ON SOME ASPECTS AND RESULTS OF RECTIFICATION FOR COMMAND AREA DEVELOPMENT

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ABSTRACT

In India it is proposed to develop about 0.2 million hectare per year and increase progressively to 1 million hectares per year for irrigation and on-farm development projects. In view of limited topographical surveying resources and relatively lower cost, rectified photographs on 1:2500 or 1:1500 from aerial photographs on 1:10,000 or 1:6000 are used for drawing contours at 50 cm or 25 cm interval by ground survey method. Outline of the major elements of the perspective rectification system, prevailing situation with respect to cost effectiveness, performance characteristics for accuracy and image quality for different scales of rectified prints are given.

So far the experience gained showed that providing control points by ground survey method using EDM instrument is better and cheaper for rectification on such large scale as 1:1500 and 1:2500. Graphs are used to compare cost of providing control points by photogrammetric and ground survey method. Tables are presented giving various planimetric errors, rate of production and cost etc. to aid in the choice of the most efficient technique for a given cartographic situation.

INTRODUCTION

Quest for a new economic order in India is amply reflected in Government's decision of taking up nation wide irrigation and on-farm development projects. It is proposed to develop about 0.2 million hectares per year and increase progressively to 1.0 million hectares per year. In India 51 irrigation projects having an ultimate irrigation potential of 13 million hectares are already identified. Our task is difficult to channelise this movement into its proper long

term perspective while the outcry is for immediate results and the topographical surveying resources are very limited. Funding is traditionally difficult because mapping is unglamorous and does not excite public interest. Although world bank is also extending financial assistance for these developmental projects located in various states, expenditure on mapping activity is inadequate. With this background the aerial photography (high-gain imagery) currently represents a very useful tool that can be used to provide improved relative horizontal and vertical information about farm/farmable lands at relatively lower cost. The paper concentrates on outlining the major elements of the perspective rectification system. It gives prevailing situation with respect to cost effectiveness and performance characteristics for accuracy and image quality for different scales of rectified prints. However these aspects depend on a large number of variable factors. The theme that was kept in mind throughout this paper was lesson learnt in producing rectified prints covering 0.35 million hectares of project area, is presented more on practical and less academic level.

RATIONALE FOR USE OF RECTIFIED PRINTS

Few developments in the field of surveying and mapping have been more exciting in recent years in India than the renewed interest in the large scale photo base map for irrigation and many other developmental projects. In large measure, these developments have been activated by :-

- a growing interest in problems related to land management.
- a growing technical ability, better instruments and aerial photographic system.
- a growing acceptance of such products by various resource managers. It is a heartening but pragmatic approach.
- a growing dependence on interpretative task, which is very important for engineering decisions.

Out of all systems of getting photo base map, rectification is the cheapest and most efficient. Rectified prints are operational products and can be produced from colour as well as black and white aerial photography. When ground relief is minimal the photo negatives are simply rectified and ratioed to a common scale before the prints are made. This will eliminate displacement due to tilt and minimize relief displacement. It is understood that photo base map is not a panacea of every measuring problem. However alternative

method of ground surveys for planimetric base map would be more costly and time consuming. This derivative of aerial photography has exhibited a great potential in the graphical mode for

* Reshaping of agricultural land.
* Increased water use efficiency.
* Introducing concept of integrated area planning and linkage of irrigation development.
* Use of principles of ecology.
* Classifying soil types.
* Updating/supplementing revenue maps.

However some problems still persist. Small contour intervals eg. 25 cm or 50 cm necessitates contouring on ground. Revenue authorities have hesitancy for reconciliation of rectified prints on large scale since the revenue maps are usually not uptodate and situation on two documents do not tally. Also field belonging to two different owners appear as one block on the photograph because both fields may have same crop at the time of photography.

DISCUSSION

Aerial photographs (black and white) on 1/10,000 and 1/6000 scales have been used for producing rectified prints on 1/2500 and 1/1500 scale. In perspective rectification, an arbitrarily directed photographic image (central projection) of a plane object is transformed into an orthogonal projection of that object in a certain plane without complete knowledge of inner orientation of aerial camera.

In spite of existing modern technology a lot of bad quality aerial photography is still produced, mainly with respect of survey flight planning. Relative positioning of individual flight lines, forward overlaps, and tilts have great influence on the cost of rectification. Photographs should be taken only after the harvesting is over. Control points are provided either by ground survey method or aerial triangulation. In case of aerial triangulation method using small scale photography to supplement control points on larger scale, the first step is to select a large number of points which are identifiable on both sets of photographs. This operation proved to be rather difficult because of large differences in the scale and seasons. The problems are encountered in the terrain which is largely forest/bush covered and rural area. Well identifiable features are usually in short supply. Such problems are not encountered

in ground survey method with EDM instruments. Fig.1 gives cost of aerial triangulation per model and control by ground method per model. Fig.2 gives degrees of accuracy on rectification with respect to control point by different methods. From these analyses it clearly emerges that ground survey method is superior as well as cheaper in this particular case. This is contrary to general belief and reasons can be attributed to operational difficulties and our present state of art. Unlike ground survey method, in case of extension of control points by aerial triangulation, there are many influencing factors which affect accuracy and economy eg. preparatory job, image accuracy, measuring accuracy; method of observation, flight configuration, available computer and software. One has also to account for graphical enlargement of all errors by a factor of about 4 or 2.5 (depending on photo and print scales) in "error budget" consideration.

