January 1992

EUROPEAN ORGANIZATION FOR EXPERIMENTAL PHOTOGRAMMETRIC RESEARCH

Proceedings of the
ISPRS AND OEEPE JOINT WORKSHOP
on
UPDATING DIGITAL DATA BY
PHOTOGRAMMETRIC METHODS
Christ Church, Oxford University, England
15–17 September 1991

Editors: P. R. T. Newby and C. N. Thompson

Official Publication N° 27

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(with 79 Figures, 10 Tables and 2 Appendices)

Editors: P. R. T. Newby, and C. N. Thompson

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ABSTRACT

The Workshop on Updating Digital Data by Photogrammetric Methods was held at Christ Church, Oxford, England on 15-17 September 1991. The Workshop was organised by the European Organisation for Experimental Photogrammetric Research (OEEPE) Commission D and Working Group IV/3 (Map Revision) of Commission IV of the International Society for Photogrammetry and Remote Sensing (ISPRS).

The objectives of the Workshop were to study the use of photogrammetric methods for updating digital data with a view to identifying topics for ongoing investigation and collaboration between OEEPE and ISPRS.

Section 1 of the Report of the Workshop Proceedings introduces the Workshop and includes an overview of the objectives of the Workshop, a commentary on the Technical Sessions and conclusions.

The Workshop was organised in six Technical Sessions with Opening and Closing Sessions. The Technical Sessions were:

The National Mapping Perspective
Applications and Experience
The Engine of Ideas - Theory and Practice
Environmental Applications
Updating DTMs - Problems and Solutions
Systems - Philosophy and Solutions

Overall the Workshop established a close working relationship between an ISPRS Working Group and a Commission of OEEPE. There were many topics discussed during the Workshop which has highlighted that there are all too few reports of practical experience over the breadth of the technology discussed, and it is to be hoped we will see more reports of this nature in the near future.

RÉSUMÉ

Le séminaire concernant la révision de données numériques par les méthodes photogrammétriques a eu lieu le 15 à 17 septembre 1991 à Christ Church, Oxford, Angleterre. Le séminaire a été organisé par l'Organisation Européenne d'Etudes Photogrammétriques Expérimentales (O.E.E.P.E.), Commission D et par le Groupe de travail IV/3 (Révision de Cartes) de la Commission IV au sein de la Société Internationale de Photogrammétrie et de Télédétection (S.I.P.T.)

Les buts du séminaire étaient d'étudier l'utilisation de méthodes photogrammétriques pour la révision de données numériques en vue de l'identification de sujets pour l'étude courante et pour la coopération entre l'O.E.E.P.E. et le S.I.P.T.

Le premier chapitre du rapport sur les papiers du séminaire donne une introduction du séminaire y inclus un aperçu des buts visés du séminaire, un commentaire des séances techniques ainsi que des conclusions.

Le séminaire comprenait six séances techniques y inclus la séance d'ouverture et la séance finale. Les séances techniques étaient:

La perspective nationale de la production de cartes
Applications et expériences
La force motrice des idées - théorie et pratique
Utilisation en vue de l'environnement
Révision de MNTs - problèmes et solutions
Systèmes - philosophie et solutions.

En tout le séminaire a établi une relation étroite dans les travaux entre un groupe de travail du S.I.P.T. et une commission de l'O.E.E.P.E. Beaucoup de sujets ont été discutés pendant le séminaire et ils ont montré qu'il existe trop peu de rapports sur les expériences pratiques dans tout le spectre de la technologie discutée, et on souhaite d'avoir plus de rapports de cette nature dans le proche avenir.

ZUSAMMENFASSUNG

Der Workshop über Laufendhaltung digitaler Daten mittels photogrammetrischer Methoden fand vom 15. bis 17. September 1991 in Christ Church, Oxford, England, statt. Der Workshop wurde von der Europäischen Organisation für Experimentelle Photogrammetrische Forschungen (OEEPE), Kommission D und Working Group IV/3 (Laufendhaltung von Karten) der Kommission IV der Internationalen Gesellschaft für Photogrammetrie und Fernerkundung (IGPF) organisiert.

Die Ziele des Workshops bestanden darin, die Anwendung photogrammetrischer Methoden zur Laufendhaltung digitaler Daten zu untersuchen im Hinblick auf die Bestimmung von Themen für laufende Untersuchungen und eine Zusammenarbeit zwischen der OEEPE und der IGPF.

Abschnitt 1 des Berichts über die Workshop Proceedings stellt den Workshop vor und enthält einen Überblick über die Ziele des Workshops, einen Kommentar zu den Technischen Sitzungen und Schlußfolgerungen.

Der Workshop umfaßte sechs technische Sitzungen mit einer Eröffnungs- und einer Schlußsitzung. Technische Sitzungen waren:

Die nationalen Perspektiven der Kartenherstellung
Anwendungen und Erfahrungen
Die Antriebskraft von Ideen - Theorie und Praxis
Anwendungen in der Umwelt
Laufendhaltung von DGMs - Probleme und Lösungen
Systeme - Aufbau und Lösungen

Insgesamt stellt der Workshop eine enge Verbindung zwischen einer IGPF-Arbeitsgruppe und einer OEEPE-Kommission her. Viele Themen wurden während des Workshops erörtert, und es wurde deutlich, daß es zu wenige Berichte über praktische Erfahrungen auf der gesamten Breite der erörterten Technologie gab. Es ist zu hoffen, daß wir in der nahen Zukunft mehr Berichte dieser Art erhalten werden.

ACKNOWLEDGEMENTS

As the convenors of the Workshop and editors of this Report of the Proceedings we would like to thank all those who helped to make the Workshop the success it undoubtedly was.

With so many participants involved in the Workshop it is not possible to thank each participant individually, but we wish to thank all delegates to the Workshop for their contribution to the discussions in the Technical Sessions, and the less formal discussion that continued throughout the course of the Workshop. The list of delegates is at Appendix 1.

Our particular thanks go to the Authors of the papers included in these Proceedings, the high standard of the papers and the excellence of their presentation. We received a very good response to our call for papers and this in itself assured us of the firm foundation on which to plan the Workshop. We are very appreciative of the hard work incurred by Authors in the preparation of abstracts, the papers themselves and their presentation.

We also wish to thank the Chairmen of the Technical Sessions who kept us firmly to the programme and most ably led the discussion that followed each paper. We also particularly thank John Wright for his commentary on the Technical Sessions and which is an important part of this Report of the Proceedings. Our special thanks also to Sue Beckett and Carol Nicholls who undertook so much of the administrative work both prior to the Workshop and at Christ Church.

Finally we wish to thank Christ Church, Oxford for allowing us to hold the Workshop in such magnificent surroundings and particularly Mr John Harris, Steward of Christ Church, and his staff for all they did to make the Workshop such an enjoyable occasion.

Chris Thompson
President
OEEPE Commission D

Paul Newby
Chairman
ISPRS Working Group IV/3

1 INTRODUCTION AND SUMMARY OF THE WORKSHOP PROCEEDINGS

1.1 Overview

The Workshop on Updating Digital Data by Photogrammetric Methods was held at Christ Church, Oxford, England on 15-17 September 1991. The Workshop was organised by the European Organisation for Experimental Photogrammetric Research (OEEPE) Commission D and Working Group IV/3 (Map Revision) of Commission IV of the International Society for Photogrammetry and Remote Sensing (ISPRS).

The Workshop was attended by some 70 delegates from 20 countries, with representation from five continents (if the British Antarctic Survey is included). A delegate list is at Appendix 1.

This report is set out in seven Sections, with Sections 2-7 incorporating the individual papers given in each of the Technical Sessions. In this Section papers giving an overview of the objectives of the Workshop, a commentary on the Technical Sessions and a review of progress of ISPRS Working Group IV/3 (including comment on the Workshop) are included at the end of the Section.

In summary, Section 1 and the associated papers provides the reader with an overview of the Workshop, with Sections 2-7 providing the detail of the individual papers presented.

1.2 Objectives

During the 1980s many organisations started production of digital map databases to be used for a multiplicity of purposes including; Land Information Systems (LIS), Geographic Information Systems (GIS) and mapping itself. However during this period problems of the ongoing maintenance and updating of these data and databases received little attention compared to that which has been applied to the development of the technology and the initial production of the databases.

In the 1990s maintenance and updating databases, combined with quality and security of data, will become predominant issues. Solutions will embrace both existing and emerging technologies and techniques. Of the emerging technologies the most important include digital imagery (satellite and aerial photography), digital photogrammetric systems, superimposition and change detection. Also of importance is cost of data maintenance and a desire for low cost map revision/data update systems.

The objectives of the Workshop were therefore to study the use of photogrammetric methods for updating digital data with a view to identifying topics for ongoing investigation and collaboration between OEEPE and ISPRS.

The scope of the Workshop is given in greater detail by Chris Thompson, President OEEPE Commission D in his Paper **"Revision and Updating of Data by Photogrammetric Methods - an OEEPE Overview"** included at the end of Section 1.

1.3 Technical Sessions

The Workshop was organised in six Technical Sessions with Opening and Closing Sessions. The Technical Sessions were:

The National Mapping Perspective (Section 2)
Applications and Experience (Section 3)
The Engine of Ideas - Theory and Practice from Universities (Section 4)
Environmental Applications (Section 5)
Updating DTMs - Problems and Solutions (Section 6)
Systems - Philosophy and Solutions (Section 7)

The individual papers of each session are incorporated in Sections 2-7 as indicated above, and listed in the Table of Contents. The full Technical Programme is at Appendix 2.

A commentary on the Technical Sessions is given in the form of a Paper prepared after the Workshop, and included at the end of Section 1, which covers the main substance of the Workshop. In introducing his commentary John Wright, who is a retired Chartered Land Surveyor and free lance member of the Chartered Institute of Journalists, explains the format of the Workshop and sets the scene for the technical sessions by identifying a number of themes which crossed session boundaries and kept recurring.

There then follows a brief description of each paper presented (and some which were not), together with some of the main comments. John Wright concludes his commentary by summarising the main conclusions which emerged during the course of the Workshop.

1.4 Conclusions

In the Closing Session Paul Newby reviewed the progress of ISPRS Working Group IV/3: Map Revision (1988-92) up to and including the Workshop, against the terms of reference for his Working Group which are:

Change detection using satellite imagery and aerial photography; and

Procedures for digital and graphical map revision, with special reference to the use of superimposition systems.

His **"Review of Progress 1988-91"** is the third, and last, paper included at the end of Section 1, and includes comment on specific contributions from the Workshop as well as the wider ranging activities of Commission III and Commission IV of ISPRS. His conclusions are included below.

A great deal of work on change detection has been reported. The numerous problems of image processing whose solution will lead eventually to full image understanding, and which include automatic correlation, feature extraction and change detection, are being addressed on a theoretical and practical level worldwide, but especially in Germany and the United States.

Work on digital map updating is now undoubtedly being considered wherever the initial capture of digital data is already complete over a substantial area. Practical reports have been given at the Workshop from Great Britain (and also at the ISPRS Commission IV Symposium 1990), Northern Ireland and France as well as some preliminary pointers to future activity in Scandinavia and India. It is to be hoped that more reports will be forthcoming from elsewhere in the near future.

Several contributions to the Workshop are a reminder that the updating of digital terrain models should not be overlooked.

On instrumentation for revision it can now be taken for granted that superimposition will be available on photogrammetric instruments, including some low cost equipment. However it has to be said that not all superimposition systems are well adapted for revision, and the original concept of an aid to initial data capture remains prevalent.

On the new generation of entirely digital equipment using digital imagery, superimposition of existing or newly captured digital map data incurs only marginal extra costs. The same is generally true of analytical stereoplotters where superimposition is incorporated in the design of the instrument. This is in contrast to the addition of superimposition to analytical stereoplotters which requires very elaborate hardware and software with a corresponding cost penalty.

Overall the Workshop has established a close working relationship between an ISPRS Working Group and a Commission of OEEPE. ISPRS tends to rely on the open communication of practitioners' individual results, whereas OEEPE has tended towards a more formal approach through specific project and research investigations.

There were many topics discussed during the Workshop, as indicated by this Report of the Proceedings. It is important that all practitioners report the results of their work. As the Workshop has highlighted, there are all too few reports of practical experience over the breadth of the technology discussed, and it is to be hoped we will see more reports of this nature in the near future.

Although no specific projects were suggested during the Workshop, it is to be hoped that future collaborative projects will emerge from among the participants in the Workshop, and also readers of this Report.

Papers included in Section 1 are:

1.5 Revision and Updating of Data by Photogrammetric Methods - An OEEPE Overview
by
Chris Thompson, President OEEPE Commission D

1.6. Commentary on the ISPRS/OEEPE Joint Workshop Updating Digital Data be Photogrammetric Methods
by
John Wright OBA MA FRICS

1.7 ISPRS Commission IV: Cartographic & Database Applications Working Group IV/3: Map Revision Review of Progress 1988-91
by
Paul Newby, Chairman ISPRS Working Group IV/3

REVISION AND UPDATING OF DATA BY PHOTOGRAMMETRIC METHODS

AN OEEPE OVERVIEW

by

C N Thompson, President OEEPE Commission D

ABSTRACT

During the 1980s many organisations started the design and production of digital map databases to be used for a multiplicity of purposes - LIS, GIS and mapping itself. Others have concentrated on specific applications such as the environment.

The problems of the ongoing maintenance and updating of these databases have received less attention. For example it is only now that the real problems of DATA UPDATING and DATA SECURITY are becoming apparent.

The use of photogrammetric methods for updating digital data will be studied during the ISPRS/OEEPE Workshop to study these matters, leading to the identification of topics for ongoing investigation and collaboration between OEEPE and ISPRS. The proceedings are being published by OEEPE.

Introduction

The role of the European Organisation for Experimental Photogrammetric Research (OEEPE) is to carry out experimental research in areas which primarily affect the efficiency of photogrammetric production and which can be implemented through the academic and production communities of the OEEPE.

The use of digital data for mapping and for land and geographic information systems (LIS/GIS) is established as an important growth area. Photogrammetry is one important means of providing the spatial data for these purposes, but there are many unanswered questions concerning the best methods of collecting and managing the data and the quality of the data.

These problems continue when new data has to be added to a map database or LIS/GIS. For many countries in Europe this is the main problem because mapping already exists of whole countries. Revision and updating of data requires the coming together of many disciplines and new technologies, to deal with problems of instrumentation, change detection and integration of new data with old. The topics to be considered by the Workshop are primarily those related to photogrammetry and include:

1. Photogrammetric systems
2. Satellite imagery and aerial photography
3. Graphic map revision
4. Digital data update
5. Digital terrain models
6. Data Quality
7. Management considerations

Photogrammetric Systems

Photogrammetry has been a standard procedure for the production of topographic maps in OEEPE countries at scales from 1:1,250 (in UK), to 1:25,000 or 1:50,000 in most countries, and in some cases 1:100,000. Despite this wide variation in scale the photogrammetric procedures remain substantially the same, providing outputs (graphical or digital) which are positionally correct, and which for digital outputs can include some degree of attribute coding and data structure.

Analytical photogrammetric systems designed for the production of digital data are replacing analogue stereoplotters retro-fitted with digital encoders. Digital imagery is also proving a powerful new source for photogrammetric data acquisition when allied to the very powerful graphics work stations for the processing and edit of all forms of digital data. The collection, storage, retrieval, analysis and presentation of data for a wide range of increasingly sophisticated applications is leading to more complex data structures and database technology which have to be considered in the design of the new photogrammetric systems.

These technologies are all directed towards information support systems, such as LIS/GIS, which require regular data update. The updating of the underlying map or spatial data has therefore to be considered against the wider information system requirements and technological capabilities. It is no longer sufficient to think in terms of map revision as an enclosed activity.

Satellite Imagery and Aerial Photography

Until recently the development of image processing has mainly been directed at satellite data. Data from satellites is used for a variety of applications in photogrammetry. SPOT data has been used to produce image maps. Aerial photography is also being digitised enabling image processing techniques to be applied.

Within OEEPE the present approach is to evaluate the geometry and the interpretability of the SPOT data before embarking on a direct investigation into the use of SPOT data for map revision or digital update. The two current OEEPE projects addressing these problems, and for which reports are expected in 1990, are:

1. Test of Triangulation of SPOT Data.
2. Experimental Test Programme "Interpretation of SPOT Imagery".

A further OEEPE project was initiated in 1989 for a test "Feature Based Segmentation". The aim of the test is to gain more insight into accuracy and performance characteristics of different categories of feature detectors in digital images in operational use. The test set of images includes SPOT data and a scanned aerial photograph. Longer term the potential exists for investigation by OEEPE of change detection using digital images.

Graphic Map Revision

Although graphic map revision is no longer a priority area for investigation by OEEPE countries, it remains an important topic for all countries where revision of mapping only is required, and also where revision of mapping is required prior to a programme of digitising.

Graphic revision of 1:25,000 topographic maps by photogrammetric methods was investigated by OEEPE Commission D in the late 1970s in the FRIBOURG test. Tests included comparisons between stereoplotting and use of mono-orthophotos and the wide range of photo-interpretation and cartographic procedures used by the seven participating centres. Accuracy, completeness and line quality were analyzed in detail, and also time and cost for each process.

Change detection and cartographic techniques were seen as the keywords for the critical path in the whole map revision process. The test itself was based on a good, reliable base map necessary for an analysis of this type, a situation not always found for map revision work. The overall results were satisfactory.

In many cases the equipment and procedures used in the FRIBOURG Test can be adapted for the production of digital data and data updating. For many organisations this approach may be adopted as the best way forward.

Digital Updating

One of the fundamental problems of map revisions using photogrammetric methods has been that of change detection. Procedures investigated in the FRIBOURG Test included photo-interpretation and comparison with the existing map base, and the use of orthophotos overlaid on the existing map. The latter approach lends itself more readily to digital updating, where both the map and orthophoto can be indexed to a digitising table and interfaced to an edit workstation for updating the digital data.

A better solution has long been desired whereby the map itself, or the digital data, can be superimposed directly into the photogrammetric model. There are two cased to consider.

The first is superimposition of a video view of the existing map into the photogrammetric model. This requires transformation of the two dimensional map image into the three dimensional model space of the plotter, with the digital output interfaced to an edit workstation.

For digital updating the second, and more powerful solution, is the direct superimposition of the digital data into the plotter model space. Photogrammetric systems which provide this capability will also incorporate powerful editing functions which may enable total on-line edit of the data if this is required.

A different approach is now offered by the use of digitised aerial photography, or space imagery. In this case the digital image can be transferred to the map data at the edit station providing a mono-superimposition of the image to the map data. The potential also exists to use stereo images. In the longer term new digital imagery can be compared with earlier digital images applying image processing techniques for change detection.

Commercial, and generally expensive, equipment is available now for most of the above techniques. There is, however, comparatively little experience of both the technical merits and economic benefits of these techniques within OEEPE. In addition to the investigation of these superimposition techniques for digital updating there are two very important related topics . First is the quality of the digital terrain model (DTM) required to support superimposition. Second is the quality of the data to be updated.

Digital Terrain Models

With one exception (where three dimensional data is available) superimposition of the video map scene or digital data into the plotter model space requires the application of an elevation model to introduce vertical displacements to the planimetric coordinates. Similarly vertical displacements need to be removed from the digital image (as occurs in orthophoto production). DTMs are normally used for these purposes.

The production and use of DTMs have become routine in many mapping organisations, and much experience gained in the use of DTMs in non mapping agencies. This does not imply that no problems remain and that new applications may not emerge.

Among these is the use of DTMs for superimposition which seems an important area for investigation by OEEPE.

Data Quality

Photogrammetric systems, computer and database technology are developing at such a rate that both hardware and software are likely to be superseded several times within the lifespan of much of the spatial data in a LIS/GIS. Typically hardware will have a lifespan of 7-10 years and software 10-15 years. By contrast the spatial data will remain valid for periods of 50 years or more if proper provision is made for data updating. As the initial digitising will constitute by far the greatest cost it follows that the LIS/GIS design, or at least the spatial database within the LIS/GIS, must ensure that data updating and data quality are maintained over the planned lifespan of the LIS/GIS.

It follows that the LIS/GIS design activity and setting of data quality standards, deserves priority above virtually all aspects of photogrammetric data acquisition and updating. It is also essential that photogrammetric systems are designed to facilitate the ongoing integrity of the digital data.

Management Considerations

OEEPE is concerned not only with photogrammetric techniques and procedures, but also their efficiency and effectiveness for photogrammetric production. For example in the FRIBOURG Test, although the overall results were cartographically satisfactory, there were wide variations in cost for similar activities.

The updating of digital data will raise more complex management issues. Most countries have only recently embarked upon substantial digital programmes and have barely reached the stage of data updating. Critical questions include:

1. What is the use of data - data product, map database, LIS/GIS etc?

2. What are the required data content and data structure?

3. What is the source of the data?

4. What are the criteria for undertaking digital updating?

5. Who is responsible for ensuring data quality and data security?

6. What are the external constraints which may influence the above?

7. What the costs and the cost benefits?

In view of the very long period over which the data may be in use careful evaluation of these factors is essential at an early stage in the design and development of a digital programme.

Conclusions

The photogrammetric aspects of updating digital data centre around the use of superimposition methods. These need to be investigated as a matter of priority.

The use of digital imagery and application of image processing techniques for automated change detection is also an important area for investigation.

For the shorter term existing analogue systems in combination with digitising and editing systems remain an option.

For the above methods of digital updating the application of DTMs is essential.

The importance of data quality and data security cannot be over emphasised.

In the management evaluation of the design and development of programmes for the production of digital data it is essential that the requirements of digital updating are considered at an early stage.

Commentary on the ISPRS/OEEPE Joint Workshop
Updating Digital Data by Photogrammetric Methods
Held at Christ Church Oxford University September 15 - 17 1991

by John Wright OBE MA FRICS

INTRODUCTION

This was a hard working and well organised Workshop held in very pleasant surroundings, and with first class meals in the magnificent dining hall of Christ Church, Oxford. The sessions in a lecture room started on time and chairmen kept a tight control on speakers; but there was limited time for discussions after each paper - of which in most cases we had received copies on arrival. However, with only seventy delegates, and most of them there the whole time, deep technical discussions could be heard continuing outside the sessions, even if they could not be recorded. The two organisers, Chris Thompson of Geonex UK and President of OEEPE Commission D, and Paul Newby of the Ordnance Survey and Chairman of ISPRS Working Group IV/3, are to be congratulated on bringing together so many representatives of the two organisation with their common interests, and on achieving a better understanding of each other's objectives and results.

As Paul Newby pointed out in his opening remarks, the delegates come from over twenty countries in all five continents (including the Antarctic) and even included one from Denmark born in Greenland; and all of them spoke enough English to participate in the discussions. They included the Swedish President of ISPRS, Professor Kennert Torlegard, and the Japanese President of ISPRS Commission IV, Takeshi Hirai; and a good mix of professionals in government, academic, and commercial institutions. Thus the papers and discussions were thoroughly practical rather than too theoretical or academic.

