*Fiftieth Anniversary Highlights**

*The Role of Photogrammetry in an "Open Skies" Program**

GEORGE D. WHITMORE,
Chief Topographic Engineer,
U. S. Geological Survey

ABSTRACT: *Under President Eisenhower's "Open Skies" proposal, the United States and the Soviet Union would be allowed to make aerial photo-reconnaissance flights over each other's territory on an unrestricted, but monitored basis. The American Society of Photogrammetry needs to be fully cognizant of this program and its technical aspects, because its membership will inevitably play a leading role in the program, should it materialize. Aerial photographic inspection provides a tremendous potential for revealing military preparations. At the same time, the program presents a number of difficult technical problems. The photogrammetry profession needs to be ready with technical know-how so that, if the program becomes operative, it can make a great contribution towards world peace.*

ONE can scarcely pick up a newspaper these days without encountering, somewhere in its pages, phrases that reflect the tremendously significant role that the science of photogrammetry can play in the world of today—phrases like "aerial inspection," "mutual photo-reconnaissance," and "open skies." Opinions on the proposed "open skies" program have welled forth like a mighty stream—sincere opinions of statesmen, politicians, editors, pundits, religious leaders, and the man on the street. I believe that it is time for something to be said on the subject by the people who would have to do the work; and that means people who would inevitably be drawn from the ranks of the American Society of Photogrammetry. For our Society is the nation's principal reservoir of personnel with the experience and know-how that would be indispensable for putting an "open skies" program into effect. While we wait in the wings, against the possibility of being called on stage to play this important role, it is incumbent upon us to become thoroughly familiar with the part, even if it turns out that the show never opens.

What aspects of the "open skies" program should we, as practitioners in the field of photogrammetry, examine as a group? Certainly not the political pros and cons for, although each of us is entitled to his individual opinion, the political facet of the program is beyond the field of our collective competency. Rather, let us leave the questions of International policy to our statesmen, with the fervent hope that they will indeed be statesmen in the highest sense. It is our duty, on the other hand, to take a keen look at the scientific, engineering, and technical problems that would arise should the policy be activated. We need to be acutely aware of the tremendous potential of aerial inspection and the possible techniques for realizing that potential. At the same time, our eyes must be open to the limitations of the program; and above all, we must not allow the public or official mind to be deluded by overblown

* Presented at the 24th Annual Meeting, American Society of Photogrammetry, Washington, D. C., March 28, 1958. Publication approved by the Director, U. S. Geological Survey.

The author deeply appreciates the kind cooperation of the White House Disarmament Staff and the U. S. Air Force in providing essential reference documents and information which contributed greatly to the preparation of this paper, and also the capable assistance of Mr. Morris M. Thompson, Photogrammetric Engineer, U. S. Geological Survey, who did most of the research, and who helped greatly in the writing task.

* The American Society of Photogrammetry was founded in 1934, fifty years ago. In recognition of that founding, appropriate material will be included in the Journal during this fiftieth anniversary year. This month's selection is reprinted from *Photogrammetric Engineering*, XXIV, No. 3, June 1958, pp 376–382.

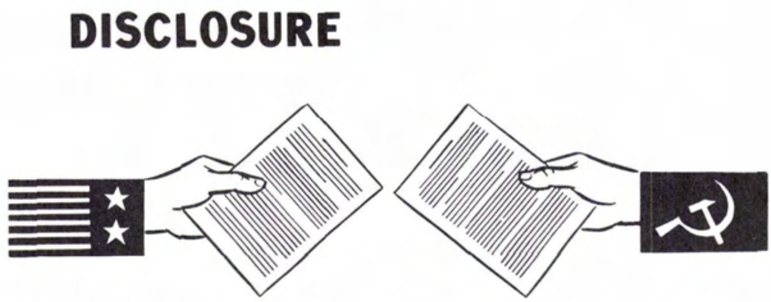

FIG. 1. MUTUAL INSPECTION FOR PEACE—HOW IT WORKS. Exchange of "Blueprints" locating military units and facilities.

ideas of photo-reconnaissance miracles. For though we can be certain that great advances in our science lie just over the horizon—and that we shall not hesitate to develop and exploit them—we have to think also of the realities on this side of the horizon. In this paper, we shall, accordingly, be concerned primarily with things that are at hand now, the things that would come into play if action were necessary today.

