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REVISION OF LARGE SCALE MAPS AT THE ORDNANCE SURVEY

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ABSTRACT

The whole land area of Great Britain is covered by mapping at one or another of the three basic scales of 1:1250, 1:2500 or 1:10 000; this requires nearly 220 000 individual map sheets. The Ordnance Survey is responsible for the custody, maintenance and revision of this "Archive" of topographic information. Many of the maps are subject to a process of "continuous revision", for which ground survey techniques are usually most suitable, but sometimes aerial photography is used; and the applications of photogrammetry for periodic update or improvement of other areas are increasing. The impact of digital mapping introduces complex requirements for the digital capture of revision information but it may permit some of the constraints imposed by scale, specification and sheet-edges to be reviewed. The full integration of photogrammetry into an environment of topographic databases promises to be interesting and challenging.

ORDNANCE SURVEY

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1. ORDNANCE SURVEY LARGE SCALE MAPS

1.1 County Series Mapping

During the 19th Century the Ordnance Survey produced Large Scale mapping of the British Isles, but on a number of Cassini projections with separate series for each County. In general the urban and rural areas of Great Britain (England, Scotland and Wales) were mapped at 1:2500, Ireland and the mountain and moorland areas of GB were mapped at six inches to the mile (1:10 560) and there was some very large scale mapping of certain city centres. Dubious revision techniques in the early 20th century, the 1914-18 war and financial stringency in the 1920s combined to bring the mapping to a state of neglect; this resulted in the establishment of a Departmental Committee which recommended a retriangulation, the adoption of a single projection with a National Grid (NG) in metric units and a new series of maps based upon it (Davidson, 1938). By this time the Ordnance Survey responsibility had reduced to Great Britain only, separate organisations having been set up in Belfast and Dublin.

1.2 Basic Scales NG Mapping

The retriangulation was started before the 1939-45 war which, of course, delayed its progress. The lack of electronic computers meant it had to be adjusted in blocks but this did allow mapping to start, in 1947, in those areas where control had become available. The "basic" scale of mapping for any part of the country is the largest scale to be published for that area; initial survey is carried out at this scale with smaller scales being derived, directly or indirectly, from it. Three scales were adopted according to the terrain, all of them not only based upon the new NG but also adopting grid lines as sheet edges.

Uncontoured 1:1250 maps are provided for urban areas; there are about 55 000 sheets in this series each covering 0.5 x 0.5km. For rural areas, including minor towns, villages, settlements and agricultural land, the selected scale was the 1:2500 of the earlier County Series mapping: this series, like the 1:1250, is uncontoured and also has a similar content specification. The unit of survey for this series is 1km x 1km and this is called a sheet; there are over 160 000 of them. In the course of publication as printed paper maps many of them were combined into 2 x 1km format for economic reasons.

Over the rest of the country, the mountain and moorland areas, the scale of six inches to the mile (1:10 560), as for the County Series, was initially adopted with contours at 25ft intervals. Long before the series was complete, two changes took place; firstly the contour interval was changed to 5m in most areas, but to 10m in the mountains, and secondly the scale was altered to 1:10 000. The series and contouring are complete but some scale conversions have not been made. The significance of this series is that it is the largest scale either to cover the whole country or to carry contours; where large scale mapping is available this is used to derive 1:10 000 maps to which contours are then added, thus the 1:10 000 basic survey is confined to areas where there is no large scale mapping. Of about 10 000 5km x 5km sheets in the series perhaps the equivalent of 3500 are basic; however many sheets are a mixture of the two methods so the position is confused but the objective is a homogeneous series of contoured maps of the whole country

1.3 Survey Techniques

The whole of the 1:1250 was resurveyed, a word used in OS to imply an 'ab initio' survey from control without dependence on earlier mapping. Early methods such as chain and graphical photogrammetry naturally gave way, in the first case, to optical tacheometry, to theodolite mounted EDM and to recording total stations; the latter was replaced by stereoplottiong (Fagan 1972) and now some of the plotters used are analytical.

