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THE STATUS OF PHOTOGRAMMETRIC MAP PRODUCTION

by D.W. Proctor, Feltham

1. Introduction

The title of this paper suggests a wide ranging review covering a broad spectrum of current photogrammetric activity. However such a paper would overlap considerably with many of the other topics included in the programme for the 35th Photogrammetric Week. Consequently this introduction will briefly review the whole subject and indicate those areas which are considered to be outside the scope of the paper and are therefore deliberately omitted from the main text in order to avoid such overlap.

The first four papers, taken together, review the status of photogrammetry and remote sensing. The purpose is to take stock of the present situation and look forward rather than back. Therefore this is not a historical review of the development of photogrammetric mapping, nor, for that matter, is it an attempt to catalogue all the world wide mapping activities which might be relevant; this last belongs, if anywhere, in the reports to (or of) Commission IV at next year's ISP Congress.

It is assumed that virtually all those attending the Photogrammetric Week are involved directly or indirectly with map production, and in most cases by photogrammetric means (by 'indirectly' is meant those in teaching/training establishments either as teachers or students, and also those concerned with the design and manufacture of the instrumentation). Perhaps, therefore, we should first establish the necessary definitions. Photogrammetry covers many aspects apart from map production so no exhaustive definition is attempted, however once a map is defined it will then be reasonably clear, though not absolutely, which are produced photogrammetrically. The normal 'line-map' is familiar to all though it takes many forms, can be at any scale, and can serve a variety of purposes; it is usually printed on paper in one or more colours if many copies are required, however for project work it is often sufficient to produce, photographically, a direct copy of the machine plot on a stable base and this is none-the-less a map. Current techniques of mapping, however, also involve the storage or presentation of topographic data in alternative, though important, forms and of these the two most significant are considered to be photo maps and digital maps. Photo maps are generally mosaics, with or without enhancement in the form of grid or graticule, contours, drainage, communications etc. produced from prints, rectifications or ortho-photos, however these are the subject of the next session and little, if any, further mention of them will be made in this paper. Similarly the whole topic of computer-supported stereoplotting forms a major portion of this meeting and so will be largely ignored in this paper; however it should be mentioned that the photogrammetric element of this work is not significantly altered from that of the line map except inasmuch as graphical and digital results require different output peripherals interfaced with the stereoplotter.

The basic input ingredients of the stereoplotting operation are the photography and the ground control. Since photo acquisition and processing is another main subject of this meeting this, too, will receive only scant attention. Ground control may be entirely provided by field survey methods, alternatively sparse ground surveyed control may be augmented by the processes of numerical photogrammetry, and if this includes the use of certain auxiliary data (from remote sensors) the ground surveyed control may, on occasion, be very sparse indeed. Since numerical photogrammetry and remote sensing are two more of the other topics of this 35th Photogrammetric Week they will also be dismissed with the remark that any reference in this paper to control means any point whose ground co-ordinates are known, however determined.

Thus in this introduction a reason, or at least an excuse, has been found for a mention of every other topic in the provisional programme, one might therefore say that the entire programme for the week is devoted to the status of photogrammetric map production in its widest sense, and therefore briefly outline the other papers to be delivered, whilst on the other hand it appears that the proper function of this paper is to restrict itself to the photogrammetric plotting of line maps. An attempt will be made to exercise the reputed English penchant for compromise and steer a course between these two extremes. Perhaps in this way this paper will help to provide a synthesis of the inter-relation-

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ship of the various topics and thus play a small part in showing that the interesting and varied programme arranged by the organisers is a single and well-balanced whole rather than a series of disjointed items. The paper will, of course, lean heavily on the experiences of the author with the British Military Survey and the Ordnance Survey; these though far from continuous and containing some significant gaps, span just over a quarter of a century. Whilst gratitude is expressed to both these organisations for allowing the presentation of the paper it must be stressed that the views expressed are solely those of the author.

2. Maps

It has already been mentioned that the meaning of a 'map' must be understood in order for this paper to achieve its objective. Whenever the presentation of any type of information is organised on the basis of geographical location this may be described as a map; commonly we think of topographical information but within the context of photogrammetric map production we may consider any type of information which can be acquired from photography (in fact some definitions would be significantly wider than this, photography is itself a general term within the range of possible emulsions, scales and camera types but there are other remote sensors the data from which, particularly if subject to a graphical form of presentation, may be thought when used geometrically to be providing a photogrammetric solution). There are special techniques related to the method of presentation (ie photomaps or digital maps already mentioned) but the fundamental task is one of recognising the required feature of informaiton and determining its location. Most of the problems, essentially the metrical ones, are common to all forms of map style. In addition to the differences of style, or presentation, of maps there are differences in purpose which influence the type of information portrayed. Topographical, cadastral, cultural, ecological and geological information are just some of those which may be abstracted from photography, even if only partially so. In considering primarily the topographic features one is not showing solely the bias of the land surveyor whose main task this is, but also making the point that the topographic map showing the relief and drainage information, communications networks, buildings and possibly field boundaries provides the base on which the other information forms may be depicted since it is in relation to the topographic features that the others are most useful. The third classification by which we may consider maps to be differentiated, and probably the most important when considering the metrical problem, is scale. Once again the geometrical principals are basically the same but the approaches vary greatly according to the scale of the final map. This statement is imprecise in the case of non-graphical maps but these must have a specification which, deliberately or accidentally, is related to some production scale. Theoretically there is no limit on the range of scales at which photogrammetric maps may be produced but when practical and economic considerations are properly taken into account there are certainly limits, albeit wide ones. It is unusual, at least in the United Kingdom, for maps at larger scales than 1:500 to be produced photogrammetrically - this is approaching the limit of usefulness of photography flown with fixed-wing aircraft. Of course there are helicopters which can fly photography, there is terrestrial photogrammetry (ie the camera axis being more nearly horizontal than vertical) and the possibility of downward looking photography from towers, balloons etc. In general though all these are more in the realms of special projects than map production; for very large scales when a high accuracy is needed the balance of economy between field and photogrammetric surveys is radically altered. At the other end of the scale limit the position is less clear since this is very dependent on the mapping situation in the area. If there already exists accurate and up to date mapping at any particular scale then it is illogical to expect to find photogrammetric mapping being plotted at some smaller scale; the obvious and normal approach is to derive the smaller scale from the larger. Thus in considering the minimum scale for photogrammetric mapping one must first assume that no reliable mapping at this or any larger scale already exists. Once mention is made of scales smaller than 1:100 000 there seem to be problems, not so much how to proceed as whether there is any real saving as compared with a larger scale for the compilation which, at a later date, might prove useful. This theme will be developed further in relation to the photography - its scale specification etc. Some satellite photography has been described as suitable for 1:250 000 mapping but this is open to discussion. Before leaving the topic of the maps themselves mention should be made of one other categorisation into which they may divided, that is to say new or revised. Most of the foregoing