If the planimetry is of primary importance, then a narrow angle camera, for instance with 30 cm focal distance; has the advantage that all radial displacement of objects standing above the ground, and all errors due to ground height differences within the complete photo are twice as small as, when using a 15 cm wide angle camera. At the same negative scale, however, the wide angle camera would provide two times better height accuracy. For 1/2500 plan, photo scale of 1/10,000 (narrow angle photography) and for 25 cm contours photo scale of 1/3000 (super wide angle photography) is adequate. This however would entail slower and stable aircraft. A pilot production is needed before this fully photogrammetric system becomes operational and cuts down the mapping cost and time considerably, as compared to existing system.

For rectified prints on 1/2500; whether photo scale of 1/6000 or 1/10,000 should be used is quite a debatable point. Fig.3 gives cost rate of production, resource consumption etc. and Table 1 shows the comparison between X 2.4 and X 4 enlargement on rectifier. From 1/6000 photo scale to 1/1500 rectified prints are neither economical nor good in quality. So far image quality itself is concerned, each regeneration of the image can degrade the resolution by about 15 to 20%. If one has only to view the prints a resolution of about 4 lines per mm should suffice, this being the resolution of the naked eye. Therefore from resolution point of view enlargement of rectified prints do not impose constraints. What scale of photography is chosen for prints on 1/2500 will largely depend upon indentor's metric and semantic requirement. The problem as I see it, is lack of guide lines and standardization for specified product.

So far only double weight bromide paper have been used for rectified prints. Often this is suspected as major source of metric inaccuracy due to its dimensional instability.

Rectified prints meant for field work and permanent record is mounted on cloth. Mounting by use of roller in reproduction units looks very crisp and neat but gets dimensionally deformed. We conducted some experiments to assess dimensional stability of double weight bromide paper of size 1 square meter and following are the results :-

* error due to photographic processing after rectification is $\sigma x = 0.3$ mm and $\sigma y = 0.3$ mm. Well distributed 154 points were considered and the prints were dried on flat wire mesh in room temperature.
* error due to mounting prints on cloth by using roller in map reproduction office is $\sigma x = 3.3$ mm and $\sigma y = 2.9$ mm. Here also well distributed 154 points were considered. This shows 11 times increase of error due to use of roller, alone. (All operational conditions were similar).

Replacement of double weight paper with polyester base photographic material, would be much costly proposition (5 to 8 times) for a small gain of dimensional stability. Water resistent, resin coated, double weight bromide paper will be a better solution. In any case the magnitude of error on this account is smaller than other sources of error of the system. If printing papers are cut and stored flat, careful photographic processing and drying on flat wire mesh frame is insured, dimensional instability can be kept minimum.

CONCLUDING REMARK

The author feels that main bottleneck in high quality production of rectified prints is in provision of easily identifiable and precise control points. So far experience gained leads to the conclusion that providing control points by ground survey method using EDM instruments is the best method for rectification on 1/2500 scale. For total number of models upto 150 it is cheaper than aerial triangulation. It is more accurate and increases the efficiency of rectification procedure. Other functional steps of rectification system is now fully operational. photolab facilities and processing needs improvement especially in case of X4 enlarged/rectified prints. For better accuracy, higher productivity in terms of number of frames and very good quality of rectified prints, aerial negative (first generation) should be enlarged about 2.5 times.