A resurvey of 160 000 sheets of 1:2500 mapping would not have been justified, the Davidson Committee had recommended that the County Series be "overhauled" by recasting it on NG and revising it. This process (OS 1972) gave an accuracy below normal standards for this scale (2.5m rms vector error or 1mm at map scale) but for rural areas, which in most countries would be mapped at 1:10 000 or smaller scale, this generally serves its purpose. Some County Series maps were 60 years out of date so this task was essentially revision (Matthews 1976); however that is not the topic of this paper despite the size of the task which, at one time, was running at over 10 000 sheets per year. A few problem areas had to be resurveyed at this scale.

For 1:10 560 and then 1:10 000 basic mapping the task was entirely a photogrammetric resurvey using precise stereoplotters. The need to replace the very sparse contours of the County Series six inch to the mile maps made it uneconomic to consider any form of overhaul for the planimetry. Similar photogrammetric techniques were used for the addition of contours to the derived mapping, the two operations being interwoven along the often irregular boundary between basic scales.

At any scale of mapping there is a need for a ground verification and names collection process termed field completion. The larger the scale the more significant this part of the task because it is either impossible or uneconomic to capture some detail by the primary technique. A method of graphical field survey using "shots, measurements and alignments" has developed in OS by which a sparse initial framework can be completed. The economic proportion for 1:1250 varied from photogrammetry providing about 70%, through total stations supplying perhaps 35-40% and optical tacheomtry only about 12-15%. The influence of this graphic technique became important when it came to revision.

2. REVISION POLICY

2.1 Departmental Committee Proposals

In addition to its recommendations about providing new National Mapping, the Departmental Committee report (Davidson 1938) made far reaching proposals about revision. In order not to repeat the earlier neglect it recommended a process of 'continuous' (as opposed to cyclic or periodic) revision under which each new map sheet would be put under continuous review, with an even higher priority than the production of new mapping. It took some 35 years to produce full cover of NG mapping since during the later stages more surveyors were engaged in revision of already published maps than were engaged in the completion of the series.

2.2 Study of Revision.

Towards the end of this period a team was set up to make a Study of Revision to ensure that efficient methods were adopted for this important task. Whilst retaining the general philosophy of Davidson, the Report (Wesley 1981) made many recommendations which still frame the general policy for work on which all the available survey resources of OS have been employed since the completion of NG mapping in the early 1980s (Leonard 1982).

2.3 Continuous Revison

Much of the country remains under the system of Continuous Revision (CR) recommended by the Davidson Committee. Under CR, field staff at over 130 local offices around the country keep the maps of actively developing areas up to date as significant change occurs. In principle under the CR system, wherever the amount of change calls for a day's economic fieldwork, this is put in hand. In practice there is nearly always a backlog of unsurveyed change, some of it minor which it is not economic to survey piecemeal. Therefore, as each map reaches the criterion at which a new edition is justified it is perambulated to 'sweep-up' all outstanding change.

2.4 Periodic Revision

In addition to the continuous revision of primary change in active areas, "age-related" sweep, the periodic revision (PR) of all outstanding topographic change in blocks of maps in less actively developing areas, is also undertaken. This applies to some 1:1250 maps, a substantial proportion of the 1:2500 scale areas and virtually all of the mountain and moorland. Because of changes in the priority attached to PR, the number of maps being subjected to this age-related sweep is currently increasing from less than 400 in 1986/87 to a planned output of about 4000 in 1988/89.

2.5 Upgrading and Resurvey

For areas whose basic scale mapping is deficient because of inaccuracies, changes in land use or extensive development, it is part of Ordnance Survey's remit to resurvey and map at an appropriate scale, if the cost is justified by the benefit of the removal of those shortcomings. In practice this leads to the categories of resurvey outlined below. Within cost and manpower constraints, programmes are determined on the basis of recommendations by regional management.