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remarks are oriented towards the assumption that ab initio mapping is intended but this is not necessarily the case, in fact perhaps there should be a bias the other way since once sound mapping has been produced this should form the basis of several revisions. Techniques of production will be different and so may the relationship of the costs of various methods, and even the practicable scales. For instance in discussing minimum scales it might have been mentioned that it was difficult, if not impossible, to recall an instance of the Ordnance Survey undertaking photogrammetric plotting at a scale smaller than 1:10 560 (or more recently 1:10 000) but this would have referred to ab initio mapping from which scale, or scales even larger, all smaller scale mapping is derived. However maps at smaller scales have a far greater turnover and require a shorter revision cycle to be useful. It is difficult to arrange for all the large scale components to be simultaneously updated and therefore revision for small scales proceeds as a compromise between direct revision and the use of large scale updating as available; in this context photogrammetric revision has been plotted at scales from 1:10 000 to 1:25 000 for incorporation in revised maps at 1:63360, the traditional one-inch to one-mile series half of which is now superseded by 1:50 000.

3. Photography

The photogrammetrist, whether involved in map production or not, is entirely dependent on his photography and often not enough stress is made of this point. The photography must be 'right' for the task, not just of good quality. By right is meant having suitable geometry as regards scale, overlap, focal length etc. Perhaps the photogrammetrist is, in this respect, his own worst enemy because some of the more interesting papers deal with the surprisingly good results often obtained, after considerable trouble and ingenuity, from photography which is utterly unsuitable, with the result that many people think any old photographs will do. Even whilst avoiding the topics of acquisition and processing of the photography there are points which can be made about its specification. One decision is the type of emulsion to use for the task; for normal topographic work a range of panchromatic emulsions are suitable depending on the part of the world, time of year, flying height etc. However there are also infra-red, colour and false-colour emulsions available for various purposes, normally the identification or interpretation of special types of feature. These again are considered to be outside the scope of this paper. The geometry of the photogrammetry is decided by specifying any two of flying height, scale, focal length. Here the choice is very wide and will depend not only on the scale of the final map but also on the specification of that map or the use to which it will be put. Pure scale can be a misleading parameter since sometimes the relationship of scale to accuracy is not maintained (ie a user wants a very large scale to give himself space to work but, his accuracy needs being low, the surveyor views this as a somewhat smaller scale enlarged). It is proposed to deal with accuracy as a topic later in the paper, therefore for the moment let us accept a figure of 0.3 mm at map scale as the rms error of firm detail to be representative of good quality large scale mapping. However at medium and small scales this figure becomes unrealistic firstly because of conventionalisation (the use of conventional signs to depict detail in approximately the correct position but exaggerated in size for clarity) and furthermore by generalisation (the deliberate movement of conventional signs to prevent them overlapping) so that 0.5 mm or even 0.7 mm rms may become more realistic.

Reasonable enlargement factors between photography and map also vary with scale, as well as between organisations. In general terms one might suggest a factor of x6 for 1:500 mapping (ie 1:3000 photography) reducing to x4 for 1:2500, x2 1/2 for 1:10 000, down to x0.8 for 1:50 000 (ie 1:40 000 photography) and may be even less, x0.5 or x0.6, for 1:100 000 mapping. This variation is contradictory to that expected from accuracies, for instance 0.3 mm at 1:500 with x6 enlargement represents 50 µm at photo scale whilst 0.7 mm at 1:100 000 with x0.6 enlargement represents more than 1 mm at photo scale. Two points are obvious from this, firstly that it is not the accuracy requirement which is dictating photo scale - if it were then photo scales of 1:250 000 or less would be used for 1:100 000 mapping, secondly that less precise techniques can be used for the smaller scale mapping owing to the smaller enlargement factor being used. There are various reasons why photo scale is not reduced in proportion to map scale; firstly interpretation difficulties, the size of specified detail at map scale gets smaller hence the need to conventionalise, and cannot be seen positively on the photography, secondly the physical limitation imposed by the aircraft -

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not all organisations have high flying aircraft, and thirdly atmospheric condition of haze and refraction which make very small scale photography proportionally less useful and accurate than larger scale. For economic reasons the minimum photo scale to give the required result should be used; it is suggested that at map scales of 1:10 000 or larger the limiting parameter is accuracy, the change over probably occurs between 1:20 000 and 1:25 000 and at map scales smaller than 1:25 000 it is likely to be photo recognition of desired detail which governs the photo scale. This is a broad and sweeping statement since obviously there will be a different break-point for rural pastureland and for desert, whilst urban areas are not really considered in this context.

