PROJECT DATA SHEET

Project No. 450807

Project Title. POLARIZER TEST EVALUATION (AIRCRAFT)

STATINTL Analyst. [redacted]

Date Rec. 3 DEC. 68

Date Comp. _____

Due Date. 31 DEC. 68

Approved For Release 2005/02/10 : CIA-RDP78B04767A000400100001-4

11 Oct. 68

Dear Jack:

It is possible at this point to draw several conclusions regarding the use of a polarizer to penetrate atmospheric haze. Under suitable conditions the polarizer produces a substantial improvement in the contrast, edge sharpness and detail which is observed in a long range oblique photograph. The improvement is observed both in color and in black-and-white photography using a No. 12 haze filter.

The improvement in contrast is most dramatic when the following conditions exist:

1. The atmosphere is clear and the dominant source of haze is Rayleigh or molecular scatter. While a polarizer is helpful on a haze day, the improvement is slight. Thus, a polarizer is primarily effective in making good photography much better.

2. The camera is pointed perpendicular to the sun and the sun elevation is low. However, a substantial improvement also occurs when the sun angle is high in the case of a long range oblique.

3. Using a haze filter and polarizer the contrast enhancement becomes greater as the path length is increased. This is because Rayleigh scattering events are less frequent in the longer wavelength end of the optical spectrum. Thus, Rayleigh haze is significant only when looking through a long atmospheric path.

Another observation which I believe will be of interest is that the resolution appears to be substantially improved by the use of a polarizer. This occurs because the contrast of the optical image has been raised above the threshold of the particular lens-film combination. Thus, small detail which would otherwise be lost in the film gradularity becomes visible, not because the resolution is improved, but because the contrast is improved.

In short, it has now been demonstrated that a properly oriented polarizer, intelligently used, will substantially increase the range, contrast, and resolution of an aerial photography. At this time the question of whether a polarizer should be used on a particular mission can only be answered on an individual basis.

I am enclosing a Program Outline which would result in a capability to plan future missions and design future systems on a sound engineering basis. While the pro-

D-011-G-3

gram is large, a reduction in its scope would seriously limit its usefulness to future system designers and mission planners. I feel that the results obtained recently more than justify a program of this magnitude.

STATINTL

Sincerely,

[redacted]

NRD:ps

PROGRAM OUTLINE

I. OBJECTIVES

A. Establish Capability for Evaluating a Polarizer under Representative Mission and Environmental Conditions.

B. Establish Guidelines for the Use of a Polarizer in Future Mission Planning and System Design.

II. AIRCRAFT INSTALLATION, CAMERAS AND INSTRUMENTATION

A. Dual Camera Mount consisting of:

1. Stabilized and Servo Positioned from Vertical to the Horizon.
2. TV Monitor Pointing as a Optional Mode
3. Digital Readout of Orientation
4. Two 13" Petzval Lenses

B. Camera Selection or Modification to Operate at Shutter Speeds Compatible with 3404.

C. Polarimeter

1. Bore Sighted to Cameras on Stabilized Mount.
2. Digital Readout

D. Meteorological Recording Camera for Cloud Coverage

1. Nikon Fish Eye
2. Pointed Up

E. Digital Data Logging System for

1. Aircraft Attitude (Heading, Pitch, Roll, Yaw)
2. Sun Position (or Time of Day and Coordinates)
3. Polarization
4. Camera Mount Orientation
5. Camera Frame Number

F. Aircraft Must be Capable of Operational Altitudes

G. Autopolarizer on One 13" Petzval Lens

H. Automatically Controlled, Programmed Data Acquisition

III. PROGRAM PLAN

A. Design, Fabricate, Install, Checkout Data Acquisition System

B. Design and Execute Flight Test Program, including:

1. Representative Atmospheric Conditions (Requires Measurement and Classification)
2. Representative Altitudes
3. Representative Sun Elevations
4. Adequate Sampling of Lower Hemisphere, i.e., The Space Below the Aircraft.
5. Close Coordination with the Customer to Insure a Relevant Program

C. Generation of Computer Program to Reduce, Analyze, and Present Digital Data in Summary Form

D. Data Reduction and Analysis

1. Engineering Analysis - Correlation of Polarization with Photographic and Atmospheric Data.
2. Qualitative Analysis - PI Analysis of Selected Photographs.

