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In the past two years, the Office of Special Projects has had numerous requests, and has given several briefings, on unconventional techniques for overhead reconnaissance. In the main, these requests have been concerned with color and night photography. In order to provide a reference to the intelligence offices on these subjects, we have published the attached report, which summarizes the most significant tests done in these areas in the last several years.

The report is up to date as of the current time; however, tests are still being run which will be included in the report at the appropriate time. For example, Mission [redacted] includes a test (900 feet) of a new high resolution color film, SO-242, the results of which will be added to this book. Other new films are in process of development (a high resolution Infrared color film, for example) which also will be tested and the results included in this report.

I sincerely hope that this document assists the intelligence offices in their evaluation of these new techniques, and I solicit your comments or questions on any of the techniques discussed therein.

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SUMMARY REPORT

SPECIAL PURPOSE PHOTOGRAPHIC TECHNIQUES FOR OVERHEAD RECONNAISSANCE

OCTOBER 1969

GROUP 1

Excluded From Automatic Downgrading and Declassification

DIRECTORATE OF
SCIENCE AND TECHNOLOGY

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Notice of Missing Page(s)

Pages 2-59 through 2-62 of the original document were missing.

The following pages of the original document were unnumbered:

i, ii, 2-6, 2-7, 2-13, 2-20, 2-21, 2-33, 2-45 through 2-48, 2-58, 2-71 through 2-75, 2-86 through 2-89, 3-8 through 3-19, 3-28 through 3-35, 4-8, 4-9, 4-18 through 4-23, 5-8 through 5-11, 5-19, 5-27 through 5-29, and 6-6 through 6-8.

The following pages of the original document were blank and unnumbered:

iv, 2-5, 2-8, 2-12, 2-14, 2-28 through 2-30, 2-32, 2-34, 2-38, 2-40, 2-42, 2-44, 2-54, 2-56, 2-57, 2-68, 2-70, 2-76, 2-82, 2-84, 2-85, 3-20, 3-24, 3-26, 3-27, 4-4, 4-10, 4-14, 4-16, 4-17, 5-12, 5-16, 5-18, 5-20, 5-24, 5-26, 5-30, and 5-34.

FOREWORD

Since 1966, the Office of Special Projects, DD/S&T, has sponsored a variety of photographic tests to determine the flexibility of various photographic collection systems and their potential application to certain intelligence needs. The vast amount of data has proven useful to this office and in several instances has been useful to the intelligence community. Many briefings and reports have served to convey pertinent information to the intelligence community at opportune times.

This office recently decided to summarize the variety of techniques assessed to date to serve as a ready reference to analytical and tasking components within the intelligence community. Detailed reports on each topic have been widely distributed throughout the community. If further information is at any time desired, feel free to contact the Office of Special Projects.

This book summarizes the contributions of many people and many organizations. While we cannot list all of these groups, special mention and recognition is made of the contributions of the Office of Special Activities, DD/S&T; the National Photographic Interpretation Center, and the United States Air Force.

[redacted]

CONTENTS

FIGURES

[redacted]

TABLES

Notice of Page Substitution

1. INTRODUCTION

For the purposes of electronic archiving, this page is a substitute for an unscannable page.

1. INTRODUCTION

Over the years, a number of tests have been run aimed at evaluating unconventional photographic acquisition techniques. These tests have been accomplished with the ultimate intent of increasing the tools available to the analyst for intelligence collection. It is the intent of this summary book to present the analyst with a capsule summary of the significant tests run in the last 5 years. In this regard, the summary book is partly for reference and partly for education. It does not attempt to arrive at any conclusion(s) relative to the intelligence value of any of the techniques, but does attempt to set down what has been done. In this regard, we hope to present detail sufficient to allow the analyst to arrive at a conclusion relative to the potential use of any of these techniques for his problems. The ultimate use of any of these techniques resides, of course, primarily with the user and not the collector.

The book contains results from primarily four programs: 112B, KH-4, [redacted] While numerous tests have been conducted on other vehicles, these four have produced the preponderance of usable and significant data. Also, we have not included results of all the tests, but only those which were (1) successful, and (2) considered of interest to the user community.

Sections 2 through 4 deal with the subject of color, a topic of considerable debate in the community at the present time. Section 2 deals with normal color, Section 3 with the infrared or false color, and Section 4 with bi-color (the producing of color from black and white records). Section 5 deals with night detection and low sun angle photography. Finally, Section 6 deals with the subject of exposure with the KH systems. While this section does not deal with tests per se, it was included because exposure does have an effect on information recording, and the intelligence community might want to use the exposure control available on the KH systems to enhance the recording of a particular target or area.

You will notice that the book has been organized so that it can be periodically updated. It is our intent to update the book when new tests are run that might be of interest to the analyst. In this manner, we hope to assist the community by providing a ready reference of what has been done and what is the latest status of these unconventional overhead reconnaissance techniques.

While the examples in this book are the best representations of the original materials that we could make, they are not necessarily as good as the original materials themselves. The duplication materials available today do not have as high a resolution level as the camera film, and some color balance distortion generally occurs in reproducing successive generations of color images.

Notice of Page Substitution

2. COLOR

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2.1 COLOR DISCUSSION

The world as viewed from a very high altitude cannot be considered a "riot" of color. Indeed, it appears rather monolithic. What is of interest to strategic reconnaissance, in terms of color, are the ways in which man disturbs this color monolith. He does this in a number of ways: by what he grows, mines, manufactures, processes; by what he produces in terms of waste from his manufacturing and processing; the color signatures he produces when he is in the process of building; and the manner in which he uses color to identify objects. For each of these cases, it has been demonstrated that a color record contains additional information not available in a single black and white record.

The principal objections to the use of color materials in high resolution satellite acquisition systems has been the low spatial resolution exhibited by these materials. In general, this problem is not connected with the kinds of color information sought, but with the information normally sought with high resolution black and white materials. For the time being, the use of color is necessarily aimed at solving color-oriented problems and not general reconnaissance problems. This is somewhat unfortunate since there are indications that color can also provide more rapid location of targets in the search mode due to the added dimension of color differences.

There are basically three techniques for obtaining color photography in satellite systems:

1. Conventional color films
2. False color films
3. Multispectral techniques.

Conventional color films such as SO-121, SO-242, and SO-255 provide a color image that is similar to the ground scene. These materials are designed to reproduce color cues visually through the use of three separate emulsions coated on a single base. For applications in high altitude photography, elimination of degrading blue atmospheric hazelight is accomplished with filtration. A Wratten no. 2E with some color correction filtration is necessary to optimize color rendition with SO-121, while the more advanced SO-242 and SO-255 are self-contained with proper filtration built into the emulsion layers. These color films have been used on various KH missions, and details of the results are reported in the following pages. The SO-121 and SO-242 are both versions of Kodak Aerial Color film on Estar thin base. The SO-255 is a version of the SO-242 emulsion tri-pack on polyester ultrathin base (UTB). Higher resolving power and lower granularity are characteristic of the SO-242/SO-255 as compared with the SO-121. Commensurately, when SO-121 is used in a system with 3404, neutral density filtration is necessary on the color film to match the speed of the panchromatic film, whereas the speed of SO-242/SO-255 is similar to that of 3404.

