TOWARDS A MORE REALISTIC APPLICATION OF COST MODELS IN NATIONAL MAPPING PROJECTS IN DEVELOPING COUNTRIES.

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ABSTRACT

The importance of realistic technical specifications, proper planning and costing are often neglected in establishing national mapping programmes, particularly in developing countries. This paper tries to contribute towards the efforts of obtaining and applying more realistic cost models in photogrammetric mapping projects. Realistic cost models as functions of Basic cost standards and production stnadards are developed with emphasis on production standards, identifying the various important influencing factors. Speciial emphasis is placed on the stereoplotting and fairdrawing phases. Difficulties experienced in applying ideal cost models in developing countries are discussed from the Nigerian experience and suggestions are made for a more realistic approach in the future.

INTRODUCTION

The problem of realistic costing is a global one. Many countries, including Nigeria, are faced with increasing need for mapping at various scales to cope with various National Development programme needs. However, unfortunately, the importance of technical specifications is often neglected in establishing these mapping programmes. The fact that this does not only apply to developing countries makes it a more serious problem. Many mapping organisation still embark on mapping programmes without efficient planning to know HOW MUCH it will COST and HOW LONG it will take. On the other hand, those who realise the need do not have reasonable information to achieve realistic specifications and cost for the project, consequently costing of projects by different organisations are known to be highly variable, and even within the same organisation. Most people think planning and costing are mainly matter of experience, intuition and tradition. Consequently, mapping specifications are simply copied from other contracts, without investigating the real requirements for the purpose of the map they now want to produce.

A Scientific and Systematic treatment of the problem of planning and costing will result in better and more realistic cost model which is greatly needed by all.

In realisation of the importance of this problem of more efficient planning and costing, two related resolutions were adopted by commission IV at the XI congress of I.S.P at Lausanne (1968) relating to the general problem of planning of photogrammetric projects. Resolution Nr. 4: proposed by Prof. A. J. Brandenberger, reading: "It is recommended to continue studies on the economic aspects of photogrammetric Surveying and mapping and to establish a System to evaluate the economy of photogrammetric operations." Resolution Nr. 5: proposed by Prof. H. G. Jerie, reading: "The parameters influencing the accuracy and cost of different photogrammetric sub-systems should be studied, in order to establish the basic relations required for planning and designing of photogrammetric projects." In another paper by Prof. H.G. Jerie "The Establishment of cost models in Photogrammetry" I.S.P commission VI invited paper at the XIII congress in Helsinki, Finland in 1976 he states "The aim of the paper cannot be, and is not, to solve the problem and give ready made answers. What the author hopes to achieve, however, is:

* to raise the interest of the photogrammetric community in this important problem;
* to initiate the necessary R&D activity required to carry out the theoretical modelling of the functional relationship between product and cost; and finally
* to initiate a programme for the collection and statistical processing of data required for the establishment of actual cost models."

The objective of this paper is to differentiate the photogrammetric mapping process into smaller subsystems or phases, identify the various influencing factors on the different subsystems and highlighting the most important influencing factors which may often easily be overlooked and thereby throwing off the final cost significantly, particularly on large projects like National mapping programmes. This will lead to development of more refined and realistic cost models to permit more efficient planning of photogrammetric projects. It will enable mapping organisations, particularly developing countries, ts know more accyrately how much a photogrammetric project will cost and how long it will take to complete thereby forcing them to find a proper balance between their real requirements and the economic and technical capacity available for their realisation.

The scope of this paper will be restricted to developing cost models in photogrammetric mapping projects with emphasis on the stereo plotting and fairdrawing phases.

COST MODELS:

Cost models are functions of BASIC COST STANDARDS and PRODUCTION STANDARDS. Basic cost standards are fairly well established. The most difficult and varying part is the determination of Production Standards for the total mapping process and in particular the photogrammetric stereoplotting and fairdrawing phases. The relationship between cost models, basic cost standards and production standards are illustrated schematically in figure 1.