E. Rapid, Specific Evaluation of Polarizer for Specific Mission and System Requirements

1. Performed at Customer's Request
2. Emphasis - Quick Response

IV. DATA PRESENTATION AND FINAL RESULTS

A. Iso-Enhancement Charts for Geometric, Atmospheric, and Sun Conditions

B. Computerized Mission, System Analysis

C. Atmospheric Measurement and Classification Procedures.

COMPARISON OF PHOTOGRAPHY ACQUIRED WITH AND WITHOUT POLARIZING FILTERS

The photography resulting from the test runs was examined with the consideration that the tests were conducted to determine if polarizers can improve the extraction of intelligence information from photography by photo interpreters. Generally speaking all of the photography taken with the combination of a polarizer and filter had greater edge sharpness, contrast and color rendition, where color was used, than any other photography acquired in the tests. Identification of small objects such as aircraft and vehicles, especially in upper half of the format was definitely enhanced by the imagery acquired with the polarizer.

Recognizing that in most cases photo interpreters do not work with the original negative contact duplicate positives as well as the original negatives of the black-and-white photography were examined for information content. Each set of D.P.'s, comprised of photography acquired with and without the polarizer, was reproduced with a single exposure setting and identical chemistry. The results showed that although there was a resolution loss the polarized imagery retained the superior edge sharpness and contrast.

Comparison of the sets of photography was somewhat hampered because only one camera was available. Minor time variations in photo acquisition and scene displacement in the format occurred in each set compared. Two cameras mounted side by side permitting simultaneous exposures would provide a more precise comparison. The polarized imagery from each set of photography was examined first for selection of targets for comments. The polarized imagery was then compared to the other imagery. The slant range to the imagery in the center of the format is approximately 15 NM in all cases. Thus the cross format scale at the center is approximately 1:85,000. The results of the comparisons are as follows:

a) Roll 7, run 5, color imagery was acquired through a polarizer and 2E filter. The sun is approximately 90° to the camera look angle at a high elevation. Run 5 is compared to the nonpolarized imagery obtained through 2E and 0.6 ND filters

on run 6, roll 7.

B-52 and C-135 aircraft at Kirtland AFB present no identification problems in the polarized imagery. On the nonpolarized imagery these aircraft are difficult to impossible to identify by type. The aircraft are located in the lower part of the upper third of the format. In this portion of the format edges on the polarized imagery are well defined, contrast is good and color rendition is good. By comparison the edges on the nonpolarized imagery are fuzzy, contrast is low and color rendition is poor.

The Sandia weapons storage site is imaged at the extreme edge of the oblique on the nonpolarized imagery and near the edge on the polarized imagery. Tunnel entrances into the mountain and buildings near them are easily defined and measurable on the polarized imagery. The nonpolarized imagery reveals that the tunnel entrances are barely discernible and the nearby buildings are poorly defined. Mensuration would be extremely difficult.

Comparison of rows of vehicles parked in and around an oval track located in the upper third of the format was made. The polarized imagery, by virtue of superior contrast and color rendition, permitted a more definitive vehicle count although counting the vehicles was difficult.

Examination of the lower half of the format revealed that ventilators and stacks on building roofs were easily discernible on the polarized imagery while on the nonpolarized imagery many of these were not resolved. The same was true of windows in buildings.

b) Roll 7, run 7, color imagery was acquired through a polarizer. The sun is approximately 90° to the camera look angle at a high elevation. Run 7 is compared to the nonpolarized imagery obtained through a 0.6 ND filter on run 8, roll 7.

The B-52 and C-135 aircraft in this case are again easily identifiable on the polarized imagery. Additionally engine pods are recognizable on the aircraft. The aircraft are difficult to identify by type on the nonpolarized imagery and the engine pods are not recognizable. The aircraft are imaged in the middle portion of the format. Hangars and fueling trucks also imaged in this section of the format are notable. Vents on the hangar roofs are clearly visible on the polarized imagery but cannot be

seen on the nonpolarized imagery. The fueling trucks are readily identifiable on the polarized imagery and cannot be identified on the other imagery. In this portion of the format edge sharpness and contrast on the polarized imagery is good. Color rendition is poor. Edge sharpness on the nonpolarized photography is fair, contrast and color rendition is poor.

The weapons storage site is imaged on the upper third of the format in both types of photography. Again the tunnel entrances are easily identifiable on the polarized imagery. The edges of buildings are sharp and windows in the headquarters building are discernible. Mensuration of structures and tunnel entrances could be accomplished with relative ease. On the nonpolarized imagery the tunnel entrances are identifiable. The windows in the headquarters building cannot be discerned. Edges of buildings and tunnel entrances are soft which would complicate pointing for mensuration purposes.

