

training, experience, and conscientiousness. The amount and kind of information that can be obtained from maps, however, is restricted by the impossibility of representing on maps everything which is contained on photographs; by the purpose for which the maps were prepared; and by the abilities of those who contribute to preparation of the maps (surveyors, map compilers and cartographers) and users of the maps. Thus, there are many sources of variables in maps which means there are omissions and uncertainties in true representation and interpretation.

Aerial photographs, both oblique and vertical, are excellent illustrative mediums, particularly the obliques, because they provide a comprehensive view in perspective of the land and the things on it—the view to which we are all accustomed. Maps, even though they may contain contours to outline the shape of the ground at intervals to represent its successive levels, are still flat and unrealistic to most people. They only convey proper concepts to the experi-

enced user.

With such comparisons in mind, it is possible for all of us to agree today that in the highway engineering field, photogrammetric methods of using aerial photographs, and of using maps compiled and measurements made photogrammetrically by use of the photographs are inseparable companions for supplying highway engineers with nearly all the information and data they require. And, to attain this full use of photogrammetry, highway engineers and photogrammetric engineers must have full mutual understanding of requirements, possibilities, and limitations in each profession.

I am sure that the panel members are well qualified to amplify these comparisons and give specific applications in many, if not all, of the specialties in highway engineering where photogrammetry and aerial surveys will serve efficiently, save time and manpower, and comprehensively provide, to the accuracies required, what is needed for the engineering of highways.

*Photogrammetric Engineering Firms' Contribution to the New Highway Program**

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THIS paper will be somewhat provocative. I did not travel 3,000 miles merely to relate statistical data available to anyone in Journals and recorded legal documents. Such statistical material as I have is largely taken from the Federal Aid Highway Act of 1956, and from a paper by C. L. Miller, entitled "A Study of the Private Photogrammetric Mapping Activity in the United States."† Also I have made

some slide-rule calculations and have drawn some conclusions. The prevailing context, however, will be largely the personal opinion of a practicing engineer—a man who has spent the last twelve years in pioneering, financing, undertaking, and completing some two-and-a-half million dollars worth of engineering project mapping by photogrammetric methods. This opinion *may* be representative of the professionally-staffed, medium-sized, photogrammetric engineering firm in the United States. I *am sure* it represents opinions of

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some in this category.

In 1945 four photogrammetric concerns were practicing in the United States. Thirty-two were listed in 1955. Since that year undoubtedly a dozen or more companies with Kelsh stereoscopic plotters have come into existence. Our company was started after the war and has been engaged entirely in various photogrammetric projects with private industry. We attained immediate success and the company has grown and expanded through the years; it has developed a fine reputation of professional ability to produce maps and surveys by means of photogrammetry. I believe we can honestly say that the first successful highway projects mapped for Oregon, Washington, and California were mapped on an experimental basis by our photogrammetric engineering firm.

Our company together with the 31 other listed concerns, which in 1955 were practicing in this country, now stand at the threshold of a great upswing in photogrammetric activity. This is due to the President's highway program, and the emphasis on the utilization of photogrammetry on a private enterprise, professionally qualified, basis. The shapers of this program have the opportunity to develop an efficient, capable, professional industry for undertaking public works projects of all sorts. The term "opportunity" is used to indicate that there is a choice. The alternative to a strong, capable, professional-type industry is 500 new inexperienced and perhaps poorly equipped businesses, climbing on what they think will be a gravy train to quick-return money. If this alternative is taken, those who pioneered a professional industry, will soon lose interest and drop out.

Engineers and professional people are by nature not the sharpest of business men. We are indeed somewhat visionary; we value our standards and reputation in some cases more than we value our pocketbooks. As an example I have sent field survey crews to check on the ground the area included in a stereoscopic model because a poor set-up, shadows, or other obstructions made photogrammetric compilation difficult. Some engaged in photogrammetry tell me that I should not take this action—"let the Highway Department check it; the chances are very good they won't check in that area anyway, and you can get by." Unfortunately, the sharpsters to date, under map-making by competitive

bid, have been absolutely right and I wrong. If the bulk of the highway program presents me with the incentive to chisel, as competitive bidding does, our firm wants absolutely no part of it.