WHAT IS THE "OPEN SKIES" PROGRAM?

Our initial concern, if we are to make a sensible technical appraisal of the program and its problems, is to line up the basic facts. Exactly what is the "open skies" policy and what has been done about it so far? The policy was quite clearly defined at the Summit Conference in Geneva, on July 21, 1955, when President Eisenhower proposed that the United States and the Soviet Union take the following steps:

"To give to each other a complete blueprint of our military establishments, from beginning to end, from one end of our countries to the other; lay out the establishments and provide the blueprints to each other.

"Next, to provide within our countries facilities for aerial photography to the other country—we to provide you the facilities within our country, ample facilities for aerial reconnaissance, where you can make all the pictures you choose and take them to your own country to study; you to provide exactly the same facilities for us and we to make these examinations; and by this step to convince the world that we are providing as between ourselves against the possibility of great surprise attack, thus lessening danger and relaxing tension. Likewise, we will make more easily attainable a comprehensive and effective system of inspection and disarmament, because what

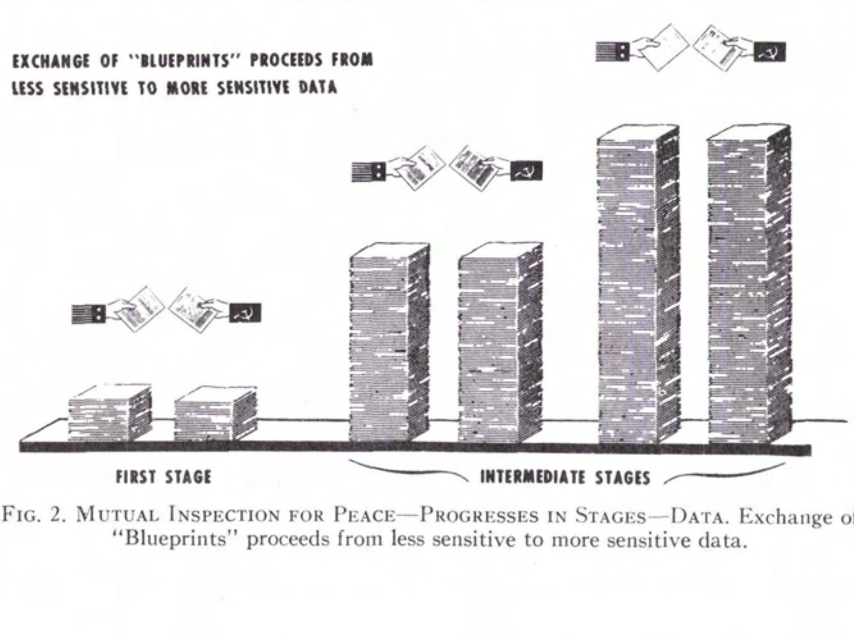

FIG. 2. MUTUAL INSPECTION FOR PEACE—PROGRESSES IN STAGES—DATA. Exchange of "Blueprints" proceeds from less sensitive to more sensitive data.

FIG. 3. MUTUAL INSPECTION FOR PEACE—HOW IT WORKS. Aerial Inspection Flights plus ground observers at key locations continuously report findings and verify accuracy of blueprints.

I propose, I assure you, would be but a beginning."

Five weeks after this proposal was made, the United States presented to the United Nations Disarmament Sub-Committee an outline plan for implementing the President's proposal. In a brochure distributed at the time this plan was submitted, the mutual inspection program was envisioned as a three-phase operation: disclosure, inspection, and evaluation.