A railroad marshaling yard is imaged near the middle of the lower half of the format. A rail car count is easily performed and some of the cars can be identified by type on the polarized imagery. Vehicle counts in nearby parking lots can be made without difficulty. An accurate rail car count could not be performed on the nonpolarized imagery and identification by type was virtually impossible. Vehicle counts in the adjacent parking lots were difficult to impracticable to accomplish. Here edge sharpness and contrast were good on the polarized imagery while color rendition was poor. The edges and contrast on the nonpolarized imagery were fair and color rendition poor.

c) Roll 10, run 2, color imagery was acquired through polarizer and 2E filter. The sun is approximately 90° to the camera look angle at a low elevation. Run 2 is compared to the nonpolarized imagery obtained through 2E and 0.6 ND filters on run 4, roll 10.

The rail cars in the marshaling yard in the center of Albuquerque can be counted on the polarized imagery with relative ease but cannot be identified by type. A car count on the nonpolarized photography is difficult and of questionable accuracy. The rail cars cannot be typed. The marshaling yard imagery is located in the middle

of the format. Contrast and color rendition are good to fair on the polarized photography and the edge sharpness is fair to poor. The unpolarized imagery is poor in color rendition and edge sharpness, contrast is fair to poor.

A tank farm and parking lot are imaged in the upper section of the middle third of the format. The tank diameters and heights can be readily measured on the polarized photography. The edges of the tanks that are in shadow on the nonpolarized photography are extremely difficult to define thus hampering any attempts at mensuration. The vehicles in the nearby parking lot can be accurately counted on the polarized photography whereas this cannot be accomplished on the nonpolarized imagery.

In the lower third of the format roof ventilators, stacks and windows in buildings are very difficult to define on the polarized imagery. Except for a few isolated cases it is not possible to define ventilators, stacks and windows in the nonpolarized photography.

The scene at the top portion of the format is a flat desert beyond mountains. Several roads, a power trace and what is probably a small building are visible in the polarized imagery. The power trace is very indistinct to not visible in some areas on the nonpolarized imagery. The roads are barely recognizable and the probable structure is not identifiable.

d) Roll 8, run 3, black-and-white imagery was acquired through a polarizer and a No. 12 filter. The sun is approximately 90° to the camera look angle at a high elevation. Run 3 is compared to the nonpolarized imagery obtained through No. 12 and 0.6 ND filters on run 4, roll 8.

Kirtland AFB is visible on the photography in the upper half of the format. Examination of the polarized original negative reveals that B-52 and C-135 aircraft are easily identifiable by type and that engine pods are clearly visible. Vents on the hangar roofs are easy to see and fueling trucks are identifiable. Contrast and edge sharpness are good. The duplicate positive from the polarized negative permit identification of the B-52 and C-135 aircraft and engine pods are distinguishable. The fueling trucks can be identified and the hangar roof vents are visible. Edge sharpness remains good but the contrast is somewhat reduced. The nonpolarized original nega-

tive permits identification of the B-52 and C-135 aircraft but only some engine pods are identifiable. The fueling trucks can be seen. A few of the hangar roof vents are lost. Edges are soft and contrast is fair. The duplicate positive from the nonpolarized original negative permits identification of B-52 and C-135 aircraft. Engine pods and fueling trucks are not identifiable. Some vents on the hangar roof can be seen. Edges are quite soft and contrast is fair.

The Sandia weapons storage site is imaged on the upper third of the format. The polarized original negative has good contrast and permits easy identification of tunnel entrances and defines building edges well. Windows in the headquarters building can be seen. On the duplicate positive edge definition is slightly reduced and the windows in the headquarters building are lost. The tunnel entrances on the nonpolarized original imagery are difficult to see and building edges are fuzzy. The headquarters building is barely discernible among the trees. Contrast is fair to poor. The nonpolarized duplicate positive permits approximately the same level of information extraction except that the headquarters building cannot be defined.

Examination of the lower third of the format on the polarized imagery reveals that roof vents, stacks and windows can be readily seen on the original negative. These items are visible on the duplicate positive. These same images are marginally identifiable on the nonpolarized original negative and, with a few exceptions, lost on the duplicate positive.

e) Roll 12, run 2, black-and-white imagery was acquired through a polarizer and a No. 12 filter. The sun is approximately 90° to the camera look angle at a low elevation. Run 2 is compared to the nonpolarized imagery obtained through No. 12 and 0.6 ND filters on run 3, roll 12.

The rolling stock in the marshaling yard in the center of Albuquerque can be easily counted and some of the rail cars identified by type on the polarized original negative. The scene is slightly above format center. Edge sharpness is fair and contrast is good. The car count is difficult on the polarized duplicate positive and identification by type is not practicable. Edge sharpness and contrast are considered fair. The nonpolarized original negative permits the same level of identification as

the polarized duplicate positive. Edge sharpness is fair and contrast is fair to poor. A rail car count on the duplicate positive is difficult to impracticable.