There were six technical sessions of an hour and a half each, during which from three to five papers were taken; and shorter opening and closing ones; these set out the objectives, and then considered how far they had been met. (A list of session titles and of the papers and their authors is included with the Table of Contents). Cutting across the formal session topics national mapping, applications in both developed and developing countries, academic theory and practice, environmental applications, updating digital terrain models and commercial systems - were a number of themes which crossed session boundaries and kept recurring, as usually happens in conferences and even more in the less formal workshop.

These included the following: Why did some countries prefer orthophotos to line maps, whether on paper or in digital form, and should colour photography be used? When was field revision more suitable than photogrammetric, with the inbuilt differences due to the former being less dependent on the weather and mostly in two dimensions only; while photogrammetry requires up-to-date photography and a knowledge of ground heights? Where were

graphical rather than digital techniques more suitable; and was this due only to the degree of local sophistication? One theme which usually recurs at such meetings of professionals was refreshingly absent; I can't remember anyone complaining that they were underpaid. What of course came across more than anything else (as it had at the Commonwealth Survey Conference at Cambridge in August) was that those concerned with maps are now involved at least as much in keeping them up-to-date as in making new ones; and that incorporating other geographical information (like land use) involved much the same techniques as topographic revision.

THE TECHNICAL SESSIONS

The Digital Scene in Europe from a CERCO Perspective

Before proceeding to papers on individual national experience, the Workshop heard from Alastair Macdonald, a Director of the Ordnance Survey, and Chairman of Work Group IX of yet another international body, CERCO. This stands for Comité Européen des Responsables de la Cartographie Officielle (which is Franglais enough for non-French speakers to need no translation).

Macdonald gave his personal view of the future role of photogrammetry in map revision, and showed a diagram of 15 countries' progress in digitising their plans and maps at different scales; but he admitted that figures from some countries were claims rather than facts - no names no packdrill as the Army says. What had emerged was that almost the only countries interested in the very large scales were in the British Isles, and that digitisation was only complete in the smallest scales (1:200,000 and smaller) and then only in a few countries. Another contrast was between those who, like France at 1:25,000 scale, were digitising while creating completely new mapping by photogrammetry; and those like the UK who were digitising existing maps. This was quicker, but less accurate, because of the weakness of some older mapping.

His paper and presentation initiated several of the themes already mentioned, like field versus photogrammetric revision; but he also predicted that the accuracy provided by large scale surveys, and required for such activities as car navigation and customer use of cheap and easy GPS fixing, might also make these more essential outside the UK. The increased precision of forward motion compensation in cameras; and the need to preserve the coordinates of existing features, would create problems where countries (as in the UK) had large numbers of existing maps based on out-of-date frameworks out of sympathy with GPS. He mentioned that customers want piecemeal (or patch-on in graphical terms) up-dating, rather than having to pay for a completely revised sheet - whether on paper or as digital data. This raised the problem of payment for data and two solutions: itemised payments, or renting with a guarantee of regular up-dating. The latter would guarantee a steady income for producers.

An important point made by Chris Thompson in advocating the use of colour photography was that interpretation by users was much simpler and, for example, that in spite of the great detail of UK large scale plans, they did not distinguish between hedges and other physical boundaries. They were therefore of no value in answering an important environmental question of how many hedges had been destroyed by farmers in the last decades.

THE NATIONAL MAPPING PERSPECTIVE

Updating Spatial Data by Digital Photogrammetric Methods - An Emerging Requirement

Unfortunately for this paper, from India, neither a text nor speakers were available, but the abstract described how their Survey department had acquired comprehensive and integrated digital mapping systems (Intermap) which used air photographs, ground information, and satellite sources such as SPOT. A pilot project of one 1:50,000 map at Dehra Dun had shown promise.

Updating the French Topographic Database

The next paper from France was presented by Christian Faad. They took the bold decision in 1983 to create a completely new database resembling the existing IGN 1:25,000 scale maps, with accuracies at 1:5,000 plotting scale which achieve 1.5m in plan and 1m in height, for hard detail such as buildings. The database is divided into blocks corresponding to existing 1:50,000 sheets. Updating will be on a seven year cycle; and the original coordinates of unchanged features will be preserved so that complete resurvey will not be required even after several cycles. For revision a superimposition system, with the S9 AP plotter, seemed the best solution. They had found it difficult to convert plotting at 1:5,000 to 1 1:25,000 specification, and were having to revise this. Paul Newby suggested that as in the UK they might find there was pressure for more frequent updating instead of cyclic revision.

The Digital Mapping Process of the Basic Map of Finland 1:10,000/1:20,000

We then heard from Jukka Artimo that in Finland they have a basic map surveyed at 1:10,000 scale, begun in 1947 and completed in 1975, soon after starting automatic plotting with their own software. They are now undertaking a digital cadastral map using a combination of aerial photographs and the original maps, with 60% of boundary corner marks signalised. Production is reaching 200 sheets a year, producing paper maps printed by hand methods. They have used both analytical plotters and converted analogue ones and had no difficulty with this combination - Belgium apparently have. They are studying database management.

Ordnance Survey Revision Problems and Solutions

John Farrow then described Ordnance Survey experience in digitising Great Britain's basic plans and in maintaining a cost effective revision service. All the 1:1,250 scale plans of towns have now been digitised and over half of the total including the 1:2,500 ones, completion is hoped for in 1998-9. Photogrammetry is only used for about a third of the revision at these basic scales; and revision is divided into primary and secondary; the latter being of smaller changes, but necessary to preserve the integrity of the map series. One major problem, in rural areas particularly, is finding out about small pockets of scattered development; the OS believes that the backlog of development not yet incorporated may be as much as half a million house units.

Since the basic plans include only spot heights, but no contours, a digital terrain model has to be created for photogrammetric superimposition technology to be used to revise them. This is done by raster scanning of the contoured 1:10,000 scale maps and interpolating heights of features being revised. Field survey in two dimensions only, using total stations and micro processor data-loggers transmitting direct to HQ, is often preferred, being fast and economical; and of course independent of the rare English weather conditions necessary for aerial photography.

Updating of a Complex GIS Data Base - The Northern Ireland Experience

In Mike Brand's absence the paper from Northern Ireland on their very good and practical experience in updating a complex database was introduced by Raymond Clements. This was an important paper based on practical and successful experience in setting up a data base in a relatively small country, but one already mapped at the large British scales of 1:2,500 and 1:1,250. The database included many details such as the type of boundary, all administrative boundaries (which unlike private ones are 'fixed' and very precisely defined in the UK), the nature of water areas and of vegetation and so on. An important question in revision was whether to retain, in a separate layer, the archival information about the feature which had been removed or replaced; and it had been decided to do this in spite of the considerable extra effort required. Details were given of how a 'hole' was created and filled with the new data, with the previous information being retained in a separate layer.

The Survey has partners in its data bank system, such as the Utilities (Water, Gas, Drainage, Electricity and Telephones), and these require rapid updating. At present the turn around time between survey and incorporation in the data base is about five days; but no figure for the period between completion of a new feature and its survey was given. Nor at present had Northern Ireland apparently any details of differences between the coordinates taken from their plans and any future system based on GPS, which they had not so far employed.

APPLICATIONS AND EXPERIENCE

Map Revision in Developing Countries

The first afternoon session was on Applications and Experience and included only three presentations and papers. The first paper, from Iran, was briefly introduced by Paul Newby, who recommended concentration on the later sections of the paper (after Section 3). These consider specifically the problems of developing countries and the extent to which they can use modern technology and include some sound common sense about the different problems in such countries. As Mr Pourkamal wrote: "Many organisations have not been able to change their beloved analogue plotters" or even upgrade them into hybrid ones; although conversion to digital systems is necessary and the makers of analogue instruments no longer maintain them. He recommended temporary use of simpler instruments capable of conversion to digital output; but in a revealing aside explains how they must be kept out of sight of distinguished visitors.

He rightly emphasizes the manpower available in such countries for field revision and how the Statistical Centre trained their own technicians for updating town maps; these were then more popular than the products of the National Cartographic Centre. However, Photogrammetry, requiring higher skills than simple field revision, limited what customer departments could do. There are some familiar "random thoughts", especially how cyclic revision is easier but less popular with customers, revision was neglected because of pressure to complete the national coverage, and the need to restrict the number of map scales to be maintained.

Orthophotography as a National Reference Land Base

Philip Allen of New Zealand then described a joint project in which his firm and the government had cooperated in producing orthophotos which were becoming very popular. However, it transpired in subsequent discussion that the difficulties caused by high buildings were very much less common in New Zealand, with a population of only three million spread over an area not much smaller than the UK; and, even more important, a tendency for most of them to live in bungalows rather than blocks of flats of two storey houses. His paper emphasized that lay people can understand an orthophoto more easily than a line map; but it is doubtful if this is true in other equally sophisticated countries. He seemed to be advocating photography as large as 1:1,000 scale in urban areas, giving absolute plan accuracies of 0.5m and relative of 0.2m; but this of course assumes that one can see all the footings of a building which will not normally be the case. Away from towns and densely occupied farmlands his favoured scale is 1:10,000.

Digital Update - A User Experience

Richard Webb of the Southern Water Board then gave a good talk, for which unfortunately he had not been able to write a paper. His Board covers West Sussex and Hampshire with some 4 million customers, 14,000km of mains, 22,000km of sewers, 2 million water and nearly 4 million sewage customers. (Half of the water users are supplied by other water companies). There are about a thousand users of the water records and OS digital mapping, and the system is running well, except when communications are disrupted by storms. The OS update the data and the Board moves it from their central database to local offices after a quality check. they have employed 30 staff for three years on digitising their own network data, and are now moving into a geographical information system with details of connections, sizes of mains, etc. They have purchased 12,000 OS digital maps to which they have added the detail of their mains etc.

Photopolis Project: Updating Digital Geographic Objects from Aerial Photos

The last paper was presented by Sylvie Servigne from Lyon (France) about updating the cadastre of Padua (Italy) by photogrammetric image processing. The opening paragraphs were fairly routine, but difficult to follow because of some unusual English terms. For example distortion is called warping; but the two authors included a beautifully concise way of describing a well known principle by saying: "the farther from the photo centre, the warper" which gave this delegate at least great pleasure. They also use the term 'segment' which seems to mean an area of a photograph or map clearly outlined. The automated image processing project called Photopolis is now in its feasibility study; a decision whether to proceed will be made in two months; and some results in as many years.

THE ENGINE OF IDEAS - THEORY AND PRACTICE FROM UNIVERSITIES

Low Cost Analytical Plotters for Revision

The second afternoon session, entitled "The Engine of Ideas", was about theory and practice from universities. David Tait, of Glasgow, gave an excellent analysis of the advantages of low cost analytical plotters for revision. He pointed out that this resembled the addition of specialist information (like land use) to existing maps; and that survey departments had been unduly influenced by the more accurate techniques and instruments required for plotting the original maps. As revision takes over, a fundamental review of techniques is required. Revision requires three distinct processes; the detection of change, the removal of the old features, and the addition of the new. He also outlined the problem of fitting new detail from precisely located photographic images to old maps with locational errors; for this kind of 'patching' precise instruments are unsuitable, as they are for adding thematic information.

He emphasized that another reason for using less precise (and therefore cheaper) instruments was that in this work more "thinking time" is required, with the instrument temporarily idle, which is unacceptable if it is very expensive. He listed a number of suitable instruments such as the Yzerman APY (described by its designer in a later paper) in which the map and the stereo model can be compared; and which he is investigating. He also listed a number of requirements: designed for the task; using existing detail in both graphical and digital form; digital output; direct superimposition of the model and the map; and above all a low price. One problem is that control points used to combine these must be in three dimensions, while ground control points often are not, with for example sharp peaks or spires good for plan (and easily fixed) and flat topped hills or buildings for height; but they have to be visited.

Integration Levels of Topo Databases and Geo-Imagery for Updating Purposes

The paper by Lemmens of Delft described the integration of photographic and satellite imagery with existing topographic bases; but was rather more generalised than the previous papers with much of the usual jargon about geographical information systems. Different solutions, ranging from marking up new detail on the photographs, comparing them after digitising videos of this and the map, and using ortho photos were mentioned but not compared in detail.

Automatic Extraction of Roads from SPOT Images

The next paper, presented by Ms Marlies de Gunst also from Delft, on using SPOT to locate roads, seemed to this writer to be unnecessarily elaborate, and produced a sneaking feeling that if the authors knew where a road was they could locate it on the SPOT imagery. In conversation afterwards the impression gained was that others were more advanced in this technique. Once again, a vehicle with GPS may be a cheaper way of getting the results - provided of course one can get it to the road.

The Importance of a Code of Origin

The presentation by Professor Jacobi of Denmark (the Greenland baby mentioned by Paul Newby) was refreshingly brisk, with a few hand drawn pictures and good humour. He described Denmark's problem, similar to that in the UK, of a change of national framework coordinates and how to accommodate this in large scale revision. However, as the average difference was under 50cm and the maximum one metre, it did not seem a very serious problem compared with the UK's larger differences. The most useful discovery was that the ideal features for use in linking successive air photographs were found to be the roadside drainage gratings. Visible on any photos at 1:10,000 scale or larger, they were seldom moved, at ground level, and were free of halation (light coloured objects spreading into a darker background) common to features like pavement corners.

ENVIRONMENTAL APPLICATIONS

Toward the Perceptional World: Transform Environmental Digital Data into Perceptional Digital Data

The first session on Tuesday was on environmental applications, but unfortunately Dr Liu Binyi of China was not present.

This paper, which is included in the proceedings, could have done with a presentation as it was difficult to follow, being rather full of jargon (including Chinese) about transferring environmental digital data into perceptional digital data: this seemed to mean converting subjective impressions into digits.

A Remote Measuring System for the Mapping of Hazardous Environments (HAZMAP)

The session opened with a paper by D P Chapman of UCL on mapping the inside of hazardous nuclear installations. Video cameras were liable to electromagnetic distortion and had too low a resolution, so he employed two remotely steerable ones which took large scale 'tiles' which were digitally recorded and built up into a mosaic. Known dimensions of the equipment were used to scale and control the models. He mentioned an alternative which is to put film cameras in place and then shoot the film in and out rapidly before and after exposure. It was an interesting paper but rather out of the main stream of the Workshop; still, the problems of mapping go all the way from contouring the retina with microscopes to mapping the most distant nebulae.

JASMAPS - A Colour Photography Database for GIS Applications

Chris Thompson then described the advantages of using digital colour photography in combination with Geographic Information Systems. Colour imagery is relatively easy for the non-specialist user to interpret, particularly when environmental and not just topographic details were required.

JASMAPS, an Apple Macintosh based system developed by his company Geonex, enabled photo and map images to be displayed as a seamless database, together with user information. The problem of the considerable cost of high resolution scanning was overcome by digitising to a resolution sufficient to allow some enlargement up to 2 times, on the screen. Forward motion compensation cameras provided additional clarity of photo images; and the remark was quoted that if we had had air photos before line maps were invented we would never have used maps.

DOW - A Flexible and Powerful Low-Cost System for Generation of Digital Orthophotos from Aerial and Spot Image

E P Baltsavias from Zurich then described how SPOT images were converted to orthophotos and digitised using powerful, flexible and general purpose computers without special hardware and modifying existing software. A Sun network was used linking VAX, IBM PC and Apple computers and two analytical plotters and an external Optronics scanner/Laser plotter. The SPOT model with nine control points achieved plan accuracies of about 15m; and comparisons of the resulting orthophoto with a 1:25,000 map showed errors about a third of this. However, no mention was made of the main problem of using SPOT for medium scale mapping or revision; how to identify the smaller items of human activity, especially in developing countries where building materials similar to the background are used.

UPDATING DTMS AND DIFFERENTIAL MODELLING

DTMs and Differential Modelling

The next session included some theoretical mathematics and dealt with the problem of updating digital terrain models (DTMs) which are essential when photogrammetry is to be used for revising maps, especially when they are planimetric only. The first paper, by K Tempfli of ITC, described how DTMs obtained by digitising existing smaller scale contoured maps often suffer from lack of precision, specially in depicting changes in slopes and deep gulleys. Of course a completely fresh DTM can be made by photogrammetry; but this is expensive, and a cheaper solution is differential modelling. In this attention is paid particularly to changes of slope, and by using 'skeleton lines' such as rivers and roads. These tend to follow the bottoms of valleys and the tops of ridges, and indicate steeper slopes by rapids or extra bends or cuttings. Updating DTMs is not much of a problem, though land slides and human activities like quarrying have to be detected.

Evaluation of Interpolators for Digital Elevation Models

The paper from Brazil dealt with much the same subject, but more abstrusely, using the unfamiliar term "beta-splines" which made it possible to interpolate cross sections at closer intervals. For proper understanding of this procedure some references were supplied.

Digital Elevation Model Accuracy Assessment for Advanced Spaceborne Thermal Emission and Reflection Radiometer to be on board the EOS-a Platform

The third paper, from Japan, suggested use of proposed future satellite imagery from EOS, due in 1997, providing advanced thermal emission and a reflection radiometer. Details of band widths etc were given with theoretical errors, which seemed rather large for revision of the kind of large scale maps covering developed areas, especially if GPS was not used for control, when height errors over 150m were suggested.

SPOT Imagery - Rapid Rectification and Automatic DTM Generation

David Gugan of Laser Scan Ltd (UK) summarised work in image rectification and stereomatching to produce DTMs and ortho images from SPOT imagery. Laser Scan have preferred to use modern off-the-shelf RISC workstations rather than embarking on coding for transporters. He also gave a forward look to the working environment of the next generation of Laser Scan mapping software.

SYSTEMS - PHILOSOPHY AND SOLUTIONS

Leica's Approach to Database Revision by Photogrammetry

In the last technical session Stewart Walker of Leica (now incorporating the well known firms of Wild and Kern) gave an overview of the equipment and systems they were producing for data base revision by photogrammetry with the facility for superimposition of existing maps and stereo models, including their latest production the SD 2000; and a simpler and cheaper plotter of the kind envisaged by Tait in his paper, the DVP Digital Video Plotter station, developed originally at Laval University. This writer got the impression that experts more familiar with the nomenclature and refinements of photogrammetric techniques and instruments are likely to find that this firm, with its absorbtion of at least two well known major instrument designers, will be worth consulting when they are planning future expansion.

Image Station: Digital Photogrammetric Workstation

Dick Kaiser of Intergraph (USA) then gave a rather long and detailed presentation on their new Image Station series of digital photogrammetric equipment. This will use digital imagery acquired using the scanner developed in collaboration with Zeiss (Germany). Stereoplotting is done on a single screen using tethered polarising spectacles; this is claimed to be the most effective of interactive stereo graphics systems currently available. Database revision on screen is facilitated by the 3D (stereo) superimposition of vector map data on the highly zoomable air photo model. This approach appears to involve very

precise and therefore inevitably expensive equipment and programmes suitable for sophisticated departments with well-trained operators, although Kaiser did claim that many parts of the working process could be done be comparatively unskilled workers.

Applications of the APY System

By contrast Henk Yzerman's practical description of his much less expensive APY system (with no moving parts except rotating glass plates) for revising existing maps (whether on paper or digital) showed greater flexibility and appeared more suitable for countries with graphical maps and even ones (as in the UK) with some inherent errors.

CLOSING SESSION

It is impossible to hold any meeting of map makers today without discussing geographic, spatial, or land information systems; though the only valid distinction between them I have heard was that made last month by the New Zealand Surveyor General at Cambridge, "Ministers understand the word 'Land' but not the others".

The last paper was one by the Chairman of the UK Association for Geographic Information, Peter Woodsford. He quoted two well known Oxford limericks about existentialism believed to be by Father Ronald Knox. They sum up very well the whole question of whether things exist if no one observes them; though the relevance to GIS is less obvious.

They are:

There was a young man who said God
Must think it exceedingly odd
    That this beautiful tree
    Can continue to be
When there's no one about in the quad.

He then received the reply:

Sir, your astonishment's odd
I am always about in the quad
    And that's why this tree
    Will continue to be
Since observed by: yours faithfully, God.

Woodsford emphasized in his paper **"Geographic Information in 1990s"** the immensely rapid growth both in the amount of data flowing from satellites and increased ease of positioning with GPS, but also the growth of the GIS industry, with a new unit, the terabyte (a million million bytes), and the increasing use and speed of networks linking computers facilitated by fibre

optics. He also stressed the cost of keeping data up to date and made one new point; users now accept the need for and cost of maintaining software as they used to that of the hardware. He mentioned that while in the USA government survey data is free, that by contrast in the UK the OS charges for it.

So to the closing remarks of the Workshop. Paul Newby, Chris Thompson, and Kennert Torlegard summed up how they thought the workshop had gone. Newby summed up the work of ISPRS Working Group IV/3 taking account also of the papers and discussion during the Workshop. He also mentioned that with the increasing commercial attitudes imposed on government departments, they too would become secretive about their commercial activities, but hoped that there would be less rather than more secrecy overall.

Thompson concluded that the important techniques requiring further investigation were super-imposition of stereo models with digital data, the new technology now emerging for exploiting digital imagery, digital up-dating of DTMs and the need to take account of quality assurance of data. He said that the development and implementation of the new digital systems must take account of the existence world wide of some 4000 analogue plotters and 2000 analytical plotters still in use.

Both Newby and Thompson stressed the importance of reports of practical experience of techniques and the handling and maintenance of data in large LIS and GIS environments, and encouraged members of ISPRS and OEEPE to cooperate in ensuring publication of results.

Torlegard stressed the importance of photogrammetry in topographic, large scale, and engineering surveys, and in studies of the environment. He stressed the need for better understanding of imagery and the use of remote sensing. He looked forward to meeting delegates again in Washington next August at the ISPRS Congress. The Workshop then ended with the usual thanks to staff, speakers, and delegates for their contributions.

ISPRS Commission IV : Cartographic & Database Applications
Working Group IV/3 : Map Revision (1988-92)
Review of Progress 1988-91 by Paul Newby

1. INTRODUCTION

I have already written at length to Working Group correspondents about the directions in which I expected developments to move during my Chairmanship. In this note I summarise the progress up to the end of the ISPRS/OEEPE Joint Workshop whose proceedings are published in this volume. I also examine the extent to which the Terms of Reference of the Working Group remain valid as we enter the ISPRS Congress year of 1992, and approach the opening of the new quadrennial session, 1992-96.

2. TERMS OF REFERENCE

The terms of reference set at the opening of this Session in 1988 were as follows:

- Change detection using satellite imagery and aerial photography

and - Procedures for digital and graphical map revision, with special reference to the use of superimposition systems.