The second technique for obtaining color photography—"false color" films—also involves a multilayer-coated film on a single base. Kodak Infrared Aero Ektachrome, SO-180, is one such film. The spectral sensitivity of this film provides an image recording capability in the near infrared region of the spectrum. The SO-180 has green, red, and NIR sensitive layers comparable to the blue, green, and red sensitive layers of SO-121 and SO-242. With such a sensitivity arrangement, color information is effectively translated down the spectrum—NIR information is recorded as red, red information is recorded as green, and green information is recorded as blue.

The third category—multispectral (or bi-color in the case of two records)—does not employ a single film. With reversal color film, the final image is obtained on the same material as used in the camera, and the reversal is accomplished in the processing stage. Color photography can also be achieved by photographing the same scene with three individual black and white emulsions.

each altered with the appropriate filtration to record the blue, green, and red components of the spectrum. With this type of color photography, the reconstitution of the image is accomplished in the laboratory where the three black and white records are superimposed and exposed through the appropriate filters. This process is called tri-color additive photography.

Classical color theory dictates that it is necessary to use three primary colors—red, green, and blue—to produce a print with a full range of colors. It is possible, however, to obtain a pseudo color print using only two records—green and red. This type of photography is called bi-color (or bi-spectral), since the color record is formed by superimposing only two records. Although it is impossible to obtain a full range of colors with the bi-color technique, theoretical tone reproduction studies have shown that the range of colors that can be achieved is large enough to produce a reasonable approximation of normal color photography, considering the degrading effects that the atmosphere has on conventional reversal color films. The KH-4B camera system has the capability to acquire bi-color photography by using the normal red filter in the FWD-looking camera and an alternate green filter in the AFT-looking camera.

Proper assessment of the value of a particular approach to color acquisition requires that it be considered in the context of the color problem as a whole. This is necessary to keep from going off on expensive and nonproductive tangents. Many of the specific color materials or color techniques have their worth either in expedience or in the solution of very specific color problems. but should not be considered as "general" solutions to the color acquisition problem. For example. there is no doubt that the bi-color approach is particularly attractive with the mechanics of current satellite acquisition. However, synthesis and exploitation of the resulting color photography is difficult to accomplish. This is particularly true for convergent stereo panoramic systems. Moreover, it now appears, from the color tests that have been run in satellite systems, that three spectral bands are required for general reconnaissance color photography. However, some applications require only information on the degree of color shading, for which the bi-color approach is acceptable. Concerning conventional tri-pack emulsions now available (e.g., Ektachrome), the color "resolution" limits their utility in very small scale photography. For example, while a very large field or settling pond may be represented properly in terms of its color, it is not possible to distinguish color bands on aircraft or the color of a missile warhead at KH-4B scales.

Perhaps the most valuable color material in connection with small scale photography such as the KH-4 system is the SO-180 IR sensitive color material. The kinds of problems which are solvable with this material do not necessarily require high resolution either in the sense of cycles per millimeter or color "resolution."

It is the opinion of this office that color reconnaissance is a valuable tool as an adjunct to black and white high resolution photography. Also, there are certain requirements for which color provides the only answer. The importance of color and the degree to which it can be practically implemented in real systems are questions yet to be answered. For this reason it is hoped that the analysts for whom this book is primarily intended will consider color as a means of answering questions about their own targets.

2.2 COMPARATIVE EVALUATION OF EIGHT COLOR MATERIALS

2.2.1 Test Type

A laboratory analysis was conducted for the comparative evaluation of eight color materials.

2.2.2 Test Objectives

Test objectives were as follows:

1. Perform a laboratory evaluation of the physical characteristics of eight commercially available color materials.
2. Determine the relative image quality characteristics of these materials under static pictorial conditions.

2.2.3 Test Details

The eight materials evaluated under this task are listed in Table 2.2-1. The test consisted of determining the basic photographic characteristics of these eight materials. Dye separations were made through selective exposure to the various dye-forming layers. From these samples, both the spectral sensitivity and the dye curve shapes were measured.

The shapes of the spectral sensitivity curves are all approximately the same except for SO-121. This film does not have a yellow filter layer between the top and middle layers as do the other seven films. The yellow filter layer is ordinarily used to prevent the blue light from exposing the blue sensitivity of the bottom two layers. Without this mechanism to effectively desensitize this unwanted blue sensitivity, the manufacturer probably relies on special desensitizing dyes. These are apparently not as good as one would like since the green-sensitive layer is almost as sensitive to blue as the blue layer itself.

The dye curves for the films are quite different. This difference is predominant in each material's cyan dye. The cyan dye peak for Kodachrome II is approximately 640 nanometers, while that of Agfachrome CT-18 is approximately 690 nanometers, a 50-nanometer shift toward the red. The Kodachrome II cyan dye curve is also considerably narrower than the remaining film layers. In all cases, the yellow dye curves are almost identical. This difference would affect the duplication capability of the materials.

The resolution of the materials was determined for samples balanced for a neutral image. The procedures involved were the same as those in the proposed USASI standard for resolution of black and white materials. A resolution camera that employed a microscope lens known to have a resolution in excess of 2.000 cycles per millimeter was used. Table 2.2-1 gives the resulting resolution values.

The END sensitometric curves for the materials as well as the constants for relating integral spectral density values to equivalent neutral density were found. The general observation from these data is that Kodachrome II has the highest contrast and the shortest exposure latitude.

In order to test these materials under simulated photographic conditions, a scale model was used. Each of the films was used to photograph this model under simulated daylight conditions with a 35-millimeter camera. Figs. 2.2-1 and 2.2-2 contain 75× enlargements of sections of these pictures.

The first observation that one makes when viewing these pictures is that the Kodachrome II imagery is sharper than that of any other material. This is the most significant conclusion of this analysis. The SO-121 and Agfachrome CT-13S assume second place as far as image quality is concerned. The two GAF products exhibit the poorest image quality of the materials tested. However, one should not draw the same general conclusion to all GAF products. The color balance of each of these materials is different; however, with the exception of SO-121, the films have approximately the same color rendition capability.

2.2.4 Results and Conclusions

1. Kodachrome II has the highest image quality of the eight materials tested.

2. The color reproduction characteristics of the materials are different; however, the correction available in the duplication process can be used to make these differences small.

3. The processing of Kodachrome II is limited by equipment design to 35-millimeter film widths. Processing of 70-millimeter Kodachrome is achieved by slitting the material into 35-millimeter widths. With no great demand for the larger format, it would be a costly requirement to design equipment to process other than 35-millimeter Kodachrome II.