Roof vents, stacks and building windows imaged on the lower third of the format are seen without difficulty in both the polarized original negative and the duplicate positive. Edge sharpness and contrast is good. Many of the building windows and some vents and stacks are lost on the nonpolarized original negative and duplicate positive. 'Edge sharpness and contrast are considered fair.

Mensuration of tanks in a tank farm imaged at the bottom of the upper third of the format can be accomplished on the polarized original negative and duplicate positive with confidence. Tank edges in the shadows on negative and positive nonpolarized photography are difficult to define. Vehicles lined up in rows in a nearby parking lot can be counted with accuracy on the negative and positive polarized imagery. This cannot be accomplished on the nonpolarized imagery.

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, New Mexico

AIMING POINT Downtown

LATITUDE _____ TARGET ALTITUDE 5000 DATE 10 Sept. 68

LONGITUDE _____ WEATHER Clear Vis 60 mi

AIRCRAFT 187H MOUNT handheld CAMERA KS67

STATINTL PILOT [redacted]

Run Identifier	Run 1 Roll 1	Run 2 Roll 1	Run 3 Roll 1	Run 4 Roll 1	
Polarizer Obliquity Angle	*180°	N/A	*130°	N/A	
Camera No.	032	032	032	032	
Magazine No.	032	032	032	032	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	SO-121	SO-121	SO-121	SO-121	
Emulsion No.	32-2	32-2	32-2	32-2	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85K	85K	85K	85K	
Aircraft Heading	295	295	215	165	
Drift Correction					
Sun Angle	205	205	215	165	
Time-Start	1337	1341	1426	1231	
Time-End	1338	1342	1427	1232	
Exposure-Start	001	025	044	077	
Exposures-End	022	040	074	114	
Shutter Speed	1/1000	1/1000	1/1000	1/1000	
Aperture	3.5	3.5	3.5	3.5	
Filter	2E + Pol	2E + .6ND	2E + Pol	2E+.6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks: *1 and 3 with polarizer
Runs 3 and 4 are 90° to sun
Runs 1, 2 and 3 on Sept. 10
Run 4 on Sept. 11

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque

AIMING POINT Downtown

LATITUDE _____ TARGET ALTITUDE 5000' DATE 10 Sept. 68

LONGITUDE _____ WEATHER Clear Vis 60 mi

AIRCRAFT Porter MOUNT handheld CAMERA KS67

STATINTL PILOT [redacted]

Run Identifier	Run 1 Roll 2	Run 2 Roll 2	Run 3 Roll 2	Run 4 Roll 2	Run 5 Roll 2	Run 6 Roll2
Polarizer Obliquity Angle	*180°	N/A	N/A	*140°	N/A	N/A
Camera No.	032	032	032	032	032	032
Magazine No.	059	059	059	059	059	059
Lens No.	003	003	003	003	003	003
Focal Length	13"	13"	13"	13"	13"	13"
Film Type	SO230	SO230	SO230	SO230	SO230	SO230
Emulsion No.	12-2	12-2	12-2	12-2	12-2	12-2
Barometric Altitude	22000	22000	22000	22000	22000	22000
Air Speed Knots	85K	85K	85K	85K	85K	85K
Aircraft Heading	295	295	295	165	165	165
Drift Correction						
Sun Angle	205	205	205	165	165	165
Time-Start	1348	1354	1357	1237	1240	1243
Time-End	1349	1355	1358	1238	1241	1244
Exposure-Start	062	088	103	115	144	175
Exposures-End	071	100	112	141	171	203
Shutter Speed	1/500	1/500	1/500	1/500	1/500	1/500
Aperture	f3.5	f3.5	f3.5	f3.5	f3.5	f3.5
Filter	No.12+Pol	No.12 + .90ND	No. 12+ .60ND	No.12+Pol	No.12+ .9ND	No.12+ .6ND
Incident Light(Ground)						
V/H						
Interval	Runaway	runaway	runaway	runaway	runaway	runaway

Remarks: *Runs 1 and 4 with polarizer
Exp. 73-87 No good) misfired accidentally runs 1,2&3 on Sept. 10
Exp. 0-62 no good) run 4 on Sept. 11
Runs 4-6 on 90° to sun

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, N. Mex.

