Planning Aerial Photography and Film Processing for Mapping Work

JOHN H. WICKHAM, JR., Aero Service Corporation, Philadelphia

All successful accomplishments are attained through thoughtful planning by competent personnel. It may be highway site location, design, construction, or maintenance. As the aerial photograph has aided the highway engineer in these accomplishments and grows in importance today and tomorrow, it stands to reason that here, too, thorough planning is required to successfully attain a photograph for its required purpose.

To secure a usable photographic negative, it must be exposed in a selected camera in the proper relationship to the terrain and its accompanying negatives, and be developed by proven procedures using chemical formulas that will satisfactorily convert the emulsion into permanent images of recognition.

To acquaint the uninitiated and further inform the more experienced of some of the problems confronting the engineer who plans aerial photography and processes films for mapping work, the paper discusses the photographic mission, including reconnaissance, flight design, camera and airplane selection, flight crew, films, filters, and exposures; and film processing, including personnel, equipment, facilities, procedures, developers, washes, fixers and drying.

● ALL professional endeavors require thorough and adequate planning to provide a creditable service. Therefore, this paper is intended to inform the highway engineer of the problems encountered in photogrammetry and to acquaint him with the procedures a photogrammetric engineer must concern himself with in planning for aerial photography and film processing for mapping work. It is designed to remove some of the clouds of mystery or misconception and afford more background for determining how products of photogrammetry may serve as an aid to the solution of highway engineering problems.

The aerial photographer has to be placed at a prescribed site in space. He must be there at a time which affords acceptable atmospheric conditions for aerial photography and be supplied with cameras and associated equipment operating satisfactorily. These primary factors are to insure that with the click of the shutter the camera will ideally record all the required detail on the film. This is a task requiring effective plans which are not merely dreamed up or hastily thrown together. To assure that the film will be developed properly in the photographic laboratory, planning must establish an operating procedure that is flexible enough to afford intelligent departure therefrom and that can be reestablished as experience is gained.

The engineer who plans a photographic mission will plan an entire mapping project, not stopping, as may be indicated here, with the development of the photographic negative. This person must understand the intended use of the picture and coordinate all equipment, operations, and use of personnel all along the work processes to obtain full benefit of his experience and ingenuity.

There are primarily three ways in which the photogrammetric engineer will be introduced to and know of a client's need for his services, as follows:

1. He may enter a proposal of work having designed a new application of photogrammetry.
2. He may establish contact with a client and negotiate for his services.
3. He may receive an invitation to bid from a customer who distinctly knows his own requirements.

Any of these approaches is a means to the same end—that of engineering a service which will be of aid in the construction of highways as programmed by the states and designed by the highway engineer. Reputable photogrammetric firms can obviate the necessity for highway departments to devote a portion of their scarce supply of talented engineering personnel to the performance of strictly photogrammetric functions. This is not to suggest that application of photogrammetry be limited only to those products provided by aerial photography and mapping firms. It is felt, however, that contracting to companies whose livelihood depends on the successful day-to-day application of photogrammetry allows a better utilization of staff engineering manpower and brings to the client the benefit of current improvements in photogrammetric methods. If the contracting firm has the facility to fulfill an engineering objective which involves the use of photogrammetry, it is to mutual advantage if the highway engineers concern themselves with making the objectives clear and leave the methods and means by which it is accomplished to the judgement and discretion of the experienced photogrammetric engineer.

To best fulfill his client's needs the engineer is continually conscious not only of the specifications which the end product must meet but also of the useful by-products which can be and are being obtained in the process. To do this intelligently, he must be thoroughly familiar with the type of information which is of value to the highway engineer and be cognizant of how he may help by providing additional services. For instance, today aerial photography is used to obtain useful information in addition to the photogrammetric compilation of planimetric and topographic maps. Aerial photographs, under the stereoscopes of specialists, yield information concerning topography, drainages, soil types, surface geology, vegetation, and land use data. The value and economical advantages of extracting these types of data from aerial photography are becoming increasingly evident to the highway engineer. With a thorough knowledge of the requirements of these users, the engineer can, where applicable, intelligently recommend a slight modification of flight planning to improve their function without in the least impairing the usefulness of the photography for mapping purposes.

With the end products firmly fixed in mind, the engineer will proceed through a cycle of accomplishments. There are no specified steps of procedure, but for efficient work which will help assure the timely delivery of the desired aerial negative, planning for the photographic mission must include consideration of area reconnaissance, camera and aircraft selection, evaluation of flight crew, and flight design.

The investigation involved in making a reconnaissance of the area is to be so tailored that the findings will divulge all the physical factors of the project area which affect the performance of the photographic mission. It is to establish the nature of the terrain and what man has placed on it, solar angles that will prevail, prediction of prevailing weather conditions, location of existing control lines and possible routes for additional survey work, and the imposed flight restrictions.

