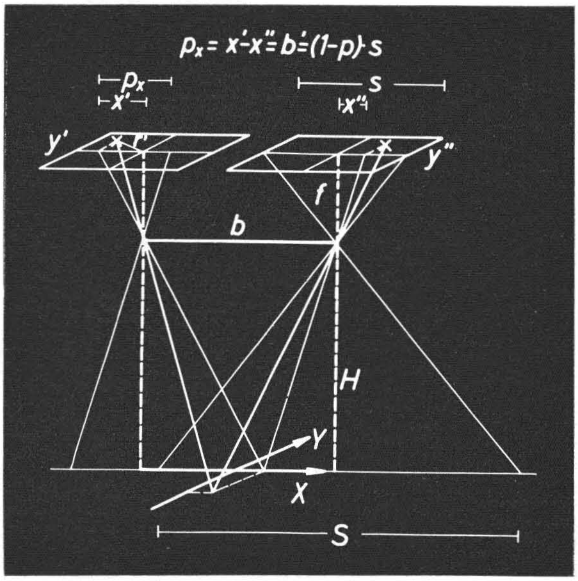


FIG. 1. Normal case of stereophotogrammetry.

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# Angular Field and Negative Size

**The errors and economies associated with the parameters of the aerial camera deserve reinvestigation in view of improved film bases and extended angular coverage.**

## 1. INTRODUCTION

THE QUALITY of the aerial photographs is extremely important for the subsequent photogrammetric plotting process. It is therefore not surprising that camera characteristics have been the subject of much study. The primary concern of the photogrammetrist is to achieve the optimum combination of scale, format and angle of the aerial photograph with accuracy and coverage of the subsequent plotting process. Two different approaches have been used to clarify this question: experiment and investigation according to the theory of errors.

Although experimental research—efficiently sponsored by the foundation of the OEEPE—was started on a large scale, investigations according to the theory of errors were only begun much later.

The ideas of G. Würtz[10] and, more recently, of W. Löscher[6] have led to a resumption of discussion on this subject. In the latter publication, film shrinkage, irregularities of the film base and the emulsion as well as optical aberrations are used to determine image coordinate errors and thus the accuracy and ground coverage obtained with different camera characteristics. The result in turn is used to compute the optimum combination of format and angular field. The investigations are limited to vertical accuracy. It would be interesting also to include horizontal accuracy. In the following, an attempt will be made to do this along the lines indicated in the aforementioned publication.

All investigations are aimed at the creation of a mathematical model which will permit certain predictions to be made regarding the results to be obtained with given camera characteristics. Needless to say, this model must be tested experimentally

ABSTRACT: *The investigations on the influence of the angular field of aerial cameras on accuracy and coverage of vertical measurements are extended to include horizontal measurements as well. A mathematical model is used as a basis. It seems necessary to refine the method still further on the basis of additional physical data. The possibility for mathematical experiments is interesting. Certain mathematical and physical difficulties continue to impose obstacles to a full treatment of the subject.*

and, if necessary, corrected. A first step in this direction has already been made with regard to the dependence of the image coordinate error on the focal length. Finally, the limits of this theory are outlined.

## 2. Angular Field and Efficiency in Horizontal Measurement

This investigation is based on the normal case of two vertical photographs shown in Figure 1 and the basic equations of stereophotogrammetry corresponding to this situation.

$$H = f\cdot\frac{b}{p_x} \qquad X = x'\frac{b}{p_x} \qquad Y = y'\frac{b}{p_x}\,. \tag{1}$$

For judging the results to be obtained with different camera characteristics in photogrammetry, we may use as a basis the so-called efficiency ratio mentioned in[6], viz.

$$L_h = \frac{m_h}{\sqrt{A}} \tag{2}$$

where $m_h$ is a measure of vertical accuracy and

$$A = (1-p)(1-q)\cdot S^2 \tag{3}$$

the plottable area per photo pair.

Analogous to Equation 2, equivalent efficiency ratios can be defined for horizontal measurement. These are:

$$L_x = \frac{m_x}{\sqrt{A}} \qquad L_y = \frac{m_y}{\sqrt{A}}\,. \tag{4}$$

These are likewise functions of the image coordinate error as well as the negative size, the angular field and the amount of overlap. In the following, they will be developed along the lines indicated in the aforementioned publication.