The expansion of towns already surveyed at 1:1250 results in an urban fringe which it is often impracticable to revise on the surrounding 1:2500 overhaul. The resurvey at 1:1250 of an extension to the existing mapping may be necessary but, if the nature of the detail permits, resurvey at 1:2500 of all or part of it may be adequate. Towns previously mapped at 1:2500 may develop to such an extent that a complete resurvey at 1:1250 is justified. In theory this programme of upgrading is almost complete but its extension to further towns cannot be precluded in the future. Alternatively if the existing overhaul standard is no longer adequate a resurvey at 1:2500 may satisfy the requirements. In some rural areas the 1:2500 overhaul is known, or is found, to be below the normally accepted standard for this mapping and such areas may be designated for 'remedial' survey.

2.6 Intelligence

In order to plan and organise revision resources efficiently, to decide on appropriate techniques and to plan aerial photography if required, it is essential to have information concerning important topographic change such as its timing, location and extent. Aerial photography can be useful in this respect, while other remote sensing is rather less so; however the principal source traditionally has been, and still is, close liaison with the authorities involved. Even if developers' plans are not sent to the field section direct, the developer first needs to seek planning approval and to contact the utilities to arrange connection of services. All the responsible bodies are extensive users of OS maps, they have an interest in the OS revision programme, and usually are happy to ensure that OS are kept well informed of significant change. Minor change has to be sought during periodic sweeps.

2.7 Measuring Change

Traditionally OS has used the 'house unit' as a measure of the change which has taken place, but this is more appropriately now described simply as a unit of change. One unit, as its earlier name implied, entails one new house with its surrounding fences or any one of several equivalents. There needs to be a whole list of alternatives but they include for example, 10m of motorway or dual carriageway, 20m of other road, standard gauge railway or canal, 50m of electricity transmission line, 100m of administrative boundary, path or tide line, one hectare of pond, quarry or change in vegetation or surface classification. The purpose of the equivalence is as an assessment of its importance to users and the need for update; it is not necessarily related to the time taken to survey it though it would be a more useful statistic if some such relationship were reliable.

A consultancy project completed in 1986 studied the nature, location and growth of topographic change. The study confirmed the accuracy of existing OS systems for recording and assessing change. No predictive indicators were found which could lead directly to improved estimates of change; however a further change count using the same methodology is being done in 1988 and the detailed results of the study are now being used to assist both short and long term planning of revision activity. OS figures suggested that, over the country as a whole, somewhat over 0.6 million primary units of change (detail of first importance in maintaining the archive) were awaiting survey at any one time, and this figure was confirmed by the consultants. Much of this is not, of course, economic to survey as it arises; however OS does intend gradually to reduce the amount of outstanding work to about 0.5 million units. Total annual change (including minor or secondary detail) was estimated at 1.25 million units, and the total unsurveyed change since previous editions of every map is estimated at 5 million units. Of course the bulk of this is secondary change, and over 85% is scattered and therefore uneconomic to survey piecemeal. By way of comparison, the entire archive is believed to consist of some 75 million units.

2.8 Supply of Revision Information

A copy of each published new map, on a stable plastic material, is supplied to the relevant section. This is the surveyors' working document on which change is graphically recorded; it is called the 'master survey drawing' (MSD) and represents the most up-to-date topographic information. The 'supply of unpublished survey information' (SUSI) system is the main way in which OS supplies revision information to its professional users. The customer can purchase a paper or film copy made directly from the MSD at any time; this constitutes direct access by users to the archive in its current state.

At a slightly lesser level of currency is the 'survey information on microfilm' (SIM) service. At intervals of approximately 50 units of change, every MSD is microfilmed. Copies from this microfilm are available at full size on paper or film, or as microfilm copycards. Finally, when an MSD has accumulated about 300 units for 1:1250, or 450 units for 1:2500, since the previous edition of that map, or when the MSD is saturated with new development and no more is planned, a new edition is prepared and a high quality litho-printed map on chart paper is produced for sale. A new MSD is also made and the cycle begins again.