Selection of the ideal camera for a particular project is a complex problem, as so aptly put by Deeg (1), as follows:

> There are many types of aerial cameras. In fact, there are so many types that a full treatment of them would require more space than that allocated to this entire manual. To some individuals, this is well understood To others, a superficial examination of the existing literature on the subject leaves them in a highly perplexed state of mind. The question heard most often from tyros is simply· "What camera should I use?" From individuals well versed in the subject, the reply is likely to be a suggestion that they first study. basic mathematics of photogrammetry. .
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> Unless an individual is well financed, he should not attempt to select an aerial camera for a particular purpose until he has a thorough understanding of photogrammetric fundamentals. It must be remembered that aerial cameras, film, qualified personnel, and flying time are costly expenditures

In selecting a camera, his thoughts would be to have available the proper camera that would most accurately portray the terrain which is to be photographed so that the terrain and features of details can be identified or interpreted and, if required, transferred to a map medium at a desired scale. This would require a camera possessing optical qualities which would resolve the necessary detail and place it on the film with geometrical qualities so that the relationship between the images can be measured and their positions established as they existed at the time of exposure. After he determines the proper camera, an assessment of the airplane characteristics must be made to afford the desired camera platform. The plane must be structurally designed to properly accommodate the camera and related equipment, have adequate crew facilities, have aerodynamic qualities consistent with the speed, range and altitude required of the mission, and, foremost, itself be operational and in good maintenance.

The engineer has an array of planes from which to make his selection, each possessing certain flight characteristics and structural design which narrow the applications for photographic work. The author's company alone has 35 aircraft ranging in size and complexity from the Piper Cub to the B17 Yet, hardly a week passes that there is not some earnest thought given to the desirability of having another which possesses certain additional flight or structural characteristics.

Therefore, the engineer must have intimate knowledge of the characteristics of each of these pieces of equipment in order to select the best combination for the job.

The experienced engineer instinctively knows that the best equipped aerial surveying airplane is no better than the men he assigns to use it, for it is impossible to separate the airplane from the skills and proficiency of the crew in predicting the success of a photographic mission. Unlike the planned and systematized operations of a ground survey crew in which mistakes can, as a general rule, be immediately discovered and corrective action taken while the work is in progress, in aerial surveying mistakes, defects, and poor execution only become apparent upon completion of the flight and development of the film. Therefore, the engineer assigns a photographer and pilot who function reliably as a team.

Knowing what he has to work with, the engineer who is involved in the preparation of maps or reports from data which were arrived at from the intelligent use of aerial photographs can proceed with a realistic program for accomplishment and make his final plans. His experience comes into play now, for here he must assess the liberties he must take in departing from an established procedure to have efficient project work suited to obtain a photograph most accurately portraying the terrain and, if need be, possessing characteristics which will afford geometrical reconstruction into an end product.

With all these considerations that must go into the flight design of a photographic mission, it is next to impossible to compile information to which one can readily refer and say: "This tells me how to design my flight." Experience is, really, the only teacher—with academic courses and study of the fine literature available being a prerequisite. Foremost of the good literature available is the "Manual of Photogrammetry," published by the American Society of Photogrammetry.

Flight planning is a design, for it conveys to the operating personnel the results of planning. The details it contains, if properly applied, furnish aerial photography as the product. Here, specifications dictate how exhaustively and/or elaborately they must be presented. In any case, the essentials are the same—to obtain a usable photographic negative.

The design entails the presentation of detailed instructions for the plane-camera crew regarding the location of the exposure stations, the flight strip, and the boundaries of the project area to be covered. This will, of necessity, include information regarding the camera to be used, the flight height, and the time at which the mission is to be accomplished, and any other pertinent data relating to the project which would give aid to the photographic crew.

These data may be presented on numerous media, the most desirable being the best available map of the area most suited for plotting the flight design information and of such character that it will afford the necessary navigational aids for contact flying by the photographic pilot.

Having established the criteria, the engineer steps out of the active role upon presenting his findings for the detailing necessary in the preparation of the flight map.

Processing the Film

After a photographic mission has been completed, attention is directed toward processing of the film.

The purpose of film processing is to convert the latent image, obtained by film exposure, into a permanent silver image. This is accomplished by successively developing and then fixing the photographic material.

Development is the process of converting the exposed silver halides into metallic silver by immersion of the film emulsion in a suitable reducing agent. Since the fixing operation has little effect on the characteristics of the finished product, this part of the process is not discussed at length. The primary purpose of the fixing bath after development is to dissolve out the unexposed silver halide particles, which with exposure to light darken and degrade the negative. In the process of development it is possible to control, to some extent, the grain structure of the silver image and to establish the relative densities of the silver deposit in the various items in the photographic scene.