The *disclosure phase* (Figure 1) calls for the exchange of blueprints of armed strength and military facilities. This exchange would lay the groundwork for an inspection system to guard against surprise attack. The exchange would proceed in stages (Figure 2). Schedules would be drawn for phasing all exchanges to assure delivery of similar types of information by each government. The exchange would proceed from the less sensitive to the more sensitive data.

The *inspection phase* (Figure 3) provides for both aerial and on-the-ground inspection. The ground observers would be stationed at key locations from which they could continuously report their findings and verify the accuracy of the exchanged blueprints. The aerial reconnaissance would be conducted by each inspecting country of an unrestricted, but monitored basis. Each inspecting country would utilize its own aircraft and related equipment. Liaison personnel of the country being inspected would be aboard each reconnaissance aircraft. Once the plan is in operation between the U. S. and the U.S.S.R. it could then be extended to other countries (Figure 4) including those countries in which there are overseas bases.

The *evaluation phase* (Figure 5) would be performed by photo-interpretation and data-analysis specialists at evaluation centers. The aerial photographs and ground reports would be carefully studied for possible evidence of surprise attack or of mobilization.

The theory of this three-fold operation is that it provides a built-in warning system (Figure 6) against massive all-out surprise attack. Such an attack requires massive preparations which could hardly escape detection and early warning under a mutual inspection system. Each of the three phases is a potential source of warning as Figure 6 clearly shows. The stupendous amount of falsification, deception and camouflage that would be required to achieve surprise in the face of open inspection would certainly be a powerful deterrent.

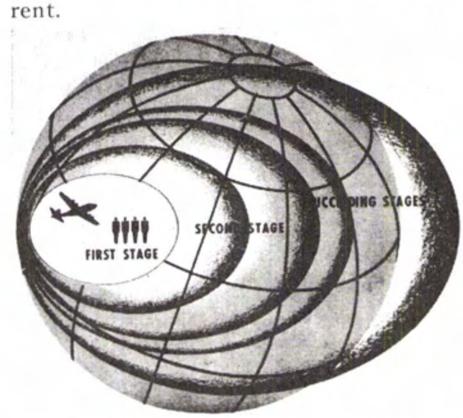

FIG. 4. MUTUAL INSPECTION FOR PEACE—PROGRESSES IN STAGES—AREA. After bilateral plan is in operation it can be extended to include other countries.

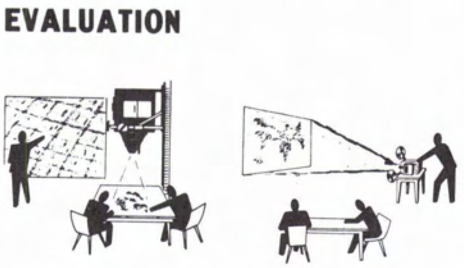

FIG. 5. MUTUAL INSPECTION FOR PEACE—HOW IT WORKS. Technicians interpret aerial and ground reports for possible evidence of surprise attack preparations or of mobilization.

STATUS OF MUTUAL INSPECTION

On December 16, 1955, the United Nations General Assembly passed a resolution urging the States concerned to implement a program for exchanging military blueprints, mutual aerial inspection and establishing control posts at strategic centers.

At various times since the President made his proposal, the Soviets have stated that they were prepared to accept aerial inspection, although not as expressed in the President's original plan. On April 30, 1957, they offered to open approximately one-third of their territory to the "Open Skies" program, if in return the United States would permit Soviet air inspection of Alaska and the territory west of the Mississippi River.

At the London Conference in August 1957, the delegations of Canada, France, the United Kingdom, and the United States proposed a number of partial measures of disarmament including several alternate proposals for opening certain specifically designated areas in both the Western and Soviet orbits to aerial inspection. The proposals ranged from limited inspection on a modest experimental basis to wide-open inspection of all areas, with the choice left to the Soviets. These proposals were summarily rejected by the Soviet delegation, and there the matter now rests. But in the words of Secretary of State Dulles, speaking of the Soviet rejection of the over-all joint disarmament proposals, "let us not fatalistically assume the Soviet response is their last word. . . . It is not impossible that those principles will yet obtain universal acceptance. Since the stakes are so high, no chance, however slight, should be left untried."