AIMING POINT Downtown

LATITUDE _____ TARGET ALTITUDE 5000 DATE 10 Sept. 68

LONGITUDE _____ WEATHER Clear Vis 60 mi

AIRCRAFT 187H MOUNT handheld CAMERA KS67

PILOT _____ STATINTL

Run Identifier	Run 1 Roll 3	Run 2 Roll 3	Run 3 Roll 3	Run 4 Roll 3	
polarizer Obliquity Angle	180°	N/A	130°	N/A	
Camera No.	032	032	032	032	
Magazine No.	023	023	023	023	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	3400	3400	3400	3400	
Emulsion No.	122-14	122-14	122-14	122-14	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	300	300	215	215	
Drift Correction					
Sun Angle	210	210	215	215	
Time-Start	1401	1405	1418	1421	
Time-End	1402	1406	1419	1422	
Exposure-Start	001	019	041	075	
Exposures-End	016	039	072	100	
Shutter Speed	1/1000	1/1000	1/1000	1/1000	
Aperture	3.5	3.5	3.5	3.5	
Filter	No.12+Pol	No.12+.6ND	No.12+Pol	No.12+.6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks: Runs 1 and 3 with polarizer

Runs 3 and 4 are 90° to sun

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, New Mex.

AIMING POINT Downtown

LATITUDE _____ TARGET ALTITUDE 5000 DATE 11 Sept. 68

LONGITUDE _____ WEATHER Clear vis 60 mi +

AIRCRAFT 187H MOUNT handheld CAMERA KS67

STATINTL PILOT [redacted]

Run Identifier	Run 1 Roll 4	Run 2 Roll 4	Run 3 Roll 4	Run 4 Roll 4	
polarizer Obliquity Angle	*170°	N/A	*115°	N/A	
Camera No.	032	032	032	032	
Magazine No.	082	082	082	082	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	SO121	SO121	SO121	SO121	
Emulsion No.	32-2	32-2	32-2	32-2	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	180	180	100	100	
Drift Correction					
Sun Angle	90	90	100	100	
Time-Start	0838	0840	0911	0914	
Time-End	0839	0841	0912	0915	
Exposure-Start	001	039	076	114	
Exposures-End	036	074	111	142	
Shutter Speed	1/500	1/500	1/500	1/500	
Aperture	3.5	3.5	3.5	3.5	
Filter	2E + Pol	2E + 0.6ND	2E + Pol	2E + 0.6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks: Runs 1 and 3 with polarizer.

Runs 3 and 4 are 90° to sunline

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, New Mex.

AIMING POINT Downtown

LATITUDE _____ TARGET ALTITUDE 5000 DATE 11 Sept. 68

LONGITUDE _____ WEATHER Clear Vis. 60 mi

AIRCRAFT 187H MOUNT handheld CAMERA KS67

STATINTL PILOT [redacted]

Run Identifier	Run 1 Roll 5	Run 2 Roll 5	Run 3 Roll 5	Run 4 Roll 5	
polarizer Obliquity Angle	*165°	N/A	*115°	N/A	
Camera No.	032	032	032	032	
Magazine No.	012	012	012	012	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	SO230	SO230	SO230	SO230	
Emulsion No.	12-2	12-2	12-2	12-2	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	180	180	102	102	
Drift Correction					
Sun Angle	90	90	102	102	
Time-Start	0846	0849	0918	0921	
Time-End	0847	0850	0919	0922	
Exposure-Start	001	028	059	089	
Exposures-End	025	056	085	115	
Shutter Speed	1/500	1/500	1/500	1/500	
Aperture	3.5	3.5	3.5	3.5	
Filter	No.12 + Pol	No.12+0.6ND	No.12+Pol	No.12+0.6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks: Runs 1 and 3 with polarizer

Runs 3 and 4 are 90° to sun

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, N.Mex.

AIMING POINT Downtown

LATITUDE _____ TARGET ALTITUDE 5000 DATE 11 Sept. 68

LONGITUDE _____ WEATHER Clear Vis 60 mi +

AIRCRAFT 187H MOUNT handheld CAMERA KS67

STATINTL PILOT [redacted]

Run Identifier	Run 1 Roll 6	Run 2 Roll 6	Run 3 Roll 6	Run 4 Roll 6	
Polarizer Obliquity Angle	*175°	N/A	*115°	N/A	
Camera No.	032	032	032	032	
Magazine No.	034	034	034	034	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	3400	3400	3400	3400	
Emulsion No.	122-14	122-14	122-14	122-14	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	185	185	100	100	
Drift Correction					
Sun Angle	95	95	100	100	
Time-Start	0854	0856	0905	0907	
Time-End	0855	0857	0906	0908	
Exposure-Start	001	035	069	103	
Exposures-End	032	066	100	131	
Shutter Speed	1/500	1/500	1/500	1/500	
Aperture	3.5	3.5	3.5	3.5	
Filter	No.12+Pol	No.12+0.6ND	No.12+Pol	No.12+0.6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks: Runs 1 and 3 with polarizer

Runs 3 and 4 90° to sun line

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, New Mex.

