It is proposed to repeat the experiments, using the same samples upon a different group of individuals. It will be of interest to see whether the order of grading, Table II, will be repeated. Development of objective measures of photographic quality could do much to standardize interpretation research and speed the development of optimum photography for use of photo-interpreters.

*Education and Research in the Mapping Sciences at the Ohio State University**

FREDERICK J. DOYLE, *Associate Professor of Photogrammetry, Institute of Geodesy, Photogrammetry, and Cartography, and Research Associate, Mapping and Charting Research Laboratory, The Ohio State University, Columbus, Ohio*

IN THE past several years many publications and addresses before various organizations have emphasized the increasing needs for more and better topographic maps. The facts are well known: that less than 25 per cent of the United States is covered by adequate maps; that the rate of obsolescence of existing maps is almost equal to the rate of production of new and revised maps; that untold millions of dollars are wasted in the planning of natural resource development, transportation, and manufacturing locations through lack of adequate maps and terrain knowledge; that the global defense commitments of the United States and efforts to improve the economic situation, particularly in the so-called under-developed countries, have been, and are being, seriously hampered by the lack of knowledge obtainable from topographic maps. Unfortunately these facts usually have been publicized primarily before such as the American Society of Photogrammetry, the American Congress of Surveying and Mapping, and similar organizations whose members are generally all too unhappily aware of the situation. Elsewhere lack of knowledge and concern is the general condition.

The reasons for the disparity between the demand and the supply are not hard to find. First, a scarcity of public funds assigned to the map producing agencies; second, a scarcity of trained scientists and technicians to execute the mapping projects; third, the lack of an adequate technology for the efficient acquisition and reduction of terrain data. It goes without saying that these reasons, particularly the second and third, are closely interrelated. The first is the easiest to alleviate, and it may be expected that when adequate personnel and techniques are available, sufficient funds will be forthcoming. But personnel and techniques cannot be voted into existence. The training of technologists, the education of scientists, and the research and development required for new methods are among the traditional objectives of a university.

In Europe this situation has long been recognized and there are established departments of surveying, geodesy, photogrammetry, and cartography in the technical universities of most countries. The mapping sciences are an acknowledged profession, and have been recognized by academic degrees for many years. Many fruitful developments have come from these efforts, and large numbers of excellent scientists have been educated.

In the United States the situation is quite different. Surveying and geodesy have traditionally fallen within the realm of civil engineering. Photogrammetry, if taught at all, may be in civil engineering, forestry, or geology, usually depending

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upon the interest of the staff member who introduced the subject. In recent years two factors have militated against the mapping sciences in the normal engineering curriculum. First, the technological advances in all areas of engineering require the student to learn a great deal more about many more subjects than were formerly necessary. Second, educators are realizing the necessity of increasing the social and humanistic courses in the engineering curriculum. The result has been, very simply, that some subjects had to be de-emphasized, and others eliminated entirely.

Foremost among the casualties have been courses in surveying—and particularly in geodesy. Photogrammetry was coming into its own at just about the time these changes were taking place. Some schools have instituted a short course in photogrammetry, others have inserted some lectures on the subject into surveying or other courses. But nevertheless, the total time devoted to the mapping sciences has been reduced almost universally, and indeed the surveyor and map maker is not infrequently considered to be "a civil engineer who couldn't make the grade." It is therefore not surprising to find that many of the younger scientists in the field have gone to Europe for some part of their training.

Shortly after World War II, the late Professor Edward Coddington, and Professor George Harding at The Ohio State University interested the Air Development Center at nearby Wright Field in sponsoring research on the problem of long geodetic lines. This was the beginning of the Mapping and Charting Research Laboratory. In a short time a capable staff was assembled, and with the guidance of such outstanding scientists as Walter D. Lambert, O. M. Miller, and the late Professor Earl Church, significant contributions to knowledge began to be made. The University is grateful to men like James J. Deeg, Assistant Chief of the Aerial Reconnaissance Laboratory at Wright Field, and to other government agencies, whose continued support, through contracts, made possible the development of the mapping science programs at Ohio State. However, this was government sponsored research on specific and immediate problems. The basic investigations necessary for long range future developments were not being made. Furthermore, the younger staff members were mathematicians, physicists, astronomers, geologists, civil engineers. Nowhere in the United States were men being educated who might properly be called geodetic scientists.

The senior members of the Laboratory staff, with backing from the leaders of government, military, and civilian agencies, presented this situation to the Board of Trustees of the University with recommendations for the establishment of an academic training unit to complement and supplement the work of the Laboratory. In 1950, the Board of Trustees authorized the Graduate School to set up the Institute of Geodesy, Photogrammetry, and Cartography, with Dr. Weikko A. Heiskanen as Director.