In the meantime, eight task forces were commissioned by Harold E. Stassen, then Special Assistant to the President for Disarmament, to design in specific terms a practical, effective, and comprehensive armament and armed forces inspection system. One of these task forces, under the capable leadership of General James H.

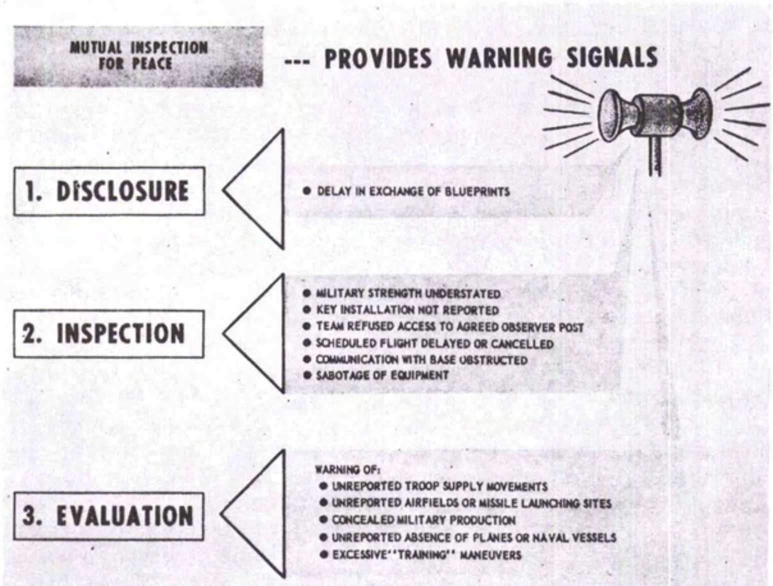

FIG. 6

Doolittle, was assigned to the preparation of a detailed study of the problems involved in the development and operation of a secure, dependable aerial inspection system. The work of the Doolittle task force has led them into such complex problems as inspection and military capability; civilian and legal considerations; the possible objects of inspection, such as airfields, aircraft and missile plants, missile test ranges; air defense and air traffic control installations; air research and development facilities; an operational plan, and personnel and communications requirements.

It is not intended that this paper state specific answers to specific questions such as we can confidently expect from General Doolittle and his associates. Rather it is intended to discuss technical aspects that are innate in the program, whether operations are conducted according to a plan developed by the Doolittle group or according to any other plan. For if the program is ever activated, members of the American Society of Photogrammetry are bound to be drawn into key technical positions, regardless of the character of the specific operational plan. We ought to be thinking about this; indeed, we must think about it.

Let us consider the photogrammetric aspects of an "open skies" program from two standpoints: first, what can be done; and second, what are the tough problems that will have to be licked.

What Can Be Done

To begin with, we can all agree that, given good photographs, at a suitable scale, expert photo-interpreters can extract a marvelous amount of information. This fact has been well-documented for popular understanding in articles such as the one appearing in *Life* magazine, October 28, 1957; this article described how skillful photo-reconnaissance work by the British during World War II led to the destruction of launching sites for German V-bombs on the continent, and thus averted a long-range attack which might have been catastrophic.

The United States, of course, also has this capability, as has been shown by the wartime work of such groups as the Military Geology Unit of the U. S. Geological Survey. As an example, we can consider the intelligence studies prepared by this group for the Corps of Engineers in connection with campaigns in the Western Pacific area. For years before World War II, the Japanese had released practically no information about the Mariana Islands. But in March 1944, the Navy furnished the geologists with some excellent low-oblique 24-inch photographs taken on a combat mission. Knowing the general geologic makeup of such islands—that they are composed of coral and volcanic rock—the geologists were able to predict where underground installations were most likely to be found, where the best areas were for airfields (these were subsequently developed for B-29's), what the water supplies would be, and where an attacking force could most safely land.

