SUMMARY OF THE RESULTS

The tests have shown that photogrammetric methods (simple photogrammetric map and photo-interpretation) can be used with success for planning long power transmission lines. The tests have shown, generally speaking, that the shortest line is not the cheapest, as other factors exercise a perceptible influence on the costs, such as ground conditions, topography, roads and property costs. Furthermore, it must be observed that in the course of discussions concerning the route for a power transmission line various interests call for the displacement of the line in one direction or another. It is then very expensive to check by traditional methods the extra costs resulting from such variations. With the method described the extra costs can be easily determined, which may be taken into consideration fairly quickly in the discussions. Furthermore, it may be noted that electronic data processing can very suitably be applied for determining the best alternative. On the other hand, the tests also show that the amount of work involved makes it necessary to modify the method if the time is very limited. This is normally the case however, in almost all modern planning of large constructions.

Aerial Color-Film in Military Photo Interpretation*

JAMES F. MCDANIEL AND JULIAN F. ARNTZ, JR.
Broadview Research Corporation, Washington, D. C.

I. Introduction and Abstract

In recent years, color-film has been and is being used in sharply increased quantities for non-military purposes. Despite the general popularity, the military services are still using only slightly larger quantities of color-film than they did before the Korean War.

This paper is essentially a review of the factors associated with the use of color-film by the armed forces. It also describes developments which may affect its role in future intelligence-reconnaissance operations.

II. What Is the General Military Viewpoint?

Most military interpreters, photographic specialists, and other reconnaissance planners have attitudes about color-photography that seem to place them in one of three categories:

Enthusiastic about the general military application of aerial color-film;

Feel that it offers very little more than black-and-white-film;

And the largest group of all—those who don't feel strongly either way.

By using aerial color-film sparingly, the armed forces have tended to giving no support to the enthusiastic group.

Actually, the three-layer emulsion, subtractive type reversal color-film which is in use today has an important although specialized, capability as a military reconnaissance tool. For the purposes of this paper, let us consider that a small, but significant "gain" is feasible because a certain percentage of the targets and images of military interest can best be interpreted on color-photography.

James F. McDaniel

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"Best" in this sense refers to the advantage in information extraction—in terms of quality, quantity, speed, and reliability of interpretation. Even though the amount of potential "gain" was not quantitatively determined, it is apparent that because of practical problems considered in the use of color film, only a fraction of it has been realized.

We find, however, that scientists and research officials—some of whom are military and civilian interpreters—have been studying color-film performance and potentials for a number of years. In fact, it is estimated by a representative of a film manufacturer that the Federal Government alone has spent more than 2.5 million dollars evaluating color-film under a wide range of conditions.[1]

One group sponsored four different contracts plus "in house" research in comparative studies of color and black-and-white films at various scales, seasons, and target types. The data from the P.I. standpoint indicated that color provided so little additional information that it should be used only for special purposes.

Despite the wealth of information now available about the relative merits of color and black-and-white-films for reconnaissance purposes, the facts are not generally known by military reconnaissance personnel, outside of research and development agencies, and there is no official doctrine for operational guidance, although a few hours of color interpretation is taught at some P.I. schools.

One of the few references to color-film which is generally available to military interpreters is a brief discussion in the 1953 Joint Photo Interpretation Handbook. Several color-film advantages for the interpreter were cited, but five different objections (none of which had anything to do with the interpretation process) were given as reasons for considering color as a special-purpose film. On the other hand, by reminding the P.I. that it is often advantageous to expose color-film along with panchromatic film in order to obtain the added advantage of observing certain features in their natural colors, the handbook implies that the interpreter should use his own judgment about requesting coverage in color.[2]

Three years after that manual was published, non-interpretation objections to, as well as P.I. limitations of color film, were still holding back its general acceptance. In one instance, a military research center wrote as follows to a prospective contractor: "There is no doubt that color adds a discriminatory factor. But the additional capability it gives has not justified the penalty the reconnaissance system must pay to enjoy it."[3]

Since the case against color is based upon the aggregate of its limitations (and many of these are slightly controversial), perhaps the best way to understand the "penalty" that color-film actually imposes on the reconnaissance system is to examine it in the military environment.