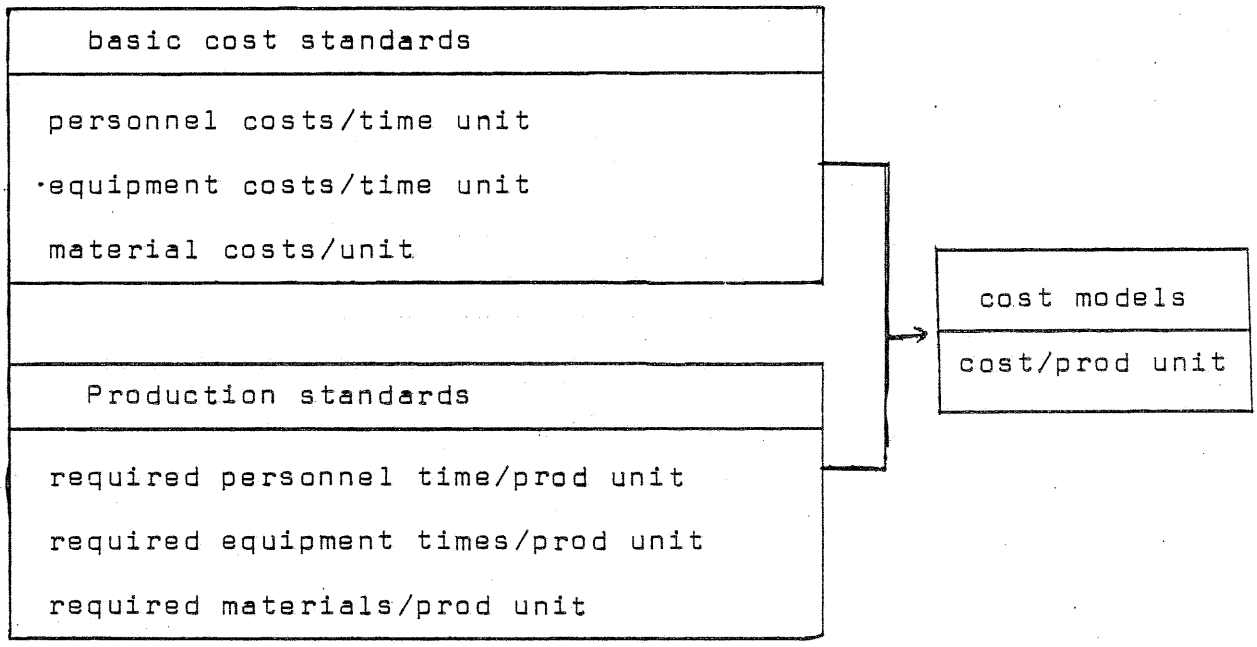


Figure 1: relation between cost models, basic cost standards and production standards.

In establishing basic cost standards it is essential to consider not only direct cost but also indirect costs (eg maintenance and building costs). This is to ensure that all general cost items are completely recovered or accounted for in the establishment of the cost of the products.

In establishing production standards functional relationship should be established between the materials and times required to produce the unit on hand, and the large number of factors which influence the production on the other hand.

The first step in the establishment of production standards is the identification of the sub-processes for which standards are required. The second aspect concerns the fact that many of the Sub-processes have, in turn, to be broken down into smaller units(Sub-sub-processes) - whereby production standards are now required for each unit. The optimal breaking down into Sub-sub-processes which will give rise to more realistic cost models is the primary objective of this paper. The production figures for mapping in one and the same map scale may differ by up to 200-300% even within the same organisation. The main factors for the output of mapping on a given scale are:

1. the amount of planimetric details to be plotted.
2. the amount of altimetric details (Contour lines,spotheights) to be plotted.
3. the type of photogrammetric plotter used.
4. the quality and scale of the photography.
5. the skill and productivity of the operator.

For the last three items, averages may be introduced for normal circumstances and deviations from the average condition do not influence the production by more than, say 20% either way. As can be seen, the first two items concern map content to be plotted and this is where the greatest spread is in the production figures. These, however, are the most dominant factors influencing the costing of photogrammetric projects and that is where emphasis is placed in this paper.

Costing in both phases of Stereoplotting and fairdrawing are very interrelated as they both primarily depend on the density of the map content. These two phases alone can account for up to 70% of the total cost of mapping at times (Jerie, 1968). Up to now there is still a big spread in the production figures of these two phases, due to the fact that the map content is treated as a composite. These map contents need to be differentiated into an optimum smaller groups, instead of being treated as a composite, to give a better estimate of their density for determination of more reliable production standards. Other significant influencing factors on the production figures apart from density of the map content are also highlighted.