Let us consider the program. Using rule-of-thumb and slide-rule methods of computation, the Federal Aid Highway Act of 1956 can be expressed as approximately 400,000 man-days of large-scale mapping work, including 80,000 shifts or man-days on compilation equipment. How much of this workload will be absorbed by various government agencies is not evident. It will be much simpler and more efficient for private enterprise to grow into the program than to set up permanently expanded Federal or State facilities under civil service. If existing private facilities were to undertake this work today a period of three to five years would be needed for completion. (The 1955 inventory of photogrammetric facilities is the basis for this estimate.) The following conclusions then become obvious:

1. The bulk of the work load in utilization of photogrammetry on the highway program will fall into the hands of private photogrammetric engineering companies.
2. To attain the fullest practicable utilization of photogrammetry, the private industry production capacity must be doubled, tripled, or even quadrupled.

Expanding an enterprise or an industry by the development of new enterprises requires:

1. Capital
2. Availability of equipment
3. Trained personnel

Capital is probably the most important; not only its availability but the type which goes into professionally competent photogrammetric enterprises. In this category, the photogrammetry profession and the construction industry are in exactly the same position. The money market is very tight; through legitimate means, it will be difficult to obtain bank loans for expanding facilities to the extent required by the highway program.

This problem of capital can be helped very greatly by highway departments through liberalizing progress-pay-procedures, thereby releasing working capital for utilization in equipment expansion. Photogrammetry in many instances, under typical highway competitive-bid contracts, is

more difficult to finance than most highway construction contracts. Quite frequently, the greatest outlay cost-wise is involved in the establishment of geodetic control, levels and bench marks, etc., not only for the purposes of controlling the photographs but also for tying in location surveys. This is usually a non-pay item under progress-payment, so the contractor performing professional photogrammetric services must realistically consider tying up as much as 50 per cent to 75 per cent of the anticipated gross income from the contract, before he starts getting progress-pay from the highway department. Serious consideration to this item will ease the capital problem for purchase of equipment to accomplish the essential expansion.

It is not healthy or desirable for the photogrammetric profession to attract too much of the boom venture capital-type of investment. Investors of this sort generally seek a quick capital gain on their investment and are not likely to be the type of stockholders that have patience with the careful and responsible management needed for handling the job of preliminary survey mapping for highway design.

Our company, and I believe many similar firms, will require some liberalization in present-day banking policies, in order to adequately expand to meet the needs of the states in our locality. Very few banks will consider expanding loans based on the prospects of contract awards being made on the basis of competitive prices only, rather than on competence and ability to perform.

The second and equally important item necessary for this expansion program is the availability of equipment. I think that all photogrammetric engineers will agree that the workhorses of this highway program will be the Kelsh and the Balplex stereoscopic plotters. These are produced by two firms in this country and the delivery schedule from these firms is already at least six to ten months behind schedule. It is a tragedy, in my opinion, that the European photogrammetric instrument makers seem to be competing to make the ultimate instrument—one that will supersede and do the work of all other instruments. (Apparently the aim is an instrument that is capable of measuring contours at a one-inch interval using photographs of the moon.) The alternative is a simple, precise plotter, capable of working on the production line and producing the kind of maps

needed for performance of essential engineering in the highway program. It is my understanding that some Government agencies have surplus quantities of Multi-plex and other photogrammetric instruments usable for highway mapping which could be made available to firms undertaking portions of the program.