I believed then that the superimposition (image injection) systems which were then becoming more widely available would be the key to digital map revision, because of their capability of placing simultaneously before the observer his three vital datasets, namely the existing digital map, the stereoscopic model created from new aerial photography, and the newly captured detail to be merged with the existing map. I was a little sceptical of progress in change detection, perhaps because of my ignorance at that stage of the great efforts being dedicated worldwide to the automation of this process.

3. ACTIVITY 1988-91 - CHANGE DETECTION

I can now report that I have seen a great deal of work on change detection reported to both Commission III and Commission IV of ISPRS. The numerous problems of image processing whose solution will lead eventually to full image understanding, and which include automatic correlation, feature extraction and change detection, are being addressed on a theoretical and practical level worldwide, but especially in Germany and the United States. At the risk of offending those omitted from these brief remarks, I would single out Foerstner (Germany), McKeown (USA), Baltsavias (Switzerland), Hahn (Germany) and Sarjakoski and Haggren (Finland) for their contributions to Commission III.

This joint workshop volume includes important papers from Baltsavias and Lemmens (The Netherlands); Laurini and Servigne's paper (France) also addresses the same issues although this team may have some ground to make up in the photogrammetric image processing field. We also have a paper on practical work using SPOT data presented by Marlies de Gunst, a member of Lemmens' team. This has echoes of work presented by

Solberg (Norway) to the 1990 ISPRS Commission IV Symposium, in which he described the experimental use of SPOT imagery to map new roads automatically for 1:50 000 revision in remote areas of his country.

All this effort and all of these reports may be summed up as representing high hopes and some real progress; they are certainly steps on the road from the computer-assisted human operations of recent years to the human-assisted computer operations which are all we can realistically hope for in the foreseeable future. Along the way it has been recognised that there is unlikely to be a single algorithmic panacea for image understanding; rather the successful processes will combine numerous approaches to the same problem in much the same way as the intelligent human operator implicitly or explicitly addresses an image or image pair. Such techniques are not yet widespread in practice and this topic remains a valid part of the terms of reference for activity in both Commission III and Commission IV of ISPRS.

4. ACTIVITY 1988-91 : REVISION PROCEDURES

Work on digital map updating is now undoubtedly being considered wherever the initial capture of digital data is already complete over a substantial area. This is the inexorable process which will lead inevitably to map revision, or rather the updating of digital geographical databases, being high on the agenda of all map makers as the millenium approaches. Meanwhile practical reports have been given from Great Britain (Commission IV Symposium 1990 as well as this Workshop), from Northern Ireland and France (this workshop) as well as some preliminary pointers to future activity in Scandinavia and India. I believe I can justly claim that only my own 1990 paper on "Digital Map Revision at the Ordnance Survey" gives any substantial detail on practical procedures, including the use of superimposition, in routine production work; I very much hope that more reports will be forthcoming from elsewhere in the near future.

An encouraging trend over the past three years has been the advancing realisation that Geographical Information Systems (GIS) must eventually cater for three-dimensional geometry and topology, as well as the fourth dimension of time. They have largely evolved as two-dimensional software, with some opportunity to include the third dimension as an attribute. As inventors became vendors GIS have burgeoned without any very sound theoretical foundation; this is now being rectified by a host of authors. As a contribution to the 1990 ISPRS Commission IV Symposium I would cite particularly the contribution by Shibasaki (Japan) on the modelling of urban landscapes, with his clear recognition of the problems of truly three-dimensional large scale mapping and the need to include an update capability as an integral part of the initial design.

Finally several contributions to this workshop have reminded us that the updating of digital terrain models (DTMs) should not be overlooked.

The papers by Tempfli (The Netherlands), Vieira-Dias (Brazil) and Arai (Japan) all address ways of improving the quality of a DTM as new data become available.

5. ACTIVITY 1988-91 : REVISION INSTRUMENTS

The main change in the last three years is that we can now take it for granted that superimposition will be available on most photogrammetric instruments, including some low cost equipment. If it is not an integral part of a new instrument when it is first announced, we can at least be sure that the vendor will make it a high priority for early incorporation. Moreover, on the new generation of entirely digital equipment (that is, using digital imagery obtained either direct or by scanning silver halide photographs), superimposition of existing or newly captured digital map data incurs only marginal extra costs. This is in contrast to the addition of superimposition to analytical stereoplotters using conventional photographs, which demands very elaborate additional hardware and software with a corresponding cost penalty. Both Walker (Leica) and Kaiser (Intergraph) discuss these and other aspects in their contributions to this Workshop.

Although now quite readily available in some form on most modern equipment, it has to be said that not all superimposition systems are well adapted for revision; the original concept of an aid to initial data capture remains prevalent. However, as reported from the Ordnance Survey of Great Britain, superimposition can be used successfully as an aid to digital map revision; the procedure naturally includes the need to incorporate height data into the existing digital map in order to achieve the correct perspective for the operator's view of the stereomodel. As I have mentioned above there is a disappointing lack of reports on practical experience elsewhere.

At the low-cost end of the market, encouraged eloquently by Tait (UK) in this volume, there has happily been some progress. Several contributions have been made both to this Workshop and to the 1990 Symposium, notably from Canada (Agnard and Derenyi) and Switzerland (Baltsavias and Yzerman). It remains to be seen whether such developments can compete successfully with higher budget equipment (sometimes from the same vendors) at the national mapping level, but they certainly have a place in thematic mapping on a topographic background (an exact analogue of the updating problem). Moreover for routine but urgently needed revision work by a comparatively large labour force tackling small areas of change on the ground, national mappers will undoubtedly be looking for low cost solutions. Finally in this vein it must be added that digital data capture from a single photograph (digital mono-plotting) has not yet taken off despite the widespread availability of DTMs to provide the necessary third dimension.

6. FUTURE DIRECTIONS

I believe that the work reported above represents real progress in addressing our terms of reference, but they do nevertheless remain valid today. The emphasis on the development of superimposition is no longer necessary, but practical reports on its application are urgently required. Ways need to be found to overcome the commercial secrecy which inhibits communication and inevitably slows down development. In view of the progress in the use of digital imagery, it would be relevant for 1992-96 to add a remark on its integration into users' topographic (map) databases. Meanwhile, system creators need to treat database updating as a distinctive task separate from initial data capture, and to ensure that they allow integration of update with users' existing systems (for by definition update implies that a database is already in place). GIS should in future be designed to be both three-dimensional and capable of updating. Obviously those vendors who do not devise cost-effective solutions will not survive the increasing financial discipline which surely lies ahead.

This Workshop has established a close working relationship between an ISPRS Working Group and a Commission of OEEPE, which is itself a Regional Member of ISPRS. Traditionally the two organisations have operated rather differently. OEEPE has sponsored quite ambitious international experiments with central direction from a lead organisation which volunteers for this role. ISPRS tends to rely on the open communication of practitioners' individual results, within the loose framework of Terms of Reference such as those discussed in detail here. As the Chairman of this Working Group, I continue to urge my correspondents to report their relevant work, whether it be in production organisations, in academic institutions working on either a theoretical or practical plane, or as system developers and vendors. I do await with great interest the possible emergence of an OEEPE-style collaborative experiment from among the participants in this Workshop; I heard one possible project, on DTM quality descriptors, mooted during the Workshop and I look forward to proposals from willing lead organisations for this or any other relevant project.

If I had one disappointment during the Workshop, it was that we failed to provide enough time for a wide ranging discussion of these matters in the closing session; we certainly intended to do so but time simply ran out. I can only hope that the Workshop Sessions did themselves stimulate participants enough for us to be able to maintain the momentum and enthusiasm for continuing collaboration outside the meeting.

Meanwhile, I also continually look sideways at contributions to other ISPRS Commissions, many of which would fit as readily into this one. There is certainly a substantial overlap of interest between Commissions II (Instrumentation), III (Algorithms), IV (Applications) and even VI (Business, Management and Education) in the matter of "updating digital geographical databases by photogrammetric methods",

the long title which I would now favour over the simple, but arguably outdated "Map Revision". "Database Update" could be an acceptable Working Group Title for 1992-96. In the longer term (perhaps 1996-2000 rather than 1992-96) I would argue that this topic should become the subject of one commission in a new horizontally-integrated ISPRS structure, which could usefully supplant the vertically-integrated but substantially overlapping commission structure we have today.

Finally, on behalf of ISPRS I would like formally to thank OEEPE for undertaking the publication of these Workshop Proceedings. These will remain as a tangible record of the start of what I hope will become a fruitful and long-lived relationship between the two organisations.

PAUL NEWBY
West Wellow
Hampshire, UK
October 1991

TP/NEWBY

2. THE NATIONAL MAPPING PERSPECTIVE

Chairman: Chris Thompson.

2.1 The Digital Scene in Europe from a CERCO Perspective.

Alastair Macdonald, Chairman of CERCO Working Group IX Updating of Digital Maps and Topographic Databases.

2.2 Updating Spatial Data by Digital Photogrammetric Methods - An Emerging Requirement.

S D Baveja and P N Koul, Survey of India.

2.3 Updating the French Topographic Database.

Christian Faad and Francois Salgé, Institut Géographique National, France.

2.4 The Digital Mapping Process of the Basic Map of Finland 1:10,000/1:20,000.

Jukka Artimo, National Board of Survey, Finland.

2.5 Ordnance Survey Revision Problems and Solutions.

John Farrow, Ordnance Survey of Great Britain.

2.6 Updating of a Complex GIS Data Base - The Northern Ireland Experience.

M J D Brand, Ordnance Survey Northern Ireland.

Paper 2.2 - Baveja and Koul were not able to present the paper for which an Abstract only is available for the Workshop Proceedings.

Paper 2.6 (Brand) was presented by Raymond Clements, Ordnance Survey, Northern Ireland.

THE DIGITAL SCENE IN EUROPE FROM A CERCO PERSPECTIVE

A S Macdonald
Chairman of CERCO Working Group IX

ABSTRACT

CERCO Working Group IX has provided an opportunity to review the state of the conversion of conventional maps to digital form across western Europe.

Interest centres on initial digitising of the smaller scales and little attention has yet been paid to the implications for map and data revision. The British Isles are alone in concentrating on data derived from large scale maps and in having developed a nationwide revision service.

The author argues that rising expectations from a variety of users will increase the pressure for national data sets of much higher precision and detail together with a rapid and regular revision service.

Cost comparisons between ground survey and photogrammetry often favour the latter for initial mapping but revision in the digital area will present very different comparisons. The weak links in the production chain - such as poor weather in the flying season - may become so serious that ground survey techniques take over. A further threat to traditional photogrammetry can be detected in the emerging digital plotters which offer the potential to de-skill the operation and the concept of dormant map information, created when required by DIY specialist users.

Photogrammetrists will only prosper in the mapping market if they can match the competition on delivery and price from ground surveyors.

In this short address, I would like to use the European perspective to develop some rather radical and idiosyncratic views about the future role of photogrammetry in map revision.

CERCO stands for Comité Europeen des Responsables de la Cartographie Officielle. It is a meeting place for Heads of European National Mapping Agencies and currently consists of the 12 EC Countries, Austria, Norway, Sweden, Finland and Switzerland. An application from Cyprus is under consideration while Czechoslovakia and Hungary have asked to become observers.

The main body has authorised ten Working Groups which meet with varying frequency and to varying effect. Perhaps the most useful are those on Copyright and Standards. My own (WG IX - Updating of Digital Maps and Topographic Databases) is designed more as a point of contact and discussion where experts can meet, discuss and shape their ideas in the light of others' experience and before they have committed themselves to a particular approach.

One of our first activities was to try to summarise the activity in data creation and revision by country and scale. We had a good response and this was the picture in 1990 (Figure 1).

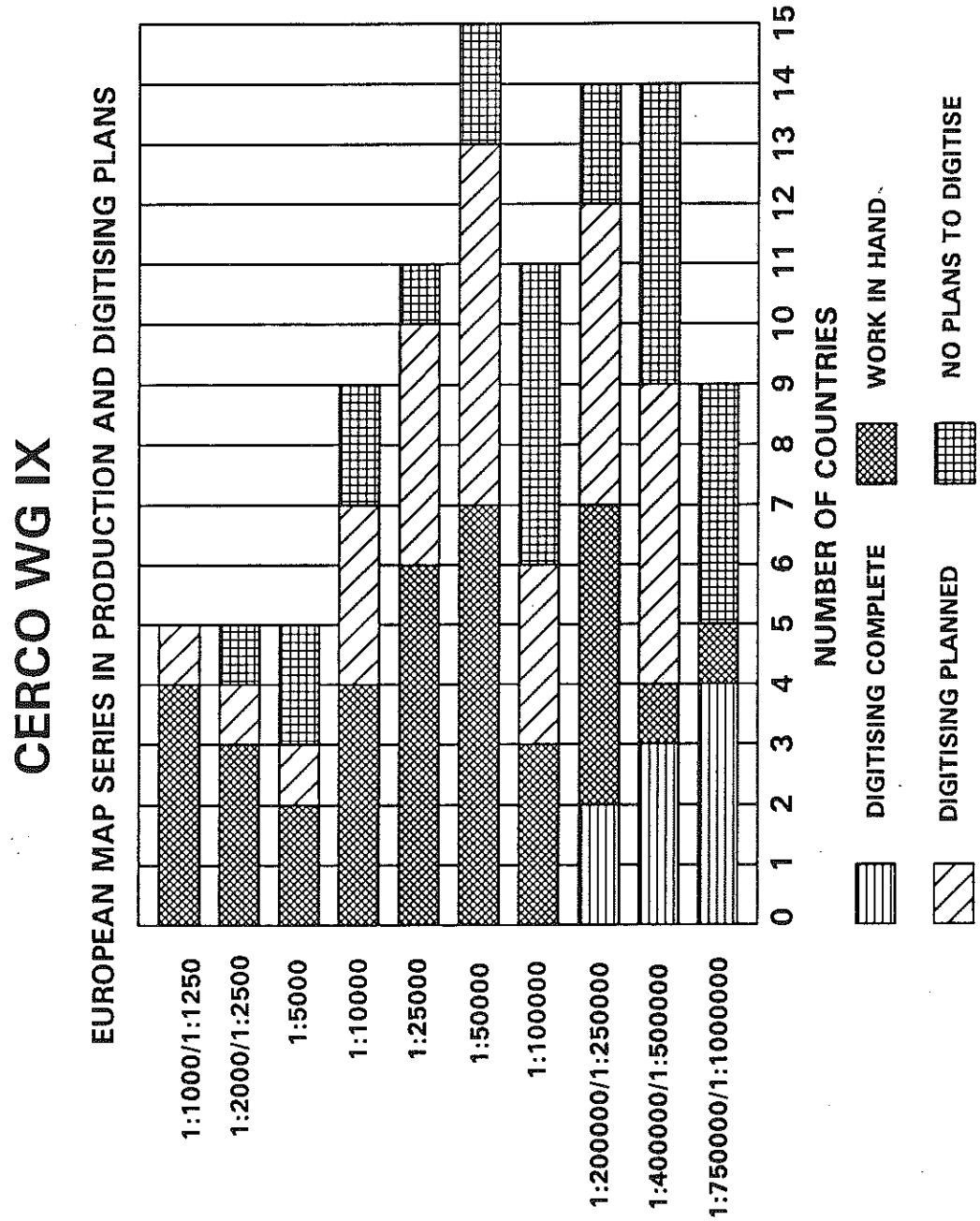
You will see that only a very small group of countries (the main ones being GB, NI and Eire) are interested in the larger scales. The main activity is at the opposite end of the spectrum. In all, 74 different map series are being or are planned to be digitised.

The role of photogrammetry in initial data creation is shown in the table below:

TECHNIQUE OF DIGITISING	NO. OF SERIES
DIRECT SURVEY	10
PHOTOGRAMMETRY	25
SCANNING MAP	39
DIGITISING MAP	48

More than one technique is used on some series so the total exceeds 74. It is clear that photogrammetry plays a significant part in the initial process. This is because several countries have acquired funds to carry out a new mapping exercise concurrent with digitisation, eg, the IGNF Topo Data which supports a new 1:25 000 map and the IGNB Database which supports a new 1:10 000 map. If funding and time are both available, this approach ensures that data consistency meets today's expectations. However, many other countries (including GB) have chosen the cheaper and quicker route of digitising existing mapping, designed in a much earlier era and of an accuracy defined by the techniques of the time. It will be interesting to see which approach appears superior in, say, 20 years' time.

Figure 1


CERCO WG IX
EUROPEAN MAP SERIES IN PRODUCTION AND DIGITISING PLANS
1:1000/1:1250
1:2000/1:2500
1:5000
1:10000
1:25000
1:50000
1:100000
1:200000/1:250000
1:400000/1:500000
1:750000/1:1000000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
NUMBER OF COUNTRIES
DIGITISING COMPLETE
WORK IN HAND
DIGITISING PLANNED
NO PLANS TO DIGITISE

Most organisations are concentrating on the initial conversion phase and have not yet been able to devote much resource to designing a revision service. However, a revision service has been implemented or is planned for 38 of the 74 digital data sets. This compares with 53 of the graphic products which are subject to regular revision.

By far the most common method of revision is to replace the entire map, often by photogrammetric plotting from new photography, with fairly long time intervals between successive editions. Switzerland is a classic example with a regular 5 year cyclic programme.

So a very coarse summary of present day activity would be that interest centres on 1:50 000 and smaller scales, that demand for a close up-to-date correlation between what is on the ground and what is on the map is low and that periodic replacement of maps is the most popular method of revision.

This scenario is good news for photogrammetry. An orderly progression from acquisition of aerial photography (possibly taken a year early to be safe) to plotting and field edit is possible and a new set of digits falls out of the process for free!

But will it last? The three Ordnance Surveys in the British Isles are currently unique in Europe in their interest in national scales as large as 1:1250. But they are beginning to demonstrate the potential of data with the precision of these large scales - as base data for utilities' GIS, as navigation data for vehicles, as support for national censuses and the like. In all these activities, a national specification and a national standard are essential while the need for precision in car navigation systems at complex road junctions is obvious. I think the question is not whether but when those countries, where cadastral and municipal authorities have traditionally fulfilled their separate requirements for the larger scales, will move towards a centralised approach to meet national (as opposed to local) needs.

And what about the need to have up-to-date information? Do digital data users expect data to be more up-to-date than users of conventional maps? Will drivers be content to receive updates of in-car navigation data every five years or even once a year?

Will utilities wait until, say, six months after construction for new houses to show on their screens, long after they have designed and delivered their services? Installation costs of new digital systems are high and users will have rising expectations of the quality of service in this as in all other fields. It would therefore seem prudent to anticipate a more demanding level of currency.

At first sight, more national map series and more stringent revision demands can be regarded as more good news for photogrammetry. New series will provide good opportunities for photogrammetry but I want to concentrate in this paper on the role of photogrammetry in revision and here I see three serious threats:

1. Will revision by map replacement remain viable in the digital era?

2. Can photogrammetry deliver rapid up-date?

3. Will instruments such as Kern's DSP1 lead eventually to DIY revision?

It seems unlikely that graphic maps will continue to be expensively replaced by replotted new editions. The availability of the data will push agencies to use that data cost effectively and, furthermore, users will increasingly resent changed coordinate values for features that have not moved on the ground, a result that is surely inevitable if replotting from new photography by different operators is attempted. Thus, the requirement will be to detect and plot change and to merge the new data with the old with the minimum disturbance. In this activity, photogrammetry has a serious competitor in ground survey, both today with electronic survey equipment and perhaps even more tomorrow with GPS black boxes. More and more national agencies are making judgements on such issues on the basis of cost and, while costs on both sides will vary with scale, density of detail, labour rates, equipment costs and so on, the competition will always be keen and photogrammetry will certainly not win every time. Our experience at OSGB is that, at the large scales, development sites of $1km^2$ or more are best done by photogrammetry but the choice is on a knife-edge.

Furthermore, I have said that users will want more frequent update. Can photogrammetry deliver? Hanging

over every photogrammetric flowline is the disaster of a poor flying season, a drawback that dedicated ground surveyors are quick to seize upon when delivery dates are being discussed. If update is needed within, say, 3 months of construction (and this is a requirement that is beginning to surface from customers for our large scale data), then the weather (in this country at least) can destroy your ability to meet the target. Ground survey, and especially GPS, is much less dependent on the weather and so the ground surveyor can quote delivery times and cost with much more precision. The photogrammetrist may have the potential to deliver more quickly and more cheaply but, until he has the photography in the can, he cannot be sure of that.

Finally, I have always been stimulated by the potential of the new digital plotters such as Kern's DSP1, not because they are just what organisations such as mine have been waiting for but because they release the potential for accurate quantification of all the specialist information contained in aerial photography by the specialist users themselves, eg, the location of street furniture by highway engineers, differentiation between tree types by foresters, checking of extensions to houses by planning officers, etc, etc. The aerial photographs themselves become a virtual map, dormant until required by the user but capable of delivering up all their information quickly and easily when required.

Of course, a base map will be required both to control the digital model and to receive the user's own selected information but whether the specification will need to be as wide as today's map remains to be seen. A more serious development both from these instruments and from GPS black boxes is the rise of DIY revision by the user if national mapping agencies do not acquire and maintain a high reputation for fast and reliable service and value for money.

In summary, I would say that as national mapping agencies in Europe move into the digital era, the traditional field of photogrammetric map replacement will shrink severely and eventually die. In the digital era, the emphasis will be on change detection and prompt delivery of change data to customers. How well photogrammetry will survive in the new era depends on how reliably it can obtain photography or satellite imagery, how far it can reduce its

production times and whether it can beat new ground survey techniques on cost and on delivery. The future success of the national agencies themselves will be dependent on how well they deal with their customers' rising expectations of quality and service, both what is supplied and when. I hope that this conference will devote some of its time to considering these issues.

The views that I have expressed in this paper are my own and should not be taken as in any way representing those of either the Ordnance Survey Great Britain or CERCO.

UPDATING OF SPATIAL DATA BY DIGITAL PHOTOGRAMMETRIC TECHNIQUES - AN EMERGING REQUIREMENT

by

S D BAVEJA & MAJOR P N KOUL

ABSTRACT

The usage of digital technology in the process of map making combined with geographic evolution has lead to many geoprocessing techniques for handling of digital data. The large volumes of digital data to be handled has given birth to the present trends in geographic and land information systems necessitating the generation of logical and accurate data bases. As a result of these developments mapping agencies all over the world have resorted to digitisation processes ie conversion of graphical (analogue) data to digital data with the aim to digitally store and preserve its purity for easy updating to meet the increasing diversified needs of their respective users. These agencies are not only confronted with the problem of generating the digital spatial data bases but also for its processing and to keep it up to date by utilising various cost effective, but accurate, techniques of updating. The present workshop is therefore, a step in the right direction and is being held at a most opportune time.

The latest techniques of digital photogrammetry have not only made it possible to capture spatial data with a higher level of accuracy but also enabled more efficient ways of generating the processing, reviewing and the updating of the spatial data files under digital environments.

