The Impact of the New Highway Program on Photogrammetry

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ABSTRACT: *Photogrammetry in the United States is entering a new era. It is estimated that $200,000,000 will be spent on photogrammetry in the next thirteen years in accomplishing the $88 billion expanded highway program. The paper discusses the impact of this program on photogrammetry and the challenge presented in advancing photogrammetry, technically and professionally. The importance of the integration of electronic computers and photogrammetry in the highway field is discussed and some speculations on the future are presented.*

A NEW era of photogrammetry in the United States was initiated by the Federal Aid Highway Act of 1956. It has been estimated that the *total expenditures* by federal, state, and local governments for *highways over the next 13 years will be $88 billion.*[1] The impact of this gigantic highway program will be extremely far reaching, involving practically every element of our economy. The impact of the program on photogrammetry deserves serious consideration by all members of the profession in order that we may make the most of the opportunity ahead.

Studies have concluded, with some reservations, that the engineering profession can probably meet the demands of the highway program. However, it is generally conceded by all that in carrying out the program, the *engineering manpower factor will be a critical problem unless every possible advantage is taken of technological developments in such fields as photogrammetry and electronics.* Undoubtedly, photogrammetry is going to play a major role in accomplishing the task of planning, locating, and designing the thousands of miles of highways involved. Mr. G. T. McCoy, State Highway Engineer of California and President of the American Association of State Highway Officials, has stated " . . . the application of photogrammetry and automation techniques, in combination, is regarded as the greatest advance in the science of highway engineering in many years."[2] He also reports that California is " . . . already saving the time and effort of an estimated 200 engineers a year . . . "[2] through the use of photogrammetry. Other states are also stepping up their use of aerial surveys, and interest in the subject is increasing at a remarkable rate.

Although an accurate estimate is impossible, it is of interest to attempt to establish an order of magnitude for the money which will be spent on photogrammetric services in accomplishing the highway program. Such an attempt by the author indicates *an order of magnitude of $200,000,000.* Others may arrive at a far different amount but it is felt that all will agree that a tremendous volume of photogrammetry is involved in an $88 billion expenditure for highways and that *the impact on the photogrammetric profession and industry will be great.*

The question arises as to how this volume of photogrammetric work is to be accomplished. For years, the profession has advocated the application of photogrammetry to highway engineering with varying degrees of acceptance. *Now that nearly overwhelming acceptance is the order of the day, are we prepared to meet the production demands of the highway program?*

So far, most of the state highway departments have relied on the private aerial survey firms for their photogrammetric services. Therefore, the capacity of the private

[1] "The Grand Plan Becomes a Big Job," Editorial, *Engineering News-Record,* July 12, 1956.

[2] "State Increases Highways Despite Engineer Shortage," by G. T. McCoy, *California Highways and Public Works,* March–April 1956.

firms is of interest. A statistical study of 50 private aerial photographic and photogrammetric firms was recently completed at M.I.T. which reported considerable important information bearing on this subject.[3] The study revealed that these 50 firms own 158 airplanes, 261 aerial cameras, 277 stereoplotters, employ 2,874 professional and technical personnel, and have been accomplishing an annual photographic and photogrammetric volume of approximately $23,000,000. Since highway contracts represented a relatively small percentage of this volume and other sources of contracts are expected to continue, it is obvious that *considerable private expansion will be necessary to meet the requirements of the additional highway photogrammetry expected.*

The private firms have previously demonstrated their ability to increase capacity to meet increasing demands as exemplified by the response to the Army Map Service program of recent years. A temporary shortage in capacity may occur during the current season but it is believed that the private aerial survey firms will meet the production challenge ahead, especially if attention is given to research on new photogrammetric methods.

Perhaps the greatest challenge is presented in the *opportunity to advance photogrammetry professionally and technically.* The fact that photogrammetric methods offer a better, faster, and more economical solution than conventional ground survey methods does not mean that we have reached the ultimate. *With our conventional or existing photogrammetric methods and instruments, we have just scratched the surface in highway engineering.*

So far our part has been mostly limited to producing a set of aerial photographs and topographic maps. To a great extent, we have been furnishing just another product, bought and sold like so many yards of concrete. This situation is partly due to a general *lack of professional and technical knowledge of photogrammetry on the part of highway engineers.* This lack of knowledge is one of the major obstacles yet to be overcome before the true potential value of photogrammetry can be realized. It is fairly safe to say that a *knowledge of photogrammetry is going to be a prerequisite for highway engineers of the future* in order to make optimum use of photogrammetric services. We may also expect to see each highway department add one or more professional photogrammetric engineers to its staff.

A professional approach to the procurement and use of photogrammetric services is urgently needed. Certainly the technical administration and wise use of $200,000,000 in public funds should be in professional hands. It is expected that the highway program will do much to increase the professional recognition of the photogrammetric engineer and that with an increased knowledge of photogrammetry on the part of the highway engineer, we can expect to see many revolutionary developments in the years ahead.