For both photogrammetry and geodetic survey work, an inadequate supply of qualified personnel is probably the most serious obstacle to rapid expansion of photogrammetric engineering firms. At present, a number of firms, including our own, have a training program. We are working with the technical high schools and the local colleges, attempting to get men who are willing to devote some time on their own to training in stereoscopy and to learn the various practical processes of photogrammetry. By another four to six months we hope to have some tangible results from this training program and obtain a part of the greater capacity under proper supervision needed to carry the additional load.

Lack of a good program of apprenticeship and training in the photogrammetric engineering profession is one of our biggest weaknesses. We have been too prone to rely on men trained by the Army Map Service, the 29th Engineers, and the Geological Survey. As a matter of principle we should stand alone and train our own people. Also we find that men trained in stereo compilation only are not what we want in large-scale mapping for highway design. Instead we need men who have a good background of experience in general survey work, who know the objectives of highway location and mapping for preliminary survey purposes and who can go into the field as well as into the photogrammetric instrument booth, and understand what is going on. The man trained in cartographic work with the Army doesn't have a sufficiently broad background for competently handling the kind of job we need in making control surveys and mapping for highway engineering purposes.

In the past six months, I have traveled in almost every state in the West and in some of the Eastern and Middle-Western states. I have utilized such opportunities as I had to visit highway departments, other photogrammetric engineering concerns, and governmental photogrammetric institutions. The talk everywhere is the tremendous amount of surveying and mapping to be done for the highway pro-

gram; in some instances I have noted intelligent and sound expansion in this direction by some of the older organizations. Many things, however, are quite disturbing:

1. On my desk are letters and brochures from at least 15 new companies organized in the past six months, purporting to be professional photogrammetrists, buying equipment like mad, "stealing" personnel from older, substantial firms, and "trying to climb on the band wagon." Some of these firms obviously are staffed by good professional people and are seriously engaging in photogrammetry as substantial, qualified, careful producers of maps. Many others, I fear, will do no more than mess up the price structure and give to photogrammetry a bad name wherever they go. This has happened too often in the past.
2. On the Pacific Coast, and perhaps elsewhere, we are now finding Kelsh stereoscopic plotters in the basement, in apartment houses, and perhaps in the corner drug store. We, and I presume other firms have experienced losing some good compilers who have been sold a bill of goods by some financier, who have bought plotters and set them up in their homes, and who are going to the highway departments saying they are professional photogrammetrists. I am not worried about their capacity for undertaking enough projects to hurt our businesses in the long run. I am more worried about what they may do to some of the essentially critical jobs and to our profession of photogrammetry. In 12 years' experience I find that to undertake this kind of work requires a competent, integrated organization, including field control men, adequate laboratory facilities, competent layout men and draftsmen, and, of course, compilers. I sincerely hope the fellows with a plotter in their living room are successful for their own good, but for the good of the entire profession I am quite disturbed by this trend.
3. There is a need for better understanding between private professional photogrammetric organizations and State and Federal highway mapping institutions. Some states have been over-

sold on photogrammetry and feel that the purchase of one Kelsh instrument solves all of their problems. In some instances, they will find themselves in the same position as the compiler with a plotter in his basement. When they finally wake to the realization that photogrammetry requires an organization rather than a single plotter, it may be too late to get much help from private effort. Each state should call in for consultation a number of qualified, reliable, private firms to discuss impartially the capacities required for its program, and to map out a plan whereby joint state and private facilities can undertake the load with the least amount of expansion.

So far, my comments have been largely critical. Let us now turn to more constructive thinking and see what we in professional photogrammetry aspire to attain.

At present, the primary incentive, under competitive bidding, has been for lower and lower prices. It has been assumed that the result of 50 pages of specifications plus a mammoth checking organization will be good work. In preparing bids we must figure on getting by with the highest possible *C* factors and the bare minimum of control. In engineering design we always use safety factors; if we use a margin of safety in figuring the cost of mapping a project by photogrammetric methods, we won't get the job.