Survey of India, the prime mapping agency in India, having identified these developments in technology, has acquired comprehensive digital mapping centres. These centres are equipped with specially designed Intermap Analytic Photogrammetric Workstations which accept inputs from aerial, terrestrial and satellite sources and enable the interpretation of the stereoscopic imageries from satellite sources such as SPOT. They enable simultaneous viewing of stereomodels and digitised line work and provide an agronomically designed digital data updating environment which make it possible to update the existing spatial data bases with the help of superimposition techniques.

One such pilot project on the updating of digital data by digital photogrammetry, was taken up in the Digital Mapping Centre, Dehradun (India) where the existing digital data base of one topographic sheet at 1:50,000 scale was updated on an InterMap Analytic Photogrammetric workstation incorporating the additional data, not existing in the original file, by using the latest available photography. The facility of superimposition was usefully utilised to append the data to the original files.

The quality assessment was carried out by carrying out the statistical analysis of the updated product with respect to another updated product verified on ground.

An attempt has been made in this paper to describe the technique adopted. The data/work flow is also included. The authors feel that the updating of maps with digital data by digital photogrammetric methods enables an accurate updating of spatial data bases and the technique is an effective and speedy tool for the purpose as indicated by the results.

Updating the French Topographic Database

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ABSTRACT

The National Council for Geographic Information (C.N.I.G.) which gathers all users and producers of G.I.S., decided in 1983 that IGN-F shall be responsible for a geographic database covering the whole of France. This database is called topographic database (BDTOPO)

The topographic database is a 3D database with a metric accuracy, its content is very close to the IGN 1:25000 scale maps. The data structure include topologic information.

Due to the specifications of the topographic database (3D), the process includes stereoplotting using aerial photographs. The main phases are : stereoplotting, field surveying and editing.

Experiments concerning the updating of the BDTOPO are in progress and aim at defining precisely the methodology and evaluating the manpower needed and which operators-skill is necessary. Quality issues are part of these current studies.

The initial specifications (content, accuracy, 3D) must be kept. So the process of updating must include a photogrammetric process. Stereoplotters with an image superimposition system seem to be the best tool to carry it out.

The different phases are : aerial photography, ground control point acquisition, aerial triangulation, investigation, stereoplotting, map checking, field surveying and editing.

The updating of the topographic database is planned to be done periodically (average cycle 7 years).

SPECIFICATIONS

The topographic database has contents which are very close to those of French 1:25000 scale maps. All points are defined in three dimensions (plan and height) and the database has a metric accuracy.

The BDTOPO is divided in themes which includes lines of road communication, railways, power lines, hydrography, buildings, vegetation, orography and administrative limits.

Topographic details are grouped in feature classes characterised by attributes (see figure 1). These classes define the descriptive level of the BDTOPO. The geometric level includes topological information, so features are composed of nodes, edges or faces. Some composite features (such as a main road or a river) are composed of linear features, node features or area features. The geometric level is composed of a plain metric layer and an altimetric layer.

Because of the specifications, the process of data capture includes stereoplotting using aerial photographs. Coordinates obtained from photogrammetry are never altered. Features are not moved.

The topographic database is planned to cover the whole of France. The entire database can't be handled as a single entity thus the BDTOPO is divided in sheets. One sheet matches to a 1:50000 scale map.

In one sheet, the geometry is topologically structured. But a topographic detail concerning two sheets is cut into two features (see figure 2). Each of them has a node on the limit of the two sheets. The two nodes have the same coordinates.

The coordinates of points are geographic coordinates (longitude and latitude) so the limit of the sheet is a rectangle.

All the data of one sheet are captured together. Features are said valid for the date of the aerial survey date.

PRINCIPLE OF UPDATING OF THE BDTOPO

The updating is supposed to be performed periodicaly. The working area fits one the sheets of the 1:50000 scale maps. All topographic details of one sheet are updated together.

After updating one sheet, a back-up on an optical disk is done. Both on-line BDTOPO made of updated features and back-ups corresponding to differents revision will be available.

When a user (for example a department or a city) builds a localised database, each item of this database (e.g. cadastral information, opographic information, network information) should be stored as independant layers. Each organisation supplying his layer is responsible of its updating. But all users can access all layers.

This way, IGN can provide periodically updated information. The user has only to replace the old topographic layer by a new one.

PROCESS OF UPDATING :

The initial specifications of the database must be maintained. The accuracy of localisation must be kept. Points has to be defined in three dimensions.

This is important, since only revisions will be performed in the future.

In the classical cartographic process of map making, after three or four revisions, the quality of the map decreases and a new refection of the map has to be carried out.

To keep the initial specifications, the procedure of updating the BDTOPO includes a photogrammetric process using aerial survey.

The different phases are :

- aerial survey
- ground control point acquisition
- aerial triangulation
- investigation
- stereoplotting
- field surveying
- editing
- integration in the database.

In fact, these processes are very close to those of the initial capture. The main difference concerns the stereoplottting.

In the revision process, stereoplotters are used as 3D editing workstations. This supposes that all informations (descriptive level and geometric level

including topological information) have to be managed on the stereoplotter.

On the other hand, stereoplotters with superimposition system seem to be the best tool for updating.

An experiment was conducted to define the methodology. The working area was in the suburbs of Paris. The Prime S9-AP stereoplotters with superimposition system were used.

INVESTIGATION :

Three methods were tested :

1- an investigation was done and reported on aerial photos at scale 1:30000. New details were drawn with a red pencil. Details to remove were drawn in yellow.

These paper photos can be fixed on the S9-AP. A spot driven by the computer indicates to the operator the point of the photo corresponding with the index of the stereoplotter.

Conclusion :

- the spot is too large and hide the picture
- the photo is too far from the operator and its scale too small.

2- an investigation was done and reported on a drawing at scale 1:25000 from the BDTOPO. New details were drawn with a red pencil. Details to remove were drawn in yellow.

3- no investigation was done. The operator on the S9-AP had to use only the superimposition system and to edit the data.

Conclusion of points 2 and 3 : the working area was in an evoluting country. A lot of details had to be added. In such an area, there is no need for an investigation. But in a rural country, the best way seems to use a drawing at scale 1:25000.

STEREOPLOTTING :

The superimposition system of the S9-AP takes care of the z coordinate. In the two occulars of the stereoplotter, an image of the features can be seen in superimposition of the aerial photographs. But a

feature will fit the topographic detail of the photo only if the z coordinate of the points are correct. That means that if some edges have been digitized on a 2D workstation during the initial capture or have been modified, they will not fit with their image on the aerial photo. In that case, a drawing of these elements can be plotted and the operator has to redigitize them.

FIELD SURVEYING :

This phase is very close to that of the classical revision of maps. The topographs need some drawings on which all the informations of the database can be distinguished. They have to draw on them what they get from the field survey.

EDITING :

This phase is very close to the initial capture phase.

CONCLUSION :

IGN France is building a topographic database. The initial capture began in 1988, but the first sheets of 1:50000 scale maps were finished at the beginning of 1991.

After the methodologic study of updating, it seems that all technical problems can be solved.

The main problem in fact is the amount of work needed for the revision of the BDTOPO. At the moment only estimations can be made.

Road network
(part)

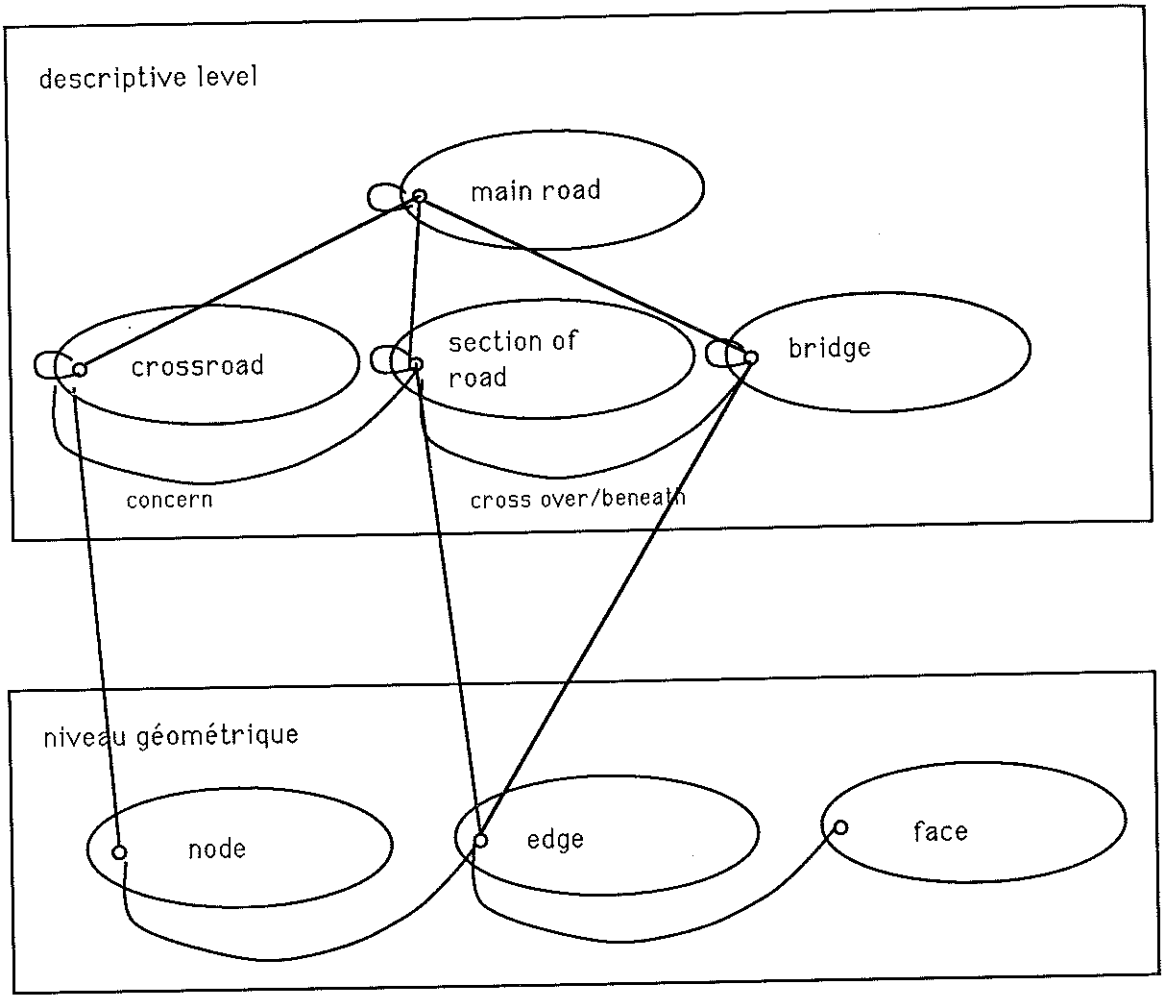


figure 1

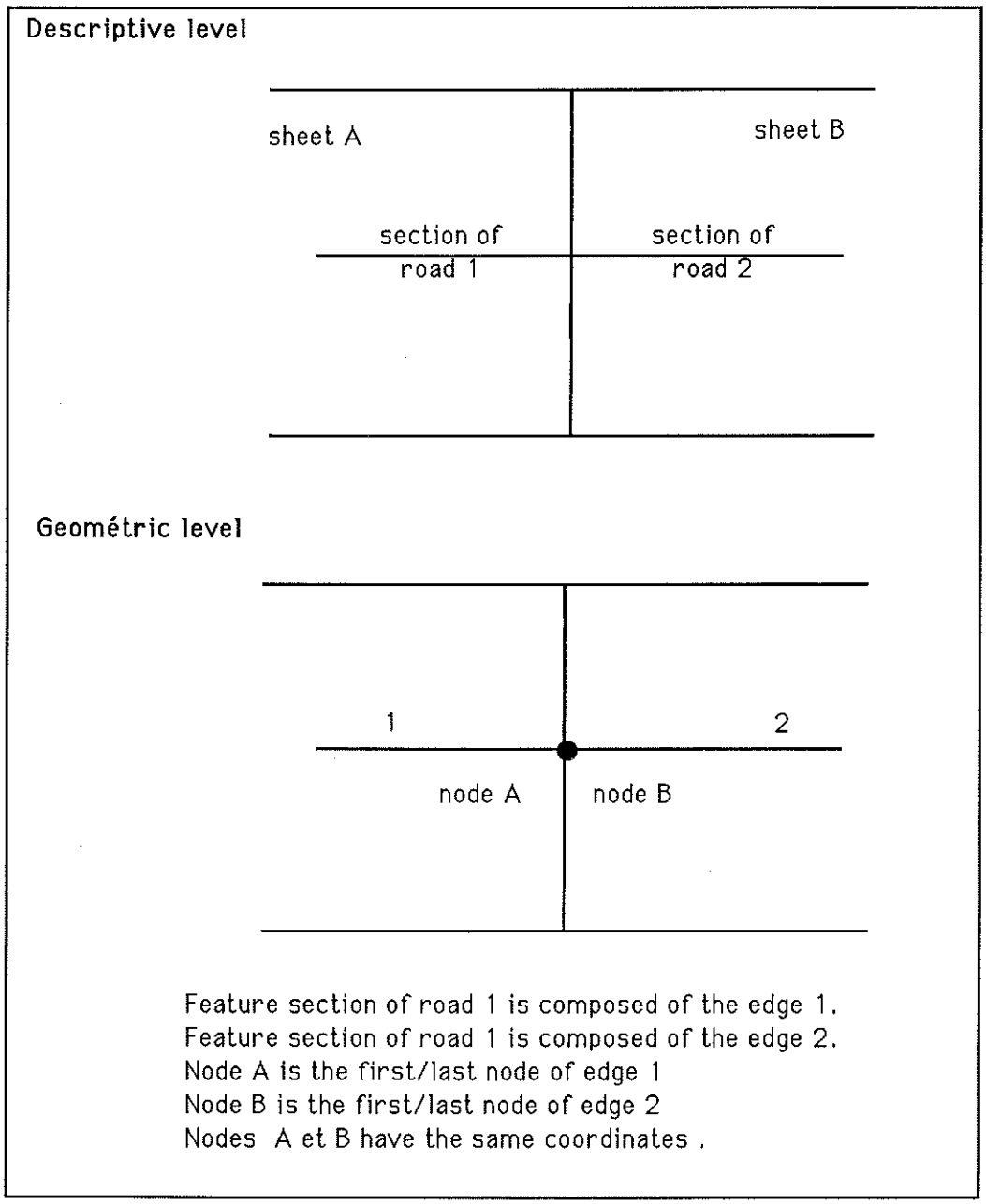

Descriptive level
sheet A
sheet B
section of
road 1
section of
road 2
Geométric level
1
2
node A
node B
Feature section of road 1 is composed of the edge 1.
Feature section of road 1 is composed of the edge 2.
Node A is the first/last node of edge 1
Node B is the first/last node of edge 2
Nodes A et B have the same coordinates .

figure 2

Jukka Artimo
National Board of Survey
Finland

THE DIGITAL MAPPING PROCESS OF THE BASIC MAP OF FINLAND 1: 10 000/1: 20 000.

Introduction

The Basic Map of Finland is a printed 5-colour map in scal 1:20 000. The actual mapping scale is 1:10 000 (southern and middle country) and 1: 20 000 (nothern parts of the country). Basic Map includes following data contents: planimetry, contour lines, real estate boundaries, roads, fields and hydrography. The total amount of map sheets is 3730, the area of each is ca. 100 sqkm. Production of the Basic Map was started in 1947 an completed 1975. Continuing updating process of the map produces a revised map approximately every 10 years.

Since the year 1972 computer aided methods have been developed in Basic Map production. First step in development was to use automatic plotters and manual digitizers mainly in order to get rid of drawing by hand.

Next step in the development process was the start of the digital Cadastral Boundary Map of Finland. It started in 1982 (scale 1:5000 and orthophoto is used in production process) together with manual digitizing of contour lines. Digital height information was needed to steer the othoprojector. Digital Cadastral Boundary Map will be completed in 1997. Digital contour lines will be completed in 1992, the project is financed also by other organizations than National Board of Survey.

MAAGIS-software (formerly FINGIS) is the product of National Board of Survey. MAAGIS-software enables direct data capture from stereomapping to the map data base. The possibility of cheap conversion of analogical spereoplotters to analytical made it possible to plan digital nationwide stereomapping.

All digital information are collected not only for the needs of the Basic Map. The Topographic Map of Finland (1:50 000) is mainly produced by using digital information of the Basic Map. The methods of automatic generalization are developed for this purpose.

Organizational environment

Basic mapping in Finland is led by National Board of Survey in Helsinki. The whole country is divided into 8 Mapping units. Each Mapping unit employs ca. 25 persons being responsible about basic mapping process from stereomapping via field checking to fair drawings in 1:10 000. The National Board of Survey then takes the responsibility of printing and delivering as well as coordinating the entire process. The budget of all Basic Map production is about 56 MFIM per year.

Equipment environment

Two accuracy types of equipmet are used:
1) for aerial triangulation and point densification (7 equipments)
- -WILD PC 2 analytical plotters (4 equipments)
- -WILD PC 3 analytical plotters (2 equipments)
- -KERN DSR analytical plotter1 (1 equipment)

2) for stereomapping (17 equipments)
- -WILD A8 with digital encoders (8 equipments)
- -WILD B8 with ADAM analog- to - analytical conversion (5 equipments)
- -WILD B8 with QUASCO analog- to - anal. conversion (1 equipment)
- -Topocart with ADAM analog - to - anal. conversion (1 equipment)
- -ADAM ASP 2000 analytical plotter (2 equipments)

In addition to the previous equipments
- -drumplotters , CALCOMP (several)
- -digitizing tables ,size A1, CALCOMP, ALTEK (several)
- -flatbed plotters, KONGSBERG (2 equipments)

Mapping units and National Board of Survey are connected with datanetwork

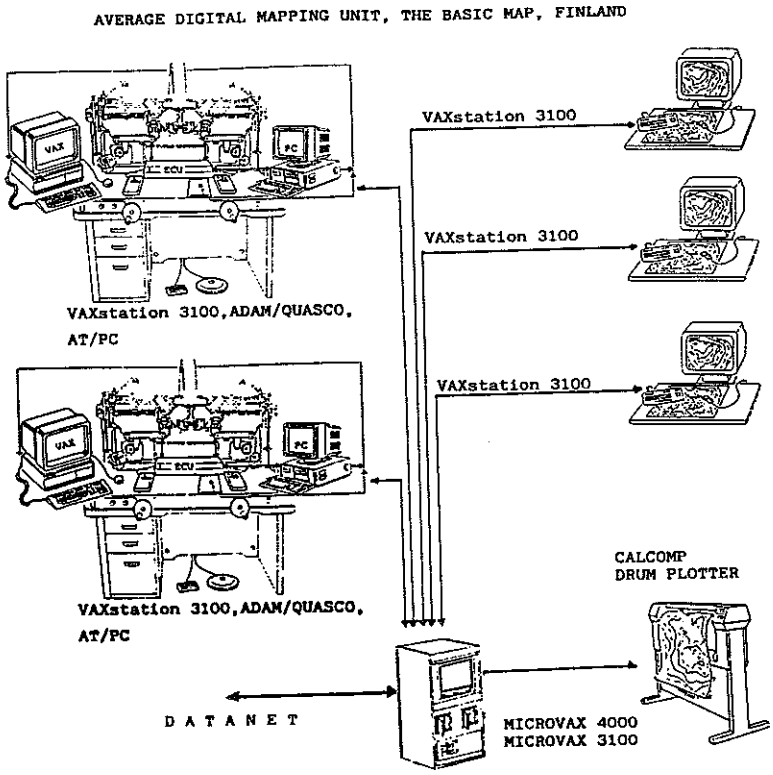
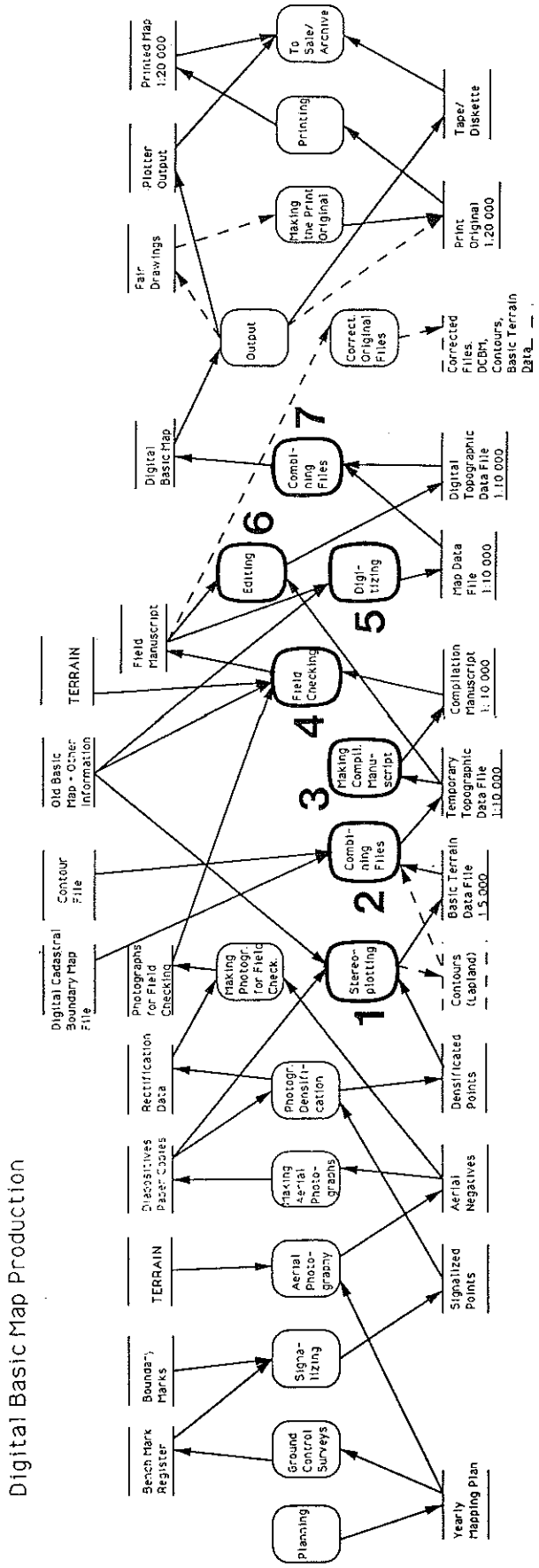


Figure 1: A schema of the equipment environment of a typical Mapping Unit.

Figure 2

The process of the Digital Basic Map production



Production process

The entire process of the Digital Basic Map production is shown in Figure 2. In this presentation we emphazize ourselves in the digital parts of the process, it means the steps marked by numebrs 1...7 in the figure.