Unless the limitations imposed by flying height are relevant it would next be normal to decide between normal, wide or super-wide angle photography. Only a few organisations use normal angle photography extensively; the Ordnance Survey is one of these particularly where the requirement is to minimise overthrow and concealed detail in urban areas and to show the ground-line of buildings on uncontoured maps. Wide angle photography has for a number of years, and certainly throughout the writers experience, been the mainstay of photogrammetric mapping giving, as it does, a reasonable compromise between planimetric and height accuracies; most aircraft enable a wide range of photo scales to be flown with a wide angle camera. Super-wide angle photography has two main advantages, both of which are relevant only to small/medium (dependent on the reader's definition of such terms) scale mapping. Firstly for a given ceiling imposed either by the aircraft or atmospheric conditions a smaller photo scale can be obtained and thus greater economy achieved and secondly the relationship of planimetric and height accuracies is altered in favour of heights. The significance of this last point is that earlier remarks about proportional accuracies being lowered for smaller scales only apply to planimetry, it is probable that the contour interval will not be proportionally increased as scales are reduced; it will frequently be the case for smaller scales that the contour interval and consequent height accuracy will determine the combination of photo scale and plotting instrument to be used.

4. Instruments

The subject of photogrammetric plotting instruments is one about which one should either say a great deal or very little, the intention here is to favour the latter. This is not the occasion for considering the relative merits of the products of rival manufacturers most of whom make a range of equipment, from precise plotters to those rather less so. Naturally greatest interest centres on developments in the precision area though in many cases the ingenuity of design is more apparent in the non-rigorous solutions. An interesting, and perhaps provocative, remark is that with a lower order instrument for maybe one fifth of the cost of a precise instrument one gets about half the planimetric accuracy and, hopefully, three quarters of the height accuracy. No doubt there is a significant role for the lower order instruments to play in the medium to small scale range.

Developments in recent years have not affected only the actual mechanics of stereoplotters (one thinks here of analogue restitution instruments in particular) but much more fundamentally in the whole philosophy of the stereoplotter cinfiguration. An attempt has been made to show this diagrammatrically using electronic computers as an analogy. Less than 20 years ago it was normal for computer manufacturers to offer a package consisting of a processor, some storate, an input device and an output device (Figure 1); one purchased that package which seemed to meet, most nearly ones requirement. Today the philosophy is changed, one designs a configuration tailored exactly to the requirement (Figur 2) having a wide choice of storage (immediate access and backing), various input output options, some of them interactive, and a sophisticated set of software also provided by the manufacturer. The same is almost as true for plotters. One used to buy an analogue restitution instrument with plotting surface (some integral some external) and start plotting (Figure 3). Today many variations are available with the possibilities of digital readout, computers on-or off-line, orthophoto attachments and many others beside, see Figure 4. Once again the chance is offered to select a configuration which might have been designed and built to ones own specification, or at least something quite near it, in order to provide any or all of the possible output results. Anyway whether the instrumental output is graphic, photographic or digital this is the 'map production' phase for the purposes of this paper which does not consider the subsequent steps leading to publication. However one should not leave the question of instruments and map production without a mention of revision. The first point to make is that there is no justification for a revision process which is in any degree less accurate than the original map or this will lead to denigration of the map and accelerate the day when a full resurvey is required. Small amounts of change can be fitted into a dense framework of precisely surveyed detail without necessarily reverting to the same high order instrumentation but in general this should be treated with caution; there is a dangerous attitude that a rapid revision will suffice, using graphical methods and possibly smaller scale photography than for the original map. This is not to decry graphical methods or low order instruments which, as already stated, have their part to play, but the only instruments designed to make revision a simple operation come into this category. Revision to high standards on a first order instrument is a troublesome procedure and it is essential for the operator to be able to see the plotting surface via some viewing arrangement. The economics of using photography for the revision of accurate (large scale) maps will be dependent on the amount of change and whether revision is cyclic or continuous.