The decisive starting point of the investigation is the image coordinate error, for the $x$-component of which $dx$ is assumed in Reference 6.

$$dx'^2 = F_0'^2 + F_1'^2s^2 + U_0'^2\left(\frac{x}{f}\right)'^2 + U_1'^2s^2\left(\frac{x}{f}\right)'^2 + C^2f^2\left[k_1 + k_2\left(\frac{r}{f}\right)'^4\right]^2. \tag{5}$$

In Equation 5,

$$ds_1 = F_0' + F_1's \tag{6}$$

is the film shrinkage,

$$dr_1 = (U_0' + U_1's)\frac{r}{f} \tag{7}$$

the irregularities of emulsion and base, and finally

$$dr_2 = C \cdot f \cdot \left[k_1 + k_2\left(\frac{r}{f}\right)^{\prime 4}\right], \tag{8}$$

the totality of optical aberrations.

Refraction and image motion* due to translation and vibration are, however, neglected.

Analogous to Equation 5, the $y$-component $dy'$ can be written

$$dy'^2 = F_0'^2 + F_1'^2 s^2 + U_0'^2\left(\frac{y}{f}\right)^{\prime 2} + U_1'^2 s^2\left(\frac{y}{f}\right)^{\prime 2} + C^2 f^2\left[k_1 + k_2\left(\frac{r}{f}\right)^{\prime 4}\right]^2. \tag{9}$$

With Equations 5 and 9, the ground has been prepared for a complete mathematical calculation. After differentiation and application of the law of propagation of errors, with due allowance made for the correlation given by Equation 7, the basic Equations 1 yield the coordinate errors $dx$ and $dy$ in the ground plane.

$$\begin{aligned} dx^2 = \frac{m_b^2}{(1-p)^2 s^2}\Bigg\{&(F_0'^2 + F_1'^2 s^2 + C^2 f^2 k_1^2)\cdot(x'^2 + x''^2) \\ &+ 2\left(\frac{U_0'^2 + U_1'^2 s^2}{f^2}\right)\cdot(x'^2, x''^2) \\ &+ 2\left(\frac{C^2 k_1 k_2}{f^2}\right)\cdot(r''^4 x'^2 + r'^4 x''^2) \\ &+ \left(\frac{C^2 k_2^2}{f^6}\right)\cdot(r''^8 x'^2 + r'^8 x''^2)\Bigg\} \end{aligned} \tag{10}$$

$$\begin{aligned} dy^2 = \frac{m_b^2}{(1-p)^2 s^2}\Bigg\{&(F_0'^{\phi 2} + F_1'^2 s^2 + C^2 f^2 k_1^2)\cdot(2y'^2 + b'^2) \\ &+ 2\left(\frac{U_0'^2 + U_1'^2 s'^2}{f^2}\right)\cdot(x''^2 \cdot y'^2) \\ &+ 2\left(\frac{C^2 k_1 k_2}{f^2}\right)\cdot(r'^4 y'^2 + r''^4 y'^2 + r'^4 b'^2) \\ &+ \left(\frac{C^2 k_2^2}{f^6}\right)\cdot(r'^8 y'^2 + r''^8 y'^2 + r'^8 b'^2)\Bigg]. \end{aligned} \tag{11}$$

However, in the Equations 4 for the efficiency ratios $L_x$ and $L_y$, the measure of

* Under practical flight conditions without image motion compensation, an image motion of 25 microns must normally be expected ($f=153$ mm., $H=1500$ m., $v=160$ $km/h$, $t=1/200$ sec). Frequency transmission thus becomes zero for a frequency of 40 lines/mm. Consequently, only frequencies below this value can be visible (or resolved) in the aerial photograph.

horizontal accuracy is not represented by the coordinate errors $dx$, $y=f(x, y)$, but by their mean values for the entire model area. Thus

$$m_{x,y} = \frac{\int_{y=0}^{\frac{1}{2}s}\int_{x=0}^{\frac{1}{2}ps} f(x, y)dx\,dy}{\int_{y=0}^{\frac{1}{2}s}\int_{x=0}^{\frac{1}{2}ps} dx\,dy}. \tag{12}$$

Integration need not be shown here. It does not present any difficulties, but is very time-consuming for high powers.