1. Stereoplotting

Stereoplotting is the one of the most essential stadges of the process. The result of stereoplotting is The Basic Terrain Data File (1: 5000). The source data for stereoplotting consist of aerial photograph and the old graphical Basic Map. The Basic Terrain Data File consists of buildings, road network, hydrography, agricultural areas and high voltage electrical network. Stereointerpretation and plotting takes 15-30 working days per map sheet.

2. Combining files

The Digital Cadastral Boundary Map File, The Contour File and The The Basic Terrain Data File are then combined together. The result of the combining process is so-called Temporary Topographic Data File (scale 1:10 000).

3. Compilation

The compilation Manuscript in scale 1:10 000 is produced by drumplotter .

4. Field checking

Field checking is made by using The Compilation Manuscript, aerial photographs (rectificated paper copies) and the old/existing Basic Map. Information content of all files are checked and the Basic Map is revised. Especially the coding/classification of stereoplotted information is checked.

The result of this stage is called the Field manuscript. Field checking takes 5-10 working days per map sheet.

5. Digitizing on table

Revised information of the old Basic Map (which are not yet in digital form) e.g. rocks, morelands, special areas, historical monuments as well as names are digitized manually on table. This stage take 15-20 working days per map sheet. The result of this stage is the Map Data File.

6. Editing

By using the Field Manuscript the Temporary Topographic Data File is updated and completed. This editing is made on the screen.

7. Combining the files

The last stage of the process today is combining all digital files together. Now we have the Digital Basic Map in one file. This file can be plotted on drum or flatbed plotters. Information can be delivered also in digital form (tapes, diskettes).

Development plans

The process described in previous chapters goes on with manual printing process. research and development work has been done to check the capability of electrostatic plotters in making colour maps. Our opinion is today that electrostatic plotters make good manuscripts but they cannot replace printed maps in accuracy and in visual quality.

Our future plan is to complete the digital production line by a map publishing system. The selection is still in process and the goal is to have a digital printing production line in production in the next few years.

"Ordnance Survey Revision Problems and Solutions"

by J E Farrow, Ordnance Survey

Paper presented to Joint ISPRS/OEEPE Workshop

"Updating Digital Data by Photogrammetric Methods"

- September 1991 -

Abstract

The Ordnance Survey (OS), like every large organisation , is faced with a continuing need for change in its business to keep pace with the demands from customers. The conversion of the OS large scale maps to digital format, now at over 110 000 (or 50%) map units, is one aspect of this. The proportion of maps suitable for revision by photogrammetric methods and falling within the digital areas is rising. At the same time there is increasing pressure from central government for Agencies such as OS to reduce costs. With the move to supplying digital data there comes a widening of the range of potential customer requirements from that of straightforward graphic maps. The paper will discuss the problems of revising the OS digital large scale map data against this economic background, and some of the solutions adopted or investigated.

1. Background

1.1 Objectives

1.1.1 The historical background to current Ordnance Survey activity in the revision processes has been described in previous papers, (Leonard [1] and Proctor & Newby [2]). The three basic scales of survey at 1:1250, 1:2500, and 1:10,000 were completed in the early 1980's and the revision of these maps is a current major activity which is reflected in one of the OS key corporate objectives.

> ' - To keep the national mapping of Great Britain up to date within criteria judged to be acceptable to users, and ultimately to achieve uniform levels of revision on all products.'

1.1.2 In parallel with this gradual move to a dominantly revision role has been the steady , since the early 1970's, introduction of digital methods, initially with the aim of reducing the costs of the cartographic processes, but increasingly as a means of directly recording the mapped objects into a digital form, and for sale in response to customer demands. This is also apparent in another key objective.

> ' - To convert the archive of basic scales mapping into digital form where required by customers, and to establish and maintain a cost-effective digital revision service.'

1.1.3 All of the published 1:1250 plans are now in digital form, and the number of digital large-scale plans has reached nearly 120,000 out of the approximately

220,000 total. The projected completion is currently targeted for 1998/9.

1.1.4 Photogrammetric methods are used to support about 30% of the revision programme for the basic scales. It is interesting to note that in spite of the changing economic conditions since [2] was written in 1988 this proportion has only reduced by 3%, though the balance of instrumental and graphic activity has altered from 1:1 to 1:2, reflecting a build up in Periodic Revision (see below). Unlike many other developed countries OS does not use photogrammetric methods to revise the maps it has cartographically derived at scales of 1:25,000 (1373 sheets) and 1:50,000 (204 sheets). This is mainly due to the fairly detailed specifications built up over a long period which is hard to meet from photography , itself not easy to obtain at the required scales in the prevailing cloud patterns over UK.

1.2 Policy and Planning Issues

1.2.1 In general the policy remains as described in [2]: Continuous Revision (CR) in areas of active development where maps are kept up to date as significant change occurs, and Periodic Revision (PR) or age-related sweep in less active areas and where there is an accumulation of minor change. These tasks are tempered by qualifying the change as 'primary ' or 'secondary'. 'Primary' is that change which is of first importance in keeping the mapping up to date and for which a wide user interest is known. 'Secondary' is all other change which is not of prime interest to the majority of users, but which is nevertheless an important element in maintaining the long term integrity of the mapping.

1.2.2 The question of how current the data should be and how to supply it to customers are still live issues. The possibilities raised within [3] for change-only-update instead of complete replacement files have yet to be realised. The increasing quantities of available digital data is leading to potential customer demand for frequency of update supply at the 1-2 'house unit'(HU) level instead of the figures of 20, 40 or 50 described in [2 & 3]. Though it is not certain that many recipients of digital update have systems capable of handling this frequency. The HU, a measure comprising one new house and its surrounding fences or any one of several equivalents, is used by OS as a unit to quantify and predict how much change has occurred to support resource planning, but also as a measure of work completed. Following a consultancy study [4], carried out by Birkbeck College between 1983-6, there have been attempts to predict how much development exists awaiting survey, or 'backlog' in OS terminology. Currently this is about 0.5-0.6 million HU. Recent investigations indicate that the level of change that exists, both primary and secondary, which is 'unknown' to the OS intelligence system is higher than desirable, though proportionately better than was the case in 1986. This change is generally to be found in small pockets of scattered development , often only found when a surveyor visits the area or aerial photography reveals its existence. The scattered nature of these changes makes it potentially expensive to survey by ground means, but conversely a possible candidate for photogrammetric methods, especially if photography is available to identify the change.

1.2.3 Other interrelated factors are; the rapid spread of the Digital Field Update System (DFUS) from the 12 units reported in [2] to a figure of 64 (from a potential total of nearly 100) to be in place by March 1992; the concept of working with a seamless data set at 25 of the DFUS sections; and improvements in

data geometry to a 'clean data' standard. The concept of 'clean' data is that there will be no overshoots or undershoots, double digitised points, or unresolved free ends, and where a junction exists it will have unique junction coordinates. These factors have all enabled an improved flexibility in the supply of updated presentation quality graphic plots in areas of digital coverage, which in turn is driven by customer demand. The range of alternative graphic options now cover defined map areas (no more points at the corner of four map sheets), non-standard scales, selected feature codes and perhaps colour, and are supplied as part of 'The Superplan Service'.

1.2.4 The Government targets for OS are to achieve an increasing proportional cost recovery , this is leading to considerations of the potential benefits that can arise from the flexibility of digital map data. It is against this background that one must set the role of photogrammetry in support of digital revision at Ordnance Survey.

2. Methods

2.1 Current

2.1.1 The range of photogrammetric production methods in use remain much as described in detail by Newby in [5]. Photography is employed for the simple, but cost effective, graphic methods of radial line plotting and fit-and-trace, described as 'Air/Ground (A/G)' within OS, and used at both 1:1250 and 1:2500 scales. This may require rectified photography which is now supported by a PC based analytical procedure for deriving rectification parameters. Conventional analogue plotting directly, or via overlays , onto the plastic Master Survey Drawing (MSD) for non-digital 1:2500 areas. Automated analogue plotting to record digital data directly, currently used for 'reformed' [5] mapping at 1:2500. This is a compromise between resurvey and revision where patches of existing detail are fitted to newly surveyed and properly controlled photogrammetric detail. And finally, analytical plotters with internally superimposed images of existing detail, or external display onto a graphics screen. All the digital work is supported by graphic editing stations with a mixture of single user workstations and older graphic screens hosted by a common computer node. All computing facilities are networked with one node acting as primary interface to the central database. The decisions on which method to employ are made by the Topographic Surveys management in the light of local circumstances to achieve an economic service.

2.1.2 As outlined in [6], the large scale products produced by OS are planimetric only, with minimal height information in the form of spot heights or bench marks, and the 3-dimensional nature of photogrammetric measurements have been ignored. Therefore, to support the revision process using the analytical plotters with superimposition facilities, a digital terrain model (DTM) is needed. This is supplied by raster scanning the 1:10,000 scribed 5m-interval contour base , produced photogrammetrically under the 1970-80's metric re-contouring programme, followed by vectorising and adding the digital spot height values from the underlying large scale data. Heights are interpolated from the DTM, and along with an arbitrary object height, assigned to the detail features. This is sufficiently accurate to enable identification of the existing digital features but not to give a measure of quality. If the assumed feature height is significantly wrong the option exists to record the correct value from the photogrammetric model ,either to the point or whole feature, and immediately refresh the view for confirmation. The source code attached to each

point or feature gives a measure of reliability but the resultant data set is obviously not of a uniform precision in height.

2.1.3 Field survey ground methods are a combination of Instrumental Detail Survey (IDS) and the graphical field completion or survey [2]. For IDS, use is made of a range of total station equipment, passing data to hand-held micro-processor data loggers for eventual processing at OS headquarters. The graphic work is directly surveyed onto the plastic MSD, or in the all-digital sections onto a plastic temporary survey document (TSD). In the latter case the revision information is digitised and merged into existing files using DFUS. In non-digital areas the revised MSD will eventually enter the initial digitising flowline controlled at OS HQ, but now largly done through external digitising contracts.

2.1.4 The 1:25,000 maps are revised by compilation from information arising from the underlying large scale revision process and may therefore sometimes indirectly benefit from a photogrammetric input. The 1:50,000 maps are revised by cartographic compilation from a combination of accumulated intelligence from the revision activities at the other larger scales and ground based graphic methods surveyed onto a 1:25,000 base obtained by enlarging the 1:50,000 component.

2.2 Under Investigation

2.2.1 With the introduction of the capability to generate a DTM the opportunity has arisen to evaluate the feasibility of digital monoplotting direct from the new revision photography. The TELLUS MonoDig application package from SysScan (Norway), used successfully for 1:50,000 revision in Norway , has been leased for assessment. The trial has identified some shortcomings in the software when applied to the OS 1:2500 task which mean that at present the accuracy requirements have not been met.

2.2.2 Whilst it is believed that commercial space imagery is not of a sufficient ground resolution to be of practical use in support of revision of the OS 1:50,000 maps, the opportunity has been taken to assess the usefulness of some Soyuz-Karta KFA-1000 film images.

2.2.3 All-digital packages are beginning to appear in the marketing lists from vendors of photogrammetric systems. These presume the existence of digital imagery and in the absence of cost-effective airborne sensors several manufactures are now offering scanners capable of recording images from normal aerial photography at resolutions as high as 7.5 microns. At the recent ISPRS Commission II/III Workshops there has been much debate on the role of such systems and their ability to supplant or augment the analytical plotters. As described in [7] OS has been using the Helava (now General Dynamic) Digital Comparator Compiler System (DCCS) and experimenting with the capabilities of the associated HAI-500 DTM system. The latter uses whole images patched together from the output of the scanner within the DCCS. At present it is not clear that these systems can be used to support the standard OS revision process.

2.2.4 However the opportunity is being taken to explore the possibilities for other outputs which might serve markets previously untapped. These could include the orthophotograph, created almost as a by-product of the DTM process. A graphic derived from an orthophograph has never been adopted as a widespread product in the United Kingdom, unlike in other countries, perhaps reflecting the

absence of a UK photogrammetrically produced medium scale map series. The explosion of interest in Geographical Information Systems (GIS) and digital products may make the use of a backdrop digital image potentially attractive to some users, particularly so if it has been rigourously rectified.

2.2.5 Mention has been made in [3 & 5] of the OS experiments in developing a prototype Portable Interactive Edit System (PIES) based upon off-the-shelf PC technology. Problems with the pen interface on the first generation notebook-PC have now largly been overcome. New second generation PC-Notebooks are now imminent with full 20Mhz Intel 386 capabilities supported by solid state memory and removeable 2-4Mb memory cards, with expectations of up to 64Mb cards being available soon. These lightweight computers (<= 2Kg) offer the surveyor the opportunity to take his digital map to the field and directly survey and merge the new information with the existing data. They also have the potential to give the field completion surveyor a ready means of incorporating much more of the desirable attribute information which is arguably best captured whilst the objects being surveyed are directly visible to the surveyor, so that quality checking can be performed in situ. Photogrammetric methods must demonstrate their cost-effectiveness compared to the range of ground based options.

2.2.6 One potential operation for which photogrammetry is unlikely to be competitive is for the survey of road kerb lines and associated features for utility customers. Trials so far indicate this to be a useful service to enable the utility customer to relate his features correctly at an early stage such that they will be in sympathy with the later as-built OS survey.

2.2.7 Control for the OS map series is currently based upon the OSGB 1936 National Grid reference system. With the advent of the Global Positioning System (GPS) the OS is progressively creating a national framework of GPS stations which will be integrated into a European Reference System (EUREF) based upon the internationally agreed WGS-84 reference system. Work has been done on generating a strategy for creating a database of parameters allowing transformations of OSGB-36 based digital data into, or from, the more uniform OS Scientific Network-80 and thence to WGS-84. This will enable the digital map data and satellite generated control to be put into sympathy. Exactly how this capability will exploited remains to be decided.

3. Problems and Solutions

3.1 Like many organisations the OS can seldom separate itself from the constraints imposed by its history and the utilisation of photogrammetric techniques is undoubtedly influenced by previous policies. However provided that any new procedure can be shown to be cost effective then OS management has shown itself to be prepared to embrace the new technological advances. We are still reaping the legacy of the economic compromise which lead to the 1950-60's 'Overhaul' method for recasting the previous Cassini based maps into the present National Grid Transverse Mercator system for rural 1:2500 mapping [1]. But until the users are prepared to pay for a resurvey, OS will continue to pursue solutions that others may view as unconventional. One area where OS has adopted a more commercial approach has been the introduction of shift working on the high cost anlytical workstations.

3.2 One of the problems with interpolating DTM's from the 1:10,000 contours is that these are a cartographic product and the specification calls for breaks at quarries, cuttings and embankments, and other discontinuities. The large scale

digital specification, under user pressure, has been reduced to a point where it is not simple to extract the bounding polygons for such breakline features. If these were available a higher quality DTM could be generated. There is therefore a potential role for photogrammetry in improving the quality of such derived DTM's.

3.3 A significant problem for the field survey operations is how to improve the intelligence gathering process to give better predictions and hence resource planning. Whether photogrammetry is a cost effective method for identifying and surveying the scattered primary change is a current issue. Also should the photogrammetrist pick up the secondary change which may be uneconomic for the field surveyor to complete?.

3.4 Our investigation into digital monoplotting for 'overhaul' areas show conceptual savings arising from the fact that the limitations of such mapping make it appropriate to use approximate methods. Work is therefore in hand to overcome the drawbacks found in the MonoDig software in order that extensive trials can be conducted. The main issues being the allowable DTM resolution, more precise use of control information , an allowance for height of objects which are significant at this scale, and incorporation of some commonly used OS vector editing routines.

3.5 The assessment of the KFA-1000 imagery is hampered by the 30cm format size and limited fiducial marks. These make it difficult to use on the OS analytical plotters with their standard 25cm stage plates. Any photographic reduction will begin to negate the 5m resolution benefits and efforts to maximise the use of existing stage plates will reduce the effective working overlap area, though limitations on radial distortion information may also restrict the useable image. The interpretability is certainly better than any other space images viewed at OS but it is by no means certain that such models will prove to be of use in the overall small scale revision process.

3.6 The major problems with the HAI-500 derived DTM's are the level of editing required, which on a point-by-point basis is time consuming, though strategies to improve this are scheduled in the next release, and the need to filter out the man-made features and vegetation to give a bare earth DTM. Conceptually, if digital planimetry exists, polygon data could be used to mask out unwanted heights and surface interpolation from surrounding nodes used to fill in with derived data. This has promise for buildings but vegetation may be harder, especially in broken woodland where the correlator may have correctly heighted ground level in clearing areas. However the envelope DTM produced by correlation methods is ideally suited to serve the needs of those who wish to evaluate line-of-sight paths at scales where the heights of man made and forest features become important.

4. Future Prospects

4.1 The current objectives for the Ordnance Survey still place the emphasis on mapping, using digital techniques to keep this up-to-date. Future aims may be to place greater emphasis on the digital archive itself and its ability to describe the environment more fully, the graphic map being just one optional output.

4.2 The historical limitation of having to map the real world onto a 2-dimensional piece of paper is now being reduced or effectively eliminated with

the spread of affordable computer systems capable of handling data models which more faithfully describe reality. This applies both to the attribute modelling and the full 3-dimensional spatial shapes of objects or scenes. Display technologies are at a point where the visualisations produced from such data sets are reaching new heights of realism. These systems, previously constrained to the Defence or TV media presentation areas, are rapidly migrating into wider commercial applications. Photogrammetry has a role in populating the geometry of such 3-dimensional data sets and could conceptually be partially serviced as a by-product of the use of photography for the primary map revision task.

4.3 Photogrammetry undoubtedly has a part to play during the final phases toward complete digital cover at the OS basic scales. Whether it is able to continue to contribute to the large scales revision process in a scenario where customers expect change to be surveyed at the sub-ten HU level , within weeks rather than months, is a challenge the OS photogrammetric managers have to face.

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UPDATING A COMPLEX GIS DATABASE - THE NORTHERN IRELAND EXPERIENCE

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A B S T R A C T

The current enthusiasm for Geographic Information Systems is seeing intense effort and resource being devoted to digital conversion and subsequent creation, of a wide range of databases.

Unfortunately in many instances little, if any, attention is given at planning stage to an equally significant factor - their maintenance. Without proper in-built provision for this from project inception remedial action at a later stage may well prove impossible. This is particularly relevant in the case of a long term programme where maintenance must move forward in tandem with continuing digital conversion.

The Ordnance Survey of Northern Ireland's computer mapping and topographic database, COMTOD, is a prime example of just such a case as it it grows to provide the geographical foundation for NIGIS, the developing Northern Ireland Geographic Information System. Here maintenance of complex topographic data both in terms of new information and preservation of an historical perspective has been considered and an action policy implemented.

The paper discusses the factors involved, difficulties encountered and solutions developed in the course of creating a system which, while admittedly not yet perfect, clearly emphasises the problems inherent in fulfilling this essential function.

1. THE VALUE OF CURRENCY

1.1 The Demand

The growth of GIS applications, or more correctly, the realisation of the true potential of GIS has resulted in a great demand for digital information. This demand for both graphic and non-graphic data is being met but the vital importance of currency has in many cases not yet been fully appreciated, or given the priority it demands. The Ordnance Survey of Northern Ireland (OSNI) in Belfast has long recognised the real importance of data currency, and to this end has established procedures to maintain the currency of its complex topographic and associated textual database, COMTOD, thus ensuring a sound basis for the developing Northern Ireland Geographic Information System, NIGIS.

1.2 User Requirement

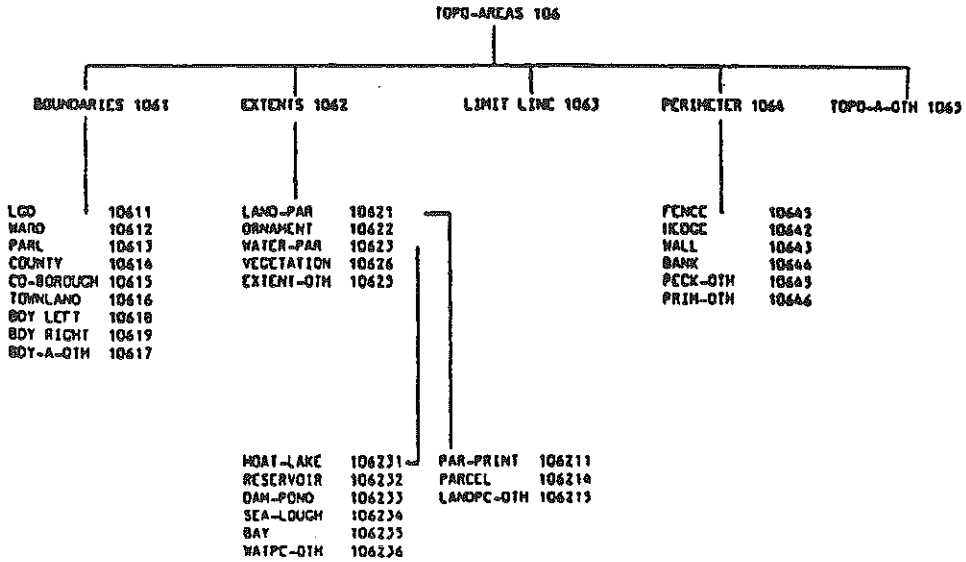
The importance of currency is related directly to the range of GIS applications, for it is only with current topographic data that NIGIS

partners can complete and maintain their own specific datasets. With its comparatively small land area and relatively simple administrative system Northern Ireland offers enormous potential to exploit GIS technology on a countrywide scale for the benefit of the whole community. COMTOD is providing the common geographical link - the Irish Grid geo-reference - to enable this to be put in place. Typical NIGIS partner organisations from Central Government are Department of the Environment (NI), - Ordnance Survey, Roads Service, Water Service, Planning Service, Land Registry, Conservation Service, Department of Agriculture (NI), Department of Economic Development, Department of Health and Social Services along with other Service Bodies such as Northern Ireland Electricity, Northern Ireland Housing Executive, Geological Survey of Northern Ireland and British Telecom (NI). The current topographic data provides the common basis for compatibility between all the GIS Partners. Corporate decisions cannot be made with any real confidence if all relevant and up-to-date data is not available, and the substantial topographic data conversion investment would rapidly be negated if data currency was not maintained. To the increasing number of users currency is vital to their application if the results of their digital investment are to be used to maximum effect.

2. FORMULATION OF THE MAINTENANCE PLAN

2.1 The deciding factors

In producing a plan for maintaining the currency of the topographic database a fundamental question had to be resolved - to archive or not expensively captured graphic and non-graphic data that is no longer extant? COMTOD is a complex database of fully structured topographic data, including multi-feature coding, and associated textual information.



PART OF COMTOD DATA STRUCTURE

The functionality and value of the data is therfore high, as of course is the cost of its conversion and maintenance.

