digital map background. It should be realised that this overall picture can be simplified by switching on and off various levels.

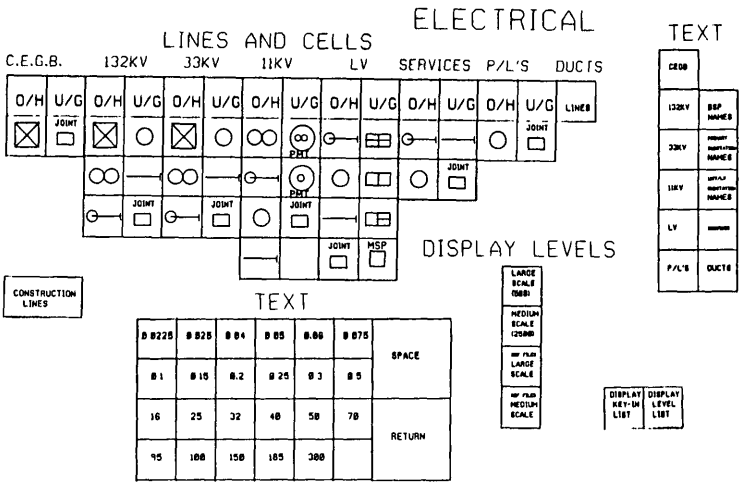


Figure 4 shows the menu used by operators to develop such records.

At the conclusion of the project the Project Team prepared User Guides to enable additional operators to be trained for the applications developed. It was also decided that Intergraph equipment would be used for the main task.

THE INVESTMENT APPRAISAL FOR PROCUREMENT OF A
COMPUTER GRAPHICS SYSTEM FOR AUTOMATED MAPPING
AND FACILITIES MANAGEMENT IN SWEB

The project development thus far described proved that the advantages envisaged were achievable and provided the basis for an investment appraisal to determine whether there was a cost benefit in adopting such a course of action. In preparing such an appraisal there were two central issues to be considered which were:

- that digital map backgrounds could be obtained for the whole of the Board's area at a rate and for locations determined by the Board's programme.

- that the Board could regulate its progress and rate of investment in computing equipment such that the overall programme would be completed within an acceptable time and also that early investment would not be quickly outdated by technological advance.

The Procurement of Digital Map Backgrounds

Throughout the project period the Board maintained a close liaison with Ordnance Survey so that O.S. were aware of the Board's intentions. In 1984 O.S. digital coverage of the south west was 75 1:1250 maps and 1273 1:2500. This represented only 150 urban and 636 rural sheets out of the total of 19,000 records! The Board gave a commitment to O.S. that if its investment was approved it would purchase every digital map that was produced.

With the best of O.S. intentions, it was obvious they would not match requirements and in consequence the Board explored many avenues to obtain digital maps. These included hand digitising map contractors and scanmapping. Trials showed that the most successful and economic sources were scanmapping systems which produce vectorised maps with two or three levels of data. The use of scanmapping is not without its problems. Enlargement from the original scale needs to be restricted if distortion of the images is to be avoided. It has not proved practical to scan SUSI sheets. The file storage for scanmaps can range from three to five times that for O.S. maps of equivalent density. Some editing of scanmaps is necessary. The final conclusion was that from O.S. or scanmap sources, a mapping base to match our programme could be obtained.

The Programme for Record Transfer and Investment Appraisal

It was recognised that the transfer of 19,000 detailed record maps to the automated map would be a formidable task. The period in which the task could be completed is a function of the number of years chosen to complete the work, the number of workstations purchased and the number of operators employed. It was decided that a period of 10 years for completion of the programme would be acceptable in terms of expectation and motivation. The assessment of digitising progress rates in the trial enabled the number of workstations required to be calculated from this decision with some phased for later introduction to allow for technological improvements.

The investment appraisal was based on the following factors:

- additional staffing cost for a conventional redraw of out-of-date records and the continued employment of staff to maintain the archive after this period.
- the phased purchase and replacement of computing equipment for record transfer to digital form, software support and digital map purchase.
- staff savings in other activities¹ as facilities become available.

The study covered a 15 year period commencing at the beginning of the project trial, and gave the following results using present values derived from a 5 per cent discount rate. (A 5 year replacement of computing equipment was assumed.)

Equipment Cost	-	£4.67M
Additional Staff Costs	-	£3.33M
Other Savings	-	£1.59M
Net Present Value of Benefit	-	£0.25M

CONCLUSION AND THE FUTURE

As a result of the Project Trial and Investment Appraisal, the Board has now equipped each of its four regional offices with Intergraph systems comprising DEC VAX 11/751 processors, workstations and the appropriate memory and disc storage. Remote workstations have also been installed at Head Office and the Plymouth Local Office, these being connected to the processors by kilostream links. During 1985 and 1986 some 25 operators were trained. In the initial year whilst the staff were developing their skills some 500 records were digitised and the programme for the current year anticipates that some 1750 records will be transferred. This work is supported by purchase of digital map tapes from O.S. where available or by purchase of scanmaps.

At present when a record has been transferred to digital form a master copy is added to the file and used conventionally. Once significant coherent areas of network have been completed the hard copy records will

be withdrawn and the computer system will be used for all purposes. At this stage mainframe compatible workstations will be introduced to provide the necessary interface between the graphics system and its data base and the related data held within the Board's other computing system. As necessary additional memory and disc drives will be purchased.

The present and future integration of the automated map/facilities management system into the Board's day-to-day business procedures is now overseen by a Steering Group of senior staff. The emphasis of this work is now concerned with development of procedures for the design of, extension to or reinforcement of the distribution system and the support of maintenance work on plant, cables and overhead lines. Procedures have also evolved for many other frequent tasks in the Board's drawing offices including the design of civil structures, office design, electrical wiring diagrams, schematic diagrams. Whilst such activities did not form part of the main justification for the investment made there is no doubt that such applications assist the general justification of the investment and increase staff involvement.

The Board has committed itself to a future in which a significant portion of its facilities management will be based upon the automated map. The decision to go forward in this manner was made from a careful assessment of the potential and costs of such systems and would recommend such an approach to any other business considering embarking on a similar path.