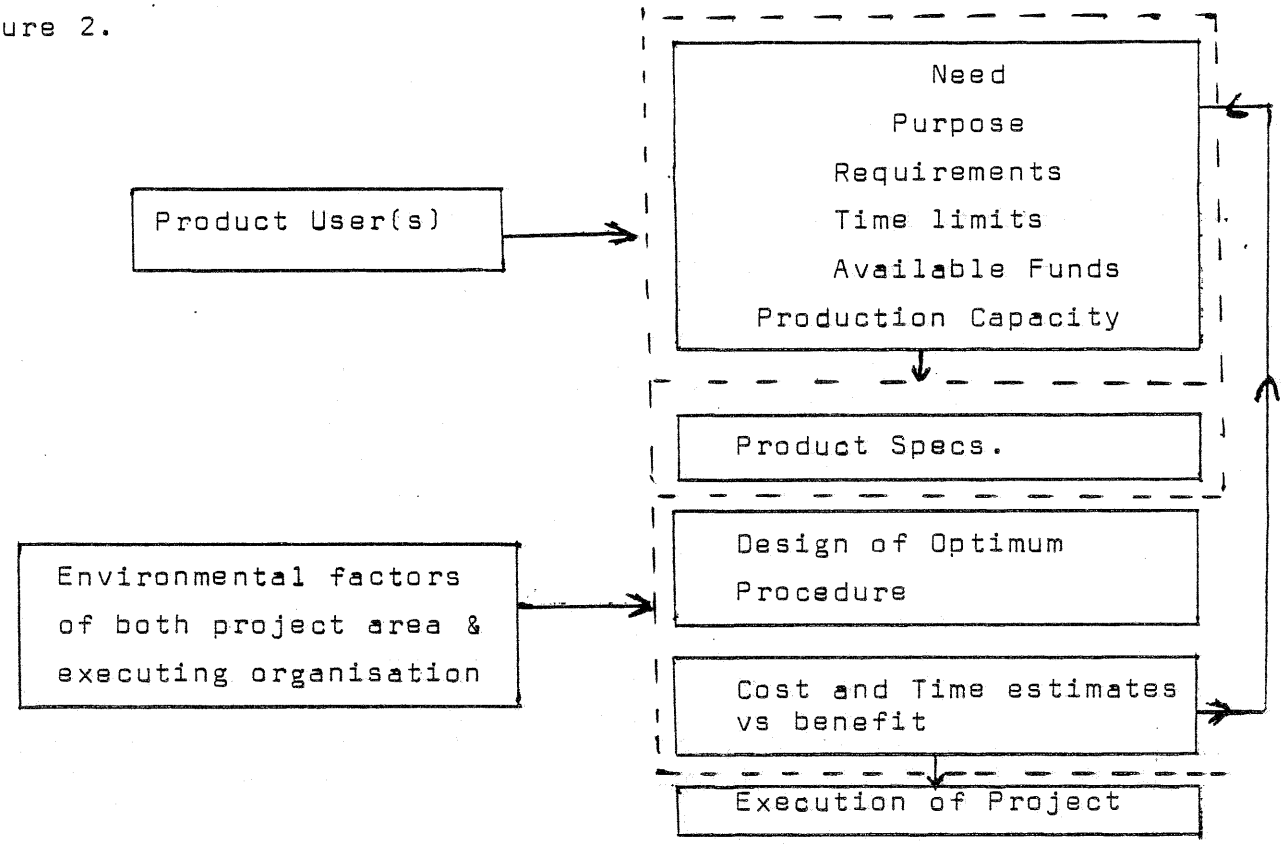
THE PHOTOGRAMMETRIC PLANNING PROCESS

The photogrammetric planning process allows a systematic or orderly approach to the entire photogrammetric mapping activities. This enables the whole project to be designed and executed in the most optimal way (i.e. in the cheapest way, in the least time and still fulfillling all the requirements). It therefore ensures that realistic specifications are made considering the purpose of the product and all available constraints. To do this properly the whole process must be sub-divided into orderly sequential phases. A simplified representation according to Prof. H.G. Jerie is given in figure 2.

The photogrammetric planning process can be subdivided into the following four main phases. (1) Problem definition (2) Data Acquisition. (3) Design. (4) Execution. (see Ogunlami 1979 for details).
The four main categories of influencing factors obtained in the data acquisition phase are:

1. Product Specification obtained in the first phase.
2. Procedure or process parameters(to be used to execute the project).
3. Environmental factors of the project area.
4. Environmental factors of the Executing Organisation.

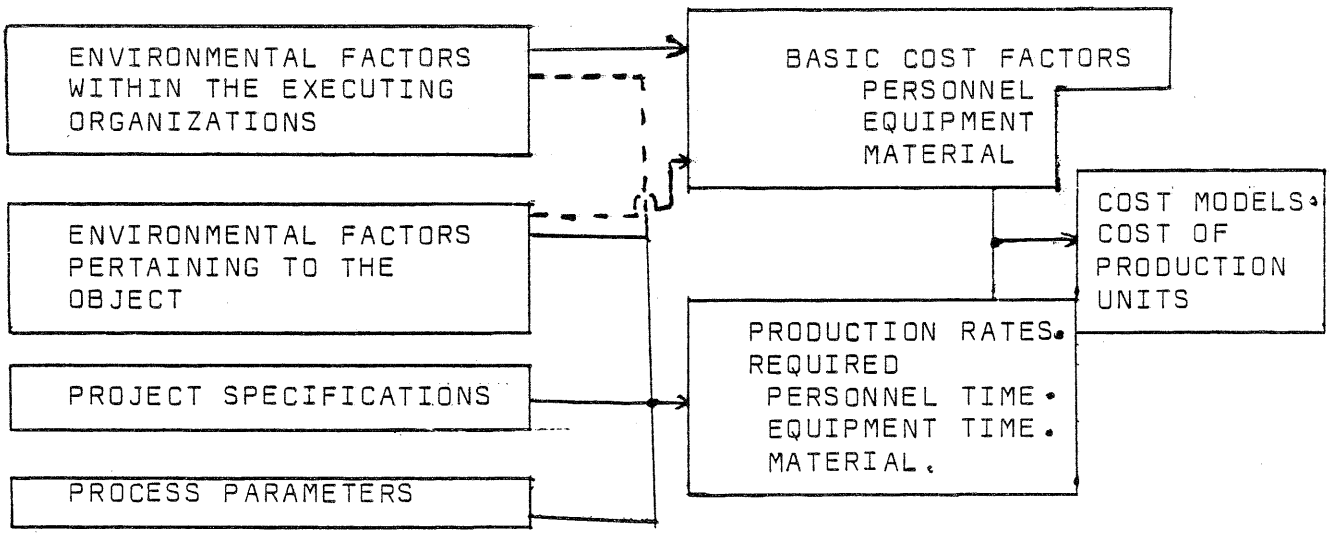
Figure 2.