The results of the computation are

$$L_x = \frac{m_x}{\sqrt{A}} = (1-p)^{-3/2}(1-q)^{-1/2}\left\{X_1(C^2k_1^2)\cdot\left(\frac{f}{s}\right)^2 + X_1\left(\frac{F_0'^2}{s^2}+F_1'^2\right)\right.$$
$$\left.+\left[X_2\left(\frac{U_0'^2}{s^2}+U_1'^2\right)+X_3(C^2k_1k_2)\right]\cdot\left(\frac{s}{f}\right)^2 + X_4(C^2k_2^2)\cdot\left(\frac{s}{f}\right)^6\right\}^{1/2} \tag{13}$$

$$L_y = \frac{m_y}{\sqrt{A}} = (1-p)^{-3/2}(1-q)^{-1/2}Y_1(C^2k_1^2)\cdot\left(\frac{f}{s}\right)^2 + Y_1\left(\frac{F_0'^2}{s^2}+F_1'^2\right)$$
$$+\left[Y_2\left(\frac{U_0'^2}{s^2}+U_1'^2\right)+Y_3(C^2k_1k_2)\right]\cdot\left(\frac{s}{f}\right)^2 + Y_4(C^2k_2^2)\cdot\left(\frac{s}{f}\right)^6\Bigg\}^{1/2}. \tag{14}$$

$X_n$ and $Y_n$ in Equations 13 and 14 are only functions of $p$. For 60% end lap ($p=0.6$) we have:

$$\begin{array}{ll} X_1 = 0.14 & Y_1 = 0.33 \\ X_2 = 0.0016 & Y_2 = 0.0016 \\ X_3 = 0.00428 & Y_3 = 0.0384 \\ X_4 = 0.000093 & Y_4 = 0.00264. \end{array}$$

Finally, in order to obtain numerical values for $L_x$ and $L_y$, the corresponding values must be selected for the coefficients contained in Equations 13 and 14.

In Reference 6 the following values were used:

$$\begin{array}{lll} F_0' = 1.5\mu & U_0' = 6\mu & C = 0.15 \\ F_1' = 0.3\mu & U_1' = 0.26\mu/\text{cm.} & k_1 = 1.3\mu/\text{cm.} \\ q = 0.2 (20\%\ \text{side lap}) & & k_2 = 1.6\mu/\text{cm.} \end{array}$$

If these values are preserved, the efficiency ratios $Lx$, $y=f(s/f)$ shown in Figure 2 result as a function of $s/f$. If the corresponding differential equation were used in a purely formal manner, optimum angular fields $\beta_x=102°$ and $\beta_y=90°$ could be determined from

$$tg(\beta/2) = \frac{1}{2}\cdot\sqrt{2}\cdot\frac{s}{f}. \tag{15}$$

Taking into account the criterion chosen and the basic data assumed, an angular field of 96° could thus be considered optimal for horizontal measurement. This value agrees very well with that of conventional wide-angle cameras. The restriction applying to this statement will be discussed later.

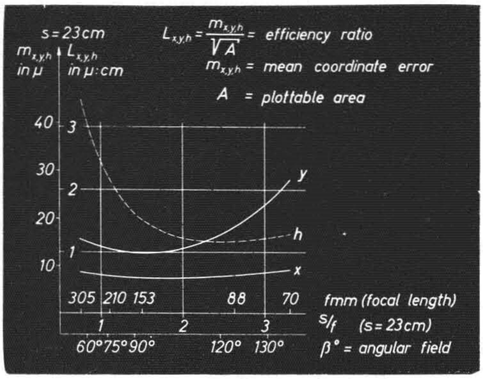


FIG. 2. Efficiency ratio and mean coordinate error as a function of angular field for the 23 cm. by 23 cm. (9 by 9 inch) negative size. (Mathematical model and initial values as in Reference 6.)

## 3. Assumed Image Coordinate Error

Leaving aside the fundamentals of the method used, it is obvious that the result obtained is decisively influenced by the formulation of the image coordinate error, and especially by the component representing the totality of optical aberrations, viz. by $dr_2$ Equation 8.* Whereas the components of film shrinkage $ds_1$ and irregularities of emulsion and base $dr_1$ can be estimated relatively accurately, it is precisely the optical aberrations component for which an appropriate mathematical model can be found only with difficulty.