We must remember, however, that the problems of general inspection of a vast area are quite different from the problems of inspecting specific installations in a limited area. This leads to the premise that two kinds of aerial photography are needed: (1) general coverage at a relatively high altitude, from which clues such as transportation lines, airfields, and construction activities can be derived to give leads on the localities where pin-point photography is needed; and (2) intensive coverage of special-interest areas at low altitudes or with long-focal-length cameras.

As an example of what can be done in the way of general photographic coverage, consider the feat accomplished by Captain Robert Sweet of the Air Force in November 1957. Flying a sweptwing Voodoo jet, at about 47,000 feet, Capt. Sweet flashed across the country from Los Angeles to New York and back in six hours and 42 minutes, photographing a strip of terrain all the way. We know that a 13½-mile-wide strip can be photographed at an altitude of 9 miles with a standard 6-inch wide-angle mapping camera such as the T-12, in vertical orientation. If the usual base-height ratio of 0.63 were used, the exposure stations would by 5 miles apart. For a ground speed of 750 miles per hour, the cycling time would be 24 seconds. Now, this is a practical, already attainable, procedure. It means that given good weather and other propitious conditions, general photographic coverage of something like 65,000 square miles could be obtained in one day using one jet aircraft. Allowing for an overlap of 20–25 per cent, the net gain per aircraft per day would be about 50,000 square miles. At this rate, the entire $8\frac{1}{2}$ million square miles of the U.S.S.R. could be covered with vertical photography in some 170 aircraft-days, at a scale of 1:94,000. If transverse twin low-oblique photography were used instead of vertical, the coverage could be obtained in half the time, although there might be disadvantages outweighing the speed factor.

Photography at a scale of 1:94,000 would certainly not reveal fine details of military installations, but it might give effective clues, by means of visible transportation facilities or construction activities, as to where a closer look is needed. I am not recommending particularly that photography be obtained at this scale, but merely citing an example of what is already demonstrated to be feasible.

Unfortunately, there appears to be a widespread notion, strengthened by a recent widely-observed television program, that high-altitude photography can be enlarged and re-enlarged and re-enlarged again, with a gain in visible detail accompanying each enlargement. The example cited begins with a single 9-inch-square photograph showing all of Manhattan, half of New York Bay, and parts of Brooklyn, Queens, and New Jersey; from this small-scale photograph there is ostensibly extracted, through successive enlargement, a clear picture of 3 persons sitting in easy chairs and drinking tea on their patio. This notion should be filed with the story of the fellow who took a picture of the whole world, but it didn't come out because somebody moved.

Anyone who is at all familiar with photogrammetry knows that if an object is not imaged on the original negative, we cannot produce its image by enlargement. And the fineness of detail that can be imaged on the negative is limited by the grain size of the photographic emulsion, the resolving power of the lens, and the scale of the photograph. On the other hand, we do have reason to hope for better resolution of fine detail than we now have; manufacturers of aerial film have recently developed a new micro-file emulsion which promises to resolve objects too small for the naked eye to detect, so that enlargement will actually bring out details to a degree never before possible. At the present time, however, small-scale photography can not be considered as an effective means of obtaining *detailed* intelligence.

It is also pertinent to mention at this time the widely circulated statement that one plane can photograph at 490-mile-wide strip across the entire United States in less than 4 hours, and that this photography can be used to determine such data as the approximate capacity of oil refineries and steel mills. The reference here is apparently to horizon-to-horizon trimetrogon photography at an altitude of 40,000 feet. Anyone who has ever worked with trimetrogon obliques can well imagine what success he would have in determining the capacity of an oil refinery 245 miles from the flight track. More likely, the best that could be done would be to identify the gray spot on the horizon as probably Omsk rather than Tomsk.

Once an area has been spotted as a special-interest area, either from ground-observer reports or from study of the general coverage photographs, the next step would be to obtain large-scale photographs for an intensive study of details. This can be done by low-altitude flying, the use of long-focal-length cameras, or a combination of the two. It is this photography, at scales such as 1:5,000 or 1:10,000 which can provide data on the capacity of a refinery or the construction of a missile-launching site.

