Francis H. Moffitt
President
American Society of Photogrammetry

Photogrammetric Mapping Standards*

A program for developing photogrammetric mapping standards directed towards large-scale mapping in the private sector is outlined.

The subject of Standards for Photogrammetric Mapping has been of concern to map producers in this country ever since the early 1930's when farsighted practitioners saw the potential superiority of the photogrammetric process over field methods. Of course, photogrammetric maps were produced even before standards existed for their preparation. The first concrete set of *accuracy* specifications was published in 1941 by the Federal Bureau of the Budget and was referred to as "Standards of Accuracy for a National Map Production Program." A modification of this set of standards was reported out in 1947 and is referred to as "National Map Accuracy Standards." It is presently applied to all topographic mapping produced by government mapping agencies, and is used by many state, county, and private agencies involved in the production of or the use of maps. These standards could probably be applied to a substantial amount of mapping performed by members of the Council, particularly in the area of relatively small scale mapping (1:10,000 or smaller). However, much of your mapping is done for detailed engineering studies for which small-scale mapping is not appropriate. And the National Map Accuracy Standards are not always suitable for this type of mapping.

You will note that I dwell on the accuracy aspect of photogrammetric mapping and not on such things as line widths, content, color, and the like. This is simply because I feel that specifications and standards for these latter items are usually not subjects of dispute between the mapmaker and the user/client, and are not nearly as serious as an inaccurate map because they are fairly easy to correct.

There are relatively few causes for serious inaccuracies or errors in maps produced by the photogrammetric method. If we can assume that the flying height-vertical accuracy relation is reasonable, based on past systems performance, then these causes can be reduced to the following:

- Bad control, whether obtained by direct field surveys or by some type of aerotriangulation (which in itself may be based on bad field surveys);
- A warped stereoscopic model;
- Uncompensated instrument-lens distortions; and
- Ground cover.

The field control is placed either by the mapmaker or by the client. In the former case, the mapmaker is at fault for bad control, and in the latter case, the client is at fault. This latter situation can be dealt with by including the appropriate wording in the written agreement between the contractor and the client.

A warped model can be prevented by specifying adequate model control such as three horizontal control points per model and at least five vertical control points, one in each corner and one in the middle.

Lens distortion should have only a slight effect on the accuracy of a map if a modern "distortion-free" camera lens is used for obtaining the photography. And a plotting instrument should always be kept in reasonably good calibration as a matter of prudence.

Ground cover can be handled either by expensive supplementary field completion, or else by allowing for this troublesome source of error by loosening up on the standards of accuracy in these areas. There are occasions when the area covered by vegetation *must* be mapped to the same degree of

* Presented at the Annual Meeting of the Legislative Council for Photogrammetry, Teton Village, Wyoming, 8-11 July 1979.

Photogrammetric Engineering and Remote Sensing,
Vol. 45, No. 12, December 1979, pp. 1637-1640.

accuracy as the rest of the map, as in the use of the map for determining pay quantities. This must be understood, then, by the client in order to justify a higher price tag on the mapping.

Of the four error sources cited above, the contractor can protect himself in three instances by properly written specifications. Instrument-lens distortion errors, of course, are fully the responsibility of the mapmaker.

It would be ideal if the contractor could charge enough for a map to allow him to make a complete check on the accuracy of the map before delivery in order to give him the opportunity to evaluate his system and correct the deficiencies. This, however, is just not feasible in the majority of mapping projects. I would like to quote a letter which I received from a member of a private mapping firm regarding this point.

"The government agencies often do a lot of field checking, I'm told, that could provide feedback on the quality of work they perform. However, it may not be entirely valid to apply the results of such checks to private industry in that government agencies are not under the same pressure to provide quality services and still show a profit. I don't doubt the dedication of many government employees, but I don't think that most of them are under the same pressure to perform as we are. Field checks are seldom performed by private mapping firms due to the expense. In my own experience with a number of private firms, I have seldom seen a map bounce as a result of checking on the part of a client. This may speak well of the expertise of the firms with which I have been associated, but it may also indicate that our clients have had such faith in our abilities that they didn't feel the need to do much checking. If the latter case is true, someday somebody is going to be put out of business by a lawsuit that could have been avoided."

Well, I don't have to tell you that this can happen. Clients can be very changeable in their attitude toward the quality of your work. All it takes is an error in one small corner of one lone model resulting in costing the client some money, and the worm will turn.

I had occasion to make field tests of a very large mapping project outside of the United States done by a foreign private mapping firm. I found the maps which contained 5-metre contours to be entirely inadequate for their intended use, with vertical errors of as much as 40 metres over large areas. We are talking about 130 ft errors. In a discussion with a private photogrammetrist regarding this project, I was told that, probably because of the remoteness of the area, the contractor did not expect the work to be checked anywhere except in those areas that were reasonably accessable and, incidentally, where the control was available. I was told further that this attitude is fairly common. Now, a job of this size could in truth put someone out of business with a lawsuit.

Having discussed some points regarding this business of map accuracy, I would like to set forth some reasons why I feel a need for up-to-date standards for photogrammetric mapping, particularly in the private sector as represented by members of the Council.

