*Education in Photogrammetry**

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Introduction

At the outset for purposes of discussing education, it is necessary to divide the subject of photogrammetry into two parts; these can be discussed separately. This bifurcation is necessary because of the inherent differences in the subject matter and in the type of students, training, and job opportunities for the two branches of photogrammetry.

The two aspects of education in photogrammetry fall into the headings (1) quantitative photogrammetry (commonly called simply "photogrammetry") and (2) qualitative photogrammetry (more commonly known as "photo interpretation"). Quantitative photogrammetry is basically a measuring problem. Fundamentally it involves the making of measurements on a photograph, comparing these with a limited number of measurements on the subject of the photograph—which usually is the ground—, and then establishing the space relationships of angles and distances necessary for translating the photographic measurements into equivalent subject distances. Quantitative photogrammetry increasingly is requiring greater precision and the consideration of more refinements in the mathematics, the instruments, and the procedures for attaining the desired end. There is an increasing trend toward analytical or computational photogrammetry apparent both in the United States and abroad. Therefore photogrammetry will be requiring men more highly trained in engineering and the sciences.

Qualitative photogrammetry or photo interpretation can be restricted almost exclusively and immediately to airphoto interpretation. The scientific principles behind airphoto interpretation are new upon the scene of photogrammetry within the past decade. Although most of the principles are simple and straightforward, nevertheless it is necessary for a photo interpreter to have experience in looking at both stereopairs of airphotos and at the ground. It is also necessary for him to have experience in evaluating and correlating. Competence requires a basic training in some field of study, including geomorphology, together with an ability to analyze and correlate all of the information shown on the photographs.

Instruction

In the same manner that it was necessary to divide the general subject of photogrammetry into the two headings, photogrammetry and airphoto interpretation, so also it is necessary to divide the teaching of photogrammetry further into two levels of instruction; (1) undergraduate and (2) graduate.

Undergraduate instruction in photogrammetry considered as a basic measuring problem is conducted in the United States, primarily at schools of civil engineering and usually in the surveying courses. There are many exceptions to this statement. For instance, there are at least two schools of mining engineering which have the equipment and personnel to teach photogrammetry to their students. Also, there are a few schools of geology, agriculture, and forestry where a limited amount of photogrammetry as a scientific subject is taught. Contrariwise, there are altogether too many schools teaching civil engineering which give little or no instruction in the fundamental principles of photogrammetry. This may not be quite so surprising when it is realized that a substantial number of schools of civil engineering have eliminated completely or substantially, the teaching of surveying to their students. Rightly or wrongly it could be asserted that generally only students in engineering have the necessary background in mathematics and sciences to adequately grasp the mathe-

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matical, optical, and spatial concepts involved in a complete photogrammetric operation.

Graduate instruction in photogrammetry is restricted to perhaps no more than five or six schools in the United States. Only two of these, Cornell and Ohio State University, provide an opportunity for a man to pursue studies in this field sufficient for obtaining a doctoral degree. At present, as will be pointed out later under Employment Opportunities, it is not probable that there will be any great increase in the number of schools giving graduate work in photogrammetry.

The teaching of photo interpretation is rather widely diversified at different schools throughout the country. For instance, photogeology is taught by geology departments. Airphoto interpretation for foresters is taught at forestry schools. Similarly a few schools of agriculture teach photo interpretation courses for agronomists and soil scientists. There may be a few others, but, as far as the broad planning aspects are concerned, photo interpretation is taught at schools of civil engineering. This is natural since the development of broad engineering plans falls logically in the field of civil engineering, and airphoto analysis is the most powerful tool available for planning extensive civil works.

Again *graduate instruction in photo interpretation* is restricted to extremely few schools, with Cornell and Purdue probably providing graduate training for more students than all other schools in the United States combined.

Research

The picture so far as research is concerned in educational institutions is rather easily described. This applies equally to quantitative photogrammetry and to qualitative photogrammetry. The schools doing the majority of research are probably Ohio State University, Cornell, Michigan, University of Rochester, Boston University, Purdue, and perhaps three or four others. This means then that research is being conducted at perhaps only a dozen schools in the country where it can be directly related back to teaching and immediate improvement of the staff members and students.