One of the interesting possibilities that has been in the news lately is the suggested use of an orbiting satellite as a space platform for aerial inspection. In view of the things that have happened in recent months, it would be foolhardy to say that it can't be done. Yet it must be admitted that it will take considerable doing to make this a profitable procedure for inspection. Suppose, for example, we were able to mount a 200-inch astronomical telescope (like the one at Mt. Palomar) in a satellite and then were able to get the satellite into orbit at 1,000 miles up, the ideal range according to Von Braun. Photography taken through the telescope, which has a focal-length of 55.5 feet, would have a scale of about 1:95,000, which again is hardly suitable for pin-point inspection. But assuming that the camera cycling problem at satellite speeds could be solved and assuming that we could recover the film readily, this would undeniably be an ideal way to obtain general coverage quickly and at frequent intervals. Of course, the mounting of a giant telescope in a satellite would present extremely difficult problems; here is where the need for finer emulsions and better lenses to give extremely high resolution is of prime importance, for they would permit the use of a smaller telescope to give the same amount of detail.

The Problems

In the meantime, we need to consider the major problems that would be faced if at some early date the program were suddenly activated and it became necessary to tackle the job with the means already at hand. It is my intention only to state these problems—we should all, as a group, be thinking about the answers.

Perhaps the most crucial decision to be made is in selecting the type of photography to be used, for on this decision rests the economy and efficacy of the whole program. A choice would have to be made between single-coverage at one flying height and multiple-coverage at two or more flying heights; between vertical photography and variants of oblique photography; between single-camera installations and multiple-camera installations; between short focal-lengths and long focal-lengths. The flight height, focal-length, and photo-scale would have to be carefully planned for each type of coverage to give the best combination of speed, economy, and effectiveness. An extremely important consideration is that the photography be designed to be compatible with the procedures to be used for evaluation and with the plotting instruments to be used in those instances when plotting is required.

The logistics of aerial inspection present no small problem. A basic decision in this respect is the frequency of repeating photographic coverage in order to keep it up to date. Weather research would have to be conducted to determine the number of photographic days per year that can be counted on, so that a reasonable determination can be made of the number of planes, crews, and cameras to be assigned to the job. The problem of supply—film, fuel, and other materiel—and the establishment of bases are other important logistical problems.

One of the knotty technical problems of aerial inspection is the detection of hidden installations—a problem which challenges the resourcefulness of our best photo-interpreters. Answers are needed on the extent to which infra-red should be used in photographing timbered areas and color photography to overcome camouflage. Photo-interpretation keys must be developed for searching out clues to underground structures. A system for coordinating photography with information furnished by ground observers is an important requirement.

A reliable procedure for relating photographs to available maps or ground control would be an essential element of the program, for without adequate control, we could literally get lost.

The procedure for evaluation of the photography utilizing the rapidly developing science of photo-interpretation, is the operation which bears the fruit of the entire cycle of operations. It must be set up to make maximum use of the best instruments and techniques for viewing, measurement and analysis.

Not the least of the problems of aerial inspection is the manning of the operations by adequately trained personnel functioning in an efficient organizational setup. A training program would unquestionably be required for personnel newly entering the field; but the American Society of Photogrammetry has a broad membership representing photogrammetric know-how and photo-interpretation ingenuity, in industry, government and the armed services, and a knowledgeable nucleus can be drawn from our ranks.

Conclusion

It is not intended to convey the impression that the mutual open skies policy, as now visualized, would be a continuing preventative to surprise attack. The job of detecting preparation for massive surprise attack under such a policy would logically change as the capability to launch such an attack increases.

Nevertheless we can see, beyond question, that there is a tremendous technical challenge to photogrammetry and photogrammetrists in the "open skies" program. If the policy becomes operative, the photogrammetry profession will have an opportunity to make a great contribution towards world peace. Let us, through our society, make it clear that we are aware of the challenge and the opportunity. Let it be known that we are deeply conscious of our responsibility as scientists and that we stand ready, if called upon, to exert our best efforts to bring the program to successful fruition.