AIMING POINT Downtown high angle.

LATITUDE _____ TARGET ALTITUDE 5000 DATE 13 Sept. 68

LONGITUDE _____ WEATHER Clear Vis. 60 Mi +

AIRCRAFT 187H MOUNT hand held CAMERA KS67

PILOT [redacted] STATINTL

Run Identifier	Run 1 Roll 7	Run 2 Roll 7	Run 3 Roll 7	Run 4 Roll 7	
polarizer, ~~Obliquity Angle~~	*180°	N/A	*180°	N/A	
Camera No.	032	032	032	032	
Magazine No.	082	082	082	082	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	SO121	SO121	SO121	SO121	
Emulsion No.	32-1	32-1	32-1	32-1	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	270	270	270	270	
Drift Correction					
Sun Angle	180	180	180	180	
Time-Start	1322	1325	1328	1331	
Time-End	1323	1326	1329	1332	
Exposure-Start	001	023	047	070	
Exposures-End	020	044	067	089	
Shutter Speed	1/1000	1/1000	1/1000	1/1000	
Aperture	3.5	3.5	3.5	3.5	
Filter	2E+Pol	2E+. 6ND	Polarizer	0. 6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks: with sun line.

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, New Mex.

AIMING POINT Downtown High Angle

LATITUDE _____ TARGET ALTITUDE 5000 DATE 13 Sept. 68

LONGITUDE _____ WEATHER Clear Vis. 60 Mi +

AIRCRAFT 187H MOUNT hand held CAMERA KS67

PILOT _____ STATINTL

Run Identifier	Run 5 Roll 7	Run 6 Roll 7	Run 7 Roll 7	Run 8 Roll 7	
Polarizer ~~Obliquity Angle~~	*135°	N/A	*135°	N/A	
Camera No.	032	032	032	032	
Magazine No.	082	082	082	082	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	SO121	SO121	SO121	SO121	
Emulsion No.	32-1	32-1	32-1	32-1	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	192	192	192	192	
Drift Correction					
Sun Angle	192	192	192	192	
Time-Start	1411	1413	1415	1417	
Time-End	1412	1414	1416	1418	
Exposure-Start	092	121	150	178	
Exposures-End	118	147	175	203	
Shutter Speed	1/1000	1/1000	1/1000	1/1000	
Aperture	3.5	3.5	3.5	3.5	
Filter	2E+Pol	2E+. 6ND	Polarizer	. 6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks:

90° to sun line

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, New Mex.

AIMING POINT Downtown High Angle

LATITUDE _____ TARGET ALTITUDE 5000 DATE 13 Sept.

LONGITUDE _____ WEATHER Clear Vis. 60 mi +

AIRCRAFT 187H MOUNT handheld CAMERA KS67

PILOT [redacted] STATINTL

Run Identifier	Run 1 Roll 8	Run 2 Roll 8	Run 3 Roll 8	Run 4 Roll 8	
Polarizer Obliquity Angle	*180°	N/A	*135°	N/A	
Camera No.	032	032	032	032	
Magazine No.	059	059	059	059	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	SO230	SO230	SO230	SO230	
Emulsion No.	12-2	12-2	12-2	12-2	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	275	275	190	190	
Drift Correction					
Sun Angle	185	185	190	190	
Time-Start	1336	1340	1405	1407	
Time-End	1337	1341	1406	1408	
Exposure-Start	001	028	059	088	
Exposures-End	025	055	085	113	
Shutter Speed	1/500	1/500	1/500	1/500	
Aperture	3.5	3.5	3.5	3.5	
Filter	No. 12+Pol	No. 12+. 6ND	No. 12+Pol	No. 12+. 6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks: Run 3 and 4 are 90° to sun line.

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, New Mex.

AIMING POINT Downtown High Angle

LATITUDE _____ TARGET ALTITUDE 5000 DATE 13 Sept. 68

LONGITUDE _____ WEATHER Clear Vis 60 mi +

AIRCRAFT 187H MOUNT handheld CAMERA KS67

PILOT _____ [redacted] STATINTL

Run Identifier	Run 1 Roll 9	Run 2 Roll 9	Run 3 Roll 9	Run 4 Roll 9	
Polarizer Obliquity Angle	*180°	N/A	*136°	N/A	
Camera No.	032	032	032	032	
Magazine No.	034	034	034	034	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	3400	3400	3400	3400	
Emulsion No.	122-14	122-14	122-14	122-14	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	277	277	190	190	
Drift Correction					
Sun Angle	187	187	190	190	
Time-Start	1344	1347	1358	1400	
Time-End	1345	1348	1359	1401	
Exposure-Start	001	025	056	084	
Exposures-End	022	054	081	110	
Shutter Speed	1/1000	1/1000	1/1000	1/1000	
Aperture	3.5	3.5	3.5	3.5	
Filter	No.12+Pol	No.12+.6ND	No.12+Pol	No.12+.6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks:

Runs 3 and 4 are 90° to sunline.