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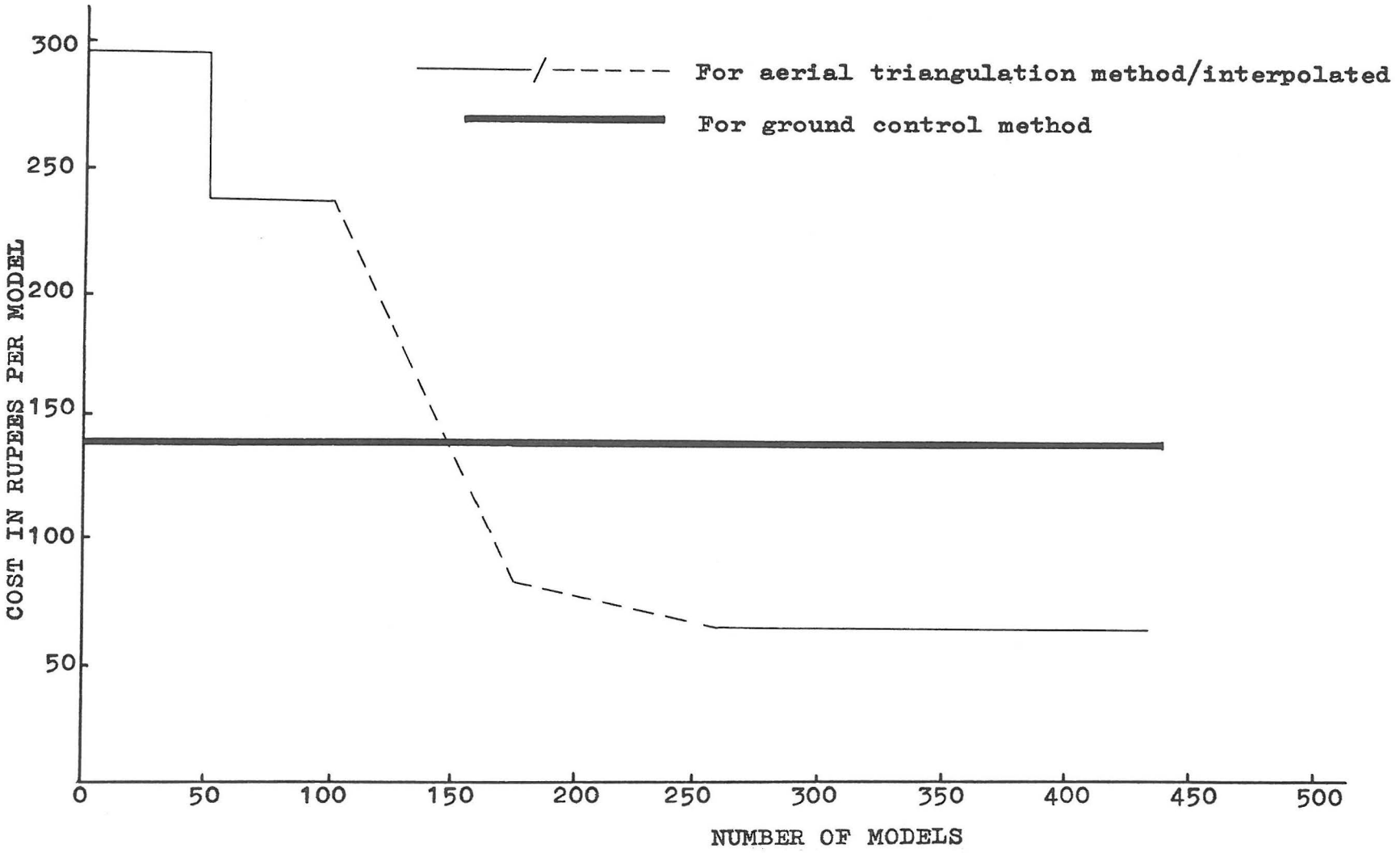

Fig. 1 Cost of providing control points (plan) by aerial triangulation and ground survey method.

Sl. No.	Method of providing control points and photo scale	Scale of rectification	Planimetric error in percentage				Total No. of control points	Repeated rectification in percentage due to
			0-0.5 mm	0.5-1.0 mm	1.0-1.5 mm	>1.5 mm		
1	Field Survey(EDM) on 1/6000.	1/2500	98%	-	-	2%	408	3%-Plotting error 0.5% Identification error
2	A.T on 1/20,000 transferred points on 1/10,000	1/2500	33%	60%	3%	4%	300	10%-Identification error
3	A.T on 1/6000 with control point from 1/40,000.	1/1500	9%	61%	19%	11%	414	7%-Numbering error 12%-Identification error

NOTE: (i) Errors are shown after distributing the residual error.
(ii) Area under report was by and large similar in relief distribution.
(iii) A.T = Aerial Triangulation.

Fig. 2 Degree of accuracy on rectification with respect to control points by different methods.

Sl. No.	Photo scale	Print scale and size	Resource consumption		Rate of production per day per shift	Effective area per print in sq.km.	Cost per sq.km in Rupees
			Personnel	Material			
1	1/6000	1/1500 45cmX45cm	36%	64%	5 Frames	0.29 (Quarter of full-prints)	397.00
2	1/6000	1/2500 55cmX55cm	23%	77%	9 Frames	1.16	137.00
3	1/10,000	1/2500 45cmX45cm	30%	70%	5 Frames	0.81 (Quarter of full-prints)	85.00

NOTE: (i) It does not include cost on account of aerial photography; control work and cloth mounting.
(ii) 61% of total format area is taken as effective area.
(iii) For Resource consumption, rate of production and cost, four copies of each format (aerial negative) is included.

Fig. 3 Cost and rate of production of rectified prints.

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Sl. No.	Points for comparison	X 2.4 enlargement	X 4.0 enlargement
1	Photographic consideration.	Very good quality is possible on regular basis.	Comparitively poor quality due to, excessive curl, difficult to keep flat on easely, more obscuring dust particles, uneven exposure in corner and central zone, dodging falsifies textural interpretation, poor/difficult washing, mechanical damage due to breaking of prints and scratches, more loss of photographic solution due to increased rate of oxidization.
2	Metric consideration.	Better relative accuracy.	Residual errors are more due to difficult accurate identification/marking control points, larger enlargement factor and poorer projection of control points towards corner.
3	Miscellaneous.	Easy indexing, handling since one frame gives one full print.	More indexing because of one frame giving full prints in 4 parts, rate of production in terms of number of prints is much low.