Currently at initial digital conversion stage this associated textual information is confined to:- (i) the full postal address of all houses and other addressable buildings, (ii) a description of vegetation within relevant polygons, (iii) the date of initial input of the whole map sheet and (iv) type and quality of survey. It is planned as resource permits to further expand this aspect to include a much wider range of associated information beneficial to GIS users. To simply delete data when it was no longer in existence would be a waste of a costly investment and would reduce the real value and potential of the database. A much more satisfactory alternative is to think in terms of exploiting all expensively captured data, by retaining it, along with all attribute information, as a separate layer within the database. This will increase the possible GIS applications and allow the facility to fully interrogate one database to provide both a current and historical perspective. Such interrogation will permit historic snapshots of the graphic and non-graphic data that existed at a particular date of database revision.

A less complex option could have been to hold historical data in the database under a separate level but stripped of all attributes. This would severely restrict the potential use of the historical data and limit the GIS applications. Another obvious option would be to retain a digital record of each mapsheet at each updating, but some mapsheets will require updating frequently so the storage space if such a system were to be kept on-line would vastly increase the size of the database in a relatively short time. The estimated final size of the OSNI database is in the region of 30 gigabytes, so retaining each mapsheet version on-line would have large storage and resource implications. An off-line system using perhaps optical media technology could of course be considered but this would severely limit the database functionality.

A variation on the previous option could be to window out areas of ground change from the digital map file and store as a deletions file with dates, etc associated with the graphic. This would, however, really only be feasible where change was confined to localised areas of the map, being less useful for scattered areas of deletion. This in turn over successive revisions could present a very complex database management task and involve major effort to recreate an "at a particular date" situation.

The only other alternative, if it could be called that, is to simply delete the data that no longer exists. This would remove completely the potential to interrogate the system for historical reasons and merely provide a current perspective.

2.2 The policy

The aim of all GIS users must be to protect and enhance the real value of their data asset and maximise on the functionality it offers for an increased range of applications. To enable this the only real option is to archive and make full use of all data that has been captured thus providing the maximum return from the data investment, in both current and historic terms. This policy forms the basis for the solution that we at OSNI have developed, to meet the demands of our NIGIS partners.

3. OSNI'S METHODOLOGY

3.1 General outline

Having looked briefly at some options which cover a range of possibilities the method currently employed in OSNI is expanded on as follows.

Update topographic information is fed into the system from either photogrammetric and EDM ground digital sources, or more commonly by manual digitising from the field surveyor's working document.

A copy of the map sheet concerned is extracted from the database, data no longer extant is suppressed, new survey data is added and the updated version replaces the previous version in the database. This summarises what, in the case of COMTOD, is a complex and labour intensive process. The main steps taken in what has been developed as a menu driven method are:-

i. Extract a copy of the relevant map sheet from the database.

ii. Flag data for suppression and extract from the file. We now have two files, one containing the obsolete data for suppression and one containing data still extant, (ie in simple terms a file with a "hole" in it).

iii. The obsolete data file has its associated data content updated, with geocodes being generated for line strings, and dates of removal added.

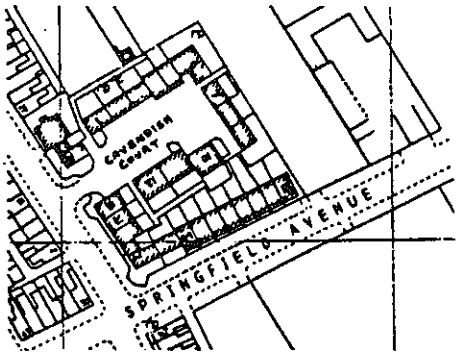
iv. A new file is created to hold the digitised and seeded update data and geo-references and generated for all new areas, line strings and objects therein.

v. The resultant update data file is now merged with the file containing the "hole".

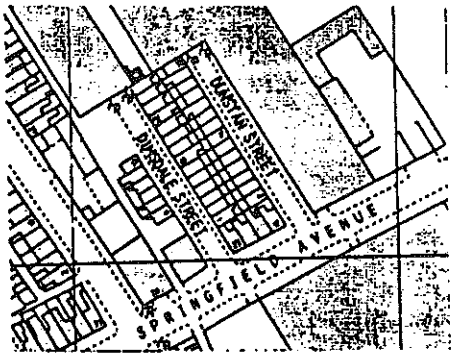
vi. The necessary associated textual data, (ie date of input, nature of survey, method employed, postal addresses of properties, nature of vegetation, etc) is added to the new geometry.

vii. The newly updated version of the database file, graphics and associated textual data, is substituted in the database.

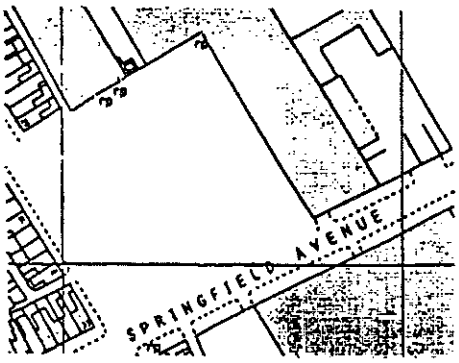
viii. The file containing the obsolete data being suppressed is deposited in a separate database layer. If required a display of the updated map sheet together with the suppressed information can be provided.



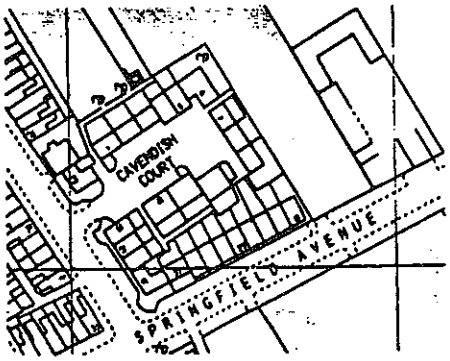
CHANGE COLLECTED
BY FIELD SURVEYOR



RELEVANT EXTRACT
FROM DATABASE



OBSOLETE DATA
SUPPRESSED



NEW VERSION
TO DATABASE

This only very broadly summarises what is in effect a very complex operation requiring a high level of competency and concentration on the part of the operator.

4. THE PROBLEMS

4.1 Preserving the historical aspect

Much time and effort was spent in developing the methods and procedures that would enable the full functionality of OSNI's policy of providing our customers with both current and historic data.

The method evolved allows the obsolete data to be archived with all multi coding and still retain the necessary link used by all the NIGIS partners to access their associated data.

4.2 Associated data

The associated textual element adds significantly to the updating task, and with it additional problems. Unique 12 figure grid refeference identifiers are system generated for all new polygons requiring the addition of associated textual information. They are also generated for all line-string and point features in the new geometry and for existing geometry that has changed feature codes, for example, a change of building use from educational to commercial. The relevant date and method of survey or date of change of use is attached to the appropriate identifier within the data files that are created. It is through these files that interrogation of the database by date is possible. When the newly digitised topographic data and the unaltered data are merged some interactive work may be required to snap the two together. Resulting from this some additional identifiers may need to be generated where for example, a closed polygon is created that requires associated data. When minor changes occur to some polygons the associated data relating to that polygon may not need to be updated. If for example, a small extension was added to a dwelling house then the associated data would be unchanged. In such a case the unique identifier of the original polygon would be noted and deleted from the file. When the geometry is updated the same identifier is reinstated, thus accessing the original associated data. The line-string identifiers will record the date of survey or date of structure change and so interrogation of the database by date will provide the date the change was surveyed. The relevance and complexity of the problem increases greatly with the number of associated data applications that are involved. At OSNI work is in hand to expand the associated data aspect by, for example, linking road names and classification numbers to the road centreline.

4.3 The effect of data structure complexity

The complexity of the data structure and multi coding add significantly to the overall extent of the file. The graphical database is topologically structured with some 190 separate levels with geometry being multi-feature coded and all map sheets matched and merged. It is the number of feature codes attached to each vector and the number of polygons that must be logically closed with a particular feature code that increase the effort to maintain currency. When geometry is added or removed it is usual that some feature codes in the remainder of a polygon may require alteration.

4.4 The degree of currency

The speed of response demanded by the NIGIS partners presents its own problems especially for efficient system management. The methodology outlined for updating is CPU intensive and involves a necessary mix of both interactive and batch processes, to achieve effective operation.

This aspect is kept under continual review in the light of experience and developing technology in order to refine the process and reduce the turnaround time between completion of the survey and all the latest information being databased. At present the turnaround is five days due mainly to the extent of batch processing used. The aim is to reduce the response time to that previously available from the paper based advance revision system.

4.5 Data integrity

Validation of the graphic and non-graphic data is vital in order to retain the integrity of the database. New data must be subjected to the same validation procedures as used at initial data conversion. If a building, for example, to which NIGIS partners add associated data was incorrectly supplied the implications and inconvenience would be enormous. All users would have to amend their own datasets to the corrected polygon with its new geo-reference. If all records were not amended then a chaotic situation would result and the whole GIS concept and functionality degraded.

5. CONCLUSION

These are in very broad terms the main generic problems of updating a complex database. As the Northern Ireland Geographic System develops, the importance of currency increases, and OSNI are responding to keep pace with the demand. The system that has been developed, while not yet perfect, has been designed to meet the criteria agreed with all the partners. The overall task of maintaining data currency has not been underestimated but further improvements will undoubtedly be required if NIGIS is to fulfill its true potential.

3. APPLICATIONS AND EXPERIENCE

Chairman: Paul Newby.

3.1 Map Revision in Developing Countries.

M Pourkamal, Senior Technical Advisor, Government of Iran.

3.2 Orthophotography as a National Reference Land Base.

Phil Allen, Air Logistics, Auckland, New Zealand.

3.3 Digital Update - A User Experience.

R Webb, Southern Water, West Sussex, England.

3.4 Photopolis Project: Updating Digital Geographic Objects from Aerial Photos.

Robert Laurini & Sylvie Servigne, Institut National des Sciences Appliquées de Lyon, France.

Paper 3.1 (Pourkamal) was introduced by Paul Newby

Paper 3.3 (Webb) - A paper has not been provided for the Workshop Proceedings.

MAP REVISION IN DEVELOPING COUNTRIES

BY

M. POURKAMAL

Sen. Tech. Advisor - Tehran, I.R. Iran

1: A FOREWORD

Developing Countries may not be categorized in the mapping and Geoinformatics domain, as is done for overall status of their socio-economic developments.
Amongst themselves, they have quite a different position in respect to the subjects related to themes for this workshop; although they may still have many problems in common. The thirst, and the growing demands for the basic data needed for Geoinformation systems is increasing day by day. Sometimes it is more felt in developing countries rather than industrialized nations, due to the fact that some of the main users of maps and data provided by Survey organizations and firms have entered the digital era, much earlier than The National Survey bodies, and this means the Survey Community have to cope, to plan, and to act in accordance with the new requests and needs of each country, namely the question of the most up-to-date digital Geometric and Semantic data" for which "Photogrammetry" remains and stands firmly in the front line, to contribute at least for 75 to 95 percent of the whole respond. The choice of the title "Developing Countries" for this paper is solely for some of the well-known, and newly raised suggestions, questions and messages through a voice from that side.

2: THE ROLE AND THE PHILOSOPHY OF SCALE(S)

Although the term "Scale-Free" has become recently popular in many cases and references, especially those related and/or close to the very large scale digital mapping. But one better be cautious, not to underestimate or ignore the role and the philosophy of scale and scale-ranges, while dealing with different aspects of map-making activities, and their related disciplines, including data aquisitions for all up-datings. The following spectrum of map scales (Fig. 1). Though simple is coverying most of the commonly used scales which fulfil the task needs of all map users regardless of the map being in the traditional form of presentation on the paper or on modern medias like tapes, disks, diskettes etc., which eventually need to be brought up to the eyes, and/or the hands of the end users.

MAP-SCALES SPECTRUM

Approx. Scale Cartograms	
1/A Mil.	
1/5.000.000	
1/2.500.000	
1/2.000.000	
1/1.500.000	
1/1.000.000	
1/750.000	
1/500.000	
1/400.000	
1/250.000	
1/200.000	
1/100.000	
1/75.000	
1/60.000	
1/50.000	
1/40.000	
1/30.000	
1/25.000	
1/20.000	
1/15.000	
1/12.500	
1/10.000	
1/7.500	
1/5.000	
1/2.500	
1/2.000	
1/1.000	
1/500	
1/250	
1/100	
SCALE FREE - MICRO GEODESY	
Microscopic scales	

Figure 1

One of the reasons for bringing up the question of scales into the scope of this workshop could be the technical specifications governing one or several master scales of a certain category. So far in developing countries limited squeezing and optimization is done to reduce costs and efforts which is focussed on "one" scale or a narrow gauge of the spectrum, without much attention to enrich also neighbouring scales. (Based on Cartographic rules.) Whereas country-wise an optimization, and squeezing of the total range of the spectrum, may lead to some "mother scales" somewhat different from the present choice. This depends much on the size and the type of terrain, homogenity of details, available sources, and many environmental, and technical factors, and possibilities.

The second reason for raising up the question of scales under the title of this paper is simply because in developing countries (even, those already have established some set ups of a fully digital or hybrid nature) is simply because in developing countries the map coverages in different scales, either the National Coverages or project maps, urban and all other thematic maps, are not a "continuous line" if merging different rows related to different users (figure 2), where as in the well developed countries or regions this is not the case (figure 3). Such tables if based on the actual statistics of any region or country may be consulted and referred to as a good criteria for the degree of overall developments. Just another complementary tool to different monitoring methods. The total number of different users, in terms of theme and scale is also a criteria for comparison and evaluation of the degree of development accomplished or undergoing. (Figures 2 and 3 may and could make a very long list of unlimited number of subject-users of certain maps in certain scales.)

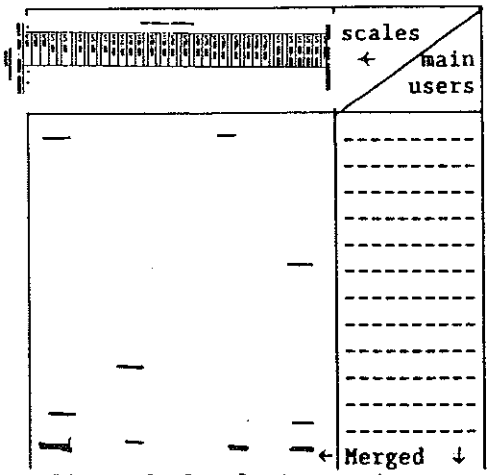


Figure 2 Developing

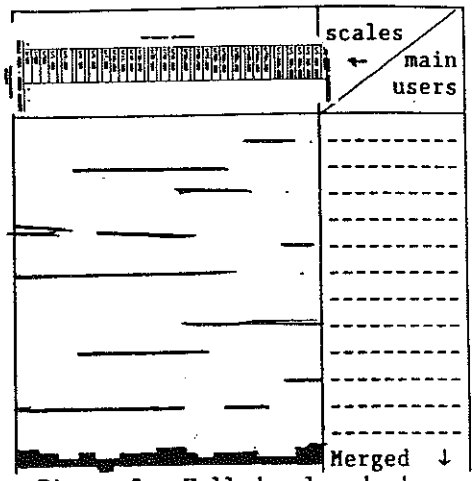


Figure 3 Well-developed

unlimited
no of users

The following schematic diagrams (Figures 4 to 11) show how different, the total spectrum of scales behave in several topics. Many more graphs could be derived, but those related directly or indirectly to updating matters also confirm the idea how "photogrammetry" can solve up-dating problems of many scales. The Photogrammetrists of present and future generations are faced with many arguments and challenges to feed more and more data into the geo-information systems. Whatever the mother-scale of any L.I.S./G.I.S. is selected, the Geometry remains to offer the skeleton to all other unlimited layers of information side by side with its "sister Geometry" so called "Topology" or waving Geometry. Again referring to the total spectrum of scales we easily find out that no other discipline exists to provide and furnish such a wealth of information both geometric and semantic into Geoinformatic systems, starting from raw materials like air photographs and many side products going through photogrammetric procedures up to a final product ready or made ready to meet the hands and/or eyes of an intermediate, or end user. In this context figure 12 may serve to show how photogrammetry is involved in spacial data gathering in terms of scale ranges and volume of work and information*.

* The pyramid in figure 12 was discussed recently with Prof. Dr. Makarovic in ITC Enschede Holland.

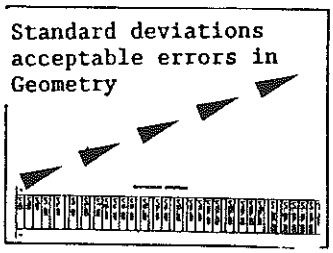


figure 4

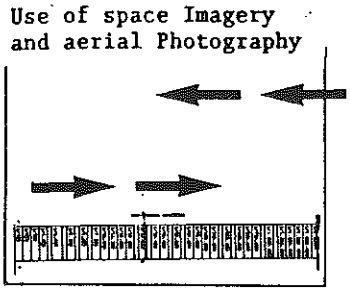


figure 5

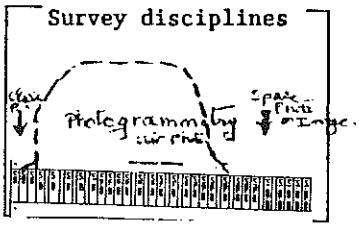


figure 6

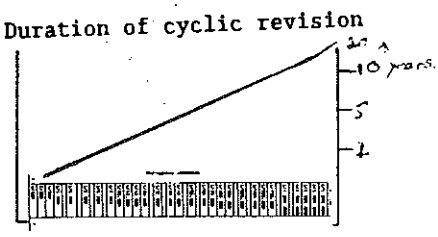


figure 7

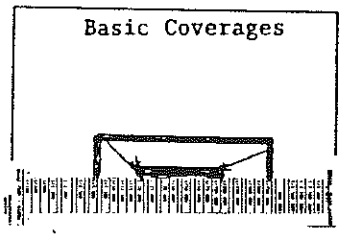


figure 8

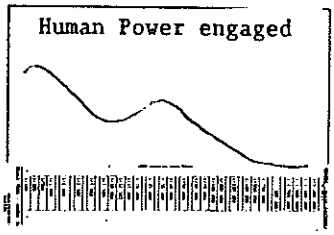


figure 9

degree of Generalization

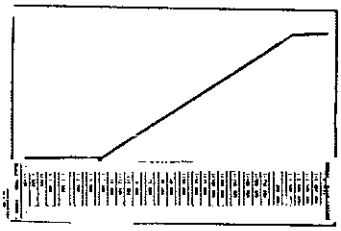


figure 10

Number of users
(also Tirage)

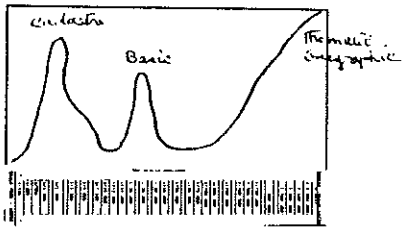


figure 11

and many other topics

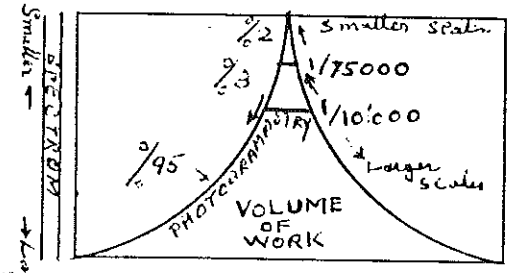


figure 12

3: MAP-MAKING PROCEDURES AND "SYSTEMS"

The word "system" is used here for the total steps taken by a survey organization from the planning phase to a final product ready to be delivered to the user(s). So it includes the total combination of man-machine and methodology. As such there are many map-making systems (though they are not so called) in use at present situation, which out of them all, in the well known Survey organizations these systems are well established and followed with minor modification till the whole system is revised. Depending on the type of product the participation of different sectors like: geodesy, aerial-survey and photogrammetry, field survey, remote sensing etc. is assigned and this is done for any or many projects all over the world, without introducing it as a system and go with it formally or informally.

Just at this moment there are at least hundreds of old and new systems in practical use. This variety exists in developing countries well, but still without a well defined concept of having a "system" though they have it, work with it, and modify it. One of the reasons for this ignorance for the introduction and classification of the "systems" in use for different mapping needs may be that as soon as a certain flow-diagram is settled and accepted to meet technical specifications and to please the users; there will be certainly a system in the whole production line; but they are never well introduced and not well recorded as "systems". No matter if the product is analogue on the paper or digital on screens and medias. This "system" approach "may need special attention by survey specialized system analysts, not because of the planning and optimisation of new projects, but also for the sake of various updatings and revision-mapping. One of the feed backs of such a system approach will be useful documentation and literature for training and educational side of mapping fields, as well as helping managerial levels of other countries. Many good technical reports, do exist and experiences in different specialized lines are reasonably distributed; internationally. But the subject is not yet well considered.

Regarding updating, a "system" approached documentation can be of a great help for those who are going to up-date the existing information and they are different people with different tools from those who have brought the information to the present stage 2-5-or many years ago.

4: SHORT AND LONG TERM PLANS FOR UP-DATING. A MULTIDIMENSIONAL TABLE OF POSSIBILITIES

Certainly the Developing Countries do believe in Technology, and so they believe its rapid changes and its advancements. But how fast and how efficient, they can gain the new expertise with the new tools, and how fast they can change and adapt? The revision of maps and updating of spatial data by photogrammetric means is not an exception. Analogue photogrammetric instruments have lost already their role and efficiency, within the digital environment. Not only because the manufacturers do not support them any more. But also because they do not fit in a new photogrammetric production chain. On the other hand many organizations and private firms have not been able to change their beloved analogue ones, due to many reasons, mainly the high cost of the new hardware's including analytical plotters. Due to this and many other reasons, some Developing Countries, still maintain plenty of analogue instruments in service, even without being able to upgrade them into hybrid. But as mentioned earlier some users can not wait long, and diverted solutions

may happen. So to avoid poor revisions also and to keep the value of good old maps on their technical market; the use of simple digital photogrammetric methods could be considered advisable for a limited period of time. Many possible types of aerial photography makes a long list including non-metric. The new photogrammetric techniques are able to handle diverse types of photography. Several simple instruments are still on the market, some with growing digital possibilities. Many simple class instruments are staying idle not because of their low precision or low production rate. But I know some of them where kept behind not to be shown to the high level visitors! In order to keep the instrument rooms more prestigious, with gorgeous and claerious looking of high order analogue instruments! With all these existing and rather cheap possibilities a large table could be derived, to make the choice according to different circumstances. I tried it but I found it multidimensional rather than two or even three dimensional, the factors and headings also change from one country to another. Let us assume that such large table(s) are made, and the choice is favourable for a certain developing country, and put into action. Having done that we have pleased only some limited users for a limited period. This could not and should not be continued on the long run especially for the National projects.

The digital information systems need no visas to enter different frontiers. They have entered our environment long ago.* They need to be fed and kept updated for many more reasons, and many more new users, than what analogue photogrammetry was responsible in its golden era. The Developing Countries may be also facing problems of coordination cooperation between different users and producers. The know how, educational and training facilities and policies should also be revised widely and duple. Organizational structures also need to be rechartered.