INFLUENCING FACTORS

Both groups of basic cost standards and production standards depends on various influencing factors. The dependence of both groups on the various influencing factors belonging to the four categories mentioned earlier is shown Schematically in figure 3.

Figure 3.



Basic cost standards depend mainly on factors pertaining to the executing organisation and oly slightly on factors pertaining to the project area. Basic cost standards should therefore, be worked out seperately for every organisation, or existing ones modified to suit the particular organisation.

Production standards on the other hand, are only slightly influenced by factors pertaining to the executing organisation. They are, however significantly influenced by factors pertaining to the project area, the product specification and the process parameters (procedure). The main phases of the total mapping procedure may be considered to be as follows:

1. Aerial photography
2. Ground control
3. Aerotriangulation and adjustment
4. Plotting
5. Interpretation, field completion and
6. Fair drawing.

Proper planning has to be made for each of these phases and the various influencing factors carefully identified for the Sub-sub-Systems to ensure a realistic costing of mapping programmes. In the context of this paper it is only possible to discuss some of the most important aspects of the various phases in general terms concentrating on the production rate and emphasis will be on the more important influencing factors on the production rate in stereoplotting and fairdrawing phases as there is a large number of these influencing factors. The others are fairly standardized. These factors are also grouped as follows in order to identify different aspects more clearly:

(1) Those affecting the amount of work

(2) Those affecting the time or rate, and accuracy.

To simplify the discussion these sub-sub-processes involved and the influencing factors as well as the cost units and total costs are shown in diagramatic forms as flow charts-developed by the author. For lack of space flow diagrams for the phases of Aerial photography, Ground control, Aerial triangulation and adjustments, and Interpretation, field identification and field completion will not be shown here. All these, except Ground controls and Interpretation field identification and field completion which are interrelated, are fairly well standardized and accurate information are available in various catelogue of systems. (See Ogunlami, 1979 for details).

STEREO PLOTTING PRODUCTION STANDARDS

There are different methods of mapping namely:

1. Conventional mapping by stereoplotting for production of line maps
2. Photomap production by either differential rectification (in the case of none - flat terrain) and by conventional rectification (in the case of flat terrain).
3. Digital mapping by digitally recording of data and on-line or off-line semi-authomatic or automatic plotting of recorded data.

In this paper the conventional mapping method by stereoplotting for production of line maps is concentrated upon, as it will be too detailed to discuss all other methods which are each complete process. The cost of the plotting phase (and the Sub-phases) in the conventional mapping and the various influencing factors are shown in fig.4.

The main Sub-phases generally considered are:

1. Plotting sheet preparation (Plotting control points. etc)
2. Setting up stereomodel (Inner Orientation, R.O. and A.O.)
3. Plotting (Contours and planimetry).

The total cost of the plotting phase can be determined by adding the cost of each of the above three sub-phase and the total cost of materials as shown in fig. 4.
These enable us to determine the production standards for the plotting phase. Due to numerous variable influencing factors, accurate figures are not available for this phase of mapping. The available production estimates need improvement and this is the essence of this paper.

FAIR-DRAWING PRODUCTION STANDARDS

There are different methods of fairdrawing namely:-

* The conventional fairdrawing method by manual inking or scribing
* The new semi-automatic or fully automatic drafting technique using semi-automatic drafting equipment.

Emphasis here is on conventional method. The cost of the fair-drawing phase (and the subprocesses involved) and the various influencing factors are described in flow chart fig. 5.

The main subphases are:

(1) Touching up of the machine plot
(2) Map sheet preparation
(3) Fair drawing

The total cost of the fairdrawing phase can be determined by adding up the cost of each of the above three subphases plus the total cost of materials as shown in fig. 5. These enable us to determine the production standards for the fairdrawing phase.
The fairdrawing phase which is related to the plotting phase is also a serious time consuming phase in the mapping process as the plotting phase, and both are highly variable. Fairdrawing usually takes between 50% to 200% of the time needed for the stereoplotting depending on the variability of the contours and other influencing factors. This indicates that there is also wide spread in the production rates of fairdrawing.