The formulation of $dr_2$ as in Equation 8 is based on the assumption that the entire portion of the image coordinate error due to optical aberrations is just as much a function of the angle of incidence and focal length as is the resolving power for high object contrast. Although present knowledge of image quality, resolving power, image motion, setting accuracy, irregular distortion and systematic optical aberrations would exclude the above physical arguments, it does not yet offer any better mathematical model. Only one detail can already be corrected now, viz. the dependence of $dr_2$ on the focal length in Equation 8.

A dependence of the image coordinate error in the center of the photo proportional to the focal length of the imaging system can be confirmed† neither by a comparison of aerial photographs (Reference 8) nor by a study of setting accuracy both in the air photo and in the goniometer during distortion measurement. It contradicts our experience to assume that if a share of $dr_2$ in the image coordinate error (in the center of the field and for an identical photo scale) is 2 microns for a photo taken with a focal length of 10 cm., then it is 6 microns for a focal length of 30 cm. It therefore appears indispensable to neglect the dependence on focal length and thus to obtain a corrected model for $dr_2$.

## 4. Corrected Relation Between Angular Field and Efficiency

In accordance with the above statement a new calculation will be made in which the totality of optical aberrations will be introduced as

$$dr_2 = C \cdot \left[ k_1 + k_2 \left( \frac{r}{f} \right)^4 \right] \tag{16}$$

* In addition, the choice of the percentage of end lap is of considerable importance. In this paper, it is assumed to be identical for all camera characteristics (60%). If a higher percentage should be considered necessary for certain camera characteristics, due allowance for this must be made, and considerably less favorable efficiency values may be expected.

† In the overall system, the influence of the eye, the viewing optical system, the film, diffraction and image motion is constant, only that of the aberrations being a function of focal length (and also of optical correction).

in which case it will also be necessary to include the efficiency ratio $L_h$ of vertical measurement in the investigation.

With the image coordinate errors,

$$d'x^2 = F_0'^2 + F_1'^2 s^2 + U_0'^2\left(\frac{x'}{f}\right)^2 + U_1'^2 s^2\left(\frac{x'}{f}\right)^2 + C^2\left[k_1 + k_2\left(\frac{r'}{f}\right)^4\right]^2 \tag{17}$$

$$d'y^2 = F_0'^2 + F_1'^2 s^2 + U_0'^2\left(\frac{y'}{f}\right)^2 + U_1'^2 s^2\left(\frac{y'}{f}\right)^2 + C^2\left[k_1 + k_2\left(\frac{r'}{f}\right)^4\right]^2, \tag{18}$$

we obtain the following vertical and horizontal-position errors, respectively, in the ground plane:

$$dh^2 = \frac{m_b^2}{(1-p)^2 s^2}\cdot f^2\left\{2(F_0'^2 + F_1'^2 s^2 + C^2 k_1^2) + \left(\frac{U_0'^2 + U_1'^2 s^2}{f^2}\right)(x'^2 + x''^2)\right.$$
$$\left. + 2\left(\frac{C^2 k_1 k_2}{4}\right)(r'^4 + r''^4) + \left(\frac{C^2 k_2^2}{f^8}\right)(r'^8 + r''^8)\right\} \tag{19}$$

$$dx^2 = \frac{m_b^2}{(1-p)^2 s^2}\cdot\left\{(F_0'^2 + F_1'^2 s^2 + C^2 k_1^2)(x'^2 + x''^2) + 2\left(\frac{U_0'^2 + U_1'^2 s^2}{f^2}\right)(x'^2\cdot x''^2)\right.$$
$$\left. + 2\left(\frac{C^2 k_1 k_2}{f^4}\right)(r''^4 x'^2 + r'^4 x''^2) + \left(\frac{C^2 k_2^2}{f^8}\right)(r''^8 x'^2 + r'^8 x''^2)\right\} \tag{20}$$

$$dy^2 = \frac{m_b^2}{(1-p)^2 s^2}\left\{(F_0'^2 + F_1'^2 s^2 + C^2 k_1^2)(2y'^2 + b'^2) + 2\left(\frac{U_0'^2 + U_1'^2 s^2}{f^2}\right)(x'^2\cdot y'^2)\right.$$
$$\left. + 2\left(\frac{C^2 k_1 k_2}{f^4}\right)(r'^4 y'^2 + r''^4 y'^2 + r'^4 b'^2) + \left(\frac{C^2 k_2^2}{f^8}\right)(r'^8 y'^2 + r''^8 y'^2 + r'^8 b'^2)\right\}. \tag{21}$$