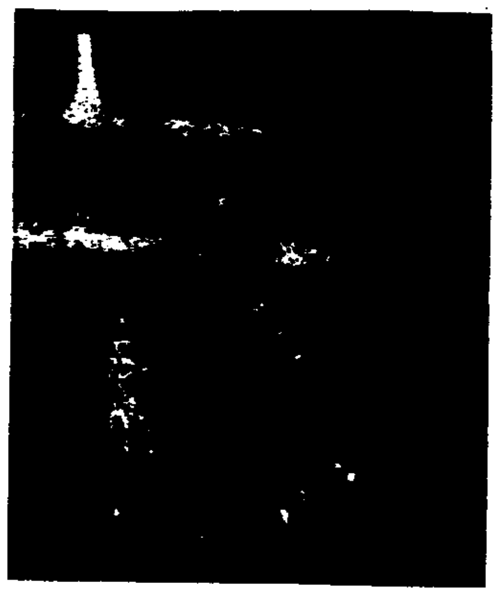
Table 2.2-1 — High and Low Contrast Resolution for the Eight Films Tested

Film	1,000:1	1.6:1
Kodachrome II	180	82
SO-121	130	73
Ektachrome High Speed	65	41
Ektachrome -X	100	58
Anscochrome D/50	92	48
Anscochrome D/100	82	46
Agfachrome CT-13S	180	65
Agfachrome CT-18	50	41

(a) Kodachrome II

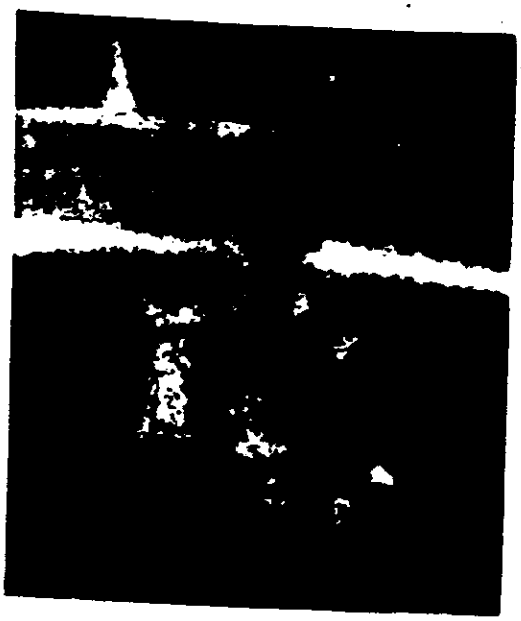
(b) Kodak SO-121

(c) Ektachrome High Speed

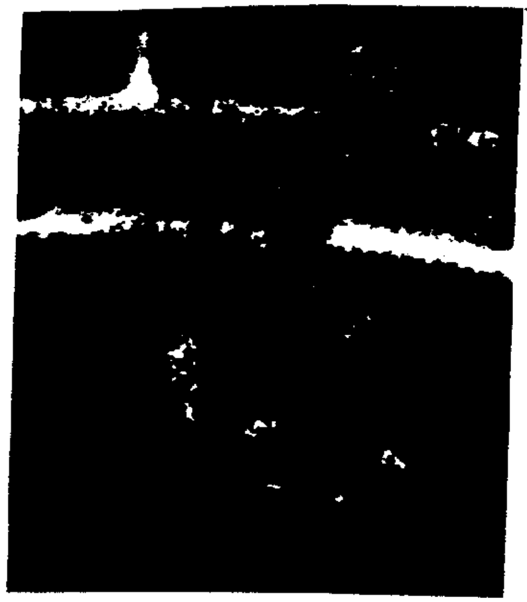


(d) Ektachrome X

Fig. 2.2-1 — Small section of the model (75×)



(a) Anscochrome D/50



(b) Anscochrome D/100

(c) Agfachrome CT-13S

(d) Agfachrome CT-18

Fig. 2.2-2 — Small section of the model (75×)(Cont.)

2.3 EVALUATION OF SO-121 AT LOW SOLAR ALTITUDES

2.3.1 Test Type

The aircraft-112B camera system was used for this test.

2.3.2 Test Objectives

Test objectives were as follows:

1. Examine the color reproduction of SO-121 at low solar altitudes.
2. Obtain an estimate of the image quality obtainable with this material.
3. Estimate the performance of SO-121 in the KH-4B system.

2.3.3 Test Details

The photography from this test was obtained on 28 July 1966 using the 112B camera system at 65,000 feet. This produced a scale of 1:33,000 at the center of format for the original negatives. The flight line consisted of a repeated pattern over Bakersfield, California as indicated in Fig. 2.3-1. The flight started early in the morning in order to acquire photography at very low solar altitudes. The photography continued from 5 degrees solar altitude to midmorning when the solar altitude was 37 degrees. In order to obtain well exposed photography over this wide range of solar altitudes, a neutral density filter was used in one camera to make a full stop difference in exposure between the two instruments. The specific camera parameters for the flight are listed in Table 2.3-1.

2.3.4 Discussion of Examples

Two photographic illustrations have been included to show the resultant photography at the extremes of the solar altitudes covered (see Fig. 2.3-2). These illustrations have been printed to look as much like the original SO-121 film as possible. It is interesting to note that in making these images many of the test prints had a much better color balance. However, they were not used since they were not good representations of the original material.

At the low solar altitude, sufficient quality is present to clearly locate small aircraft. There is little improvement in the recognition of these aircraft (or support vehicles) at the higher solar elevation. The overall color cast of the material at low solar altitudes is bluish. However, there are areas of warm tone where the sunlight strikes the area directly. In the shadow areas, such as near wooded terrain, there is a severe loss due to underexposure.

At the higher solar altitudes, the image has a warmtone cast, principally brown. Almost the entire scene is illuminated by direct sunlight. As such, there is detail prevalent in the wooded areas. High reflectance objects are really not that much easier to identify and recognize. This can be noted in the light aircraft, the terminal area, the swimming pool, and the parking lot.

2.3.5 Results and Conclusions

The following results and conclusions were obtained from this evaluation:

1. SO-121 can generally be used at solar altitudes as low as 10 degrees with 112B. Certain types of information can be recorded at solar altitudes as low as 5 degrees.

2. A full load of SO-121 could be properly exposed at solar altitudes as low as 13 degrees in the KH-4B system. Only slight underexposure would occur at 10 degrees. A partial load, however, would be more severely limited since one of the filters would have to be used for the

black and white film. Thus, neutral density on one of the filters could not be used for an exposure control. The range in exposure available on KH-4B is 1 1/3 stops, which does not encompass the speeds of both 3404 and SO-121.

3. The Petzval lens is not optimized for the entire visible spectrum. The 2:1 resolution performance to be expected from a split load of 3404 - SO-121 is 40 to 50 lines per millimeter for the SO-121. There would be no loss in the 3404. The resolution expected from a full load of SO-121, where the lens can be set at peak focus for this material, is approximately 50 to 60 lines per millimeter. It would be worth considering a lens design corrected for the entire visible wavelength band if color is to be used extensively in the KH-4B system.

4. Color reproduction is poor at the low solar altitudes when using the nominal color-compensating filter pack. For a full load, where both prime and alternate filter positions can be devoted to the color film, a separate filter pack should be used at low solar altitudes. However, this is not practical for a partial load of color film since one filter position would have to be used for the black and white emulsion.

5. Poor color balance (from either improper filtration, inadequate exposure or low solar elevations) can be partially corrected in the duplication stage.

6. The blue component of the color image is severely affected by atmospheric haze, resulting in very low contrast. A stronger haze-cutting filter (such as the Wratten no. 4) would be useful in improving the contrast. However, there must be an appropriate color correction filter used to offset the yellow cast that would result in the highlights.