DEVELOPMENT OF REFINED MODELS TO ESTIMATE PLOTTING AND FAIRDRAWING PRODUCTION STANDARDS

The most important aspects in the development of refined production standards is the optimal differentiation of the sub-sub-phases and the correct identification of the influencing factors on the different sub-sub-phases. Detailed study and experiments conducted showed that those for fairdrawing need not be differentiated further as the number of influencing factors are small and the effect not critical as they are not affected by the highly variable factors of the project area. However, those for the plotting need to be differentiated further into a number of smaller sub-sub-phases

because of the numerous factors mainly of the project area and the varying degrees these affect each sub group of features in some cases.

Stereoplotting phase could be optimally differentiated into twelve (12) sub-sub-phases, to give a more refined model, as follows:

(1) Plotting sheet preparation

(2) Relative Orientation (Including Inner Orientation)

(3) Absolute Orientation (Scaling and levelling)

(4) Plotting of hydrographic features

(5) Plotting of controls

(6) Plotting of other point features

(7) Plotting of communication

(8) Plotting of built up areas and individual buildings.

(9) Plotting of vegetation and Cultivation boundaries

(10) Plotting of Administrative boundaries

(11) Plotting of physical boundaries

(12) Plotting of contours and spot heights.

This differentiation is based on the results of experiments conducted by author on development of a new classification scheme for map content. The results show that map content may be optimally divided into the following ten (10) object classes or subgroups in the order of their considered priority for plotting and fairdrawing.

(1) Hydrographic features

(2) Controls

(3) Point features

(4) Communication and transmission lines

(5) Built up area and individual buildings

(6) Administrative boundaries

(7) Physical boundary features

(8) Vegetation and Cultivation boundaries

(9) Contours and spot heights, and

(10) Names and Abreviations (which are not plotted).

The philosophy of the development of this classification scheme would be too labourious to discuss here. (see Boss et al 1968; Larsen, 1971 Spices,1970; Neumaier, 1966 and 1972 and Ogunlami, 1979 for details). The cost of plotting from the more differentiated sub-sub-phases and various influencing factors to give a more refined and more realistic cost model is summarised in the flow chart fig. 6. The total cost of the plotting phase should therefore be determined by adding up the cost of all these sub-sub-phases plus the total cost of materials.

The differentiation approach will enable us to determine the production standards for the different sub-sub-processes of plotting more reliably but these must be determined under actual production environment by the individual mapping organisations to be able to quantify the effect of the respective influencing factors of the various sub-sub-processes. It should be noted that in all the flow charts, the various influencing factors have been numbered to indicate the group of influencing factor it belongs to. Those affecting time or rate and those affecting the amount of work are also distinguished before leading to the cost unit of each sub-process or sub-sub-process.

DIFFICULTIES IN APPLYING IDEAL COST MODELS IN DEVELOPING COUNTRIES

In applying ideal cost models in national photogrammetric mapping programmes a lot of difficulties are encountered.

* There is an accute shortage of photogrammetric costing and planning experts due to the deficiency in photogrammetric education in developing countries. This leads to inadequate planning and inaccurate cost estimates due to lack of knowledge of basic principle of effective planning that should be followed with futuristic trend/need anticipation (See Agarwal, 1980).

* There is usually an urgent and impatient request for maps by users, and particularly Government, on photogrammetrist at every short notice due to the hectic and rapid national development requirements for maps, consequently not leaving sufficient time for this "ideal" approach to the solution of problems.

The photogrammetrist is generally stampeded into taking immediate decision without at times being able to consider suitable alternatives and sometimes the real requirements of the maps are not clearly defined and the technical available resources (Human, equipment and material) are not properly balanced with the proposals for mapping adopted. Sometimes even when expert advice is given it might not be accepted. The result of this is that some countries embark on mapping programmes at wrong scales, with completely wrong estimates as to how much it will cost and how long it will take. Eventually they find themselves battling for several years to produce maps from aerial photographs acquired over a few months which soon get out of date. This problem is particularly more serious with very large countries embarking on national mapping programmes. Generally by the time the map is produced it is already outdated.

* There is also a general lack of reliable information on production standards. No proper records are usually kept by most organisation if any at all, and when they do only final cost of the project are available with no records of production standard estimates, which are not useful to other users or other project areas. Most costing estimates are based usually on generalised composite costing instead of the proposed differentiation into sub-sub-systems. Some significant influencing factors are sometimes not even recognised and this can completely throw off cost estimates with the composite approach. If the differentiation approach is adopted the influence on the over all cost estimate will not be as large.

* Most mapping organisation are still relatively young with little experience at mapping and record keeping. This situation it is hopedwill improve with time if they learn to appreciate the importance of adequate records of production rates for various projects executed with their different and numerous influencing factors.

* It is not unusual to find mapping organisations attaching some sort of secrecy to these information when they have them even long after the project had been completed and there is no more competetion.

