PHOTOGRAMMETRIC GEODESY AND GEODETIC PHOTOGRAMMETRY*

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IN CHOOSING the title for this paper, no thought of levity was intended; rather, the aim was to focus attention upon the relationship between these two sciences—geodesy and photogrammetry. One's first reaction, after only a cursory examination of this relationship, is usually framed in a smile. And the smile is prompted by the thought that these sciences are not related—that geodesy is the science of making measurements of ultra high precision and accuracy, while photogrammetry is concerned with measurements that are miniature and graphical in nature and hence of quite low order in precision and accuracy.

This hasty conclusion, even though partially braced by facts, is not true, and for several reasons. In the first place, accurate and precise measurements are not the distinguishing and exclusive properties of any one science—the attainment of better and more reliable measures is earnestly sought in all the physical sciences. Furthermore, it is known that photogrammetry is capable of furnishing measurements of great accuracy and precision—the positional astronomers have proved this. And again, if anyone believes that geodesy has a monopoly on accuracy, let him try to fit new triangulation or leveling to previously fixed work.

Actually, there is a large area of overlap between geodesy and photogrammetry. (Here, of course, is meant photogrammetry as it pertains to mapping and charting.) When any project is considered, these two sciences should be viewed conjointly in the light of the ultimate objective. An attempt should be made to answer this question: Which portion of the total job can be most effectively performed by geodesy and which portion by photogrammetry?

These observations will perhaps become clearer if the aims and techniques of each science are examined separately; it will be seen that the merging of interests and influences is quite natural.

The two primary objectives of geodesy are (1) the determination of the size and shape of the mean-sea-level surface which, by definition, is called the geoid, and (2) the determination of the location, that is, the position and elevation, of certain points on the physical surface of the earth with respect to the geoid.

All are familiar with the conventional techniques of geodetic surveying employed in traversing, leveling, and triangulating, and know that positions and azimuths are frequently determined for geodetic purposes by timed observations of the stars. The determination of such astronomic positions and azimuths is included in that branch of astronomy known as geodetic astronomy.

This suggests a reasonable delineation of the field encompassed by *geodetic photogrammetry*. (It must be understood that distinction between "*Geodetic Photogrammetry*" and "*Photogrammetric Geodesy*" is purely arbitrary, and that, strictly, either phrase is appropriate for the area of common interests.) *Geodetic photogrammetry* may be defined as that division of photogrammetry which is concerned with the geometry of the earth. "But," it will be said, "this includes nearly all pure photogrammetry." Indeed, it does, and should cause no surprise when one recalls the tremendous reduction in ground survey requirements

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brought about by photogrammetry. And, the most exciting challenge in photogrammetry today is to effect further reductions in cost through the development of aerial triangulation techniques to minimize ground control.

Two methods of approach to this problem are being considered at present. One consists of making simple coordinate measurements on the photographs and then carrying on the aerial triangulation computationally by means of electronic computing machinery. The other approach is the optical-mechanical solution by the use of stereoscopic instruments aided in some instances by auxiliary data obtained from solar or horizon cameras, and from radio and pressure altimeters.

In this connection, the inherent potentialities of high altitude photography for control extensions are not being overlooked. Considerable attention is also being given, both here and abroad, to the propagation of errors in photogrammetric control extensions and to the development of appropriate adjustment procedures.

The encouraging trends for improved photogrammetric control extensions, which, incidentally, will take from the geodetic surveyor an ever larger part of his job, are too numerous to mention. One can even look forward to the time when the orientation of aerial photographs can be accurately determined and recorded at the moment of exposure.

It is clear, then, that the impact of geodetic photogrammetry on the second objective of geodesy has been great and beneficial and that this trend will continue at an accelerated pace. But how about the determination of the size and shape of the geoid? Can photogrammetry help in this operation? It certainly can.

Three ways immediately come to mind, and there may be many others. Photogrammetry can be of service in reconnaissance surveys for triangulation, in gravity surveys, and in the determination of geoidal undulations by astronomic leveling. The possible applications to reconnaissance surveys are obvious, so these remarks will be confined to the last two applications.

At points where the intensity of gravity is measured, at least rough positional and elevation data are also required. Meagerly controlled photographic surveys, such as those used so effectively for exploration purposes and for planning in the Point Four technical assistance program, are entirely adequate for the positional information. The elevation requirements are somewhat more stringent, but, for general gravity survey purposes, photogrammetric compilations furnish this information quite satisfactorily.

As to geoidal undulations from astronomic leveling, there is a prevalent notion that deflection of the vertical stations should always coincide with triangulation stations. This is, of course, desirable at Laplace stations where an azimuth check is to be introduced, but in general, triangulation stations are not optimumly located for studying geoidal undulations.

For many such studies, the requisite geodetic positions can be furnished by photogrammetry, either computationally or from photogrammetric compilations of 1:25,000 or larger, which meet the National Standards of Map Accuracy. Then, too, there is the stimulating possibility that the accuracy of astronomic position determinations with the zenith camera will ultimately be suitable for this purpose.

Next, a brief glance at the techniques of photogrammetry and the implications of *photogrammetric geodesy*—that division of geodesy which is concerned with the geometry of photographs.

At present, four distinct operations are noticeable in aerial photogrammetric map compilations. The first comprises the photographic mission; the second, the necessary ground survey control, which, although trite to say so, is definitely photogrammetric geodesy; the third operation consists of establishing the mapping framework, that is recovering the position and orientation of the photography, and this operation has heretofore been in the realm of pure unadulterated photogrammetry; finally, the fourth operation concerns the plotting of the desired topographic and cultural details and is a selective process which overlaps into the techniques of the cartographer.

Geodesy can render photogrammetry very great additional service in the first and third of these operations. This possibility has been brought about by the recent developments in electronic mensuration techniques such as Shoran—both air to ground and air to air. These techniques are applicable to the dual function of guiding an aircraft to a predetermined position and of determining the position of an aircraft at any given time.

Experiments to date indicate that 1:50,000 scale mapping of standard accuracy can now be horizontally controlled in this manner. Of course, a considerable amount of experimentation is still necessary to develop and improve the over-all operational procedures, but the potentialities of these electronic methods for accelerating mapping, particularly in remote, difficult terrain, seem to be limited only by our own timidity.

This ability to establish the horizontal position of the exposure station greatly increases the significance and urgency of obtaining an accurate practical solution to the perennial problem of photographic orientation, independent of ground information. Knowledge of orientation is indispensable for the accurate transfer of position from air to ground.

Also, to take full advantage of the achievements of electronic techniques in establishing horizontal positions, it is necessary that rapid and accurate methods be developed for the extension of vertical control, and considerable efforts are presently being directed to this purpose.

It is hoped that these brief and general remarks suggest the intimate relationship between geodesy and photogrammetry in the field of mapping and charting. Too often, in this age of specialization, sight of the end product is obscured by overzealous attention to one speciality out of the many that may be involved. There is also the tendency within a particular discipline to emphasize certain features without due consideration of the desired goal.

Modern mapping has advanced in the last few decades from the relatively simple processes of the topographic surveyor to those of a highly complex enterprise which cuts across the fields of many disciplines. It has become an operation requiring the closely coordinated teamwork of many specialities.

In these circumstances, and with the increasing demand for maps, it is imperative that inventory be taken at intervals to properly assess and to group the demands, and to ascertain the suitability of the currently used techniques. It may be necessary to revise old specifications or to establish completely new specifications.

In any event, we are confident that geodesy and photogrammetry will go forward as vigorous partners in speeding the commerce of the world and in safeguarding the security of the free world with adequate maps and charts.