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, New Mex.

AIMING POINT Downtown low angle.

LATITUDE _____ TARGET ALTITUDE 5000 DATE 13 Sept. 68

LONGITUDE _____ WEATHER Clear Vis. 60Mi +

AIRCRAFT 187H MOUNT hand held CAMERA KS67

PILOT _____ STATINTL

Run Identifier	Run 1 Roll 10	Run 2 Roll 10	Run 3 Roll 10	Run 4 Roll 10	
polarizer Obliquity Angle	*105°	*105°	N/A	N/A	
Camera No.	032	032	032	032	
Magazine No.	082	082	082	082	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	SO121	SO121	SO121	SO121	
Emulsion No.	32-1	32-1	32-1	32-1	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	245	245	245	245	
Drift Correction					
Sun Angle	245	245	245	245	
Time-Start	1722	1724	1727	1730	
Time-End	1723	1725	1728	1731	
Exposure-Start	001	029	061	085	
Exposures-End	026	058	082	104	
Shutter Speed	1/500	1/500	1/500	1/500	
Aperture	3.5	3.5	3.5	3.5	
Filter	2E + Pol	2E + Pol	2E+. 6ND	2E+. 6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks:

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, New Mex.

AIMING POINT Downtown Low Angle

LATITUDE _____ TARGET ALTITUDE 5000 DATE 13 Sept. 68

LONGITUDE _____ WEATHER Clear Vis 60 mi +

AIRCRAFT 187H MOUNT hand held CAMERA KS67

PILOT [redacted] STATINTL

Run Identifier	Run 5 Roll 10	Run 6 Roll 10	Run 7 Roll 10	Run 8 Roll 10	
polarizer Obliquity Angle	*105°	*105	N/A	N/A	
Camera No.	032	032	032	032	
Magazine No.	082	082	082	082	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	SO121	SO121	SO121	SO121	
Emulsion No.	32-1	32-1	32-1	32-1	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	247	247	247	247	
Drift Correction					
Sun Angle	247	247	247	247	
Time-Start	1733	1736	1738	1741	
Time-End	1734	1737	1739	1742	
Exposure-Start	107	127	153	183	
Exposures-End	125	150	180	210	
Shutter Speed	1/500	1/500	1/500	1/500	
Aperture	3.5	3.5	3.5	3.5	
Filter	Polarizer	Polarizer	.6ND	.6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks: Runs 5, 6, 7 and 8 magazine malfunction

PHOTOGRAPHIC

TARGET IDENTIFICATION Albuquerque, New Mex.

AIMING POINT Downtown Low sun angle.

LATITUDE _____ TARGET ALTITUDE 5000 DATE 13 Sept. 68

LONGITUDE _____ WEATHER Clear Vis. 60 Mi +

AIRCRAFT 187H MOUNT hand held CAMERA KS67

STATINTL PILOT [redacted]

Run Identifier	Run 1 Roll 11	Run 2 Roll 11	Run 3 Roll 11	Run 4 Roll 11	
polarizer Obliquity Angle	*105	*105	N/A	N/A	
Camera No.	032	032	032	032	
Magazine No.	059	059	059	059	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	SO230	SO230	SO230	SO230	
Emulsion No.	12-2	12-2	12-2	12-2	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	247	247	247	247	
Drift Correction					
Sun Angle	247	247	247	247	
Time-Start	1743	1746	1749	1751	
Time-End	1744	1747	1750	1752	
Exposure-Start	001	037	064	088	
Exposures-End	034	061	085	107	
Shutter Speed	1/500	1/500	1/500	1/500	
Aperture	3.5	3.5	3.5	3.5	
Filter	No.12+Pol	No.12+Pol	No.12+.6ND	No.12+.6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks:

PHOTOGRAPHIC FLIGHT LOG

TARGET IDENTIFICATION Albuquerque, New Mex.

AIMING POINT Downtown low sun angle.