* Finally most people wrongly think that this approach is too theoretical and yet the problem of accurate costing still continue to pose a lot of headache to them. It is believed that if this attitude changes the sooner it would be possible to get a more realistic cost model in photogrammetric mapping.

CONCLUSIONS AND RECOMMENDATIONS

It should be obvious from the little contribution of this paper that effective planning and costing for a mapping project can be a very complicated task due to the numerous and highly variable influencing factors and the large number of sub-sub-phases that make up the total mapping process. It is therefore evident that only by a scientific and systematic treatment of the problem will more refined and realistic cost models be obtained which is greatly needed by all. The usual principle of whole to part is recommended.

The two phases of plotting and fairdrawing dorminate generally the total cost of mapping and particular effort should be made at improving production estimates in these areas. They alone may take up to 70% of the total cost of mapping programmes. Realistic specifications (Accuracy, Scale, Map content, etc) should be drawn up for mapping programmes as they affect cost a lot. There is need for proper record keeping of production standards by each mapping organisation for different projects and different procedure. Reports on new methods and procedure should not be accompanied by figures of total production cost, but rather by detailed information concerning the production standards established. Only this is of importance to other organisations interested in applying the proposed procedure to other project, other project areas and possibly with other product specification.

The significant parameters influencing the accuracy and cost of different photogrammetric sub-sub-systems and their relationship are identified and summasized on Figure 4 to 6.

A proposal is hereby made for the classification scheme for plotting of map contents into ten (10) object classes or subgroup in order of their priority. (See page 8).

An optimal differentiation into sub-sub-system is also proposed for the stereoplotting and fairdrawing phases.

Production standards with this guide must be determined under actual production environment by the individual organisation to be able to quantify the effect of the respective influencing factors of the various sub-sub-processes.

This paper is only a contribution towards eventually final modeling of the functional relationship between product and cost required for the establishment of actual refined cost models for the total mapping process.

There is need for more cooperation among mapping organisations, to disseminate information among themselves more freely, particularly in developing countries. To this end the call for an African Regional International periodical (ARIP) in photogrammetry under the auspices of a special commission for photogrammetry and Remote Sensing in Africa (CPRSA) is hereby supported (See Ayeni,1984). The need to organise more national, and regional or subregional conferences, seminars and workshops cannot be over emphasized.

To assist developing countries in the area of economic mapping of their vast land areas with their limited resources (human, finance and equipment) more members from developing countries should be coopted into the ISPRS special working group that deals with this area of economics of mapping. Large portions of the world are still unmapped and this can only be done effectively by judicious use of the scarce available resources.

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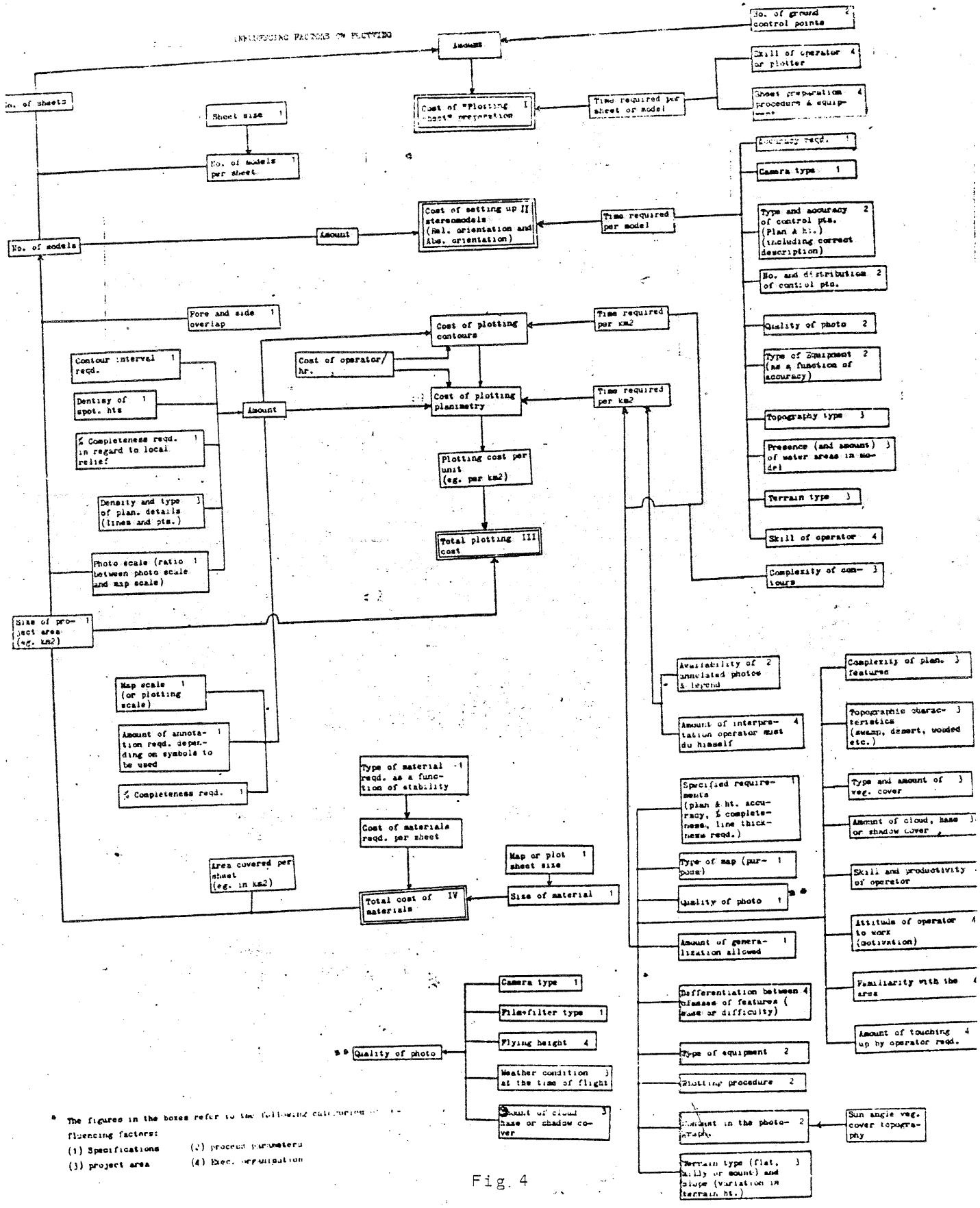