The next step is the transition to the mean values $n_h$, $n_x$ and $n_y$ over the entire model area by means of integration. After introducing these mean values into Equations 2 and 4, the desired efficiency ratios are obtained as follows:

$$L_h = \frac{m_h}{\sqrt{A}} = (1-p)^{-3/2}(1-q)^{-1/2}\cdot\frac{1}{s}\left\{H_1(F_0'^2 + F_1'^2 s^2 + C^2 k_1^2)\cdot\left(\frac{f}{s}\right)^2\right.$$
$$\left. + H_2(U_0'^2 + U_1'^2 s^2) + H_3(C^2 k_1 k_2)\cdot\left(\frac{s}{f}\right)^2 + H_4(C^2 k_2^2)\cdot\left(\frac{s}{f}\right)^6\right\}^{1/2} \tag{22}$$

$$L_x = \frac{m_x}{\sqrt{A}} = (1-p)^{-3/2}(1-q)^{-1/2}\cdot\frac{1}{s}\left\{X_1(F_0'^2 + F_1'^2 s^2 + C^2 k_1^2)\right.$$
$$\left. + X_2(U_0'^2 + U_1'^2 s^2)\cdot\left(\frac{s}{f}\right)^2 + X_3(C^2 k_1 k_2)\cdot\left(\frac{s}{f}\right)^4 + X_4(C^2 k_2^2)\cdot\left(\frac{s}{f}\right)^8\right\}^{1/2} \tag{23}$$

$$L_y = \frac{m_y}{\sqrt{A}} = (1-p)^{-3/2}(1-q)^{-1/2}\cdot\frac{1}{s}\left\{Y_1(F_0'^2 + F_1'^2 s^2 + C^2 k_1^2)\right.$$
$$\left. + Y_2(U_0'^2 + U_1'^2 s^2)\cdot\left(\frac{s}{f}\right)^2 + Y_3(C^2 k_1 k_2)\cdot\left(\frac{s}{f}\right)^4 + Y_4(C^2 k_2^2)\cdot\left(\frac{s}{f}\right)^8\right\}^{1/2}. \tag{24}$$

With the aid of these formulae, the definite relationship between the chosen criterion and the angular coverage is finally determined. Here also, $X_n$, $Y_n$, $H_n$ are only a function of end lap and for $X_n$, $Y_n$ they are identical with the values shown in Section 2. The following values of $H_n$ for an end lap of 60% can be taken from Reference 6:

$$\begin{aligned} H_1 &= \quad = 2.00 \\ H_2 &= \ \ P_2 = 0.14 \\ H_3 &= 2P_3 = 0.1384 \\ H_4 &= \ \ P_4 = 0.005644 \end{aligned}$$

A final decision is then required regarding the coefficients contained in Equations 22 through 24. In a first step, $F_0'$, $F_1'$, $U_0'$ and $U_1'$ are also taken over from Reference 6 and $C$, $k_1$, $k_2$ adapted in such a manner that identical values are obtained for a focal length of 15 cm.

In the first step we thus have:

$$\begin{array}{lll} F_0' = 1.5\mu & U_0' = 6\mu & C = 1.5 \\ F_1' = 0.3\mu/\text{cm.} & U_1' = 0.26\mu/\text{cm.} & k_1 = 2.0\mu \\ q = 0.2 (20\% \text{ side lap}) & & k_2 = 2.5\mu \end{array}$$

The corresponding functions $L_{h,x,y} = f(s/f)$ are shown in Figure 3a.

Tests have shown that the new polyester bases permit considerably lower film

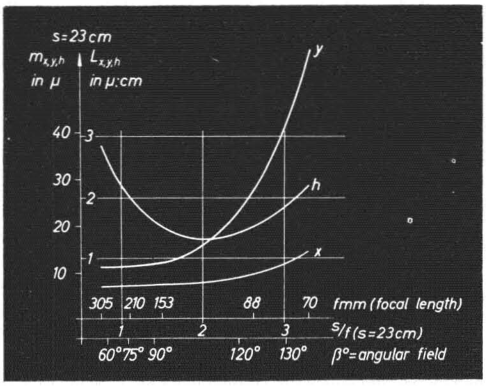


FIG. 3a. Efficiency ratio and mean coordinate error as a function of angular coverage (negative size 23 by 23 cm. or 9 by 9 inches) for the corrected mathematical model (independent of focal length). (Initial values as in Reference 6.)