2.9 Conventional and Digital Mapping

Implicitly all the foregoing has described graphical techniques being applied to a graphic record (the MSD) which represents the archive. Digital methods were introduced as a process in the conventional flowline though subsequently a demand has arisen for digital data. The survey policy here described applies equally to either production technique; the main difference is that until recently a digital update comparable with SUSI has not been available, change only being digitised when the 50 unit criterion has caused a replacement of the microfilm.

3. INSTRUMENTATION FOR MAP REVISION

3.1 Continuous and Periodic Revision

The instruments and methods for map revision are themselves under continuous review. Graphical survey techniques, with results being plotted directly on the MSD in the field, remain the prime method for revision of small amounts of change and for field completion of all photogrammetric work. One third of OS revision work makes use of aerial photography, about half of this leading to rigorous stereoplotting and the remainder being used with graphical air survey techniques on 1:2500 overhaul sheets only. An increasing amount of instrumental detail survey (IDS) uses electronic tacheometers equipped with data loggers, followed by automatic plotting onto the MSD, with graphical field completion of remaining detail as usual.

Extensive areas of redevelopment may lead to a request for photogrammetric assistance; the decision is based on the likelihood of achieving photography when required as well as on the likely relative costs. However, in general, 1:1250 scale areas containing more than 175 units of change, and 1:2500 scale areas containing more than 350 units, are likely to justify photogrammetry. The need for reliable intelligence is clear; existing photography may be used for this but would not be flown specially as there are other sources available. If there is enough change to warrant it, aerial photography may be obtained for plotting pockets of intensive change on stereoplotters or for revision, by the older graphical methods, of the whole area photographed.

3.2 Upgrading and Remedial Survey

The balance of economy between field and photogrammetric surveys for 1:1250 scale extensions and upgrading is kept under review. Despite the power of modern instrumental detail survey, since the early 1980s photogrammetry has been the more economical method for most tasks covering one whole map sheet or more. Howver, individual tasks are treated on their merits depending both on the predominant type of detail and on user needs. In particular, new areas of compulsory Land Registration may coincide with a 1:1250 resurvey task and because of the urgency these cannot wait for photography to be obtained in our uncertain climate.

For remedial work at 1:2500 scale, extensive trials have taken place over a long period. These have ranged from rigorous stereoplotting to a variety of attempts to refine the graphical air survey methods in normal use for 1:2500 revision. They have included the use of orthophotography both as a graphical revision tool and, with a stereomate, in an approximate instrument specially designed and built for the OS. The outcome of the original trial was that not only was rigorous stereoplotting controlled by aerial triangulation more accurate than all other methods, but that surprisingly it was also considerably cheaper (Mayes and Smith 1986). Normal revision on a stereoplotter, when the operator has continually to consult the map being revised, is time consuming. The Ross Orthophotoplotter did permit superimposition of the document into the ocular viewing the orthophoto; it achieved its objective but was not the most economic method. Revision problems are exacerbated by the overhaul maps not being up to resurvey standards and decisions about which detail to move to get better sympathy appear to make it more economic to plot everything visible and transfer text and hidden detail from the old map, a process described as reformed mapping. A more extensive trial to confirm the experimental finding is still in progress, but the original trial took no account of the possibility of collecting the photogrammetric data as input to the digital mapping system, which will give it an added advantage.

4. REVISION OF DIGITAL MAPS

4.1 The Digital Databank

The Ordnance Survey has been capturing digital data since 1972; the vast majority of this has involved the manual digitising of existing graphic material. About 40 000 of the 220 000 basic scale maps are now held in digital form, and this data is being captured at an accelerating rate which now exceeds 6000 sheets per year in response to user demands. The system was first introduced for the purpose of automating the final drawing from which the published map, after addition of stipple and some ornamentation, was printed. This continues and now all resurvey and new edition publication is via the digital process but this only accounts for some 1400 sheets per year. The rest of the digital programme is the capture of digital data by manually digitising the current MSD; new editions are not produced from this flowline so each MSD is returned to the section responsible for its maintenance. At present, even after digitising, the MSD remains the master source of topographic information; however the revision of the digital data, and the possibility that it, rather than the MSD, will become the definitive source in future, are the subject of intensive development effort. In both the revision of the digital record, and the supply of such revision to the customer, OS is necessarily breaking new ground.