5. Accuracy

When discussing maps the term 'accuracy' can be an emotive one, mainly because it has various meanings according to the user. Many non-professional users will describe a map as inaccurate if it is out of date, and vice versa. The motorist or hiker expects all roads, tracks or footpaths (according to taste and scale) to be depicted, correctly classified and more or less in their correct relative positions though a few metres here or there will not even be detected. For the surveyor who makes the map, and for engineers and any others who wish to make precise measurements on it, the term must mean the metrical precision in the location of depicted detail, and this is intended in this paper. There can still be ambiguity about the absoluteness of 'accuracy'; is it relative to adjacent detail or relative to the grid or graticule which in the limit implies accuracy in relation to the origin of the principal control framework? Earlier it was suggested that 0.3 mm rms was reasonable for an unconventionalised large scale map of good quality. The time has come to define this statement and justify it, for which purpose the Ordnance Survey is again cited as an example. Firstly then the checking process aims to be an order of magnitude more precise than the detail survey, this would be prohibitively expensive in the case of 1:1250 surveys in which case the checking is about 50 % more accurate. Secondly local ground control of any order is considered error free, in other words the check is made relative to the same basic control framework as that from which the survey was made and the residual errors are therefore those of the detail survey; in the case of aerial triangulation control it is still ground control which is used for the check and the resultant error figures include those of the aerial triangulation as well as those of the plotting. Accuracy tests are conducted at all three basic mapping scales and the acceptance criteria have been developed from what has been found reasonable rather than pre-set with the process designed to achieve them. The rms error on a large number of points of firm detail checked according to this definition has been found to be more or less 0.3 mm at each scale though one can note, for plotting in first order instruments, that at 1:1250 the enlargement factor between photography and plot is between x4 and x5, at 1:2500 the factor is x4, and at 1:10 000 the factor is x2.5 and in this latter case though the photogrammetric plotting maintains 0.3 mm at plot scale this is difficult to achieve for the field completion detail (these are of course the remote mountain and moorland areas). The fact that these figures have only subsequently become acceptance criteria for techniques that were introduced as logical and economic methods for their respective scales, and that a similar accuracy at map scale is found for the three scales despite the range in enlargement factor is not taken as a coincidence but as a real indication that 0.3 mm rms is a realistic figure for sound photogrammetric mapping; specifications demanding 90 % of detail to within 0.3 mm at scale have been noted but to achieve this probably demands compilation at a larger scale. One has to mention that much of the OS 1:2500 work consists of recasting 19th century mapping to the National Grid followed by graphical photogrammetric, and field, revision at a lower standard of accuracy dictated by that of the original mapping; the interesting point here is that it has been found both adequate and economic to conduct the accuracy tests by analytical photogrammetry using photography at scales as small as 1:25 000 and flown for mapping or contouring at 1:10 000. There is not a lot to say about the accuracy of photogrammetric revision, and much of the Military Survey photogrammetry comes into this category, except to repeat that it ought not to be allowed to denigrate the original work.

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6. Economy

To consider the status of photogrammetric map production without reference to its economic benefits would present an incomplete picture, however that is the only reason for its inclusion. The alternatives, presumably, are either to produce maps solely by ground surveys or else to do without them. The former course will almost invariably be more costly, the latter obviously will save survey costs but the consequential losses to the development of the community are not to be countenanced. To make a comparison is very difficult since conditions and costs vary so much from country to country even for a common scale. In the areas where labour is cheaper, and field methods are labour intensive, perhaps one can generalise and say that communications are poorer so the ground is less accessable, however the ruggedness of the terrain can also cause inaccessable and inhospitable areas where labour costs are high. Economy was a significant factor in suggesting 1:500 as the upper scale limit for photogrammetry but even this is only half the story; photogrammetry tends to become uneconomical for very small areas, the costs of positioning an aircraft, awaiting suitable weather and then flying for a few frames of photography are prohibitive, so there must be a worthwhile target to fly but small targets can be taken on an opportunist basis by an aircraft en route nearby. At smaller scales the benefits of aerial phtography are so manifest that discussion is pointless. Perhaps the most significant remark one can make about economy is to point out that, assuming commensurate accuracy in each case, large scale maps obviously cost much more than small scale of the same area, <u>and</u> that the extra cost is probably greater for photogrammetric work than for ground survey. It is therefore possible that our engineers and planners have in the past lived in a 'fools paradise' in which the cost of a survey is only slightly influenced by the scale? If so, now that most surveys are photogrammetric, it is time they realised, no doubt some have, that large scale with accuracy is expensive and should by amply justified by real need whereas large scale without accuracy is only an enlargement of, technically, a smaller scale and is less expensive. Finally those responsible for paying for maps, or for making a profit out of producing them, have had to invest a considerable sum in capital equipment and training for photogrammetry which they now use at most scales for nearly all tasks. This would not have been the case unless the economy of using photogrammetric methods had been established beyond doubt.

7. General Status

The word status could have two meanings in this context, either the current position and state of affairs or else the standing and acceptability. In this paper the former has been presumed to be the requirement so the latter may first be dealt with briefly. Clearly photogrammetry is an accepted method of map production which has now, and for some years past, achieved a position of respectability. Not only have reputable surveyors adopted and endorsed photogrammetry but also many have built their reputations on photogrammetry itself. Furthermore it is also now respectable to be a photogrammetrist without being a surveyor. However, in UK at least, the great majority of those practicing photogrammetry are land surveyors and this includes a preponderance of those using photogrammetry for purposes other than map making. Turning then to the present state of affairs, associated with which is the idea of future trends, one should attempt to summarise. Nearly all detail surveying for map production at all reasonable scales is done, partly or totally, from photography. The standards of aerial cameras and photogrammetric instruments are such that maps of high quality can be produced more economically than by traditional ground methods. This statement applies whether the maps are graphic, photographic or digital though this is obvious in the second case. This paper, for reasons given in the introduction, has concentrated on line maps or the graphic output, though the importance of the other types is recognised; in fact these are the main development areas. As for the future clearly photogrammetry will continue to be used, for the most part using conventional photography because the other remote sensors still tend to be more expensive and lower in quality and are used where or when photography cannot be obtained. Both photo maps and digital maps are, and will continue to be, on the increase. However the need for line maps will continue and at present rates the production of these by digital means is barely economic unless a byproduct in the form of derived scales can also result, like most forms of automation this will also gradually become economic. Readers may have noticed the special mention of Software in Figures 1 and 2 but not in Figures 3 and 4; this was a deliberate omission saved for this con-