In addition to the few universities, some government agencies have research organizations of their own. A very few photogrammetric companies have what might be termed self-sufficient and basic research organizations, but several more are conducting sponsored research for government agencies. Finally, there are a few unaffiliated research institutes doing research in some aspect of photogrammetry. It is probably safe to say that 99.44% of the research is either by, or with financial support by, government agencies, with an overwhelming proportion of this being sponsored by the military.

Unfortunately, the results of a preponderance of the research in photogrammetry presently being conducted, is very slow in being passed on to the teachers. This is unfortunate because it is at the teaching level that the ideas and new developments can be passed on to the students to prepare them for being most useful five or ten years in the future. More could be said about the relationships of research and education but that is beyond the scope of this paper.

Students

Next the students who may be taking studies in photogrammetry. Again it will be useful to divide into two groups: (1) those taking photogrammetry, and (2) those taking airphoto interpretation. It is also again convenient to divide the students into two levels of instruction: (a) undergraduate, and (b) graduate students. It is of course obvious that what was said above about instruction must apply to the students being considered here because without the students there would be no teaching and vice versa.

Now let us consider a little further the type of student, his motivation for taking the course, and how he expects to make use of the knowledge he gains upon the completion of his formal studies. A further subdivision of the students becomes apparent since the courses may be: (1) required, and (2) elective.

The *undergraduate students* in civil engineering who take photogrammetry as a required course or as part of a required course in surveying for the most part have the same feelings toward this course as toward any other required course. Since photogrammetry is somewhat more glamorous than some others there may well be more interest generated and a resulting stimulus to do a good job. No recent study

has been tabulated but it is safe to say that about 75% of the students in the country who are required to take a course or sequence of courses in surveying are exposed to photogrammetry. This exposure varies all the way from one 50-minute lecture to as much as a three-credit hour course for one semester. For instance, at Cornell the electrical engineering students are required to take a one-credit hour course in surveying; that is, in engineering measurements. They are exposed to one $2\frac{1}{2}$ hour combined lecture and demonstration period in photogrammetry. On the other hand, the civil engineering students in their surveying sequence are required to take the equivalent of $1\frac{1}{2}$ semester hours of photogrammetry. It should be noted that a school which requires five years of education to complete the baccalaureate degree in engineering can devote more time to courses deemed important than can be devoted by four-year schools.

Qualified undergraduate students who elect to take a course or courses in photogrammetry are the ones most likely to become really interested in the profession. Presumably they all have engineering or scientific backgrounds. These are the boys—and girls—who have been stimulated by their instructor, by the glamor of an airplane, by curiosity over such a long word as photogrammetry, or by a "buddy" who is taking the course. Probably not more than 50 to 100 of such undergraduate students obtain three or more credit hours of training in the United States each year. This is the group most likely to provide a source of manpower for addition to the ranks of photogrammetrists.

Next let us consider the situation in *undergraduate airphoto interpretation.* Here again a substantial number of undergraduate students take a required course in photo interpretation, whether it be photo interpretation as a portion of a civil engineering course, or it be photogeology, photo interpretation for foresters, or similar courses for agronomists, land planners, or others. As above with the photogrammetry courses, most of these required courses are quite limited in scope.

The undergraduates who elect to take studies in photo interpretation usually have in mind work for oil companies, conservation departments, land or regional planners, or else they are foreign students who plan to return to their homelands, and use their training in making inventories of natural resources from airphotos. The number of undergraduates electing airphoto interpretation courses exceeds the number electing photogrammetry.