Table 2.3-1 — Specific Camera Data for the Bakersfield SO-121 Flight

	AFT-Looking Camera	FWD-Looking Camera
Film	SO-121	SO-121
Slit width	0.031 in.	0.031 in.
Exposure time	1/600 sec	1/600 sec
Color correction filter	30CCB	30CCB
Haze-attenuating filter	Wratten no. 2E	Wratten no. 2E
Neutral density filter	None	0.35
Scan mode	II	II
f/number	3.5	3.5

NOTE: A 0.9 neutral density filter was placed over the frequency markers and frame counter on both cameras.

Fig. 2.3-1 — Flight lines for SO-121 test over Bakersfield, California

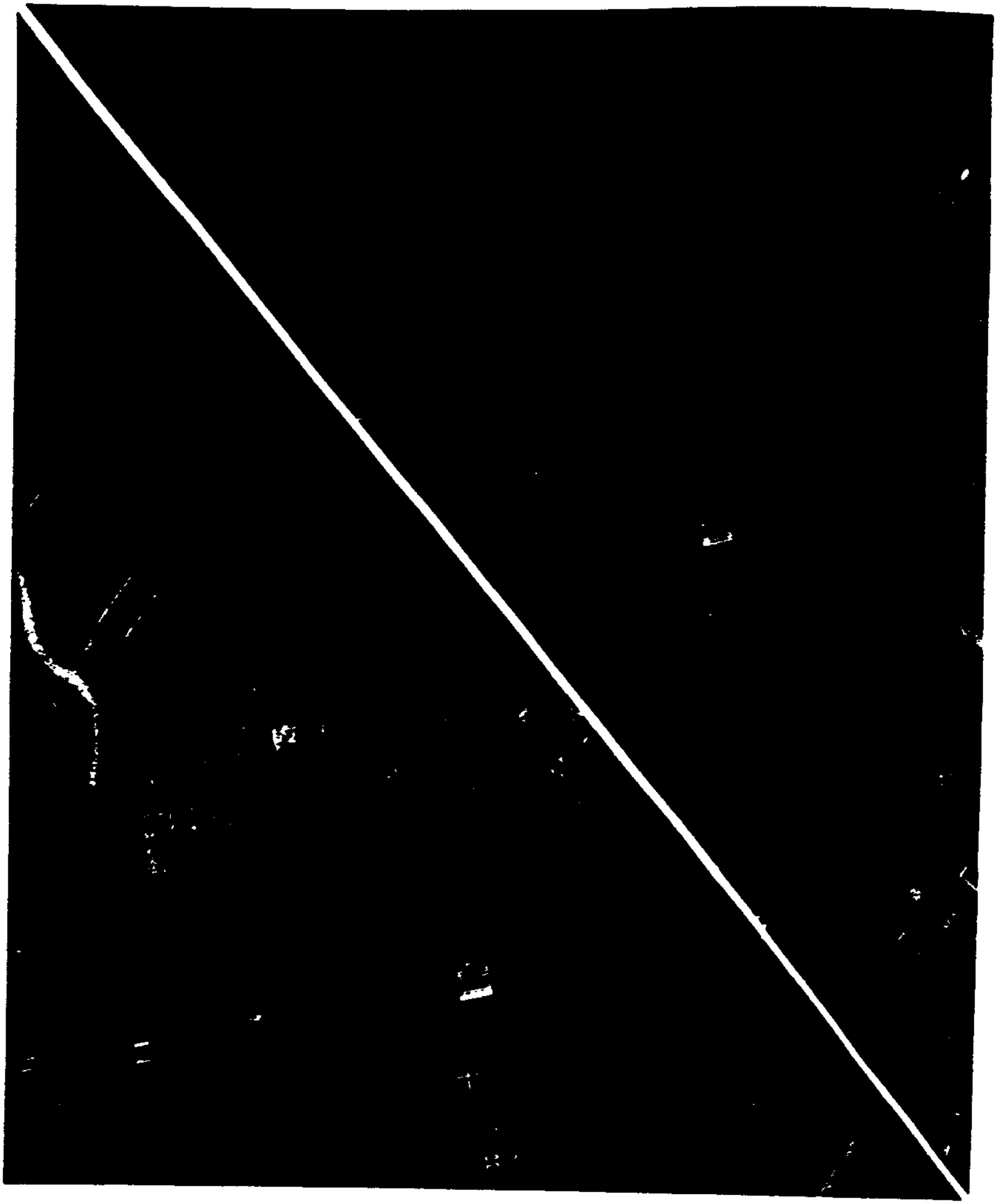


Fig. 2.3-2 — Photographic samples at 5.9- and 37.3-degree solar altitudes (from SO-121)

2.4 METRIC COMPARISON BETWEEN SO-121 AND 3404

2.4.1 Test Type

The aircraft-112B camera system was used for this test.

2.4.2 Test Objective

The objective of this test was to indicate what change, if any, is to be expected in image mensuration precision when SO-121 color film is used in conjunction with or in place of the standard black and white film (3404).

2.4.3 Test Details

Complete black and white and color stereo coverage of a suitable target area was acquired with an aircraft flight employing the two 24-inch stereo cameras of the 112B system. These 13-degree convergent cameras were flown at 65,000 feet, giving a scale at center of format of 1:33,000. The 3404 was used in the FWD-looking camera and the SO-121 was used in the AFT-looking camera. Additional details concerning these cameras are listed in Table 2.4-1. The flight paths consisted of two cloverleaf patterns over Phoenix and Tucson, Arizona (see Figs. 2.4-1 and 2.4-2). The photography used for this test was selected from the Phoenix flight and consisted of one stereo pair (2 frames) of each film type giving almost identical coverage of the same target area.

Prior to the mensuration phase of the test, a variety of different types of duplicates of the original photographs were made. These dupes were made from the original 3404 and SO-121 imagery. The dupes from the color film were made through a series of filters—red, green, and blue—and also with white light. All of these dupes were analyzed for relative image quality and image content. The mensuration phase of the test was limited to the black and white positives of the 3404, the black and white positives (white light) of the SO-121, and the original SO-121 color positives. These were felt to best represent the types of materials to be used by the dimensional intelligence and mapping communities.

Within the area covered, a group of measuring points was selected. These points were then measured on a Wild STK-1 Stereocomparator, making monoscopic pointings, stereo pointings, and stereo parallax measurements. The black and white and color materials were used both independently and in combination for these measurements. All of the measurements were repeated a number of times to provide sufficient statistical data for a metric comparison of the materials.

2.4.4 Discussion of Figures

Figs. 2.4-3 and 2.4-4 contain the images made from the separation records. The most immediately noticed feature is the very unsharp blue record image. Notice the large amount of specular reflection from one of the commercial aircraft at the terminal. The "ballooning" is considerably reduced in the red separation record, even though both were made from the same original SO-121 image. The CORN target resolution values for the various prints are listed in Table 2.4-2. For optimum results with SO-121, the camera focus should be shifted slightly. This was not done in this test, and, as a result, the color film resolution was 48 cycles per millimeter (as determined from mobile CORN targets) instead of the expected maximum of 60 cycles per millimeter.