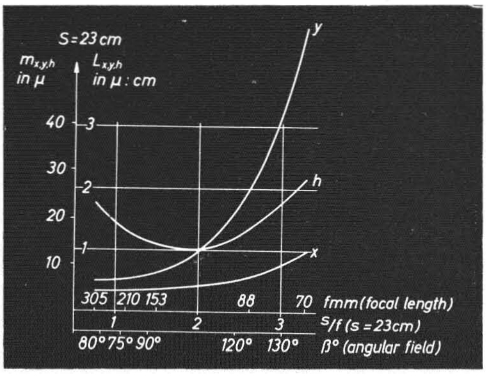


FIG. 3b. Efficiency ratio and mean coordinate error as a function of angular field (negative size 23 by 23 cm. or 9 by 9 inches) for the corrected mathematical model (independent of focal length) and half the values for film shrinkage.

shrinkage values to be used. In order to make allowance for this fact, only half the values of the first step were used in a second step for

$$F_0' = 0.75\mu \quad \text{and} \quad F_1' = 0.15\mu/\text{cm.}$$

while all the other values were left unchanged. The functions thus obtained are shown in Figure 3b.

Finally, we can use Equation 15 in a purely formal manner here to determine the angular fields for which the efficiency ratios reach a minimum. For the first and second step we thus obtain:

$$\begin{array}{lll} 1.\ \beta_h = 111° & \beta_x = 0° & \beta_y = 0° \\ 2.\ \beta_h = 107° & \beta_x = 0° & \beta_y = 0°. \end{array}$$

Consequently, taking into account the chosen criterion and the assumed conditions, a mean angular field of about 60° can be considered to be best suited for vertical and horizontal measurement. This value agrees fairly accurately with conventional normal-angle cameras.

## 5. Limits of the Investigation

At the beginning of this paper mention was already made of the fact that the mathematical model chosen must be compared with experimental results. In the past, when studying errors, image coordinate errors were assumed to be constant; however, comparison with practical measuring results very soon revealed the shortcomings of this method. The aforementioned mathematical model makes far better allowance for existing physical conditions, but further corrections are, without any doubt, necessary.

The high value of a refined model consists in the fact that it allows the effect of the different sources of error to be studied by mathematical experiment. After the introduction of modern stereocomparators of the highest precision, the residual photogrammetric errors must be largely attributed to the photograph. The experiments described above may therefore be of particular interest at the present moment. Mathematical calculations depend exclusively on the model chosen and the assumed numerical data which, varying with cause and effect, make it possible to obtain correspondingly varying results. The results of experimental research show very similar fluctuations. It is our task to restore the casual connection between the two.

### A. Limits of the Criterion

To begin with, it is obvious that the statements made under sections 2 and 4 apply only to those cases in which the decisive criterion is the efficiency ratio introduced as a compromise between accuracy and area covered. If other demands are made,* it is necessary to use other criteria and, as a result, different results for optimum camera characteristics must be expected.

An example of a sphere in which entirely different conditions prevail is that of aerial photography for forestry purposes, for which pertinent investigations (References 5 and 7) have revealed that normal-angle photography must be considered as best. City surveys and the construction of aerial mosaics are other important examples.

Another point to be taken into account is the fact that the above study covers only the errors inherent in the photograph, while the plotting process is considered to be free of errors, thus limiting it to precision comparators. Further research (Reference 1) would therefore be required for plotting with analog instruments, which is of great practical importance.

### B. Mathematical, Physical and Physiological Problems of Accuracy Determination

As mentioned above, the mathematical model under discussion makes allowance for film shrinkage, irregularities of emulsion and film base and, in an additional term, the totality of optical image errors. It thus offers the advantage of relatively easy mathematical treatment. However, there can be no doubt about the fact that the complete process with all its manifold sources of error is much more complex.

A first problem is the question to what extent independent sources of error occur and where correlations must be expected. As regards the irregularities of emulsion and film support and their effect on image coordinate errors, such sources have al-

* For the 23 cm.×23 cm. (9×9 in.) negative size, information on accuracy is directly available from Figs. 2 and 3. For other formats, it can be determined without difficulty.

ready been taken into account. A similar dependence, although in a much more complicated form, should also be expected for the optical errors.