4.2 Digital Update

Once a map is stored in the digital databank, it is necessary to carry out a digital update in step with the revision of the MSD. This is usually done when the MSD comes to HQ under the 50 units criterion for replacement of the microfilm; new information is manually digitised and interactively merged with the existing digital data. However it has frequently been considered more economical to redigitise ab initio on a blind digitising table than to revise by means of an extensive interactive edit. This procedure of course means that digital customers cannot benefit from the immediacy of the SUSI service unless they buy a graphic and digitise change themselves. Moreover the MSD is no longer available to the field office while it is held in the HQ flowline, often a period of several months.

4.3 Digital Field Update System (DFUS)

For these reasons a digital field update system (DFUS) has now been developed, whereby an interactive workstation is installed in the local field surveyors' office, and update is carried out using the surveyor's pencil detail immediately after any substantial CR survey. The MSD is then updated by automated plotting, thereby eliminating the time consuming penning task and providing a better quality document ready for the SUSI or SIM services. This trial has recently been extended to twelve field offices, almost 10% of the total (Coote 1988). One office has been equipped with an optical disc drive, to examine the implications of write once, read many (WORM) technology for digital map data stored remotely from the central databank. Of course the selection of offices for the trial has had to be from those where there is existing digital cover for all or most of their area of responsibility, and preferably where there are customers for a digital update service comparable to that available in graphic forms.

4.4 Project 88

In response to the more radical suggestion that the digital databank, rather than the MSD, should constitute the archive, a trial known as Project 88 has been set up. The Milton Keynes section now operates a digital field office. Digital data for all MSDs covered by that section was brought up to date, whereupon the MSDs were removed. When further revision is required, a plot of existing data is made for an arbitrary sheet defined by the surveyor. After field revision the databank is edited interactively. The SUSI customer, whether graphic or digital, can have an immediate service from the databank, unconstrained by conventional sheet lines or scale. The section only falls short of being entirely digital because of the need for graphical revision techniques in the field; the search is on for the portable interactive edit station (PIES) but technology has not yet produced a viable, compact, cost-effective machine to permit the direct conversion of the surveyor's shots, alignments, offsets and so on into the digital map form.

4.5 Photogrammetric Digital Data Capture

Direct digital data capture at photogrammetric plotting stage has been under investigation at OS for some time (Newby and Walker 1986). The study has drawn attention to the inconsistency between the standards of accuracy expected and obtained in stereoplotting, which are generally expressed in stochastic or statistical terms (but are related to absolute National Grid Coordinates), and the deterministic standards demanded of the field surveyor on all occasions, albeit for local or relative accuracy only. The problem is exacerbated by the fragmented nature of much of the detail customarily plotted by the photogrammetrist, which consequently tempts the field surveyor not only to complete the detail but to make minor corrections to detail already plotted. Because of the high cost of interactive editing after field completion, this flowline was not initially cost effective. Fundamental changes in philosophy and practice are necessarily being fostered in both the photogrammetric and field survey area for the current stage of this project, in order to exploit the full potential of digital data capture. So far this trial has only considered the resurvey case and the second (modified) phase is in hand (Proctor 1987). Revision was originally included but this, even more difficult, task has been made the subject of a separate study.

4.6 Photogrammetric Digital Revision

A difficulty with revision is to reconcile new photography with existing mapping of variable history and accuracy whilst maintaining not only the accuracy but also a high graphic quality. If the existing map is digital and surveyed to rigorous modern standards the digital merging is tedious but straightforward; however for a digital overhaul map the subsequent edit process can be so slow as to demand the digital equivalent of reformed mapping with data capture as for a resurvey. In some case development of a digital counterpart to 'fit-and-trace' methods may be needed to avoid wholesale redigitising of a revised graphic with resultant degradation in accuracy. Techniques will vary according to whether the existing graphic or its digital version is regarded as the archive, but all methods involving stereoplotters without superimposition of the digital data will be time consuming; such facilities are becoming available, particularly for analytical plotters, so OS is investigating purchase of a system for trial and assessment.