Grain size in the developed image is important because it limits the size of the smallest items that can be portrayed by the photograph. It is, therefore, of primary concern to obtain as small grain size as possible while developing to a suitable contrast. Extremely fine grain development of emulsions suitable for aerial photography is, unfortunately, associated with development to a low contrast, which, as shown later, imposes serious limitations on its application to aerial photography. It is, therefore, necessary to select the development process that allows the best combination of small grain size and necessary negative contrast.

Before undertaking a discussion of the control of negative contrast in development, it is necessary first to discuss the significance of contrast and to define certain pertinent terms. A developed emulsion conveys information to the observer by virtue of the differences in density of the silver deposit that has resulted from differences in intensity of light reflectance from the various objects within the scene.

Without going into great detail concerning the theory of photographic tone reproduction, it may be said in general that the difference in density of the silver deposit of two items within a scene is related to the difference in light intensity reflected from the two objects by a factor known as the "gamma" of the negative. When the gamma is low, the differences in density of the silver deposits are also low and the photograph has a very flat appearance. Much detail in the photograph is lost due to the fact that the differences in density produced by adjacent objects is not sufficiently large to be discernible to the human eye. On the other hand, when the gamma is too high the photograph tends to be overly contrasty, presenting an abnormal appearance to the eye, and detail is lost in the highlights of the photograph.

To obtain the correct gamma on a terrestrial photograph, particularly of nearby objects, is a relatively simple matter compared to aerial photography. The complicating factor in aerial photography is aerial "haze" caused by light reflection from the numerous particles suspended in the atmosphere. Even on an apparently clear day, there is some atmospheric haze present. Aerial photography for commercial purposes is flown only under the best atmospheric conditions; but in some areas the best is still considerably hazy because of the presence of industry and other contributors to aerial haze. The effect of haze is to add a uniform increment of light to all objects within the scene, thereby reducing the effective differences in light intensity between objects.

To a certain extent this effect can be compensated for by developing the emulsion to a higher gamma to heighten the density differences between objects. Because the gamma increases with time of development when the proper developer is used, it is necessary to determine the development time required to obtain the desired contrast. Because no two rolls of film have been exposed under exactly the same conditions, there is no substitute for a large backlog of experience, both recorded and personal.

It may be interesting to consider the step-by-step procedure of processing a typical exposed roll of aerial film as it is done under operating conditions. The film is sent to the photographic laboratory by the flight crew as soon as it has been exposed. The photo lab begins processing immediately, because the flight crew can not be released from its assignment until the photography is known to be satisfactory. When the film is received by the laboratory, a search is made of all records concerning the procedure used on photography of the same area. These records show the developer used, length of development, an assessment of the resulting quality, and include pertinent exposure information (such as the date and time of exposure, weather conditions, flight altitude, camera number, and even the name of the photographer). These records are compared to the mission report for the film to be developed and, when applicable, serve as a valuable guide to the procedure to be followed. The film is then placed on one of two spools of a Fairchild-Smith tank apparatus. This equipment allows for the winding of the film from one spool to the other and back again while both spools are submerged in liquid. The film is first placed in water and manually wound onto the second spool. The purpos of the preliminary water bath is to insure that the developer which follows will flow evenly on the film. Now the apparatus is submerged in a suitable developing bath, either Kodak formula DK-50, D-19, or D-76, and the film is continually wound from one spool to the other by electric power. A constant temperature of 68 F is maintained for all liquids used during development. Several minutes before the end of the anticipated development time, the film is examined under a dark green safelight by a laboratory technician, who then determines how much longer the film shall be developed to obtain the desired contrast. When development is completed, the film is immersed in stop bath or water during a complete cycle of winding, and then placed in a fixing bath for continuous winding for 10 to 20 minutes. Drying is carried out by passing the film around the outside of a large drum, the back of the film being held against a series of rollers by air pressure through many small slits. The instrument is so designed as to insure that no stretching of the film base occurs.

The success of a photographic mission and the value of any derived products is directly dependent on competent planning at all stages.

For the successful execution of the complex job of planning aerial surveys, experience is the best teacher.

The use of aerial photography in highly precise stereoscopic mapping instruments is beyond the scope of this paper. Nevertheless, it should be apparent that photography is the basis on which subsequent maps are to be made. Therefore, proper planning and execution of the photographic mission is of the utmost importance.

REFERENCE

1. Deeg, J.J., "Manual of Photogrammetry," Chapter III, p. 69, 2nd Edition. Amer. Soc. of Photogrammetry (1952).