The red and green records have resolutions of 24 and 30 cycles per millimeter when made from the 48-cycle per millimeter color material. The green is slightly higher because the green-sensitive layer in SO-121 film is coated on the top and the lens performance in both of these regions is almost equal. The blue, however, suffers considerably, having a resolution of only 9 cycles per millimeter.

Although there is not a great amount of color in this scene, one aspect of the tonal rendition is easily seen. The ground in this area is principally brown, as evidenced by the color print. This means that the ground is very dark with respect to the blue filter and light with respect to the red filter. The best example of this is in the region of the CORN targets. In the red record, the white panels of the CORN edge almost blend in with the dirt surroundings. However, the reverse is true in the blue separation record. The white panels stand out and the black ones almost blend in with the background.

Figs. 2.4-5, 2.4-6, and 2.4-7 show the results of the mensuration analysis. The ordinate on these three figures is the standard deviation of the repeated measurements on each target point. Fig. 2.4-5 shows the precision of the monocular pointings and indicates that those made on the 3404 images are consistently better than those on either the SO-121 original or the black and white print of the SO-121. Since the average precisions on the latter two materials are approximately equal, and the deviations between them for individual targets do not correlate to the color of the targets, it would appear that the lower pointing precisions for these materials are related solely to their lower resolutions. This same conclusion might be drawn from Fig. 2.4-7 which illustrates the precision of stereoscopic parallax measurements made in balanced stereo models formed by two images on similar materials. This conclusion, however, is not substantiated by the results of the stereoscopic pointings as illustrated in Fig. 2.4-6. In this case, the two black and white materials show equal precision despite their differing resolutions. The plots of the pointings and parallax measurements made in the combined or unbalanced stereo models (not shown) illustrate similar conflicting results.

2.4.5 Results and Conclusions

1. Black and white separation positives can be made from SO-121 film. The tonal relationship in these positives can be made to be nearly identical to 3404 by using a red filter in the printer. In the contact duplication employed in this test, the resolution of the red separation positive was 50 percent of the original SO-121 level. The green separation was higher—75 percent. The blue record resolution was only 20 percent of the SO-121 level.

2. In this test, none of the pointing or parallax measurements showed any definite dependencies upon the color of the target. This held true even for the mobile CORN target color panels.

3. Although this test indicates a trend for the measurements on the higher resolution material to be somewhat more precise than those on the lower resolution material, the magnitude and significance of the numbers associated with these precisions need some qualification. The average measuring precisions on the 3404 and SO-121 materials differ by approximately 1/2 micron while the precisions of the individual targets on both materials differ as much as 1.5 to 2.0 microns. The magnitudes of the average precisions, then, may vary through this 2-micron range depending on the particular selection of targets. The average value for both materials, however, should vary together, thus maintaining a spread of approximately 0.5 micron. This would indicate then that the choice between the two materials for the measurement of intelligence type targets would only be important in the most precise operations where a difference in measuring precision of 0.6 micron or even 1.0 micron would be significant.

4. No conclusions from this test should be extrapolated to SO-180 (infrared color film) since its image formation and system resolution are not the same as SO-121.

Table 2.4-1 — Specific Camera Settings for Metric Flight

	AFT-Looking Camera	FWD-Looking Camera
Camera	I3	I4
Film	SO-121	3404
Slit width	0.049 in.	0.049 in.
Shutter speed	1/385 sec	1/385 sec
Haze-cutting filter	Wratten no. 2E	Wratten no. 21
Color correction filter	30CCB	—
Neutral density filter	0.68	—
f/number	3.5	3.5
Scan mode	II	II

Table 2.4-2 — Resolution Values From Mobile CORN Target

Image	Resolution, cycles per millimeter
Blue separation	9
Green separation	30
Red separation	24
White light print	30
Original 3404	77
Original SO-121	48

Fig. 2.4-1 — Flight lines for metric coverage of Phoenix and Tuscon, Arizona, and Los Angeles, California

[redacted]

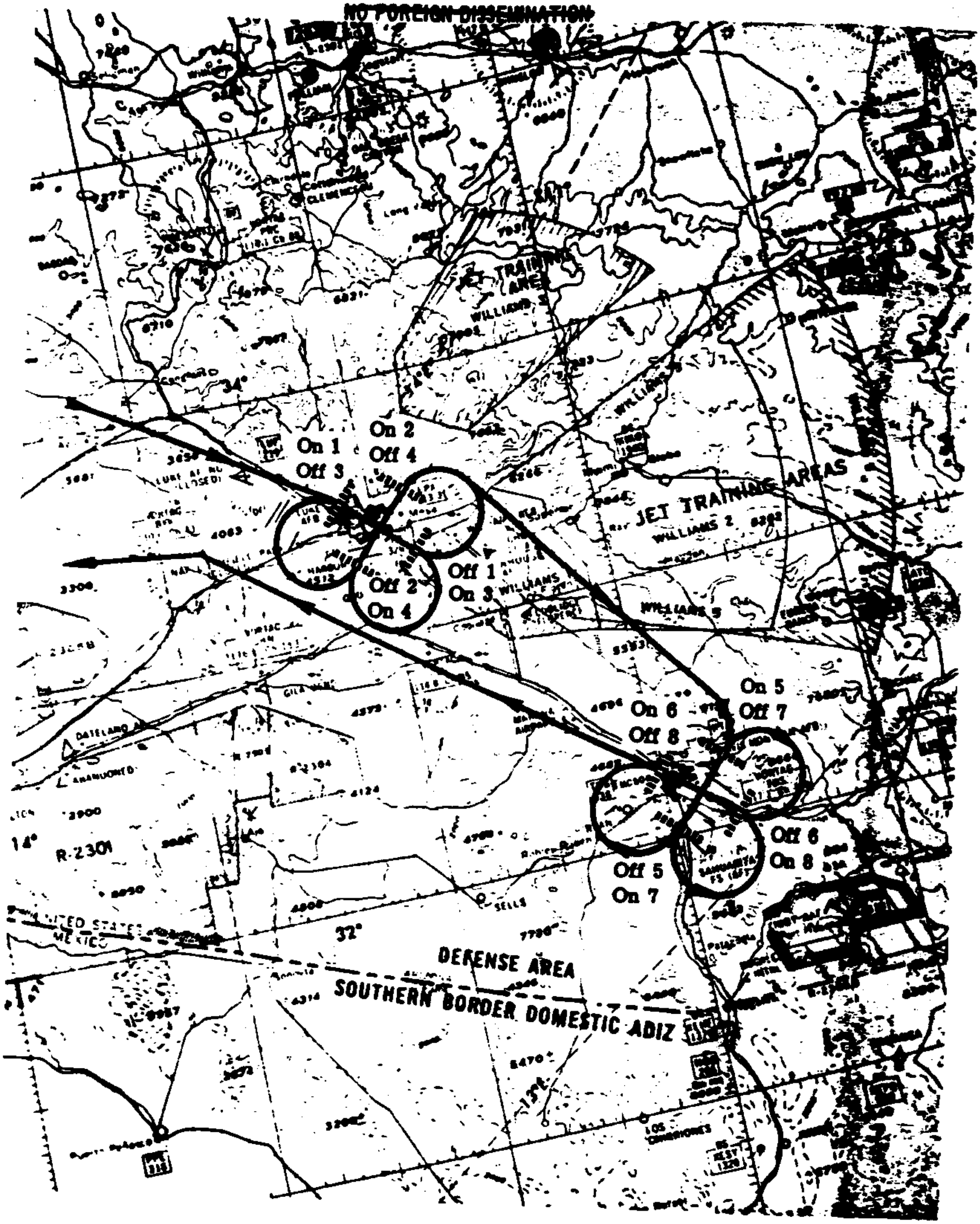


Fig. 2.4-2 — Flight lines for metric coverage of Pheonix and Tuscon, Arizona, and Los Angeles, California (Cont.)