Let us consider the impact of color-film on the *major steps of the reconnaissance cycle—Collection, Processing, Analysis, Presentation and Dissemination.*

III. Disadvantages of Present Materials, Techniques, and Equipment

A. COLLECTION

Many factors must be considered when selecting a film for a reconnaissance mission, yet none are more important than the characteristics of the film itself. The limitations of a three-layer emulsion, reversal color-film are fairly well known and several of them will be mentioned by other members of the panel. The film is relatively slow. The exposure index of the new aerial color-emulsions range from 32 to 40 ASA.[4] Even the newer films require precision exposure adjustment. The tolerance for optimum color is only one-half stop more or less than the correct exposure.[5]

One of the most serious drawbacks to full color-film as a standard reconnaissance load is the fact that atmospheric haze and scattering of near-ultraviolet light often block out ground images in the blue bands of the spectrum. The selection of proper haze and color balance filters, therefore, is of critical importance, but even the use of filters does not necessarily insure good results.[6]

Since the urgency of military situations seldom permits the luxury of postponing reconnaissance missions until uniformly bright, hazeless days, naturally color-film sometimes fails to satisfactorily record target-area detail under operational conditions. This situation is unlike that of mineral explorations, timber surveys, crop damage assessments and other non-military photo missions which, presumably, can be scheduled with greater flexibility toward achieving optimum altitudes and weather, and where incident light conditions can be determined fairly accurately in advance of the flight.[7]

Another basic consideration regarding the film is the storage problem. Because latent image will deteriorate slightly on exposed, but unprocessed, color-film is sometimes given as an argument against its general use.[8]

A different type of problem is the extra time required to manufacture color film. It

is conceivable that in wartime our limited film-production facilities could be overloaded if the ratio of orders for color-film to black-and-white were not on the low side.

B. PROCESSING

Ordinarily, problems of film processing are of no immediate concern to the photo interpreter. For color film, however, the complexities of developing the film are a vote cast against having the film loaded and exposed for the interpreter in the first place. There is no question that the present processing techniques—by requiring sensitive temperature control, strict time periods for each bath, and careful agitation—place an added hardship on busy military photographic labs.

Another problem under the present system is the difficulty in making duplicate transparencies and color-prints. Furthermore, the loss of resolution and color balance when color-prints are produced, reduces their value to the photo interpreter.

C. ANALYSIS

It is true that a few cultural objects of military interest—such as railroad tracks and buried objects—frequently are more easily identified on infrared and panchromatic film than on color-film.[9] One of the greatest problems the military interpreter faces, however, is trying to extract information from scenes that are hidden behind the bluish veil of haze, and scattering of near-ultraviolet light which middle and high altitude color-photos almost invariably record. A longer wave-length filter reduces the haze, but also may drop out images reflecting blue light as well as other adjacent images in the target area.

The other major problem confronting the color-film interpreter is the lack of a satisfactory viewing system. Color-transparencies hold greater information content than color prints, but standard-issue viewing equipment —unfortunately this at some advance bases and ships is still the pocket stereoscope and a makeshift light-table—simply does not present the images to the interpreter in a manner suitable for detailed analysis.

Although not as critical as the two problems just mentioned, other problems tend to reduce the effectiveness of color-interpretation. There is the possibility that the interpreter may be misled by distortions of poor color balance. This would be so when dependence is placed on color-tones being true.[10] Other film characteristics such as flattening of color-contrast caused by atmosphere and altitude, resolution and image sharpness usually inferior to black-and-white-film, and, when magnified many times, an effect of graininess, also contribute a certain "noise level" to the interpretation effort.[11]

Finally, and in spite of what the military interpreter thinks color film can or cannot do for him, he has no key nor other reference manual which systematically guides and assists him in its use.[12] He probably has received very little training and experience in color interpretation;[13] nor has he had an opportunity to read and abstract the findings of the numerous comparative studies on the subject. His understanding and exploitation of object size, shape, texture, over-all pattern, and associated features may be almost second nature, yet the implications and direct value of tone or hue as diagnostic characteristics for specific targets and conditions are not as familiar to him.

D. PRESENTATION AND DISSEMINATION

The interpreter and the intelligence officer work with the photo personnel, publications staff, and other military units to report and distribute the products of the reconnaissance effort. Combat units, forward-area units and rear-area echelons are all accustomed to receiving reports and "hard copy" enclosures from operating reconnaissance groups. In the case of color-photo enclosures, this requirement is obviously not practical in with present processing and duplication methods. In addition, there are the annotation difficulties and special handling techniques required for shipping color materials.

IV. Impact of New Developments

Up to this point we have presented a brief review of the limitations, and some of the practical objections, to increased use of color-film for military reconnaissance. The remainder of the paper will attempt to point out how technical advancements and applications of the systems approach to the use of color-film could give it somewhat greater utility in future military operations. Again, the frame of reference is the Reconnaissance Cycle.