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clusion. The human brain is an advanced piece of computer technology (I am informed that in medical terms the eyes function as cells of the brain rather than external limbs or organs of the body); the pre-programmed ability of the photogrammetric operator to carry out inner, relative and absolute orientations of stereo models, and then to recognise and plot many types of topographic and other information is ome quite sophisticated software. Whereas there was a great increase in sophistication of the software between Figures 1 and 2 the same is not true between Figures 3 and 4. Of course there is some more complicated hardware to be manipulated but these only really require 'patched-in' sub programs. Conversely the appearance of automated image correlation in Figure 4 is an indication of a trend towards the elimination of the human operator. The actual elimination of parallax has been overcome for 12 years or more, and is efficient even though very seldom adopted. A major advantage of the orthophoto is that this degree of automation is sufficient for production purposes though human intervention for detail enhancement will usually be necessary. The line map, however, still requires the recognition of features and publicised attempts to program this have been only slightly successful and one may only speculate as to what is beneath the covers. It will be a few years yet before we see one operator controlling five or more high speed automated plotters and only having to monitor or check the absolute orientation to ensure computer recognition of control points.

Summary

The introduction to this paper considers the breadth of the subject of photogrammetric map production in all its forms. However many aspects are covered in the titles of other sessions in the 35th Photogrammetric Week and an overlap is avoided as far as possible.

When the presentation of any data or information is organised according to geographical location this is a map. The information may be of many types and the presentation graphic, photographic or digital. This paper, again to avoid overlap, concentrates on the graphic (i.e. line-map) and deals mainly with topographic information. In this context it is suggested that photogrammetry is most effective for scales between 1:500 and 1:100 000 though even these wide limits are not exclusive.

A section on photography considers the selection of photographic scale, focal length and flying height, any two of which define the third. It is noted that the enlargement factor between photograph and map varies, in common practice, with map scale and that the direction of this variation is contradictory to that expected from the anticipated accuracy variation.

Instrumentation is not considered in detail, nor by specific mention of particular instruments. The philosophy of instrument design is considered, the analogy being made with electronic computer developments, whereby the restitution instrument is a central processor whilst a wide range of input/output peripherals give the versatility to satisfy differing customer needs from a small range of basic instruments. The difference between 'ab initio' mapping and map revision is noted.

A section on accuracies is next included. The justification is made of a figure of 0.3 mm rms at map scale (used earlier in the paper) for maps at scales large enough to obviate conventionalisation and generalisation. Ordnance Survey accuracy testing is cited as an example.

The economics of photogrammetric mapping are dealt with only in very general terms since these will vary so much with scale and area but the point is made that such a large proportion of mapping being done photogrammetrically is evidence itself of the economy.

In conclusion photogrammetry is described as the accepted technique for nearly all mapping, producing high quality results at economic costs. Future trends are seen mostly in the photo-map and digital-map area, which are outside the scope of this paper, whilst development of automated techniques for the production of conventional line maps (i.e. automation of the photo interpretation and plotting, not the cartography) are still seen to be somewhat remote.

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Zusammenfassung

Der Vortrag beschäftigt sich einleitend mit der gesamten Breite des Themas der photogrammetrischen Kartenherstellung in allen ihren Formen. Da viele dieser Aspekte auch in anderen Vorträgen der 35. Photogrammetrischen Woche behandelt werden, sollen Überschneidungen so weit wie möglich vermieden werden.

Die Darstellung von Daten oder Informationen nach geographischer Lage wird als Karte bezeichnet. Dabei können die Informationen sehr vielgestaltig und die Darstellung sowohl graphisch als auch photographisch oder digital sein. Um Überschneidungen mit anderen Vorträgen zu vermeiden, befaßt sich dieser Vortrag mit der graphischen Darstellung, d.h., der Strichkarte, und im wesentlichen mit der topographischen Information. In diesem Zusammenhang wird die Ansicht geäußert, daß die Photogrammetrie am leistungsfähigsten bei Maßstäben von 1:500 bis 1:100 000 ist, wenngleich selbst diese weitgesteckten Grenzen nicht absolut sind.

In Betrachtungen zur Aufnahmetechnik wird die Auswahl des Bildmaßstabs, der Brennweite und der Flughöhe besprochen - Faktoren, von denen jeweils zwei den dritten bestimmen. Die Vergrößerung von Bild zu Karte ist im allgemeinen vom Kartenmaßstab abhängig, und die Richtung, in der sich diese Änderung bewegt, ist gegenläufig zu der erwarteten Genauigkeitsänderung.

Geräte werden weder im Einzelnen abgehandelt, noch im Besonderen erwähnt. Die Tendenzen des Gerätebaus werden untersucht. Als Analogie wird die Entwicklung auf dem Gebiet der Elektronenrechner herangezogen. Danach ist das photogrammetrische Auswertegerät die Zentraleinheit, während ein umfangreiches Programm an Peripheriegeräten für Eingabe und Ausgabe jene Vielseitigkeit beisteuert, die zur Befriedigung der unterschiedlichen Bedürfnisse des jeweiligen Anwenders mit einem kleinen Stamm von Grundgeräten erforderlich ist. Es wird auf den Unterschied zwischen der Kartenneuherstellung und der Kartennachführung hingewiesen.

Es folgen Genauigkeitsangaben. Eine mittlere Genauigkeit von 0.3 mm im Kartenmaßstab (die eingangs im Vortrag zugrunde gelegt wurde) erscheint gerechtfertigt für Karten, deren Maßstab groß genug ist, um eine Generalisierung unnötig zu machen. Als Beispiel werden die Genauigkeitskontrollen des Ordnance Survey angeführt.