When the project is finished, if proper records and checks are made, we know exactly how good the job is; we know all of the weak spots caused by shadows, ground cover, faulty picture pointing, and so forth. Also we know the areas that are strong and will meet the most rigid accuracy tests. To get by under competitive bidding, these facts must be kept top-secret; there begins a gigantic guessing game between map checkers and the contractor. If the check profiles hit a weak area, the checking officer assumes the entire job is weak, and sheets are rejected right and left, and the contractor loses a few thousands of dollars. If, on the other hand, if the first profiles hit a strong area, the work is hailed as a monument to photogrammetry and a few dimes and a reputation are made by the contractor.

Real engineering checking in other fields requires a close liaison between designer and checker. We need to have enough

money in a photogrammetric budget so that we can check our own weak spots and take full responsibility for the work. We want to be able to give the checking engineer a full report on the good and bad aspects of the project without the fear that some accidental error may cause severe financial losses. We want the incentive to produce quality control survey's and maps rather than to "get by" with the minimum.

We don't aspire to have 50 plotters and a mass production line for professional work. On the contrary, as the years go by, we want our seal to become the guarantee of good, reliable quality in all of our services.

To work for us we want to attract the kind of men from the schools and colleges who treasure pride of workmanship above anything else. We want to instill in these men the desire to succeed by hard, careful, and accurate work and a strong sense of integrity in their relationships to us and to our clients.

We don't want to be forced to employ men who make their reputations by clever ways in getting jobs accepted, or in their abilities to get around specifications.

We want our employees to take pride in working for an organization which aspires to turn out the best product—not the cheapest.

We desire to make a reasonable profit on quality work. We can then reward men of outstanding ability in our organization and develop the necessary revenues for improvement in facilities and equipment.

Returning in conclusion to the thesis of the opening paragraphs of this paper, the challenge of responsibility rests squarely on the shoulders of those holding the purse strings in the various state and federal agencies, directing the expanded highway program. The next 12 to 15 months will tell the story of how this expansion will work out with the photogrammetric industry. Are we going to attract "bandwagon riders" and "get-rich-quick venture capital" into a professional field, or are we going to see an orderly and responsible growth of qualified and competent professional firms as a result of this large volume of vitally important work?

MR. PRYOR:

I am sure many people here this afternoon feel well reimbursed, if Mr. Wood is not so financially, for his three thousand mile trip here. I personally concur in a majority of what Mr. Wood has said. There

are two things, however, that I would like to amplify a little.

Number one: Photogrammetry is an engineering profession. Let's think of it and talk about it as such. Then other people, those who do not understand photogrammetry, will have a better impression of our work.

Number two: Competitive bidding is not shall we say, the proper way in which to offer or engage professional services. They should be negotiated for on (1) reputation, (2) ability to perform, based on previous qualifying performance and (3) present capacity. We might say, therefore, that some particular photogrammetric engineering firm that already has more work than it can do is not qualified for your new job. It is already working to capacity.

The specifications prepared and published as a Reference Guide Outline and recommended to the State Highway Departments, suggest that in their use the Department request from the photogrammetric engineering firm with which negotiations are being made, a statement of that firm's experience, financial resources, personnel and equipment available for the work and other qualifying information that will serve as a yardstick of ability and responsibility for performance to the contract on time and in accordance with specified requirements.

Then, on the basis of this submission, the Highway Department may judge the qualifications of that firm for the particular work required.

This recommended procedure requires a mutual understanding between the two engineering professions—photogrammetry and highway—of the advantages, the possibilities, the limitations, the pitfalls, and so forth. The sooner we bridge the gaps of understanding, the sooner we can weed out some of the problems that Mr. Wood has pointed out as existing today. When a firm bids competitively, they know that they have to "cut corners," and in "cutting corners" accuracy and quality are sacrificed. Consequently the kind of highway engineering that can be done based on inferior photogrammetric work will be inferior likewise.

Actually, in my experience, where photogrammetry is fully and properly used, it always pays back many dividends in the quality of highway engineering that can be accomplished on the foundation of good photogrammetric engineering.