FACTORS AFFECTING SPECIFICATION OF OVERLAP AND THEIR ECONOMIC SIGNIFICANCE

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Introduction

CONSIDER a truly vertical pair of photographs exposed at the same height above level terrain. For this ideal case the limiting condition for continuous stereoscopy—in the absence of crab—is 50% fore and aft overlap with the flights just touching laterally.

Apart from the fact that allowance is necessary for the establishment of pass points, departure from the ideal condition results in the necessity for the provision of much larger overlaps, 60% fore and aft and 20% lateral being a usual specification. Factors governing the specification of overlap are relief, tilt, and tracking error. Their effects upon the economics of flying are discussed below.

The path of an aircraft relative to the ground is along the resultant of the air speed and the wind velocity, the angle between the axis of the aircraft and the true velocity vector being known as the angle of drift, or crab. In order that the photographic base lines may be parallel to the format—avoiding loss of overlap from this cause—the camera is rotated in azimuth until the angle between the format sides and the aircraft axis is equal to the angle of drift.

In what follows it is assumed that crab is completely corrected.

Relief

Relief on the ground causes outward displacement of the image point radially from the plumb point. This displacement, from the position which the image point would have occupied had it been on the datum plane, is given by

$$d = r\frac{h}{H} \tag{1}$$

where r is the polar coordinate of the point. Table I gives numerical values in inches for $r = 3.60$ in.

Table I. Effect of Relief
$r = 3.60$ in.

h/H%	d inches	Percent of 9-in. Format
2	.07	—
4	.14	1½
6	.22	2
8	.29	3
10	.36	4
12	.43	5
14	.50	6

Usually the two camera stations are not at the same altitude—but as this variation is small in comparison to H, it may be neglected insofar as loss of overlap is concerned.

To apply the above table, H should be considered as the height of aircraft above the lower terrain levels—which assumes the aircraft to be flying at such height as will give the requisite scale in the valleys. Then h is the height of the peaks above the valleys.

Tilt

The next gremlin is tilt of the aircraft, resulting in departure of the camera axis from true verticality. Consider the ideal pair to have been exposed with a certain overlap. Now if one axis be rotated, in the basal plane, through an angle θ in a direction to reduce this overlap, the loss of overlap in inches is

$$\text{loss} = \frac{W}{2} - (f \tan (\theta/2 - \theta)) \qquad (2)$$

where W is the format dimension in the direction considered, and $\theta/2$ the half angle of the cone along the base line of the photograph, not across the diagonal of the photograph.

This formula is rigidly correct only for the condition stated, i.e. one axis vertical. However, when both axes are tilted, θ may be taken as the relative tilt without sensible error.

Table II gives numerical values for a six inch cone on a 9 in. $\times$ 9 in. format.

Table II. Loss of Overlap Due to Tilt
f 6-in., 9 in. $\times$ 9 in. format

θ Total Relative Tilt, Degrees	Loss of Overlap, Inches	Loss of Overlap % of 9 in.
1	0.16	2
2	0.32	4
3	0.48	5
4	0.63	7
5	0.77	9
6	0.91	10
8	1.19	13
10	1.46	16
12	1.72	19
14	1.92	22

In applying the above table note that θ is the relative tilt. That is to say, considering the lateral overlap, opposing tilts of 6 degrees would result in a 12 degree angle between the axes. So with relative fore and aft tilt, but this latter is not likely to be so large.

Where photogrammetry is carried out by means of three dimensional plotters, the only effect of tilt to be considered is loss of overlap.

Specification for Overlap

Let h/H be 10%, and let it be assumed that opposing lateral tilts of 4° may occur.

From Table I, loss 4% due to relief of 10%
From Table II, loss 13% due to total tilt of 8°
Total effect 17%

While it is but an approximation to add these effects arithmetically, the answer is sufficiently close for practical purposes. We may then conclude that a specification of 20% lateral will result in gapless photography, for the above conditions, *if the aircraft can be kept on course.*

As fore and aft tilt is much smaller, 10% fore and aft overlap, in addition to the basic 50% will suffice for the prevention of short overlap. Further,

neither departure from course nor incorrect setting of the camera in the aircraft will adversely affect fore and aft overlap, whereas both affect lateral overlap.

Departure from Course

In the preceding paragraph it was stressed that 20% lateral overlap is adequate only if the aircraft is on course. Departure from course must occur, and will result in lateral gaps unless the lateral overlap specification be increased.

First consider the loss of overlap due to departure from course—departure being considered as difference between the distance apart of the actual flight lines and their designed distance apart. This, in inches on the photograph, is approximately departure × Scale. The left hand side of the alignment chart Figure 1, shows the effect. For example at 1:15,000 scale a 1,500 ft. departure from course will result in some 13% loss of overlap. (See Fig. 1.)