Die Wirtschaftlichkeit der photogrammetrischen Kartierung wird nur sehr allgemein behandelt, nachdem sie sehr stark von Maßstab und örtlichen Gegebenheiten abhängt. Allein die Tatsache jedoch, daß ein so großer Teil der Kartenherstellung heute auf die Photogrammetrie entfällt, ist ein ausreichender Beweis für die Wirtschaftlichkeit dieses Verfahrens.

Abschließend wird die Photogrammetrie als eingeführtes Verfahren für praktisch alle Kartierungsaufgaben beschrieben, ein Verfahren, das hohe Qualität bei vernünftigem Preis bietet. Wesentliche Neuentwicklungen dürften primär auf dem Gebiet der Photokarte und der Digitalkarte zu erwarten sein, die beide nicht in den Themenkreis dieses Vortrags fallen, während die Entwicklung automatischer Verfahren zur Herstellung konventioneller Strichkarten (d.h., die Automatisierung der Photointerpretation und Auswertung, nicht jedoch der kartographischen Arbeiten) noch in fernerer Zukunft zu liegen scheint.

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Résumé

L'exposé passe tout d'abord en revue la production photogrammétrique des cartes sous toutes ses formes. Il s'efforce autant que possible de ne pas empiéter sur les thèmes d'autres conférences de la 35ème Semaine Photogrammétrique qui traitent de nombreux aspects de la production des cartes.

Une carte peut être définie comme la représentation d'informations ou de données en fonction de leur position géographique. Les informations sont bien souvent de nature très différente; leur représentation est graphique, photographique ou numérique. Pour éviter tout recoupement avec les autres conférences, l'exposé se concentre sur la représentation graphique, c'est-à-dire sur la carte dessinée au trait et sur l'information topographique. Dans ce secteur, il apparaît que la photogrammétrie atteint son efficacité maximale à des échelles comprises entre 1/500 et 1/100 000, bien que ces très larges limites ne soient pas absolues.

Au sujet de la technique de prise de vue, l'exposé examine le choix de l'échelle-image, de la distance focale et de l'altitude de vol, deux de ces facteurs déterminant le troisième. Le rapport de grossissement entre la photographie et la carte varie en général avec l'échelle de la carte. Le sens dans lequel cette variation se déplace est contraire à la variation supputée de l'exactitude.

L'exposé n'aborde pas les appareils disponibles, mais étudie les tendances de leur conception. Ici, il établit une analogie avec la configuration des calculateurs électroniques, l'appareil de restitution photogrammétrique constituant l'unité centrale. Une abondante série d'appareils périphériques offre alors de multiples possibilités d'application aux utilisateurs ne possédant que quelques équipements fondamentaux. La différence est soulignée entre la confection de nouvelles cartes et la mise à jour des cartes.

Des données de précision sont ensuite indiquées. Une précision moyenne de 0.3 mm à l'échelle de restitution (admise au début de l'exposé) semble justifiée pour les cartes dont l'échelle est suffisamment grande et rend inutile une généralisation. Les contrôles de précision de l'Ordnance Survey sont cités à titre d'exemple.

La rentabilité de la cartographie photogrammétrique n'est mentionnée que de façon très générale, vu qu'elle dépend sensiblement de l'échelle et des conditions locales. La forte proportion des cartes qui sont confectionnées aujourd'hui d'après des méthodes photogrammétriques témoigne toutefois d'une rentabilité incontestable.

En conclusion, la photogrammétrie est décrite comme une technique qui convient à presque tous les travaux cartographiques et qui garantit une haute qualité à un prix raisonnable. Les développements futurs devraient s'opérer primairement dans le domaine de la photocarte et de la carte digitale qui sortent toutes les deux du cadre de l'exposé. L'évolution des méthodes automatiques pour la production des cartes conventionnelles dessinées au trait (c'est-à-dire automatisation de la photointerprétation et de la restitution, mais non des travaux purement cartographiques) se situe vraisemblablement dans un avenir assez lointain.

Photogrammetrische Woche 1975
Institut für Photogrammetrie
Schriftenreihe, Heft 2, 1976

Resumen

La conferencia trata al principio sobre toda la amplitud del tema de la confección de mapas fotogramétricos en todos sus aspectos. Como muchos de ellos se tratarán también en otras conferencias de la XXXV Semana Fotogramétrica, se tratará en lo posible evitar repeticiones.

La representación de datos e informaciones según su situación geográfica se denomina mapa. Las informaciones pueden ser muy variadas y la representación tanto gráfica como fotográfica o digital. Para evitar repeticiones, esta conferencia trata sobre la representación gráfica, es decir, el mapa de trazos, y principalmente de la información topográfica. A este respecto se opina que la fotogrammetría ofrece el mayor rendimiento a escalas desde 1:500 hasta 1:100 000, si bien no son absolutos ni siquiera estos límites tan amplios.

Al tratar sobre la técnica fotográfica, se habla de la elección de la escala de la imagen, de la distancia focal y de la altura de vuelo - factores éstos, dos de los cuales determinan el tercero. El aumento entre foto y mapa generalmente depende de la escala del mapa, y la dirección en la que ocurre esta modificación es de sentido contrario a la de la variación de exactitud esperada.

No se tratan los instrumentos ni de forma general ni en detalle. Se estudian las tendencias actuales de la construcción de instrumentos. Como analgía se cita el desarrollo en el sector de las computadoras digitales. Según dicha analogía, el restituidor fotogramétrico es la unidad central, mientras que un amplio programa de equipos periféricos para la entrada y la salida proporciona la versatilidad que se requiere para satisfacer las distintas exigencias de cada usuario con un pequeño grupo de equipos básicos. Se indica la diferencia entre la confección de mapas nuevos y la actualización de los existentes.