On the surface it would appear that we have made great strides in photogrammetry and this is not denied. *But how much concentrated research has been done on photogrammetric systems as directly applied to highway engineering or other types of engineering projects?* In addition to improving current practice, there is ample room for the development of entirely new approaches, not only in new and wider applications but in production itself. In fact, photogrammetry will feel the effects of the same problem it is trying to help solve—the shortage of engineering and skilled technical manpower. The Federal mapping agencies and the private aerial survey firms have been responsible for most of the developments in photogrammetry to date in this country. But in the years ahead, the highway departments must participate directly in photogrammetric research as it applies to highways if they are to derive maximum benefit. *Photogrammetry should rate high on the research schedule of every state highway department. The engineering schools can also play an important role in the research to be done.* Highway departments have worked closely with the engineering schools on other subjects in highway engineering in the form of cooperative research. Similar research in the field of photogrammetry should be encouraged.

Considerable attention is now being given to the use of electronic computers as another method of conserving engineering manpower and time in meeting the de-

[3] "A Study of the Private Photogrammetric Mapping Activity in the United States," by C. L. Miller, *M.I.T. Photogrammetry Laboratory Publication 102*, August 1956.

mands of the highway program. An electronic computer may be considered as a data *reduction* system. Photogrammetry may be considered as a data *procurement* system. *These two systems must be integrated for maximum efficiency.* Apparent efficiency in computing is only part of the solution. The computer should be using data procured in the most efficient manner and presented to the computer in the most efficient form for reduction. Although some have recognized such an obvious conclusion, it appears that many are directing their efforts in programming data procured and presented in a form that, if not already, will soon be obsolete. Therefore, there is great need for an extremely close partnership of highway engineer, photogrammetric engineer, and computer engineer. The next decade should see considerable activity in *integrating stereoplotters and electronic computers*, another factor which will have a decided impact on photogrammetry.

It is interesting to speculate on what the future may hold for the coordination and integration of photogrammetry and computers in the highway field. There are of course a theoretically infinite number of spatial locations for a proposed highway between two points and a theoretically infinite number of spatial geometric designs for each location. In conventional practice, although we eventually arrive at a satisfactory solution, we do not necessarily arrive at the best solution. The mind of the experienced highway engineer can eliminate vast areas of possible solutions at a glance, but in the final analysis, a detailed numerical evaluation of only a very small number of possible solutions is practical using essentially manual methods.

In looking to the future, we may imagine the development of an automation system as follows: The areas of possible practical solutions are divided into strips or route bands much as in conventional practice. *The plotter-computer system is applied to each strip for a comparative analysis.* The data on the configuration or surface shape of the strip of terrain would be procured with the stereoplotter and fed directly to the computer without intermediate steps such as plotting maps and cross-sections. *In addition to terrain configuration, air photo analysis would furnish data on the composition and subsurface nature of the terrain, land use and value, and similar location factors and controls.* Other location data could be inserted in the system by the highway engineer. The spatial location of all data would be furnished by the stereoplotter. Note that the stereomodel itself is a highly efficient data storage system. The computer would only have to store that portion of the data it is working on, erasing old data and drawing new data from the model as it moves up the strip. The system could be made one dimensional during the location and comparative study stage by expressing appropriate data in units of economic value or cost with provision for recording of the spatial elements.

The geometric location specifications governing alignment, grade, and section would be programmed and stored in the computer. With the location data and specifications in hand, *the computer would be asked to "select" the best location line within the strip and report on its general geometric design and economic weight.* The process would be repeated for other strips. Upon selection of the final location and geometrics, *a set of larger scale stereomodels would be used in combination with the computer for final design of geometrics and the computation of quantities such as earthwork.* Of course the human element would by no means be completely eliminated. The whole system would merely be the efficient slave of the engineer, requiring his constant guidance and judgment in arrivin at a practical solution.

In describing the imaginary system above, the sole purpose of the author is to encourage new thinking and imagination in applying photogrammetry and computers to highway engineering. In so doing, it is hoped that we can occasionally skip a few stages in development to supplement the alternate approach of a continuous step-by-step improvement of current methods.

Research on photogrammetry and computers as applied to highway engineering is currently underway at M.I.T. by a research team which includes the author, Professor S. Namyet, Research Assistants D. Schurz, P. Roberts, and E. Newman. The majority of the work is now being performed as part of a sponsored research contract with the Massachusetts Department of Public Works. Several other *progressive state highway departments* have similar programs underway which *will tend to encourage more attention to education*

in photogrammetry for highway engineers.

Cooperative research between the aerial survey firms and the engineering schools should also be strongly encouraged to help attract more young engineers into the photogrammetric profession. Although the engineering schools have generally lagged behind the photogrammetric profession, *another important impact of the expanded highway program will be the impetus it will give to strengthening photogrammetry in our engineering schools.*

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The expanded highway program offers a great challenge to the photogrammetric profession, the highway engineering profession, and the engineering schools. We have a complete set of new horizons ahead of us.