Graduate students are a somewhat different group than they were before World War II. For one thing, most graduate students are married and have families. But perhaps the greatest difference lies in most graduate students having some way of earning money while they are in school. Some graduate students, while pursuing their studies, are employed by the colleges as part-time or even full-time instructors. A great many are employed on research projects and most of these are able to secure employment in their own field of studies on sponsored research projects being conducted at the school. Of course some of the students are recipients of graduate scholarships and fellowships from funds available to the university. Finally, some seek employment wherever they may find it in the town or in some other part of the university. All of this means that unless the school has an opening where it can hire a prospective graduate student as an instructor or can grant him a scholarship or fellowship from endowments or from gifts of unrestricted funds, then the school almost has to have some sponsored research project on which the student can be given employment before he is able to embark on his studies. *With research in surveying being almost nil, and with research in photogrammetry being as indicated earlier, it is not surprising that there are very few graduate students in photogrammetry.*

As with undergraduate students, there is no easy way to determine exactly how many graduate students in photogrammetry receive advanced degrees each year in the United States. It is probably safe to say that the combined total for both masters and doctors degrees would be between ten and twenty. Of this number perhaps approximately $\frac{1}{4}$ go into teaching, $\frac{1}{4}$ into some field where they are not directly making use of their technical training, and at least $\frac{1}{4}$ are foreign students who return to their own country. Thus *there remain about* $\frac{1}{4}$, or certainly at best not more than a half dozen students, *with advanced degrees available to go into the profession of photogrammetry in the United States each year.* Remember this is a profession which if it is to remain a profession needs a regular influx of men with a high degree of

specialized training.

One increasing trend is worthy of mention. As rather generally known, college instruction in surveying for the last twenty or thirty years has for the most part been relegated to the newest and least experienced instructors in civil engineering. Partly as a result of this practice, a *great many of the surveying courses have been taught at the technical institute level rather than at the college level.* These courses are now under careful scrutiny by engineering educators as well as by employers of engineers. The young instructor teaching surveying has seen little opportunity to improve his status, earn promotions, and grow in stature in the eyes of his colleagues unless he would be able to get into some other aspect of civil engineering and to earn an advanced degree. Usually he has excused himself from surveying as soon as possible. But, in the last few years, some of these young instructors have seen that there is an *opportunity to get advanced training of real graduate level work which can be challenging as well as rewarding* and there does seem to be an increasing interest on the part of teachers to take graduate work in the surveying field. However, as just mentioned above, *if more fellowships or sponsored research projects are not made available* so that these men can earn while they learn, the number will never become very large; *the profession runs a risk of "drying on the vine."*

Employment Opportunities

Up to now, this paper has made a rather factual presentation of the status quo in education in photogrammetry. Under the heading of "Employment Opportunities" is the time for the payoff. It is at this stage that *a critical investigation of the profession* should be made and it is hoped that the following statements are factual and not too badly biased.

Although much can be done to improve both the quality and the quantity of teaching of photogrammetry, there is not much of a real need to do this unless the job opportunities warrant such improvement. The picture as far as *employment for photo interpreters* is concerned is for the most part quite satisfactory. Very attractive salaries are being offered by oil companies, agronomists, lumbering companies, state highway departments, and increasingly by consulting civil engineering firms. Several companies doing photo interpretation on a consulting basis are giving attractive salaries to men who hold either undergraduate or graduate degrees with training in photo interpretation. This is particularly true of some companies in foreign countries, especially in Canada. A large number of the students thus hired make studies in faraway places throughout the world, and to a lesser extent within the continental United States.

However, the *picture is not as rosy for photogrammetrists with a background in engineering, mathematics, physics, and other sciences.* Civil engineering students graduating from four-year engineering schools in the United States in June 1956 accepted job offers at an average of about $425 per month. Civil engineering students completing a five-year curriculum accepted jobs at an average of $464 per month. At least as far as outward appearances to the faculty and the student are concerned, there is very little competitive demand at the above salaries either for graduating seniors or for holders of advanced degrees with training in photogrammetry.

Very few photogrammetric companies have done any interviewing at colleges. In fact, most of the interviewing for jobs entailing photogrammetry recently has been done by government agencies, and they have about given up on obtaining engineers and are really interviewing for mathematicians —who are almost as scarce. At present, as is very well known, the market for engineers is very competitive. Those organizations needing engineers with some specialized training are making very concerted efforts in interviewing, to attract these graduates. Photogrammetric companies have not done this. *The Government Mapping Agencies* which have been *classified by the Civil Service Commission under the rating of cartographers, rather than engineers, are definitely at a disadvantage* in trying to attract engineering graduates.