5: FIELD WORKS NEEDED FOR UPDATINGS

5.1: A case history

Although being more expensive and more time consuming, some developing countries have still the man power available, especially when the existing maps to be revised are of good standards and the changes are not too rapid. Also much depends on the user requirements. Talking only about planimetry which needs more cyclic or random-case updating I have a personal example.

Statistical offices and centres of each country or province need large scale maps for their data collection, sampling, etc., from the cities and towns which in our spectrum of scales occupy a short line crossing three or four columns. The National Cartographic Centre of Iran (N.C.C.) had produced large scale town maps at the scales of 1/2.000 - 1/2.500. The Statistical Centre of Iran (S.C.I.) was one of the main users. After some years they found out that the maps are rather out of date. They did not refer back to the Survey office (in this case N.C.C.) for updating after some discussions finding out that the updating needs a lot of time and money if done by N.C.C. So they trained their own technicians, who could update the town maps referring to the good points of existing details. These "statistical" surveyors located in the provinces, updated

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* In domains other than map making disciplines.

the planimetric details with a quality, meeting their needs, using simple instruments. They also generalized the details which already existed and were valid. Diazo prints were made containing enough information for filling statistical forms and questionnaires. Soon these maps were known to some government organizations, private firms, consulting engineers, and so on. They were much more welcomed than their mother-map by many users just because of some degree of updating. So the S.C.I. had much more orders for town maps, than the main survey organization (N.C.C.).
Why this happened? First because the S.C.I. was furnished with printed good standard town maps prepared by N.C.C. and secondly because the N.C.C. was not prepared to cope with updating of her own maps, (1973).

I have seen also some of these town plans with the following history some years ago.

1. Aerial photography, Field Control points (±) aerotriangulation, photogrammetric plotting, field completion, fine cartographic works up to offset printing; all done by the N.C.C.).
2. Field work revision after 4-5 years by S.C.I. (semi-accurats planimetry only) or a similar organization with excellent toponemy.
3. Direct levelling on the ground with a good number of points along the streets, and around the town, carried out by a third client. Mainly by consulting engineers who did the job through a small survey firm or by their own staff. This case may not happen in large cities like Tehran for the whole city, and also can not be the case for many smaller scales, and also never the case for specialized geometrically oriented users.

Similar cases may have happened in other countries which we can underline as "Map revision by the users!" This possibility is raising with good computer facilities that some of the users have available in their own offices. But thanks to "photogrammetry" this self-revision-by-users can not go beyond a limit. This attempt gives many potential users a much higher degree of appreciation for the Survey community, especially photogrammetry.

5.2: Growing need for Multipurpose Cadastre

The Land Information Systems, related and based on Cadastre and utility Cadastres is a good example for the percentage of field work still necessary. Even for change detection field reports are the most reliable ones. In this exceptional case, Developing Countries may have the advantage of available man power though not all. The comming decade seems to be a challenging one in the field of "Cadastre" going fully digital. But in any case with the good participation of digital photogrammetry a whole modern cadastral system could be considered nothing but continuous up-datings. A static cadastre does not exist.

6: CATEGORIZATION AND CLASSIFICATION OF USERS

Some maps are made for a limited number of users, where as some others have multiple users. The first group always consist of subgroups who are planning and executing infrastructure, out of all different users who should get the priority of updating. In a developing country the priority should be given to the sectors, who are involved with basic development programs for the sake of the public.

7: SOME RANDOM THOUGHTS ON MAP REVISION*

7.1 Cyclic revision if done as a sub-system along with the national mapping programmes has its advantages. But if user needs and demands are taken into account, then selective methods are preferable.

7.2 Revision has long been neglected regarding the National Survey Coverages the reason being: let us first finish the total coverage!

7.3 Percentage of changes to the total map contents to commence revision, should be base on both
1. "Nature of changes" and
2. "Number of changes"

7.4 New demands has put a pressure on mapping agencies to become more efficient, more productive especially with regard to digital products.

7.5 Data sources and data acquisition methods for map making as well as revision are not limited. Flexibility can help while planning.

7.6 The changes to be updated are not uniform so each country could develop their own methods for detecting changes.

7.7 The duration of revision itself has become much shorter with the new techniques.

7.8 The contents of basic Data Bases/Maps with the possibility of so many other layers could be and should be kept as simple as possible.

7.9 The support and cooperation of local authorities for change detections is very vital. The full-time and half-time local survey teams in large countries for the left side of the scales spectrum, has not less value than space imagery and periodical photography for the right-side smaller scales.

7.10 Nation-wise do not spread your activities around many different isolated scales. First categorize the spectrum according to your main user's needs (+ 7.5).

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* Most of these points were drawn after a discussion with Mr. J. Kure, ITC, Department of Geoinformatics.

8: ALONG WITH THE TRANSITION PERIOD AND OUR TECHNOLOGICAL 'PURGATORIO'

8.1 The Islamic Republic of Iran has been facing a long war. So needless to mention, how different activities, including map-making areas are affected. Concerning "Map-Revision", we can consider pre- revolution and pre-war time, one period with the main works as follows:

a - partial updatings of the National Coverage 1/50.000 with scattered aerial photography, and analogue instruments, followed by relative amounts of field work (N.G.O.).

b - very limited number of large scale (1/2.000) maps of few towns were done by analogue instruments. Many more were redone after 10-15 years. The changes were enormous.

c - special revisions were carried out by oil-gaz sector all in 1970's using aerial photography of 1/30.000 - 1/75.000 SWA and 1/20.000. Production scales for this revision activities were 1/50.000 and 1/10.000 for reasonably vast areas.

8.2 The attached national report on "Geodesy & Geophysics" submitted to the 20th general assembly of IUGG (Aug. 1991) gives an idea how much work in different areas are ahead namely, the 1/25.000, Cadastre, and many physical-reconstruction plans. Though analytical and digital methods are not yet introduced into the production chain, but they have been already welcomed by paying much attention to the training side of this transition period (from analogue to digital). Limited small pilot projects in digital form are promising. We hope to be able to include a digital subsystem at least to the main national projects for updating. Efforts are numerous for making this transition period as short as possible.

Attachment.: 1

ORTHOPHOTOGRAPHY AS A COMMON REFERENCE LAND BASE

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Abstract

A common reference landbase for spatial datasets between mutual parties for each geographic region of a country provides not only a significant financial saving in the construction and maintenance of the "base" dataset but also allows a certain amount of exchange and data brokage of combined or value added datasets. This paper highlights the benefits of orthophotography as an ideal common reference landbase for a wide range of map users and resource managers in respect to speed of production, consistency of future landbase updates, accuracy, quality assurance and cost recovery.

Introduction

With more emphasis being placed today on the commercial resource manager to better manage his resources, a more visual and user friendly style of spatial dataset is required for general use in the commercial world. This commercial world also demands practical and cost justifiable solutions for the creation and maintenance of such datasets. We, as data suppliers and specialists in data capture must adjust our methods and procedures to meet the market requirements and provide an affordable product to our clients.

Orthophotography in both hard copy and digital form does provide a cost effective method of providing maps suitable for the lay person to understand and is an ideal base for the construction of datasets due to it's consistent relative and absolute accuracies.

The following outlines the importance of a consistent and accurate base for the establishment of spatial datasets, the benefits for co-operation between various bodies and the New Zealand experience to date.

The Client

First, it is important to understand our market and their needs for spatial data in regard to: viewing, querying, analysis, modelling, demonstrating and decision making. The client is a very complex animal in the sense that he can comprise of very technical and precise people, to lateral thinking managers who deal in concepts through to financial directors who demand value for money.

To make this point clear, we only need to look at a local authority to see that the combination of technical design specialists, conceptual planners and managers and the non-technical elected councillors all need to make decisions derived from the datasets that we provide. The better these people can relate to and understand the data, the better informed they will become, and therefore, the better the decisions that can be made.

Where orthophotography wins over non-photographic datasets for such a wide spectrum of people is it's ability to portray an extensive amount of detail simplistically in picture form to a very high level of accuracy with an assurance in the positional quality.

The Reference Landbase

It is important to define what we mean by a common reference landbase. This is a layer or co-ordinate system within a dataset which can be jointly used by a number of parties to reference or link all their spatial data. This then allows the ability for these parties to maintain and take responsibility for individual parts of a complete dataset and allows for a quid-pro-quo exchange of data. For example, a Gas Board, Local Authority and Water Supply Authority may all have the same common reference base, yet each maintain their own individual layers of data and can have an agreement to access certain layers of eachother's system (see Figure 1).

To build a large spatial dataset for the management of a resource (whether this resource is a large geographical area, a water catchment area or a utility network) a reference base is required as the initial building block. This reference layer is paramount in controlling the absolute positional accuracy across the complete database. The reference layer can either be a layer containing a significant amount of information captured to a consistent

Figure 1.

A COMBINED SPATIAL DATASET

LANDBASE	Spatial Dataset	OWNERS
Orthophotography & DTM provides spatial accuracy for the dataset.	. . . .	All Participants
LEGAL Property information Cadastral information Legal Description Survey definition Valuation Demographics Zoning	. . . .	Local Authorities Government Departments
UNDERGROUND SERVICES Sanitary sewer Stormwater Water reticulation Gas Power Telecommunications Fibre optics	. . . .	Local Authorities Utility Companies
EMERGENCY SERVICES Civil Defence Route Planning	. . . .	Civil defence Police Fire Brigade Hospitals
SPECIALIST SERVICES Soil maps Hazard mapping Vegetation Transportation Pedestrian flow Regional patterns	. . . .	Specialist market analyst and research groups.

accuracy from which all other data can be plotted in relationship to, or it could be a 'co-ordinate system'.

The co-ordinate system is obviously the ideal. It provides a defined and consistent accuracy determined by the method of capture to specific tolerances. For industrial sites and small geographical areas, photogrammetry using analytical plotters produces a high quality accurate and cost effective product. However, as the geographic area increases in size, the affordability of the product starts to diminish.

Therefore, for larger geographic areas the preference has been to use existing hardcopy maps and to scan these into the system and warp them into a defined co-ordinate grid to remove some of the inherent distortions. To date this has been a viable and far cheaper solution to the 'co-ordinate system' method for large areas. This method, however, suffers from two significant drawbacks. These are:

- the inaccuracy and inconsistency of accuracy of the original drawings, and

- the lack of a common drawing that can be used as the reference layer for a number of parties. This is usually because of the problem of finding enough cross-reference points between 'various parties' data to gain the benefits of a common reference base (see Figure 1.).

Orthophotography as the Common Reference Landbase

An alternative to the use of 'co-ordinate systems' or scanning of existing maps as the common reference landbase is to use orthophotography. The strengths of Orthophotography can be summarised as follows:

- Offers a consistent absolute co-ordinate accuracy.

- Provides a very high relative accuracy between features.

- Contains most physical features as at a specific defined date.

- Unless significant earthworks has occurred, updated or repeated orthophotography is significantly cheaper than the initial product cost because the digital terrain model (DTM) does not need to be reproduced and this guarantees revision consistency.

- Quality assurance on the positional accuracy of an object on an orthophoto is significantly higher than on a line-and-symbol map.

- Significantly more data can be shown at any one time than with line-and-symbol layers.

- Lay people can readily understand a photograph where they can sometimes struggle with a line-and-symbol map.

By constructing a mosaic of scale accurate photographic images across a complete geographic region to a co-ordinate base we can achieve similar results to a 'co-ordinate system' solution for the construction of a reference landbase at a significantly reduced cost.

The cost benefit is difficult to quantify because it is dependent on the amount of data that is of value to the client in the photographic image and how much of that data the client needs topologically structured. From our experiences to date this can be in the vicinity of a 2x to 5x cost benefit against capturing from an analytical plotter.

The New Zealand Experience

To meet the market requirements for GIS spatial datasets, Air Logistics (NZ) Limited and the Department of Survey and Land Information (DOSLI) have joined forces to produce a digital orthophoto product called 'Orthomap'. The product is offered both in digital and hardcopy form to satisfy the various requirements of our clients.

Orthomap is marketed nation wide as a "National Reference Landbase" for the construction and viewing of spatial datasets. Over urban and intensive farming areas the imagery is produced at 1:1000 scale to allow for zooming on

screen down to around 1:50 and at 1:10,000 to allow for zooming out to 1:20-50,000 for large catchment studies. For low density rural areas 1:10,000 only is recommended.

Using the 1:1000 scale imagery an absolute accuracy in positional co-ordinates of ± 0.5 metre is achieved with a relative accuracy between objects being generally better than 0.2 metre.

With the above specifications raster files can be configured within a system and edge matched such that a continuous image can be displayed for a geographic area in a co-ordinate base.

The areas where orthophotography offers significant benefits to our clients are:

- To jointly participate and share costs with other parties to initially produce the orthography and DTM over a joint area to form the common reference landbase.

- To jointly share the costs in the updates at pre-arranged intervals.

- To jointly share or individually extract certain data off the imagery using 'heads up' digitising off the screen (i.e. manholes, footpaths, kerbs, buildings, physical boundaries).

- Orthophotography offers a significantly lower initial entry cost into the establishment of a GIS or AM/FM system which can be very attractive to clients. They may find that they do not need a complete topologically structured database of all features immediately and therefore can pro-rata the dataset construction costs over a longer period than if they only had line and symbol data. By having the photographic image as a backdrop, other information not yet captured in vector form can be extracted on a 'as required basis'.

- Repeated Imagery can be built into a regular flying programme to provide a very cost effective maintenance programme for the dataset. The digital terrain profile is not required to be repeated unless significant earthworks has been carried out since the last photography.

- Orthophotography offers the ability to record the position of underground services without the expertise of a land surveyor by simple offsets to physical features. These dimensions can also be recorded within the system for relocation in the future.

- For public counters in large organisations, the advantage of having digital orthophotography on the computer screen with your services overlaid on top is very convenient and understandable for the general public to interpret. They can more easily recognize the area to be discussed and explain the problem. Contractors wanting to know where buried services are can visually see the position to physical features.

- For the construction of as-built plans of underground services, orthophotography provides the exact position of surface features such as manholes, cess-pits and junction boxes. When scanning in existing drawings of old services, corrections can immediately be made to adjust for distortions in the hardcopy records.

- Orthophotography provides a high level of quality assurance on positional accuracy over line-and-symbol maps.

- For technical officers that need to verify what is on the ground for confirming compliance in relation to building permits etc. can significantly reduce field time by having on screen the combination of orthophotography and vector linework of underground services.

- A by-product of orthophotography is the Digital Terrain Model which is very useful for a client wishing to analyse gradients, overland flow and catchments studies.

- The ability to use intelligent raster and link pixals to attribute data can reduce dataset construction time.

Conclusion

The combination of the strengths of orthophotography combined with vector linework can provide a very powerful dataset at a significantly more affordable price for some clients. The Rolls-Royce product for accuracy is still digital data derived off an analytical plotter but we must be aware of the ability of our clients to be able to afford our data.

Orthophotography has the ability to get clients into developing large datasets more quickly to a consistent accuracy, which has significant advantages over using scanned maps for the construction of a reference landbase in regard to accuracy and cost.

Orthophotography as a Common Reference Landbase offers the potential of not only shared common layers between various major resource management parties but also benefits to small developers, consultants, real-estate, etc. who could access these datasets to compile customized datasets on a data brokage arrangement.

PHOTOPOLIS PROJECT :
UPDATING DIGITAL GEOGRAPHICAL OBJECTS FROM AERIAL PHOTOS

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ABSTRACT

Updating geographic databases in a modern city is a very heavy task. Generally speaking, updating is done via map digitizing or ground measuring techniques for instance via theodolites. These operations are very slowly and not exempt from errors. The idea of the PHOTOPOLIS project originated from the City of Padua is to use aerial photos in order to accelerate the updating. Presently, we are on the feasibility study. The role of this paper is to present the general structuring of this project realized by a group of researchers of Lyon and financed by the City of Padua and the Siemens Data SpA Milan.

1 - PRESENTATION OF PHOTOPOLIS

The City of Padua has amazing problems for updating its digitized cadaster due to technical and administrative reasons. The conventional way was to modify the geographic data base either from surveyor's measures or from digitizing their drawings.

Aerial photos look as a promising technique for updating geographic objects. So a collaboration was raised between the City of Padua, Institut National des Sciences Appliquées de Lyon, and Siemens Data SpA Milan in order to develop a feasibility study.

Initially, updating cadaster was the main goal. But, it fastly appears that cadastral objects like plots of land have often theoretical (no materialized) limits which cannot be recognized on aerial photos. So, the initial scope shifts to updating of geographic objects instead of cadastral objects. By geo-objects we mean objects which are existing in the real 3D world and are seen or can be guessed from aerial photos.

So as to perform the feasibility study, the City of Padua has offered several photos and their corresponding digital maps in which some control points can be recognized.

At the present time, cadasters are updated infrequently and slowly, which can lead to delays and inaccuracies, giving rise in their turn to mistakes of interpretation and ill-informed urban planning decisions. Some authorities hold their information in a digital form within a computer system. However, even these systems are not exempt from the

updating problems referred to above, because of the methods used to capture and update the data. Currently, information is captured by manual digitization of maps or more directly from standard surveying techniques. A similar manual approach is used for updating the information.

Updating digital cadasters from aerial photos is easier than creating them. Indeed, detection of geo objects in aerial photos from scratch is very difficult whereas detecting with a priori information in a database is simpler. That is the reason why this project is devoted to updating digital cadasters from aerial photos with an existing version of a geographic database.

The principal long-term goal will be to design and implement a system for the automatic establishing and updating of computer-based land registry information (cadasters). Data capture will be achieved by the use of aerial photography. The project will bring together image processing techniques and geographical information systems. A knowledge-based approach will be used for the interpretation of the images and for the monitoring and updating of the spatial knowledge bases.

2 - ARCHITECTURE OF THE SYSTEM

The architecture of the system is the following :

- Starting from aerial photos, the first step is to **correct** images because they are distorted for a lot of technical reasons.
- The next step is the problem of image **segmentation** in order to find boundaries of textures and demarcate pictorial objects.
- Then starting from digital cadaster the problem is to **confront** pictorial objects and stored geo objects in order to see whether updating is necessary.
- One of the main difficulties is to design the **knowledge base** integrating all urban knowledge necessary to facilitate future updating from aerial photos.

3 - IMAGE DEWARPING

Starting from aerial photos, image dewarping is the first step so as to correct distorted images.

Photogrammetry is a measuring technology which gives methods to determine shape, size, space positionning of any objects. It uses photos of the object taken from two different viewpoints. The photographic cover of an area is constituted of all the pictures taken from an aircraft. The shots which are realized in metric rooms are done through special manners.The metric rooms optic axis must be very closed to verticality.

The photographic cover is constituted of rectilinear swaths of photos which overlap each others at 60%. The photographic scale is approximative, it changes with the elevation of the pictures regions: tops have a bigger scale than valleys.
We observe that planimetric errors of object position are more frequently found in uneven ground areas with high buildings and in photo border (the farther from the photo center, the warper)
The causes are the angle i between the nadir line and the optic axis of the camera (the nadir is the vanishing point of all vertical lines of the soil), and the landscape relief.

Control points have coordinates which are established in the Gauss-Boaga system. We find them frequently on the roads but also they can be particular points such as church steeples. They are very important because they are our reference: We have their real coordinates and we can measure their photographic coordinates. If they are not the same they help to find a mathematical transformation.

In fact we have a mathematical system whose specifications are unknown. We have the output image and we want the input image: the F transformation is the way to do it.

4 - IMAGE ANALYSIS

Starting from aerial photographs, we have to produce information on geographical objects present For that, we provide to the data base boundaries of those objects and labels concerning texture of neighbouring areas. Information given by texture must enable us to discriminate different objects and then improve the updating process.
In the following, we shall only deal with problems of imaging techniques from the input images to an output which is sent to the base.

At the moment, we got from city of Padua and Siemens Data SpA. three digitized images, each of them in the YCMK system of colors representation. One of those images is a scene of Old Padua, another is a scene of a suburb of the City and the last is a scene of a country side area. The images have a 1980 x 1980 pixels resolution, each pixel is coded on 32 bits (4 x 8 bits for the three colors and the contrast).

4.1 - Some particular problems

The images we have to analyze present some specific features which generate particular problems and need to develop adequate processes.
First of all, geometric aberrations are present due to acquisition techniques. Those aberrations are specially numerous and important on the borders of photographs. Because of those aberrations, façades of buildings are sometimes visible which is never the case in a cadaster.

The second problem comes from shadow areas which can cause a loss of information by hiding objects or details which are present in the scene. This problem has already been well studied but only in the case of monochromatic images. In fact, approaches which seem the most operational are those which use computation of texture and geometric parameters. In our case, with quadrichromatic images, we get an advantage by working on each color image.

The third problem comes from the fact that information is very contextual. So we must process in an intelligent way in order to detect objects. In particular, the recognition of these objects must be conducted in relation with their environment and after having defined charasteristics which discriminate them.

4.2 - Overview of the approach

We propose a system composed of two hierarchical levels. The lower level consists in processes of restoration and enhancement, in segmentation of images and in computation of attributes. That level gives to the upper level a segmented image from which objects can be detected by using attributes computed at the lower level and techniques such as discriminant analysis, clustering methods, logit analysis, and so on.

At the end of the process, if we can think that the result is enough good, we produce elements to be transmitted to the multimedia data base. Otherwise, we return to the lower level to ameliorate the intermediate image which comes from that level towards the upper level.

To do the image analysis process, we used several imaging techniques : filtering techniques, an homogenization process, segmentation techniques and texture analysis methods.

4.3- First results

We have implemented ad hoc algorithms on a SUN 3/60 workstation, on which already were implemented some usual imaging algorithms (filters, binarization...).

First of all, it appears that usual filters such as Sobel or Roberts filters, are inoperant on our images. The best result we got was obtained by using the minmax filter with a 5x5 mask. The homogenization process works very correctly and provides an image with an very improved information. Here, however, there remains the problem of selecting an appropriate threshold. The results we got, lead us to propose the following process :

1- take the input image, apply it the minmax filter,

2- on the result, apply the homogenization process with an adequat threshold,

3- on the homogenized image, apply the segmentation technique we developped from runs,

4- the last step is to get a binary image from the previous result.

This process provides us a part of the global result : a binary image which contains contours to put into the data base.

The second part of the global result is given from the computed statistics, based on criteria developped in the section about texture analysis.

An estimate of those parameters was got after sampling four type of textures found in the images : dark roofs, bright roofs, vegetation, streets and roads.

5 - GEO-OBJECT RECOGNITION

The aim of this section is to show the modifications generated in a cadaster due to new constructions or demolitions from segmented images and maps with an a priori knowledge base.