* The figures in the boxes refer to the following categories of influencing factors:

(1) Specifications (2) process parameters

(3) project area (4) Exec. organisation

Fig. 4

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INFLUENCING FACTORS ON Fairdrawing

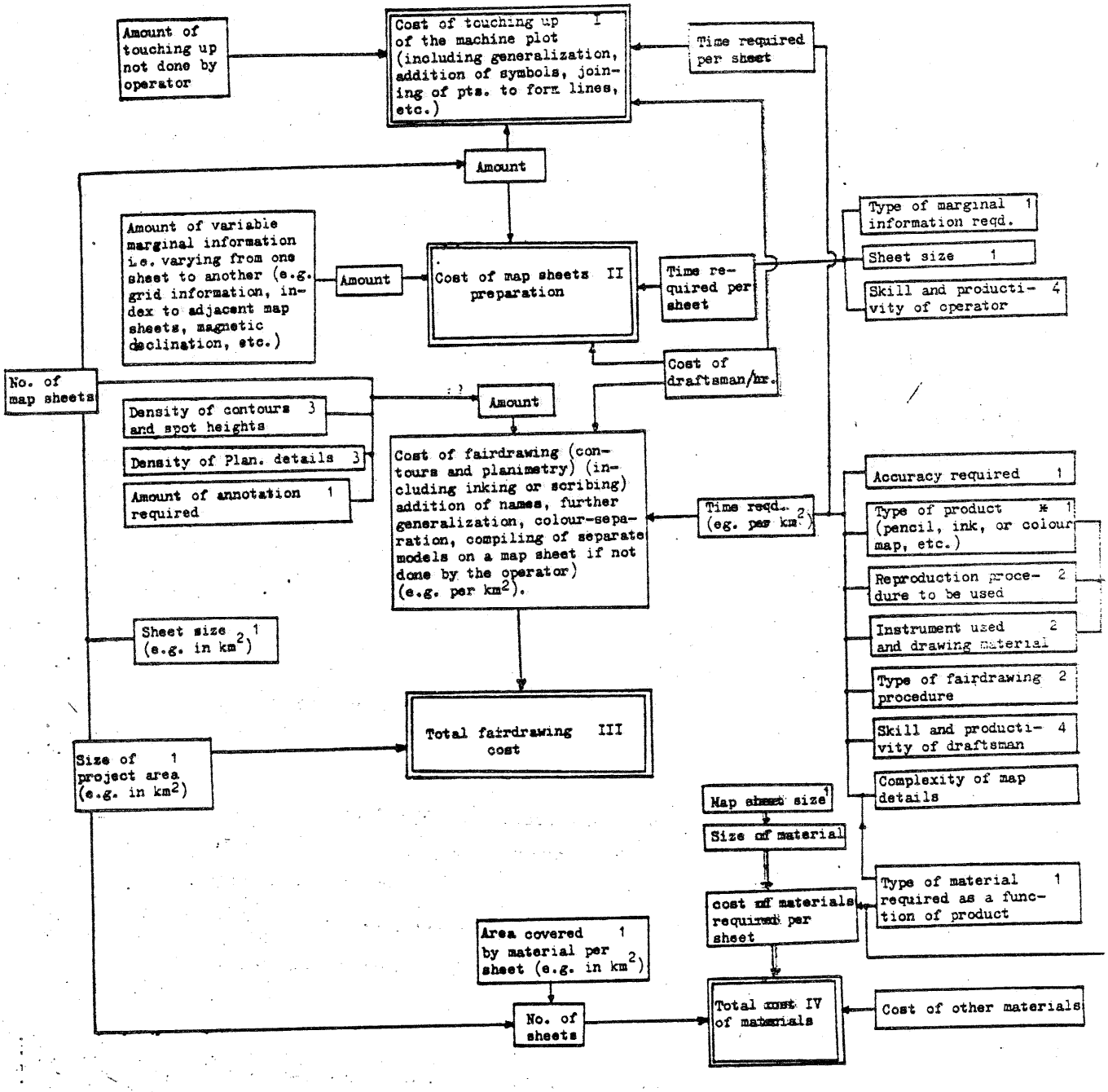

Fig. 5