A. COLLECTION

Overcoming the problem of taking aerial color-photos in average and perhaps below-average incident light conditions is now largely a matter of converting new higher-speed emulsions into a film which meets aerial specifications. One new color-film, although manufactured for terrestrial purposes, has an ASA rating of 100, finer grain than

some 32 ASA films, and has been used as an aerial film at low altitudes with excellent results.[14] Another firm is planning to introduce a new aerial color-film which is reported to have improved performance characteristics—particularly in terms of resolution.[15] New developments in hardware are also encouraging. Airborne devices for automatically controlling exposures have reached advanced stages of development.[16] Many new types of cameras are being designed and built with image-motion compensation devices and a variety of format-sizes for manned and unmanned vehicles operating at a wide range of altitudes. It is more feasible, of course, to send a drone in to cover an important target at low, haze-free altitudes with color-film than a photo pilot who risks his life against enemy defenses.

The persistent haze problem is being attacked in other ways. Current and future reflectance studies will help determine those military objectives which may be in the blue spectral bands, but nevertheless are capable of being recorded by narrow band filtering without undue interference. Several other film filter investigations, such as additive color techniques and deliberately distorting recordings of color reflectances, may also increase our understanding of the problem and how to cope with it.[17]

B. PROCESSING

Progress in color-processing in recent years indicates that this problem can no longer be considered a serious technical obstacle to the routine use of aerial color-film. In addition to successful automatic color-film processing machines already developed, an announcement is expected in the near future which will mark the development of a color negative and self-processing color positive paper.

C. ANALYSIS

Here we are directly concerned with the interpretation "payoff" of the "gain" which is possible with color-film. Virtually all government-sponsored research studies agreed on the one point namely that color-film was equal to and in most cases superior to monochrome films for detecting and identifying practically all natural features. Although often rated either the poorest, second best, or sometimes equal to other film-filter combinations, color-film was regarded as the best media for identifying a fair number of man-made objects and certain forms of military, industrial and general activity.[18]

The following is a listing from a number of research studies of military targets and conditions which are likely to be identified more easily and/or more accurately on color film:

Amphibious Operations
- water depth determination
- identification of bottom materials
- water pollution
- tidal currents
- identification of water vegetation
- analysis of beach materials

Trafficability
- earth scars
- foot paths
- earth tone
- ground moisture content
- rock types
- faults
- fractures
- general terrain analysis
- general vegetation analysis
- water bodies

General Tactical Operations
- track activity
- dead and dying vegetation (used for camouflage)
- helicopter landing areas
- sites for combat bridges
- small marine craft
- gun positions
- detail in shadows and under trees

Strategic and Support Operations
- buildings
- mining industries
- chemical industries
- industrial components
  - ground stains
  - stock piles
  - end products
  - waste piles
- construction scars
- effects of fuels, smokes and other substances
- surroundings

It is now technically feasible to build high-speed, highly automatic systems for handling and viewing color-transparencies. Such a device might provide variable magnification, variable illumination, and filter selection and control. The latter would enable the color-film interpreter to increase the contrast between an object and its background, by selecting and using the optimum combination of light and filters.

If we consider the equipment which will be available for use in the near future, the basic problem of a suitable system for viewing color film can be regarded as much closer to solution.

D. PRESENTATION AND DISSEMINATION

The value of presenting military information in color has long been recognized. Terrain models, maps and projected color trans-

parencies are only a few of the means employed. Eventually military commanders and combat teams can receive intelligence and operational information in the form of projected color-photography on the screens of viewers, like those mentioned earlier, or on special automated display devices.[20]

In this connection, one naturally thinks of the broader military applications of color-television, and magnetic tape as one means of keeping distribution lists supplied with up to date photographic data.

V. Summary and Conclusion

In the past, color has been regarded by the military as a special-purpose film primarily because of:

1. Inherent limitations in the film
2. Complex (manual) processing procedures
3. Viewing difficulties

In 1959, however, better films are available, and quality control and automation are possible for a price in the color-processing and film viewing steps. This suggests a reappraisal of color-film for military use. But does this reappraisal suggest that the potential gain of color-photography can be raised, and that the military should promptly incorporate color film as a standard film load? Probably not. But it does mean that a military project which picks up loose ends, and brings these new developments and trends together in the form of a color subsystem, would get us much closer to a realization of the potential gain than we have ever had before.

The big point, however, is that the potential gain is essentially limited because of the inherent characteristics of the film itself and its direct application to the specific military interpretation problem.

Therefore, the military research laboratories, which are constantly working on this problem are not likely to impose the penalties onto the collecting aircraft and other phases of the reconnaissance cycle, until a major breakthrough has been achieved by the film manufacturer which gives increased information collecting capability.

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