Any educational organization which plans to present studies in geodetic sciences must realize at the outset that there are two distinct levels at which personnel are required. At the practical level there are the land surveyors, geodetic survey crews, photogrammetric instrument operators, cartographic draftsmen, reproduction technicians, computers, and many others. The demand for individuals with this type of knowledge is far beyond the supply. It is probably true that this amount of information could be efficiently presented in a two year program at a technical trade school. But no such programs are currently being offered by any trade schools in the country. Most technicians of this type learn their trade in on-the-job programs at government and commercial mapping organizations. Either of these arrangements has a double disadvantage. First, each individual usually learns only one small phase of the mapping process; second, the indispensable social, ethical, and intellectual concepts which are the mark of an educated man are completely lacking.

To offer a program comprehensive in technical content and balanced in social and humanistic studies, the Institute staff outlined an interdepartmental curriculum leading to the degree, Bachelor of Geodetic Science. For administrative purposes the program was placed in the Geology Department in the College of Arts and Sciences. This curriculum specifies an integrated program of courses in mathematics, physics and astronomy, surveying, geology, geodesy, photogrammetry, and cartography. The non-technical courses required to meet the Arts College requirements are selected by the student in consultation with his advisor. The graduate of this program is competent to become a valuable employee of any government or commercial mapping organization. In addition his intellectual curiosity has been stimulated so that he may continue his education either by self development or by formal graduate studies leading to advanced degrees.

The second level for which education is required is that of project supervisors, office chiefs, and research scientists. The goal of the graduate program in the Institute is to equip men to handle these positions.

Two major facts must be kept in mind in considering the place of graduate education in geodetic science. The first is, that for the time being at least, the demand for such personnel is relatively small. Probably a hundred men per year could fill the entire requirements of government and private agencies. The second fact is that the wide range of knowledge applicable to geodetic science can hardly be encompassed by one man. Specialists are required in mathematics, electronics, physics, geodesy, geophysics, photogrammetry and others. In addition a very large outlay for expensive laboratory equipment is required. Thus, the organization contemplating a comprehensive graduate program in the geodetic sciences is faced with the dilemma of small enrollment and with large staff and equipment requirements. It is therefore not too surprising to learn that The Ohio State University is the only one in the country which offers work leading to under graduate and graduate degrees in the geodetic sciences.

The existence of the Mapping and Charting Research Laboratory on the campus made it possible for the Institute staff to plan a strong graduate program. Professors from the cooperating departments of Mathematics, Geology, Civil Engineering, Photography, Geography, and Physics and Astronomy present courses extracted from the regular catalog of the Graduate school. In addition to these, a series of special problems and advanced studies courses have been outlined in geodesy, electronic mensuration, photogrammetry, and cartography. These courses are taught on a lectureship basis by the research associates from the Mapping and Charting Research Laboratory. This particular arrangement has permitted graduate students to work under the direction of such outstanding scientists as Drs. Felix A. Vening Meinesz, R. Roelofs, T. J. Kikkamaki, Bertil Hallert, Arthur Brandenberger, and Reino Hirvonen. It would not be possible for the University teaching budget to support such a staff for the relatively small number of students enrolled. But successful execution of the contract research program in the Laboratory is dependent upon the services of these men who are brought to the University for this purpose.

Another very important advantage of the mutual cooperation between the Institute and the Laboratory is that qualified graduate students may obtain part time paid employment on the contract programs in the Laboratory, and may in some instances use the results of their research for thesis and dissertations. The proper spirit of scientific inquiry in thus promoted by actual work on existing problems. Finally, the University operates a Numerical Computation Laboratory which is now equipped with the IBM 650 magnetic drum storage computer. The staff of this Laboratory has been very generous in presenting seminars to Institute personnel on the coding of problems and operation of the computer. This work has been particularly valuable for analytical photogrammetry, adjustment of aerotriangulation, studies of the geoid based on gravity observations, etc.

The physical facilities of the Institute have been slowly improving from practically nothing to a stage where the staff members are almost satisfied. Recently the Institute was moved to a new building on the main campus of the University, where for the first time adequate office, classroom, laboratory and storage space is available. The geodesy section has a Worden gravimeter, a complete selection of modern optical reading theodolites and levels, optical distance measuring instruments and tacheometers, a Bamberg astronomical transit with complete timing equipment, and modern base line measuring apparatus. The photogrammetry section has numerous stereoscopes and parallax bars, radial line plotting equipment and sketchmasters, a reflecting projector, a modernized Zeiss SEG-1 rectifier, a photo theodolite, and a stereometric camera, KEK and Ryker PL-4 third-order stereoplotters, Multiplex and Kelsh second-order instruments. At the present time a Wild A7 with coordinate printing device is being installed; this, incidentally, is the first and only first-order stereoplotter in any United States educational organization.

The Institute staff feels that the graduate student in this program has the opportunity not only to learn existing techniques, but to gain the fundamental knowledge on which new developments must be based. It is hoped and expected that the graduates of this program will take a prominent place in the future scientific progress of the geodetic sciences.