A second problem is the effect of relative and absolute orientation which may be expected to reduce the influence of systematic errors (e.g. regular deformation of the pressure plate). On the other hand, the errors existing at the edges of the picture also become effective in the center of the field due to the influence of the control points. Consequently, the unfavorable conditions at the edges must be assigned greater weight when considering the overall negative area.

So much about mathematical problems.

Whereas the physical effects of distortion, film shrinkage, irregularities of emulsion and film support, image motion, curvature of the earth and the geoid can still be assessed relatively accurately, serious difficulties are created by refraction, particularly in the boundary layer surrounding the fuselage of the aircraft. Other examples are the influence of temperature changes in the camera lens (Reference 3), variations of air pressure, etc.

Furthermore, no answer has yet been found to the important question of the effect of image quality on setting accuracy. Sine wave response may perhaps enable us to find a certain relationship here into which we shall undoubtedly also have to include the haze which degrades the quality of the photograph, above all in the corners (Reference 9). However, solution of this problem is complicated by the fact that the eyes of the operator see two photos of different quality at one time, which fuse to give a three-dimensional image.*

And lastly, experiments (Reference 2) have shown that in this spatial image we will probably also have to expect a non-linear relationship between the base-height ratio and the accuracy of vertical stereoscopic setting. No solution to the entire problem is yet in sight.

### C. PROBLEMS OF ECONOMY

The economy of a given set of camera characteristics is another widely disputed subject. In the aforementioned efficiency criterion this question has been reduced to the simplest terms by merely considering the plottable area per stereo pair. However, there are undoubtedly other considerations which must not be overlooked.

Thus, for instance, subsequent terrestrial determination of invisible points may reduce the economy of a certain set of camera characteristics to a greater or lesser degree. It is no secret that dead spaces due to buildings and vegetative cover are a function of the tangent of the angular field, so that they are less pronounced in normal-angle photography than in wide-angle photographs.

It is beyond the scope of this paper to name all of the factors influencing economy. But there is one aspect which deserves special mention. It is the fact that the choice of the photograph scale (and consequently of the area covered) is not only influenced by the desired accuracy, but particularly by image quality. Thus it is mentioned in (Reference 4) that in practical work the photo scale is chosen so that in plotting not only the required accuracy but also the necessary detail is guaranteed. Modern high-performance lenses have been proved to allow a considerable reduction of the photo scale and, as a result, multiplication of the plottable area per photo pair. It is therefore beyond any doubt that there is also a direct connection between image quality and economy, which has to be taken into account.

In closing it may be said that the problem of camera characteristics has proved to be extremely complex, as was expected. It is hardly possible to indicate one field

* Another part of this problem is the question whether and under which conditions it would be permissible for stereoscopic observation to derive the y-coordinate error from the mean between the right-hand and the left-hand photo and thus to reduce

angle which would be ideal for all purposes. On the contrary, the decision must be made in accordance with individual requirements in each case.

Suggestions such as those contained in Reference 10 to stereophotogrammetry may serve as a general indication, but they would have to be extended to cover single-photograph measurement in the rectifier, and now also the Orthoprojector.

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* W. Löscher: Optimum Field Angle for Aerial Cameras, PHOTOGRAMMETRIC ENGINEERING v. 4, 1964, page 613.

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# *FORUM*

## The Airphoto Index

We take pleasure in reproducing portions of a letter from Prof. Richard L. Threet, Geologist, San Diego State College, to Dr. Gene Avery:

"You and Mr. Richter have done a great service to teachers and students of physiography by compiling "An Airphoto Index to Physical and Cultural Features in Eastern United States," which appeared in the (September 1965) issue of PHOTOGRAMMETRIC ENGINEERING.

"I hope that you have a reprint of the paper which you can send me; and I hope you also send a reprint to my colleague (address enclosed) for he is not a subscriber to the Journal and may not have seen your paper. He recently expressed a need for such an index unaware that you were going to publish one.

"Do you have plans to prepare a similar index for the Western United States? I am sure that Mr. William Tomsheck, Director of the ASCS Western Laboratory in Salt Lake City would be very cooperative."

## APSE Abstract Rates Reduced

The Board of Directors of *Abstracts of Photographic Science & Engineering Literature* (APSE), published by the Society of Photographic Scientists & Engineers, Inc., has taken to reduce the cost of *individual* subscriptions, effective January 1966. The new rates are:

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