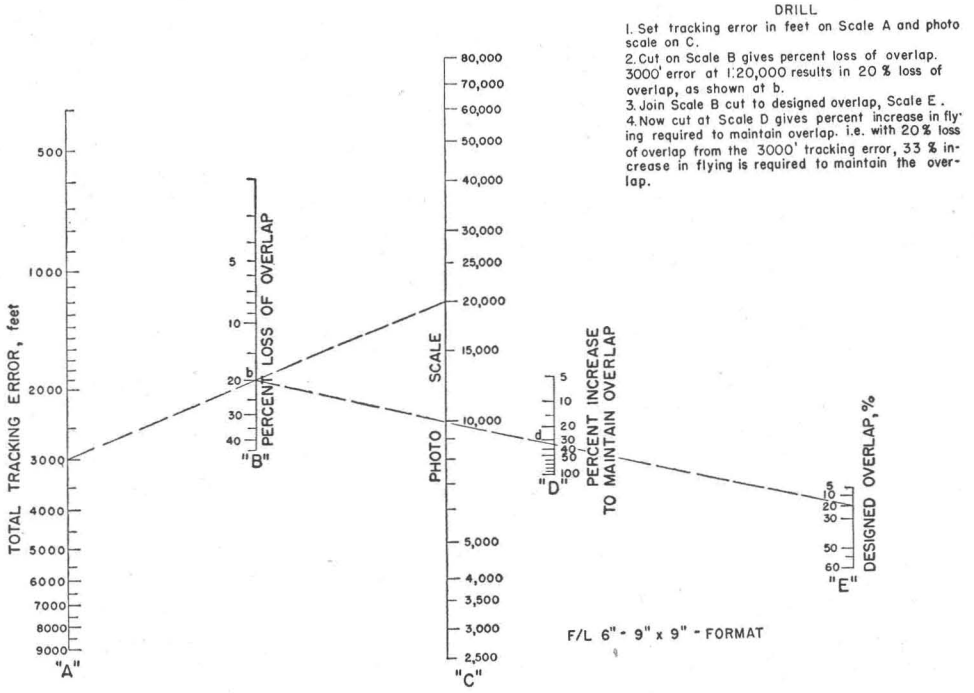

Fig. 1

The designed overlap being 20%—to make allowance for a probable 1,500 ft. departure from course, an increase of 20% in number of exposures, and in flying, is necessitated if gaps are to be avoided. At this time it is pointed out that while flying a gap will fill it, the photogrammetry (whatever the means) is weaker than, otherwise, would be the case. It is further pointed out that mapping costs —again regardless of the method—vary sensibly as the number of exposures. Hence the 20% increase above is reflected in a 20% increase in mapping costs.

For 3,000 ft. tracking error under the same conditions, increase in flying and mapping costs exceeds 50%.

Conclusion

Relief is not under human control, although we may estimate and allow for

its effect with some precision. The magnitude of opposing tilts is controllable, at least to some degree, and present flying aids keep tilt to reasonable proportions.

In unsurveyed country it will readily be seen that departures from course must be expected, and allowed for. Having regard to the figures of the preceding section, it will be seen that departure from course may then be costly, and it follows that any means to improve tracking will be of financial value.

LATE NEWS NOTES

As PHOTOGRAMMETRIC ENGINEERING goes to press, we are pleased to announce Leland R. Smart of the Geological Survey as the second recipient of the Ford Bartlett Membership Award. In a single "matter of course" day Mr. Smart has turned in fourteen new members. Furthermore, he anticipates a good day in the near future.

It is apparent that a surprisingly large number of persons are interested if the advantages of the Society are brought to their attention. A new member is usually assured if presented with an application blank while talking about the Society. The membership Committee Chairman or the Secretary-Treasurer will furnish blanks upon request. Every member is eligible to earn the gold emblem award. You need not be assigned to a committee.

A considerable number of former members from foreign countries are requesting reinstatement to membership. This group became delinquent during the war years when restrictions prohibited transfer of funds from their homelands. From Great Britain, in particular, new members and reinstatements are being received.

In response to inquiries frequently received, it is desired to state that no formality is involved in the case of former members desiring reinstatement. Payment of dues for the current year is the only requirement.

Harry Tubis, recently returned from a trip to Europe, has promised for publication in the September issue of PHOTOGRAMMETRIC ENGINEERING, an article on commercial photogrammetry in Italy.

Several years ago historical articles covering a number of our Sustaining Members were published in PHOTOGRAMMETRIC ENGINEERING. After a lapse of several years this practice is being resumed as a matter of interest to our readers. Attention is invited to the Grant Photo Product article which appears on page 293. Additional articles of this nature will be published as received, and space permits.