Recommendations

As far as education is concerned, it is apparent that there is ample room for improvement. For instance, some of the mathematical relationships occurring in the geometry of a single photograph have not been completely worked out. Even more work remains in establishing the geometry of a pair of photographs of an area to take advantage of new concepts in mathematics. There is a need for new in-

struments and procedures in photogrammetry. All of these will take considerable research and study. The increasing use of analytical photogrammetry and high speed electronic calculators will have a profound effect on photogrammetry within the next five to ten years. The movement toward electronic calculators is already being felt.

Photogrammetry needs trained personnel to help develop these new relationships, instruments, and procedures. There is a vast untapped reservoir of students entirely willing to obtain education which will enable them to make these new developments. Under the age-old laws of supply and demand, the students are or can be available if there is a demand for their services at a satisfactory price. It is hereby recommended that photogrammetrists take steps to acquire trained manpower; that is, to obtain brain power to help them with their problems.

It is apparent that *the profession of photogrammetry needs to do some serious re-evaluating.* Parenthetically it can be added that surveying as a whole also needs to do some soul searching. It can be expected that this re-evaluation finally will become the self-appointed task of the American Society of Photogrammetry.

At present there are *two major attractions* which are an added incentive to a student to learn more about photogrammetry. The first is the *student membership* opportunity which the Society provides at bargain rates. The other encouragement which is pointed directly at students is the *Bausch & Lomb Photogrammetric Award* provided by the Bausch & Lomb Optical Company. *It is hereby recommended that efforts be made to establish scholarships and grants-in-aid for students wishing to pursue graduate studies in photogrammetry.* Perhaps the American Society of Photogrammetry can establish a scholarship. This could be done, for instance, by a contribution of fifty cents per member. Perhaps some of the local sections might wish to establish a fund for grants-in-aid to students pursuing studies in photogrammetry. Following the example of Bausch & Lomb Optical Company, perhaps some of the other instrument makers or photogrammetric mapping companies can see their way clear to aid a worthy student.

Some objectors may point to the acknowledged leaders in photogrammetry saying "He did not have the formal training you are suggesting, and he is successful." No attempt is being made to belittle these men. Without them, the profession would be far behind its present state of development, but remember it has taken these men twenty to forty years to learn the things they know. *It is not fair to ask a man entering the profession now to spend a like time learning by the same method of slow and sometimes painful experience.* An alternative would be for these leaders themselves to become teachers.

Conclusions

From the foregoing, a few simple conclusions may be drawn. But first, let us make the following comparison. No one at this meeting believes that the man on the automobile assembly line will become an engineer for the company without a considerable intensive period of high-level instruction. Similarly, there is not much likelihood that a high school lad trained as a chainman or a rodman will become a geodetic engineer without extensive training in mathematics, physics, and engineering subjects. *Photogrammetrists should not be deceived that there is any greater likelihood that a high school lad trained to operate a multiplex projector will become a photogrammetric engineer, without similar extensive engineering training.* Of course, this does not say that there is not a need for the man on the automobile assembly line nor for the rodman and chainman nor for the stereoplotter operator, but each field needs men with a broader and more intensive training.

It is apparent that the education for photogrammetry can be conducted at schools already established. Few such schools exist in the United States at present. There is little incentive for more schools to establish photogrammetric curricula because the demand for the trained personnel at competitive salaries is not large. Finally, *photogrammetrists must ask themselves these questions and obtain clear-cut answers.* "Is this a profession which for its conduct and practice requires men with a particular training?" "Does it also require men with a broad understanding of the principles of nature?" "Does the profession have in its ranks men with this specialized training?" And, "does the profession maintain a steady flow of trained scientists and engineers into its ranks?" It is by obtaining the answers to questions like these that the Society can be of the greatest benefit to education, and to itself.