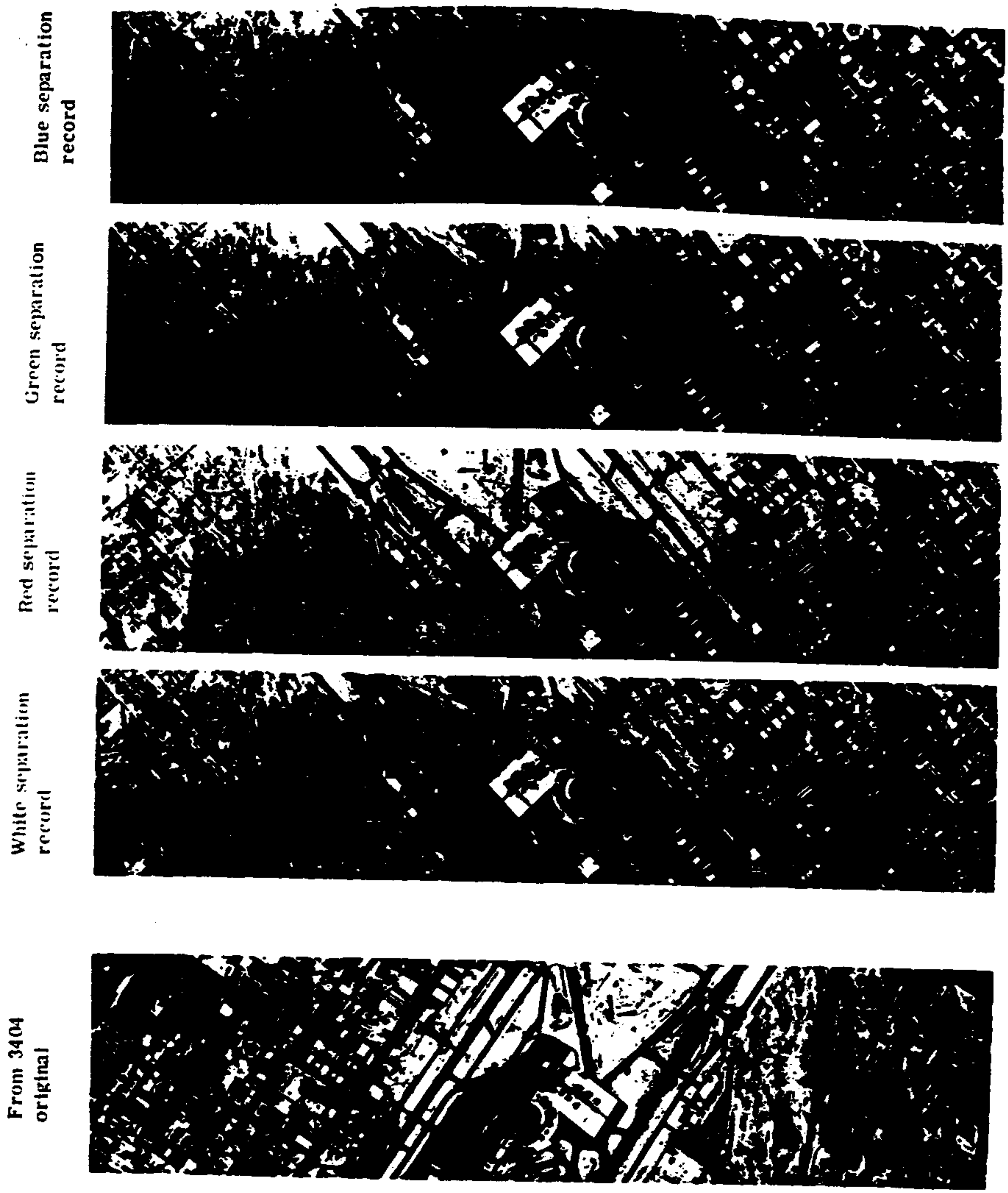


Fig. 2.4-3 — Black and white images from SO-121 and 3404 original materials

NOTE

The black and white images on the previous page were made by contact printing the SO-121 original transparency (through separation filters) on a black and white panchromatic sensitive film. These negatives were then duplicated on the paper to make these figures.