4.7 Photogrammetric Superimposition

Without in-house access to this facility trials have begun using borrowed time on various instruments; these tend to confirm the expected problem of using OS digital data which is two dimensional. This may be adequate, but awkward, where the operator only needs to check which detail is old and which requires capture. However for tasks such as the overhaul, where old detail is to be checked and, if necessary, moved it is clear that either all features must have heights at the uppermost visible level or else an accurate DTM is required with facilities to correct for the heights of tall objects. It may become possible to have a real-time feed-back from the stereoplotter Z to improve the superimposition. A problem arises when the digital data contains sound photogrammetric capture with heights merged with two-dimensional field completion to provide a jagged superimposed image and it is noted that even good data when superimposed impairs stereo-viewing unless frequently switched on and off. The trials are at such an early stage that no comparison has been made of stereoscopic and monocular systems to decide whether the extra cost of the former is justified, but it already appears that the solution for digital revision will be some form of superimposition.

4.8 Digital Revision by Instrumental Detail Survey (IDS)

If a field section equipped with DFUS needs to supply IDS to support the completion of a patch of change the work is observed exactly as if for conventional mapping. Normally at this point both observations and MSD are returned to HQ firstly for computation and secondly for plotting directly to the document; however in the DFUS case only the observations are returned, and after computation a digital mapping update is provided to the section. It is then reasonably straightforward for this update to be plotted on the section's own plotter, ready for field completion, and for the digital data to be merged. After field completion another digital update incorporates it and the section finishes with a dataset which includes both the IDS work and the field completion whilst retaining the original IDS co-ordinates. For an IDS resurvey extension or the revision on a digital sheet not covered by DFUS the various edit operations have to take place in HQ and development work is in hand to make this more economical than full redigitising which causes a degradation of the computed IDS co-ordinates.

5. THE WAY AHEAD

5.1 Revision Activity

Since completion of the NG mapping the OS survey effort, apart from some scientific work and the maintenance of horizontal and vertical control frameworks, has been devoted to revision. In this context however the word embraces the entire maintenance of the topographic archive. The conventional meaning of additions and deletions to the existing maps as change occurs is too narrow a definition; it is also taken to include the upgrading resurvey at the same or a larger scale to replace existing mapping. There is also the possibility of remedial revision where existing detail is also checked and moved if appropriate, or of reformed mapping which is tantamount to a resurvey in that a complete photogrammetric re-plot is made, augmented by the transfer from the old map of additional detail such as names or other text, vegetation classification and detail obscured by trees, shadow or the perspective view. There is no particular reason why all these activities should not continue in the digital era but the choice of method will be influenced by the economy of combining the collection of digital data.

5.2 Objective

In the medium term OS must look towards the day when all the topographic archive is digital, meaning not only that digital maps exist for all areas but that these, and not the graphics, form the archive. All revision processes should entail digital capture of the new information from which an updated digital map is available at the time or very soon after.

5.3 Topographic Database

A two and a half year intensive study into the potential benefits of a topographic database was completed at the end of 1987 (Haywood 1987). This has included an in-depth review of data structures (Smith 1988) which would simplify the use of OS digital mapping for Geographic Information Systems which are considered to be the applications of the future (Chorley 1987). A Pilot Implementation lasting about 18 months has been approved in order to verify the potential. It may not affect the surveying side of revision but will certainly add complexity to its incorporation into a structured database. It is not yet clear whether this will make a significant difference to digital capture or whether the incorporation will be an off-line automatic edit.