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* The figures in the boxes refer to the following categories of influencing factors:
(1) Specifications (2) process parameters
(3) project area (4) Exec. organisation

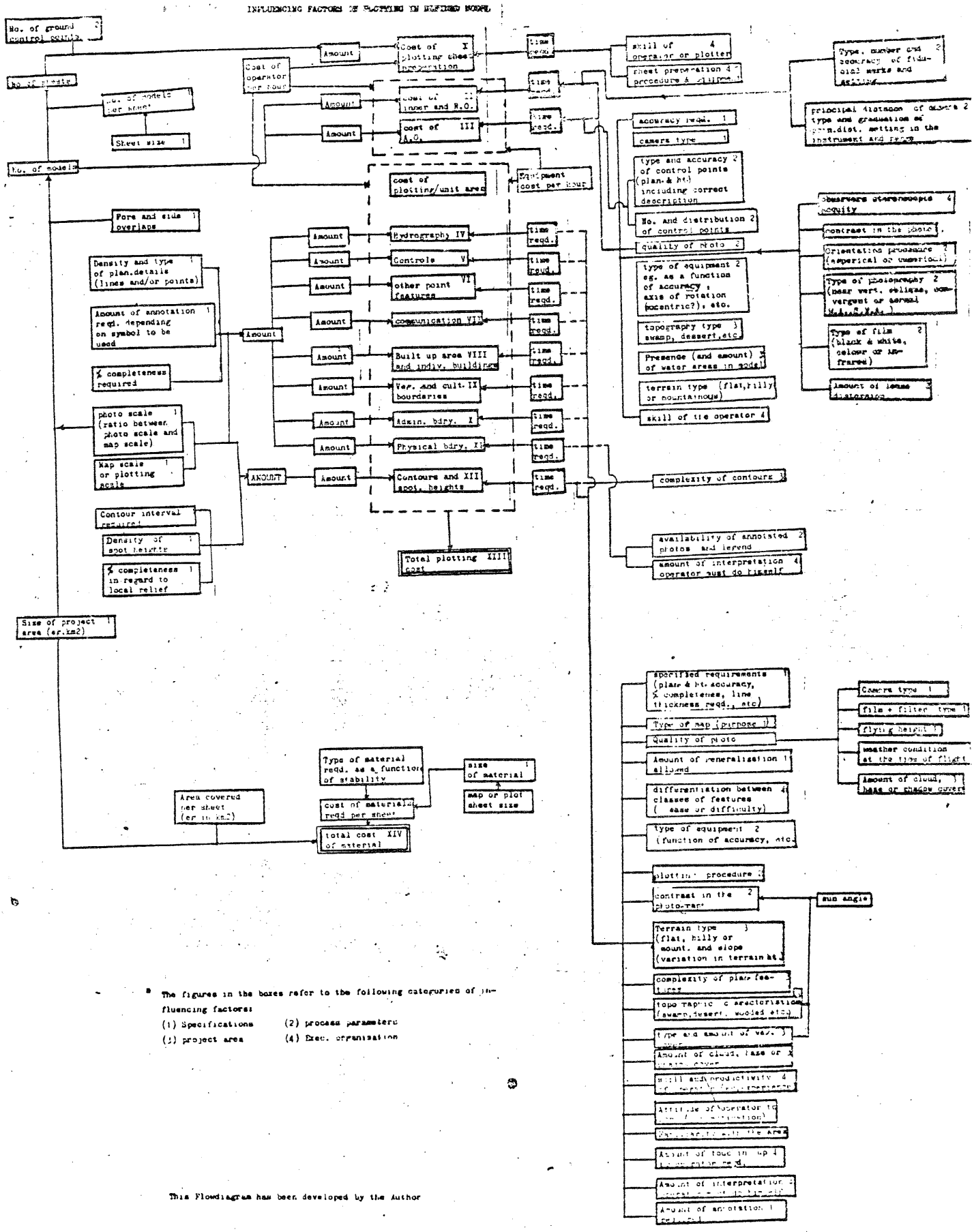

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Fig. 6