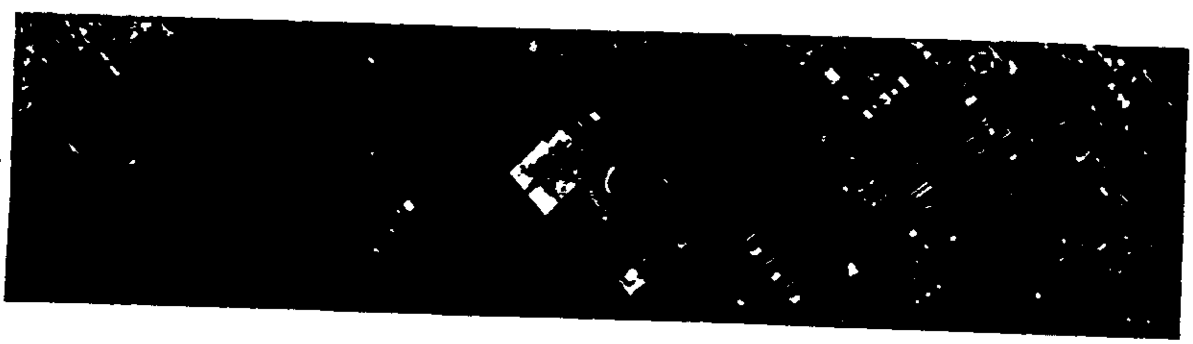


Fig. 2.4-4 — SO-121 film

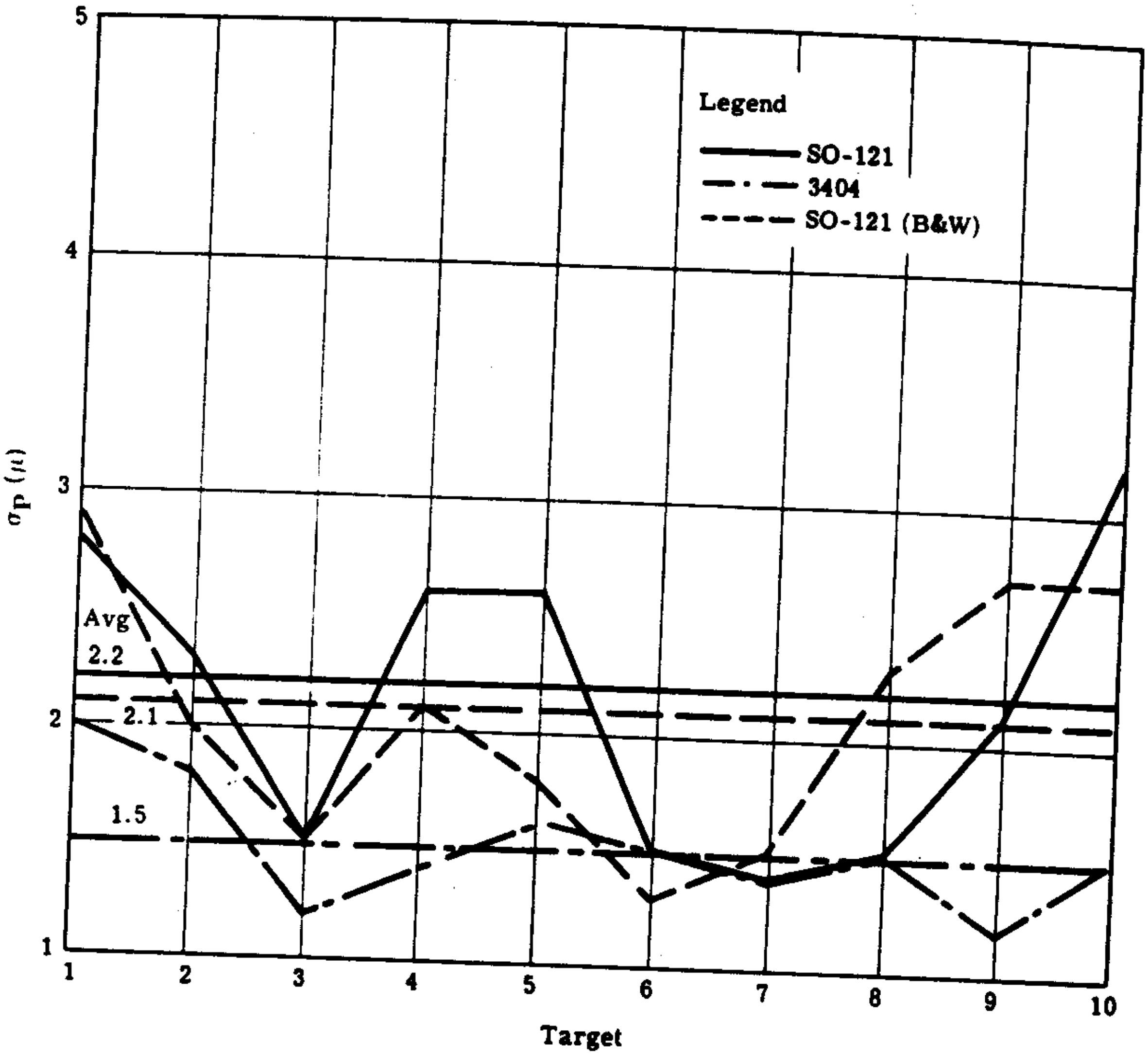


Fig. 2.4-5 — Error from monocular pointing ($\sigma_P^2 = \sigma_x^2 + \sigma_y^2$)

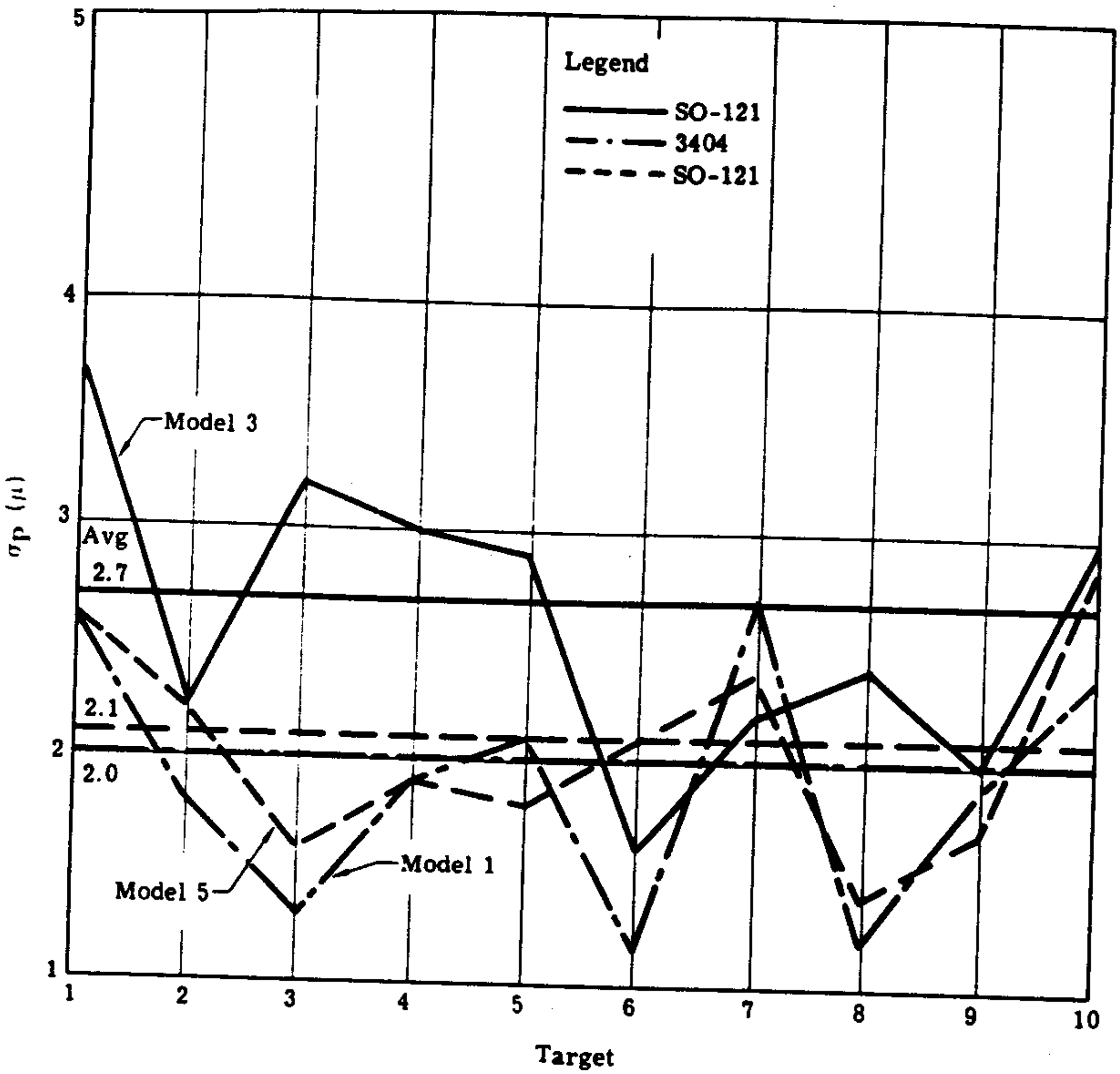


Fig. 2.4-6 — Error from stereoscopic pointing of balanced models ($\sigma_p^2 = \sigma_x^2 + \sigma_y^2$)