We have two kinds of input data :

- digital cadaster maps organized with the object oriented approach. Each object is delimited by segments and represents a road, a building, a parcel... These segments bring information; we know that a segment belongs to a hurdle, a wall or a road;
- segmented photos organized with alone segments and areas of uniform texture delimited by segments which represent the road system, buildings, parcels but also shadows, car parking lots or line of buildings due to perspective.

Ideal output information of the system must be : new segments which can represent new buildings, and missing segments which can represent removed buildings.

5.1 - Generalities about confrontation

We have to compare the two kinds of input data : sets of segments coming from maps and sets of segments issued from segmented photos, so as to determine the new segments and the missing segments. Segments belonging to maps have to be recognized in segmented photos. So, for the comparison, we can perform an edge-following method which allows a sequential analysis without back tracking; only one analysis of segments which belongs to two parcels or two buildings is necessary. As there are a lot of segments coming from the segmented photos, we must organize these segments to accelerate the comparison. A R+-tree organization (cutting out in rectangles by levels) seems to be interesting as we have a pseudo-rectangle level provided by the different photos.

The major problems are due to :

- **interferences** (shadows, vehicles, perspective) which bring out, during the segmentation process, detection of added segments in comparison with maps,
- **hidden information** (road or building hidden by trees, camouflage due to shades) which bring out detection of fragmented segments and not whole segments,
- **orientation discrepancies** : if maps and segmented photos are superimposed, map segments and photo segments, will be highly close at hand but not exactly superposable. We can note that the difficulty is variable according to the season of taking of photograph : sunlight involves shadows, snowing involves uniformity...

A priori, the percentage of new information is less important than the percentage of stable information because of the number of demolished buildings and new buildings which is low compared with the total number of buildings.

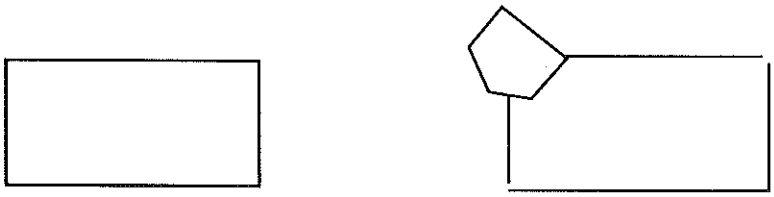
5.2 - Assimilation

To assimilate an object, we have to match each segment composing an object. There are four main cases :

1/ There is no problem : all segments matched, so the object is assimilated;

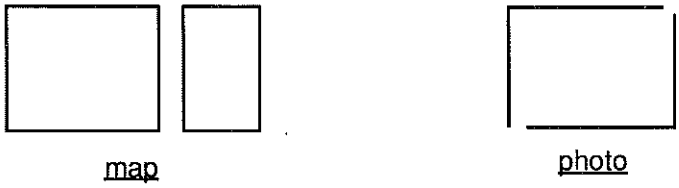
map photo

2/ Some segments of the object are partially or entirely hidden by an unknown area; the unknown area delimited by segments has a texture which may give information on what this area can represent. Then the use of the knowledge base can give a response concerning the nature of the unknown area.



map photo

3/ Some segments or complete areas disappeared in the photo but still exist in the map. So we can deduce that modifications are due to demolition.



4/ segments or areas of the photos do not appear in the maps. We have to use the knowledge base so as to determine the nature of the new objects, to know if they are constructions or not. In this case, the existence of a building licence must be verified (building permit file).

5.3 - Correspondence and matching methods

Doing the map to photo correspondence depends on the data structure : pixel, segment, or region and on the matching methods.

There are several methods which do the template matching, using masks, graphs, geometric constraints or the relaxation technique. The most interesting method for our problem is the relaxation process because of:

- the use of segments and not pixels as input data;
- the "not-too-bad" reaction of the method when map segments are missing in aerial photo and conversely.

5.3.1 - Relaxation

It consists in affecting a weight to a relationship between two primitives (two objects, one from the photo and one from the map) and then to make intervin the influence of the proximity so as to make the weight involve. Relaxation is in fact an interative process which tries to label objects. Two kinds of relaxation techniques exist : the discrete relaxation and the probabilistic relaxation.

In the discrete relaxation process, the weight can have only two values : 0 or 1. So, when two segments matched, the result of the matching is yes or no which is not so easy in most cases. When two segments or more, from the photo, may be associated with one segment of the map, it might be interesting to be able to qualify the degree of correspondence with a value ranging between 0 and 1. That is what is done through the

probabilistic relaxation. Moreover the discrete relaxation is very sensible to noise, when existing segments in the maps are away in the photo and conversely, which is less important for the probabilistic relaxation.

5.3.2 - Probabilistic Relaxation

We want to associate, to every segment of the map, one segment of the photo. So we define that the OBJECTS are map segments and photo segments are the LABELS. In theory, the elements of the map are the labels for the elements of the photo which are the objects. But in our case, the number of map segment is less important than the number of phto segments. So, for programming reasons, we are going to do the correspondence from map towards photo.

A priori, every segment of the photo can be the label for every segment of the map. But we know that map and photo represent the same area without big displacement between them. We may have some orientation discrepancies because of the data capture process so photo segments and map segments are not exactly superimposable but are not far from each other. This remark allows to reduce the set of possible labels for one object (segment of the map). Therefore for each object, we have to define a neighbouring area where the label should be. This area is defined by a translation process. So the set of possible labels (photo segments) for an object (map segment) must be into the neighbouring area.
Moreover each label must have exactly or approximately the same direction (rotation process) as the object.

To allow this first step of the relaxation process, we have to define the parameter maximum values for the translation and the rotation so as to determine the reduced set of labels for every object. And we associate the same probability value for each label of an object. So the sum of probability values : p_i (l) is equal to 1 where i is the number of objects : a_i. Then we have to define a relation of proximity for each object to determine a set of near objects.

The relaxation process consists in improving the probability estimation at every iteration. At each iteration, new probability values $p_i^{(k+1)}(l)$ depends on the previous probability values $p_i^{(k)}(l)$ of the object a_i and depends on the previous probability values $p_j^{(k)}(l')$ of the near objects of a_i.

We have to use a compatibility function so as to measure the interaction between two labels. The "compatibility" values represent correlation between events as : [ai is labelled l] and [aj is labelled l']. The compatibility measures depends on the own constraints of the problem which are, for us, essentially geometric constraints like angle preservation.

6 - ELEMENTS FOR THE KNOWLEDGE BASE

One of the major problem is that textures can evolve during time and change from one photo to an other one without any object change. We can distinguish :

- Objects changing their texture during the **daily use** : for example, a tennis or a soccer stadium with or without audience, a parking lot with or without cars, a school playground with or without childrens;
- Objects changing their texture according to **seasons**, for instance vegetation (summer/winter), or object changing textures each years, for instance a field of wheat becoming a field of maize the following year, etc...
- Objects with a **temporary texture**, such as building sites, fields partly ploughed or harvested, roofs under repairs, etc...
- Objects changing texture according to **temperature**, for instance tar on hard topped streets;
- Textures changing from **aircraft position**, such as façades, mirroring effects of water rivers, ponds, outdoor swimming pools, etc... in this category, we can also include texture variations according to aircraft altitude;
- Objects partly or totally **hidden** by vegetation and shadows.

To sum up, we can say that it is mandatory to precisely know :

a/ **flight conditions** in order to model texture evolution depending on aircraft position, soil temperature, the hour of the day (in other words, sun position) implying variations for shadows and different kinds of geographic object usage, the date in the year (essentially for vegetation),

b/ **rules governing object evolution**, such as building site evolution, roof evolution, field evolution etc...

Of course, some others factors will contribute to texture variations and will be integrated into the knowledge base.

7 - CONCLUSION

The goal of this paper was to give an overview of the PHOTOPOLIS project which is now in its feasibility study. In the near future, we intend to ameliorate this study by taking into account several other information such as file of new construction permits, file of new roads and so on. Due to this extra a priori information, the image confronting process will be easier.

However, presently, we can assert that:

- **in image processing**, pictorial objects are discovered and labelled and now we have to find more precisely their limits as boundaries of two different textures;

- **in segment confrontation**, the methodological foundations are established for the recognition of pictorial/geographical objects within a low-level prototype (few segments); however, we have ideas in order to design a second prototype in a more realistic situation (thousands/millions of objects);

- **in image warping**, fundamentals are also placed in order to find rubber-sheeting functions not only for zones located in a single image but also for geographic zones located in overlapping images; remember that the ideal would be to demonstrate that, taking incertainties and accuracies into account, those functions were considered as not necessary;

- **in the structuration of the knowledge base system**, we have to complete the formalism for describing not only alphanumeric spatial knowledge, but also topological and geometric knowledge as needed for passing from pictorial objects to geographic objects.

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4. THE ENGINE OF IDEAS - THEORY AND PRACTICE FROM UNIVERSITIES.

Chairman: Alastair Macdonald.

4.1 Low Cost Analytical Plotters for Revision.

David A Tait, University of Glasgow, Scotland.

4.2 Integration Levels of Topo Databases and Geo-Imagery For Updating Purposes.

M J P M Lemmens, Delft University of Technology, The Netherlands.

4.3 Automatic Extraction of Roads From SPOT Images.

M E de Gunst, Delft University of Technology, The Netherlands.

4.4 The Importance of a Code of Origin.

Professor Ole Jacobi, Instituttet for Landmaling og Fotogrammetri, Denmark.

LOW COST ANALYTICAL PLOTTERS FOR MAP REVISION

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ABSTRACT

The problems of employing for map revision photogrammetric instruments which were designed and bought for new mapping are discussed and the possibilities of using low cost analytical plotters for revision work are explored in the light of experiments carried out on the Yzerman APY Analytical Plotter.

1. Introduction

In most countries with complete map coverage at topographic scales, their mapping agency has been working at the task for very many years and, long before complete coverage was reached, the problem of revision had to be addressed. In fact, it has often been recognised that pushing ahead to extend coverage is not the best use of manpower and facilities when existing maps are passing the point of usefulness because of the need for revision. For such agencies, map revision is therefore not a new problem, but has gone on simultaneously with new mapping and revision policies exist even in those topographic mapping agencies for which full national mapping coverage is still some way off.

However, as more countries approach full coverage, the problem of revision becomes more acute and this explains the increasing interest in this type of mapping in recent years.

Outside topographic mapping agencies, revision has always been an important mapping activity. Many foresters, geologists, botanists, etc., have never attempted to produce new maps as such but have found it more convenient to add their specialist information to existing maps, usually to the national topographic map at the most appropriate scale. This operation is, of course, essentially one of map revision and has mainly been carried out using simple photogrammetric equipment and methods, often resulting in the specialist information being plotted with an accuracy much lower than that of the topographic base into which it has to be merged.

2. Revision Methods

The revision methods adopted over the years in the older established survey organisations have been influenced greatly by the equipment and techniques used for basic map production. The equipment was there; its use was well understood and the revision task could be accomplished with only small variations to the normal procedures.

As the proportion of time spent on revision increases, a time does come when revision must be regarded as a major task in its own right or indeed as the principal task of the organisation. This is also the time to review the equipment and methods used for revision and to choose equipment for the future to solve the revision tasks, rather than devising procedures for revision suitable for use on existing equipment.

The time has also come for more thought to be given to the photogrammetric procedures used by field scientist to add thematic information to existing topographic maps. Many of these agencies are attempting to create geographical or land information systems, or at least wish to become involved in digital mapping methods. The use of the simpler photogrammetric equipment and procedures will no longer be sufficient for this digital environment.

It is true to say that, up until recently, most photogrammetric instrumentation and methodologies have been developed with new mapping tasks in mind (Walker, 1984). The assumption has been that the drawing sheet or digital data base starts off empty. The role of the photogrammetric instrument in such a procedure is vital and it is not surprising that there has been pressure for the continued development of plotting instruments to be used for new mapping worldwide.

However, the situation in the revision of topographic maps and in the production of thematic maps from existing topographic maps is quite different and many (but not all) of the recent developments in photogrammetric instrumentation are quite inappropriate for the revision task because revision, by definition, does <u>not</u> start with a blank sheet or an empty data base but with a previous map or data base, much of which could be quite correct and therefore useful. For any revision method to be efficient, it must recognise the existence of this source of potentially useful information and exploit it to the full in the design and implementation of its procedures. It therefore follows that instruments and methods developed and optimised for new map production are not likely to be able to bring similar efficiency to the task of map revision.

3. Problems Specific to Map Revision

In all revision methods, three distinct phases can be identified, namely (i) the detection of change; (ii) the deletion of old features from the existing map; and (iii) the addition of new features to the existing map. Even this rather simplistic view of the revision process is sufficient to indicate requirements and difficulties not normally associated with new map production.

3.1 Need for comparison.

In each of these stages, a comparison must be made between the existing map and the new aerial photography or, better still, the stereoscopic model formed from the photography.

Furthermore, this comparison must be continuous. By far the most efficient way in which this can be accomplished is for the image of the photogrammetric model to be superimposed on the image of the existing map, not only for the detection of change, but for the plotting of this change. This facility is not a requirement for new mapping, where the plotting sheet (display screen or data base) is empty until features are plotted onto it.

3.2 Accommodation of errors in old map.

Discrepancies between detail obtained from new photography and that on existing maps, especially older maps produced by field survey techniques or maps remodelled from previous series, cannot always be attributed to change in the terrain. It may become apparent that new detail cannot be made to fit old detail because the old detail, while correct in content, is incorrect in position. For consistency, new detail may have to be plotted "wrongly" in order to fit this old detail. These errors may be acceptable and the use of revision methods which fit new detail to (wrongly plotted) old detail may result in a map which still meets the original specifications. Therefore local fitting procedures can be justified and are appropriate for revision plotting. Such procedures are quite different from the plotting of individually orientated models, each regarded as an undeformed model of the terrain. Not only is the interpolation over an entire model from the few control points not necessary, it is not possible in this type of revision plotting if local matching to existing detail is to be achieved. This has consequence for the type of instrument used for the task. Rigorous photogrammetric instruments of the traditional type are ideally suited to resurvey, or revision when every error in existing detail is to be corrected, but these are not so well suited to the small area patching and fitting which characterises many of the revision procedures used today, nor for the methods employed by field scientists attempting the addition of thematic information to existing topographic maps.

3.3 Graphic to Digital conversion.

Thirdly, the survey organisation may have gone over to digital mapping procedures. Some organisations are in the process of converting their data archive from graphical to digital form by means of an extensive programme of cartographic digitising. The revision of an existing graphic map can be carried out to produce another graphic to be held as the survey archive or, during the process of revision, the graphic can be converted to a digital record, thus contributing to the overall conversion programme, a procedure recommended by Makarovic (Makarovic, 1982). In the future, however, more maps will be held in digital form and the instrument used for revision should be able to handle both types of input.

3.4 Preparation for map revision.

The comparison between the existing map and new photography,

combined with the need for careful photointerpretaion and map interpretation, will take time. A certain amount of thinking time will be necessary on the part of the operator, when no obvious production will take place. It is only when the operator is in a position to accurately plot the new features and make exact deletions of old features that it is worth delineating these features in detail. Obviously this operation must be carried out on the revision instrument. The instrument will be used for much of its time as a comparison aid. This points to the need for revision instruments which can be acquired in some numbers and consequently these instruments must be relatively cheap.

4. Instruments used for Map Revision

Over the years, a number of instruments have been developed or adapted for revision purposes, for both large and small scale topographic mapping, but the results have generally been disappointing. The so-called "approximate" photogrammetric instruments often failed to meet the accuracy specification of the original mapping and the restricted field of view can lead to insufficient control being available from the existing map in rural areas (Leonard, 1982). The use of orthophotography for revision at large scales has also been investigated (Mayes and Smith, 1986), but proved not to be cost effective. At smaller scales, both approximate instruments and orthophotography have been more successful; for example, in France the Revicarte Facet Plotter, developed by IGN, has been used for 70% of the revision work on the 1:25,000 scale series, with orthophotography used for 10-20% (Ducher, 1982).

The Kartoflex of Zeiss Jena has proved very useful in the planimetric revision of topographic maps at 1:5,000 scale of open cast mining areas (McMillan-Kay, 1988). A similar solution is obtained, but with off-line plotting, using the Bausch and Lomb Zoom Transfer Scope and digital monoplotting has also been suggested for map revision but its full potential cannot be exploited unless a DTM of the terrain is also available (Bethel, 1987; Searle, 1984).

However, many topographic agencies still use conventional plotters and procedures developed primarily for new mapping, because of the difficulties in utilizing alternative instrumental solutions and many field scientists use instruments such as the Zoom Transfer Scope, Sketchmaster or Radial Line Plotter.

In recent years, there has been a shift from analogue to analytical photogrammetric instruments (Petrie, 1988) and for many tasks these new digital instruments have proved to be efficient and cost effective. It is not surprising, therefore, that this new technology should be considered for map revision activities. Since these instruments are of high accuracy, can handle almost any type of photography and can give a digital output, it is of course possible to use the range of mainstream analytical plotters for map revision. Their programs will allow even the patching and fitting procedures which are difficult and lengthy opera-

tions on conventional analogue plotters. But the great disadvantage of the mainstream analytical plotters for revision work is their cost. It would usually be quite unacceptable to have such expensive instruments used as viewing devices only, when the thinking time referred to earlier becomes extremely costly.

However, one of the most interesting trends in instrument design over the past four or five years has been the development of several low cost analytical plotters, aimed mainly at the thematic mapping market and, initially at least, produced by manufacturers other than those producing conventional photogrammetric equipment.

Stereoscopic analytical instruments, by which is meant one where a stereoscopic model is formed, viewed and measured, can be classified into three main types :-

1.	Image Space Plotters	- Zeiss Stereocord G3
2.	Analytical instruments with image coordinates primary	- Topcon PA 2000
3.	Analytical instruments with object coordinates primary	- Yzerman APY

The low cost analytical instruments generally use as their base the optical and mechanical components of existing lower-cost machines and there are three main possibilities:-

1.	Scanning mirror stereoscopes	- AP 190
2.	Optical transfer devices	- Yzerman APY
3.	Converted analogue instrument	- Qasco
		- Adams Technology

A further distinction could be made between those instruments using full sized photographs and those limited to small format photography, such as the 6 cm format of Adams Technology MPS-2 and the 12 cm of the Pentax PAMS.

The superimposition of plotted detail on a photogrammetric model has received much attention in recent years. Such a facility has obvious benefit - but the implementation has not been without problems. Monoscopic superimposition of the plotted detail on the stereomodel is useful for checking purposes, but one cannot distinguish between discrepancies due to inaccurate planimetric plotting and those due to incorrect height setting. Stereo-superimposition gives very good registration, irrespective of terrain morphology, can cope with urban areas and gives a three dimensional model of the map superimposed on a three dimensional photogrammetric model. This process is complex, demands a high speed computer and is therefore very expensive to implement.

While the attractions of stereo-superimposition are undeniable and may be justified in analytical instruments designed for use in new mapping in a totally digital environment, the complexity and expense involved makes stereo-superimposition unsuitable for instruments designed for map revision, especially at topographic scales. It is also the case that most topographic maps which need revision

at the present time are in graphical form. There is therefore a need for superimposition of the stereo model and plotted detail on the existing graphic image, a facility not available in the most sophisticated systems which assume a totally digital environment, without the scanning of the graphic.

It can be concluded that a non-perspective, plane version of the plotted detail, superimposed on the map being revised and only in sympathy with the photogrammetric model at the measuring mark, offers an acceptable and economic solution for many revision tasks. This is easiest to achieve in the low cost analytical plotters based on optical transfer devices.

5 Ideal specification for a revision instrument

From the preceeding discussion, it would appear that a revision instrument for the 1990's and beyond should have the following minimum characteristics:

a. The instrument should be designed to perform the revision task. If, as a consequence, the instrument is not suitable in any way for new mapping, this should not be regarded as a disadvantage.

b. The instrument should make maximum use of existing map detail, whether presented on a hard copy graphic or on a screen, both to cut down unnecessary replotting and also to minimize, or perhaps eliminate, the need for the special provision of control points by ground survey or aerial triangulation.

c. The output from the instrument should be in digital form. If a graphic revision of a graphic map is necessay, a situation less likely to occur with the passage of time, then a small format plotter could be used to provide this hard copy output which could then be registered with the original map for final compilation.

d. The instrument should be able to revise maps in both graphic and digital form and thus play a role in any graphical to digital conversion programme.

e. From a single viewing position (the main binocular eyepiece), the operator should be able to view (i) the stereoscopic model, (ii) the existing map, whether a graphic or a screen image, and (iii) the detail which has so far been plotted or marked for deletion. Furthermore, the superimposition of any two of these views should be possible in the main eyepiece for orientation, comparison and change detection and progress monitoring.

f. The instrument should be inexpensive so that perhaps three or four could be purchased for the price of one mainstream (analytical) instrument used for resurvey or new mapping.

Considering the flexibility and accuracy demanded from and delivered by modern analytical plotters, the specification outlined above is not so demanding, at least in these two areas which have been major pre-occupations of instrument designers aiming at the new mapping market. With flexibility and highest precision not being major requirements for a revision instrument, the design challenge is still there, but in a different area. The market for such instruments does exist and will grow as more countries complete their coverage and turn more attention to their revision programmes and as more field scientists adopt digital methods in their thematic mapping activities.

The analytical plotter has brought to the top end of the photogrammetric market many advantages over the universal and precision plotters which it replaced. An analytical solution to what is currently achieved by analogue topographic plotters is perhaps not so necessary, since so many of these devices are still working well and with the addition of digitising and automatic tables still provide an efficient mapping solution. While basic mapping on such analogue machines will still remain attractive for some years, the use of these same machines for the revision of the maps which they have so successfully produced is just not appropriate. No longer should revision methods be devised to exploit as best as possible existing equipment; equipment should be designed to allow realistic and efficient revision methods.

6. Yzerman APY Low Cost Analytical Plotter

The APY instrument (Yzerman, 1984,1987) is a low cost analytical plotter, specially designed for map revision. It is a development of the Zoom Transfer Scope (ZTS), via the Stereo ZTS and the Stereo Facet Plotter.

The map to be revised is placed on the map table, which incorporates a digitiser and over which is moved a cursor. This cursor acts as a floating mark in the stereo-model, as well as a digitising cursor on the map sheet. After orientation, the map sheet and the model can be viewed together and the superimposition and orientation is maintained as the cursor is moved around the model by image displacements achieved by rotating plane parallel plates in the optical system. The output is digital, with the measured detail being displayed on a graphics screen. In the most recent version of the instrument, the image on the graphics screen in injected into the optical train so that the existing map, model and plotted detail can be viewed separately or in any combination.

This instrument therefore satisfies the six main requirements discussed earlier. The degree to which each of these requirements is satisfied has been investigated in a series of test carried out at the University of Glasgow and provisional results of the digitiser and orientation tests are reported here. A full report on the tests will be available later this year.