Siguen algunas indicaciones sobre la exactitud. Una exactitud media de 0.3 mm a la escala del mapa (supuesta al comienzo de la conferencia) parece justificada para mapas cuya escala es lo suficientemente grande para hacer innecesaria una generalización. Como ejemplo se mencionan los controles de exactitud empleados por Ordnance Survey.

La economía de la obtención de mapas fotogramétricos se trata sólo de forma muy general, ya que depende mucho de la escala y de las condiciones locales. Sin embargo, el solo hecho de que una gran parte de los mapas se confeccionan hoy día por medio de la fotogrametría, es una prueba suficiente de la economía de este método.

Finalmente, se describe la fotogrametría como método popular para prácticamente todos los aspectos diferentes de la cartografía - un método que ofrece alta calidad a precio razonable. Nuevos desarrollos importantes probablemente son de esperar ante todo en el sector de los mapas fotográficos y digitales, que no son tema de esta conferencia, mientras que el desarrollo de métodos automáticos para la confección de mapas de trazo convencionales (es decir, la automatización de la fotointerpretación y la restitución, pero no de los trabajos cartográficos) parece encontrarse todavía en un futuro muy lejano.

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COMPUTER PACKAGE DEAL

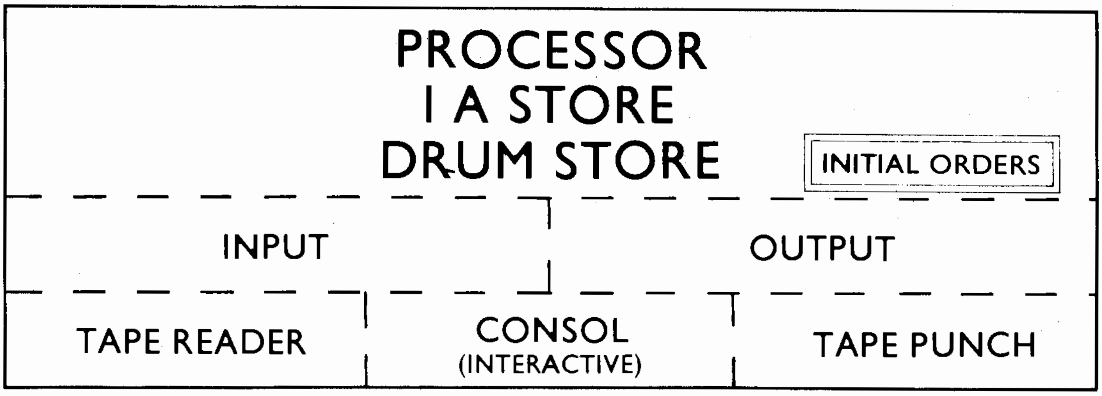

Figure 1

COMPUTER SELECTIVE CONFIGURATION

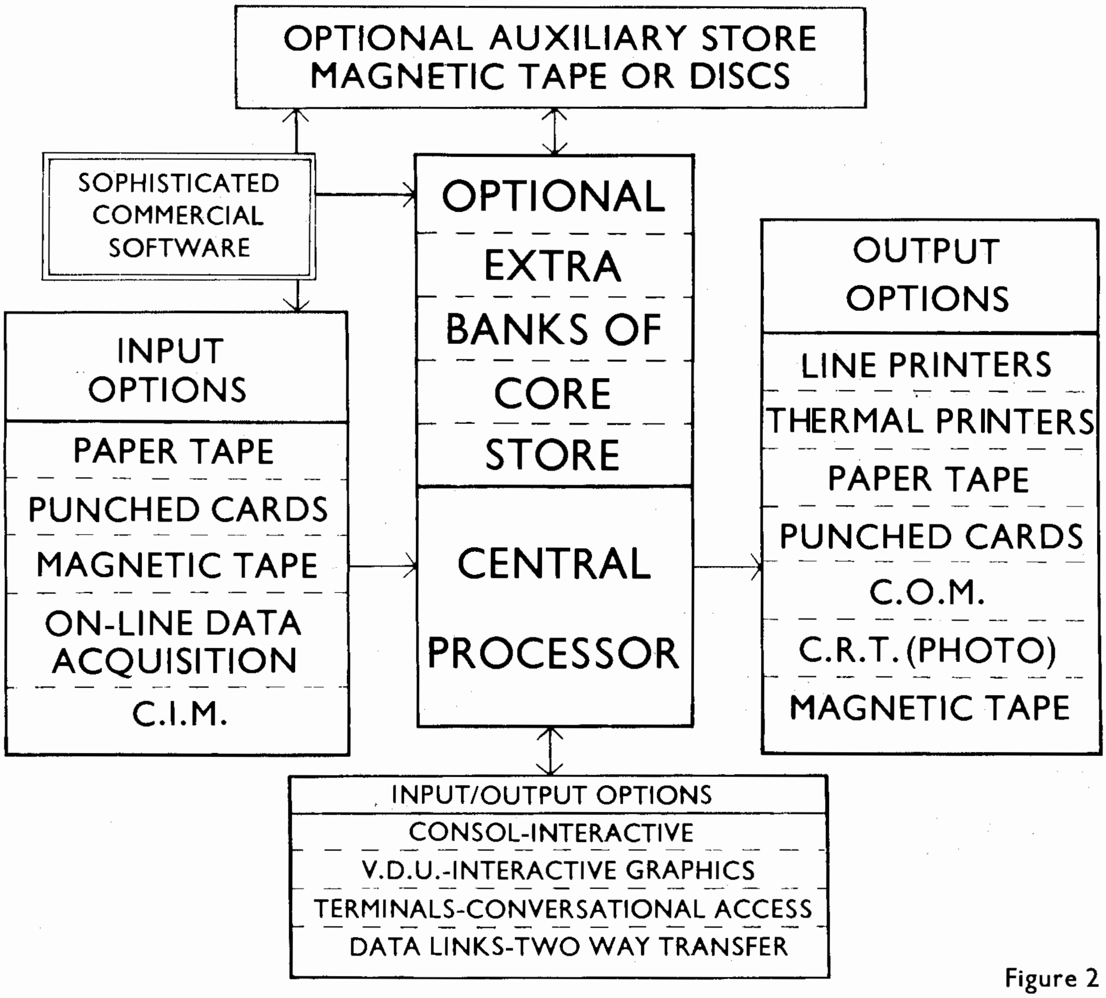

Figure 2

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STEREOPLOTTER PACKAGE DEAL

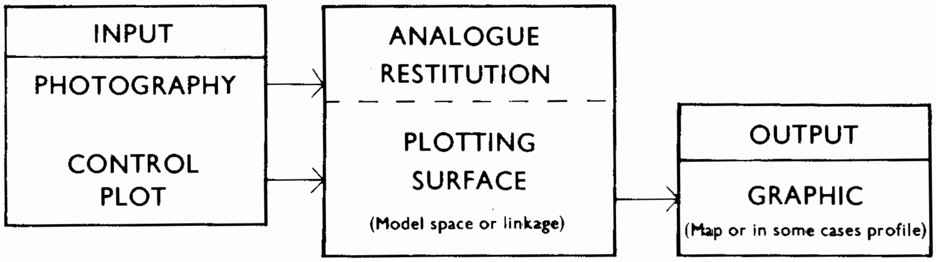

Figure 3

STEREOPLOTTER SELECTIVE CONFIGURATION

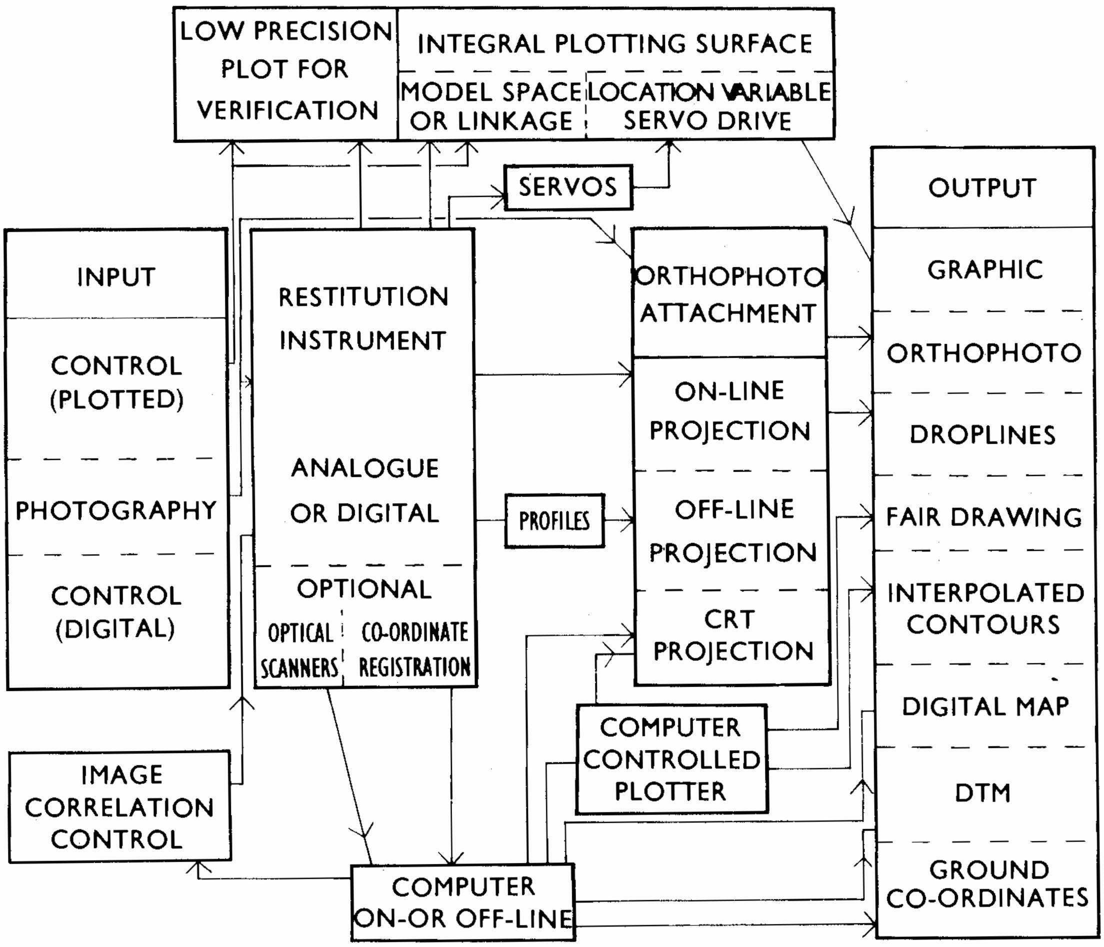

Figure 4