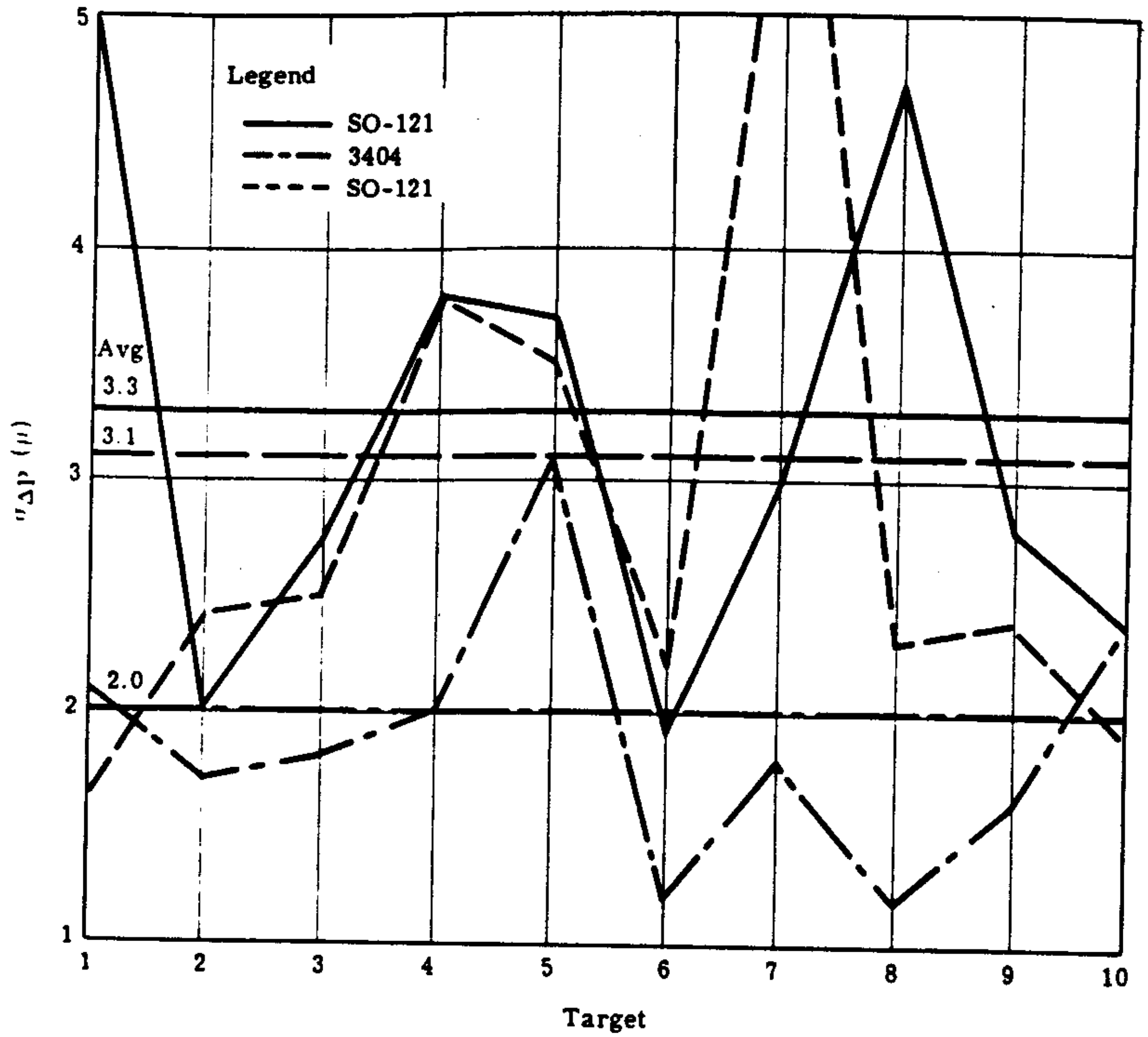


Fig. 2.4-7 — Error from stereoscopic parallax of balanced models ($\sigma^2_{\Delta P} = \sigma^2_{\Delta P_x} + \sigma^2_{\Delta P_y}$)

NOTICE OF REMOVED PAGES

Pages 2-25 through 2-48 are not provided because their full text does not contain CORONA, ARGON, LANYARD programmatic information.

2.7 CR-5 AND CR-6 SO-121 FLIGHTS

2.7.1 Test Type

The satellite KH-4B camera system was utilized for this test.

2.7.2 Test Objectives

The mission 1105 SO-121 test was intended to: (1) obtain for the first time conventional color photography from the KH-4B system; and (2) demonstrate the capability of the KH-4B camera system to handle SO-121.

The COMIREX requirement for SO-121 on mission 1106 was to obtain color-oriented intelligence over central China.

2.7.3 Test Details

2.7.3.1 Mission 1105 SO-121 Flight

Mission 1105 contained 500 feet of SO-121 spliced to the end of the primary mission film load of SO-380 on the AFT-looking camera. A material change detector on board the vehicle automatically brought the alternate filter into position when the color film was in use. Color coverage was obtained on five photographic passes as indicated in Figs. 2.7-1 and 2.7-2. The film change occurred on revolution no. 273 as the vehicle passed over the central USA. The color imagery from this pass provided the best resolution from the color film of this mission. The next revolution, no. 274, covered the coast of California on almost the same ground track as the SO-180 flight of mission 1104. Thus, comparable coverage of the same area (however, at different seasons) was obtained on the two basic types of color films available—conventional color (SO-121) and false color (SO-180). Clear weather photography was obtained over Korea. Of the two remaining passes over the Soviet Union, one was cloud covered and the other was partially cloud/snow covered. Representative black and white and color samples for this mission are shown in Figs. 2.7-3 and 2.7-4. Camera parameters are listed in Table 2.7-1.

2.7.3.2 Engineering Test

In order to maintain maximum quality with the KH-4 systems, the filtration must be accomplished with a single filter. However, in order to obtain the most suitable color balance and exposure, a combination of several different types of filters is required. Therefore, Eastman Kodak fabricated a special filter for this flight. It consisted of the proper haze filtration (Wratten no. 2E), the proper color-balancing filter (20CC cyan), and the proper amount of neutral density (0.40 density Inconel coating). Although SO-121 is faster than SO-380, this speed differential cannot be used practically when the mission contains a split load of SO-380/SO-121 films because the slit width range on the KH-4B system is only $1\frac{1}{3}$ stops, and cannot, therefore, encompass satisfactory exposures for two films of such speed differential. Therefore, the philosophy adopted was to employ filters with neutral density coatings for the color film to make the speed effectively the same as the SO-380/Wratten filter combinations for that particular camera. This afforded maximum operational convenience and minimized the chances for an exposure error.

2.7.3.3 Mission 1106 SO-121 Flight

In January 1969, a requirement was levied upon the KH-4B system to obtain color-oriented