The technological developments of the past fifteen years have not bypassed the mapping sciences. There have been phenomenal advances in geodetic measuring methods of which HIRAN and the geodimeter are only examples. Modern aerial cameras and stereoplotting instruments are a joy to behold. In spite of these developments, it must be admitted that, compared to some other sciences, mapping is still almost medieval. That contour lines must still be drawn one by one, and be completely dependent upon the interpretation and stereoscopic acuity of one individual, is absolutely fantastic. Some high powered mathematics, information theory, and electronic engineering will be required to conquer these problems. Perhaps an entirely new method of data acquiring is needed. The men who succeed in automatizing the mapping process must be real scientists. Particularly in the United States, where the map makers are still struggling for professional recognition, it is imperative that we begin to think and act like scientists. It is the earnest endeavor of the staff of the Institute that the graduates of this program may soon know more than any or all of us, and may make real contributions to the future developments of the mapping sciences.

In conclusion it might be well to describe briefly some of the research problems under investigation in the Mapping and Charting Research Laboratory and in the Institute of Geodesy, Photogrammetry, and Cartography.

In geodesy, the Laboratory is conducting a world wide gravity program to determine the undulations of the geoid and the deflections of the vertical. In 1954, four expeditions composed of Laboratory and Institute personnel were sent out to observe the total solar eclipse of June 30. And again last year one expedition went to Viet Nam to observe the annular eclipse of December 14. One Laboratory program was devoted to a study of methods for automatic computer reduction of Shoran readings to geodetic positions. Institute students have recently completed a detailed gravity map of the State of Ohio. Shortly after this map was published, a major oil company staked a claim in the area shown to have a large gravity anomaly. The dissertation of the Institute's first Doctor of Philosophy, entitled "The Parallel Radius Method of Solving the Inverse Shoran Problem," by Col. Clair E. Ewing, was adopted by the U. S. Air Force as its standard.

The Laboratory has conducted an extensive study of the "Basic Factors Limiting the Accuracy of Mapping and Aero Triangulation by Photogrammetric Procedures." Professors Roelofs, Hallert, and Brandenberger were the major contributors to this program. Another Laboratory investigation developed "Methods for Obtaining Dimensional Intelligence from Single Oblique Aerial Photographs." A new computing technique for analytical aerial triangulation has been developed and tested by the Laboratory. On the basis of trials made at Cornell University, this system has been recommended for adoption by the Corps of Engineers. At the last annual meeting of the American Society of Photogrammetry, two Institute students received first and third place in the Bausch and Lomb Award for student papers in photogrammetry.

The Laboratory is in the initial phases of a new program to study, in cooperation with Ohio State's School of Optometry and Laboratory of Aviation Psychology, the human factors affecting photointerpretation with particular emphasis on the way in which these factors affect the engineering design of data gathering equipment.

The Laboratory has a strong radar section which has made significant contributions to knowledge of the geometry and interpretation of the radar scope image. Devices for improving the calibration of the radar scope have been developed, and investigations of methods for preparing aeronautical charts from radar scope photography are under way. The Laboratory's cartographic section has conducted investigations of new methods for representing relief and terrain cover on aeronautical charts. Some results of these studies are displayed in the Congress Exhibition. Another very interesting study of techniques for obtaining a wide variety of color gradations with only three press runs has just been completed.

The staffs of the Mapping and Charting Research Laboratory and the Institute of Geodesy, Photogrammetry, and Cartography are proud of the contributions which The Ohio State University is making to research and education in the mapping sciences. Much remains to be done, but it is felt that these two organizations are beginning to fill an important void in the American technological development.

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*Atmospheric Haze in Aerial Photography**

PAUL BULLOCK,
School of Civil Engineering,
Cornell University

"THE quality of the atmosphere known as haze often prevents a cloudless day from being suitable for aerial photography. . . . [The] picture will be flat because of lack of sufficient contrast, and will appear veiled or milky."[1] In this brief manner many of the textbooks and publications currently being used in conjunction with basic photogrammetry courses pass over the subject of atmospheric haze. Admittedly the subject is a minor one in a course (or courses) which must range from optics to map compilation and reproduction. However, this state of affairs leads many students, particularly those with little background in photography, to dismiss haze as an indefinite and unimportant factor. In consideration of this, and in view of the paucity of information on haze and haze factors available to the student who does seek it, this paper is presented in the hope that its compilation and organization of various material will prove of value.

Photogrammetry, as the science of obtaining measurements from photographs, is directly dependent upon the photographs from which the information is being taken, and the success of its application may be considered as in part proportional to the quality of these photos. Unfortunately this quality is a highly variable item. It is desired that the photographic prints (in the usual case aerial) be of exacting definition and accurate featural reproduction. These factors are not consistently available without careful consideration and treatment of the light reflected from the terrain being photographed. Even under apparently perfect weather conditions, a lack of definition and contrast may result in one instance and not in another, even though the same equipment (camera, film, developer, etc.) is employed in each case. This is basically due to the large distances that separate the camera and the object being photographed.

* This paper was submitted in competition for the Bausch & Lomb Photogrammetric Award. It was given Second Prize.

[1] Harman, William E., Jr., "Aerial Photography," in the MANUAL OF PHOTOGRAMMETRY, 2d ed. Washington, D. C.: American Society of Photogrammetry, 1952.