(1) You deal with a wide variety of clients with different backgrounds. Many of these clients are managers and planners whose technical background in mapping is very limited if it exists at all. These clients depend entirely on your advice and expertise. As a professional, you are bound to operate against a set of standards for the protection of your client (and, not incidentally, for your own protection). Probably most of your clients do have some sort of a technical background which makes your job of communication somewhat easier. They are more likely to hold you to a set of standards on which you have mutually agreed. Then we have the civil engineer client who is supposed to know what a map is, what is involved in its production, and what map accuracy means to his operation. He will surely hold you to map standards.

In the litigation described by Gene Lafferty in the *Photogrammetric Coyote* (Vol. 1, No. 4) and in the responding article by Vern Cartwright (Vol. 2, No. 1), the engineering firm ran into trouble on earthwork which was based on a map which in no way was prepared for the development of grading plans. At the trial, the jury was convinced that there was no reason to assume that the civil engineers should know anything about the accuracy of a map because that was the expertese of the photogrammetrist. So, even in dealing with civil engineers, trouble can develop.

(2) The development and universal application of a set of mapping standards for the profession will lend more credence to a map, and will give a quasi-legal standing to the standards. I am convinced that in the litigation cited above, if such a set of standards had been in existence, the photogrammetrist would have had a better chance to successfully defend himself. We live in an era of consumer activism. Litigation is much more

prevalent than it was when the National Map Accuracy Standards were first published. These standards are the most widely used throughout the profession at present. But other conflicting standards exist for individual agencies which can be used in court to confuse a jury.

(3) Photogrammetry can offer a wide variety of products in addition to the standard topographic map. These include digital and graphical profiles, digital and graphical cross-sections, digital and graphical flood plain limits, orthophotos and mosaics with or without superimposed contours, and digital terrain models. Very few standards exist for these products, and yet the private photogrammetrist is heavily engaged in the development of these varied products.

(4) We are all coming to depend more and more on the establishment of model control by analytical and semi-analytical methods, simply as a matter of economics. The Standards Committee of the Digital Processing and Photogrammetric Surveys Division of the American Society of Photogrammetry is at present developing standards for establishing geodetic control by analytic aerotriangulation methods. These standards will serve the industry when you are engaged in establishing, by photogrammetric measurements, the positions and elevations of subdivision monuments, in performing cadastral-type surveys, or in establishing control for construction surveys.

(5) Universally adopted standards will raise the professional level of the entire photogrammetric community in public and the private sector.

Recognizing that 36 percent of the members of the American Society of Photogrammetry are drawn from the members of the private sector, I've appointed a Task Committee on Photogrammetric Standards to develop standards for the private photogrammetrists as well as for government agencies. The committee consists of the following:

Chairmen:

Dr. Dean C. Merchant, The Ohio State University (Educator)
Mr. Morris M. Thompson, Formerly USGS (Federal Government)
Mr. L. R. Evans, Madison, Wisc. (Private Practice)
Mr. Richard G. Crouse, your President
Mr. Elmer M. Clark, Englewood, Colo. (Private Practice)
Mr. Alex R. Hoffman, Oakland, Calif. (Private Practice)
Mr. Robert F. McGivern, Rochester, N.Y. (Private Practice)
Mr. Donald Reid, Aneheim, Calif. (Private Practice)
Mr. Francis Moffitt, Berkeley, Calif. (Educator)

Dr. Merchant has had a considerable amount of experience with studying mapping standards through his work with the American Society of Civil Engineers. Morris Thompson, the only other non-private photogrammetrist besides myself, is well-known to you all. He is Mr. Standards of the USGS. We are fortunate to have him serve on this committee.

The tentative procedure outline which we have developed is as follows:

I. Develop standards for conventional line maps produced by photogrammetric methods.
  A. Develop and define map classifications.
    1. For each intended map use, specify:
      a. Appropriate ranges of scale and contour interval
      b. Content
        Reference system, planimetric data, hypsographic data, names and labels, marginal data, symbolization, colors, legibility, esthetic factors.
      c. Horizontal accuracy
      d. Vertical accuracy
  B. Develop inspection, testing, and checking procedures for each class of map.
    1. Specify testing organization, instruments, and/or operations for checking and testing
      a. Horizontal accuracy
      b. Vertical accuracy
      c. Content: appearance, completeness, and correctness
    2. Specify procedures and a time limit for rectifying discrepancies and errors.
    3. Specify a time frame for accepting or rejecting a map.
  C. Develop schedule of materials to be delivered.
    1. Aerial photographs and photoindexes
    2. Ground control

3. Manuscript map
4. Reproductions

II. Develop standards for photomaps
   A. Uncontrolled mosaics
   B. Controlled mosaics
   C. Orthophotographic maps, orthophotomosaics, orthophotoquads, orthophotomaps.
   (For A, B, and C, develop classifications, checking procedures, and schedule of materials, following the outline for I, as appropriate.)

III. Develop standards for aerial photography.
(Adapt existing standards.)

Since the goals of both ASP and LCP are pretty much the same in the matter of Standards, I would like to see a cooperative effort develop between the two organizations. I would at this time like to pledge our cooperation with the Council.

Thank you for the opportunity to discuss this with you.