5.4 Scales

Many references have been made in this paper to the three basic scales and digital data is held by sheets in a form which depends on the source scale. The ideal of a single scale-free database for all purposes is not currently seen as a practical proposition, but at present the differences between 1:1250 and 1:2500 digital data are small apart from the resolution and dimensions of the sheets into which it is divided. In digital data some partitioning is necessary because a data set of some 150 Gbyte would be unwieldy, but perhaps grid lines are not the best boundaries. The significant difference between one class of survey and another is the accuracy and it may be more logical to think of three or four accuracy standards, with appropriate resolutions, than scales. An upgrading survey, at a higher standard of accuracy, may be needed up to the boundary of recent development rather than the (current) sheet edge; this concept of using natural boundaries between one specification and another is being tried in Project 88 as and when development takes place. Provision has already been made to allow digital update to work across sheet edges and it must also be able to work across accuracy boundaries.

5.5 Supply of Data

The conventional SUSI graphic is a very successful service for providing customers with up-to-date information, but it is restricted to the scale, sheet lines and cartographic style of the MSD. With digital data there is no reason, subject to extra cost, why the customer for graphic output should not specify the area required, the scale of the graphic, the selection of features to be plotted and the colours. This is also being investigated in Project 88 using a pen plotter. At HQ a colour raster plotter is being used for customer plots from current data (CPCD) in an experiment to evaluate data structure and polygon seeds for generating buildings and vegetation symbols. The digital customer can easily perform his own merging, editing and filtering operations to construct a database to his liking, attaching to it his own data and attributes.

He needs a reliable source of update information but when he receives it he does not want to have to repeat his own data manipulation. His need is for "change only update" which has also been investigated; it may not be desirable to introduce this with the present data structure, but it is seen as essential if a structured database is introduced.

5.6 The Revision Problem

With conventional graphic mapping the revision of a reliable map is seen as a fairly simple task. The existing detail provides a framework, ground control may therefore be unnecessary and the whole operation is much simpler than the original mapping task. For digital data it is interesting to note that it is revision, the regular and efficient supply of digital update in a form suitable for customer databases, which looks like being a far more challenging problem than the initial capture of digital data.

REFERENCES

CHORLEY, LORD (Chairman), 1987. Report of the Committee of Enquiry into Handling Geographic Information. HMSO London.

COOTE, A M, 1988. Current development in field-based digital mapping systems at Ordnance Survey. Proceedings of Mapping Awareness Conference, Oxford.

DAVIDSON, the VISCOUNT (Chairman), 1938. Final Report of the Departmental Committee on the Ordnance Survey. HMSO London.

FAGAN, P F, 1972. Photogrammetry in the National Survey. Photogrammetric Record 7(40): 405 - 423.

FARROW, J E, 1987. Photogrammetry in the Ordnance Survey: 1972 - 1986. Ibid 12(69): 275 - 285.

HAYWOOD, P, 1987. The OS Topographic Database Study: First Stage Report. Proceedings of Spatially - Oriented Referencing System Association Workshop, Durham.

LEONARD, J P, 1982. Revision of Ordnance Survey 1:2500 scale maps. Photogrammetric Record 10(60): 681 - 685

MATTHEWS, A E H, 1976. Revision of 1:2500 scale Topographic Maps. Ibid 8(48) 794 - 805.

MAYES, M H and SMITH, A B, 1986. Orthophotography for Rural Map Revision. Ibid 12(67): 45 - 61.

NEWBY, P R T and WALKER, A S, 1986. The use of photogrammetry for direct digital data capture at Ordnance Survey. International Archives of Photogrammetry and Remote Sensing: 26(4), 228 - 238.

ORDNANCE SURVEY, 1972. The Overhaul of the 1:2500 County Series Maps. OS Professional Paper New Series No 25. (30pp).

PROCTOR, D W, 1987. Digital Mapping at the Ordnance Survey. Proceedings of the 41st Photogrammetric Week, Stuttgart: 171 - 179.

SMITH, N S, 1988. Data Structures and a National Topographic Database. Proceedings of Automated Mapping/Facilities Management (AM/FM) Today Conference, Nottingham.

WESLEY, P W, (Team Leader) 1981. Report of the Study of Revision: OS.