LATITUDE _____ TARGET ALTITUDE 5000 DATE 13 Sept. 68

LONGITUDE _____ WEATHER Clear Vis. 60 Mi +

AIRCRAFT 187H MOUNT handheld CAMERA KS67

STATINTL PILOT [redacted]

Run Identifier	Run 1 Roll 12	Run 2 Roll 12	Run 3 Roll 12	Run 4 Roll 12	
polarizer Obliquity Angle	*105°	*105°	N/A	N/A	
Camera No.	032	032	032	032	
Magazine No.	034	034	034	034	
Lens No.	003	003	003	003	
Focal Length	13"	13"	13"	13"	
Film Type	3400	3400	3400	3400	
Emulsion No.	122-14	122-14	122-14	122-14	
Barometric Altitude	22000	22000	22000	22000	
Air Speed Knots	85	85	85	85	
Aircraft Heading	249	249	249	249	
Drift Correction					
Sun Angle	249	249	249	249	
Time-Start	1754	1757	1759	1802	
Time-End	1755	1758	1800	1803	
Exposure-Start	001	033	060	085	
Exposures-End	030	057	082	111	
Shutter Speed	1/500	1/500	1/500	1/500	
Aperture	3.5	3.5	3.5	3.5	
Filter	No.12+Pol	No.12+Pol	No.12+.6ND	No.12+.6ND	
Incident Light(Ground)					
V/H					
Interval	runaway	runaway	runaway	runaway	

Remarks:

1. The following discussion is in response to your request for an informal commentary ~~on the material and the contractor's findings~~ OF [redacted] STATINTL Final report on "Evaluation of Polarizer For Use In Oblique Aerial Photography" AND CONTAINS EXCERPTS FROM "Evaluation of a Polarizing Filter in High Altitude Photography" [redacted] STAT

2. Polarization

A. The light, both image forming and nonimage forming, which a reconnaissance camera sees looking down on the earth, ~~from above the atmosphere~~ is always polarized to a ~~greater or lesser~~ degree. This polarization is basically ~~basicly~~ the result of two naturally occuring phenomena. The first is due to the polarization that results from the reflection of energy from a surface, and the second is the result of scattering

in a molecular environment. The fact that the energy reaching the ~~aerospace~~ camera is partially polarized suggests a possible means of enhancing image quality by taking advantage of this phenomenon. This might be accomplished by incorporating a polarizing filter in the camera system, oriented in such a direction as to filter out the unwanted polarized energy, and thereby increase image contrast to obtain, ~~better~~ higher quality photography

B. a polarizer ~~absorbs the light~~ reflects reaching it except for ~~polarized~~ the light in a ~~peculiar~~ particular plane.

a polarizer acts like a slit ~~in~~ through which only a plane of light (polarized light) will pass ~~through the slit~~ only ~~if the slit~~ if it is orientated so the plane of polarized light and the plane of the slit are parallel.

C. The ~~tracelight~~ scattered light from haze which reduces object-background contrast can often be

reduced by the use of a polarizing filter in the camera system. To the degree that this unwanted light is plane polarized, it can be eliminated by a polarizing filter in the proper orientation. The amount of polarization depends upon many factors, such as the solar elevation and azimuth with respect ~~to its zenith angle~~, to the target position, nadir angle ~~and azimuth~~, the prevailing atmospheric attenuation, ~~composition of the atmosphere~~, and

the reflection characteristics ~~overall albedo~~ of the scene.

~~below.~~ all these factors affect the amount and direction of polarized light reaching the camera.

5. For maximum polarization all the factors mentioned above and the orientation of the polarizing filter must be critically adjusted. ~~just right.~~ Maximum polarization is lost as soon as the polarizing filter is not oriented properly and/or the image forming light reaching

the camera is not at its maximum amount of polarization.

~~This commentary contains excerpts from Evaluation of a Polarizing Filter in High Altitude Photography~~

STAT

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3. Comments on "Evaluation of Polarizer For Use In Oblique Aerial Photography."

a. The report "Evaluation of Polarizer For Use IN Oblique Aerial Photography" appears to be correct but incomplete. ~~is good as far as it goes.~~ ~~However~~ The report fails to ~~mention~~ specify:

1. The relation ship between the two altitudes at which the test flights were flown,

2. The relationship between the oblique angles of 30 degrees and 70 degrees which were used to aquire imagery,

3. The relationship between

~~1.~~ low sun elevation and high

~~sun~~ elevation at which the test

flights were flown.

4. The paragraph describing when the polarizer is most helpful does not completely define the orientation of the camera, ~~very well~~ SUFFICIENTLY. the terms used are vague and ~~in~~definative.

~~The study does conclude a polarizer is very helpful in obtaining good oblique photography when looking perpendicularly to the sun on a clear day.~~

5.0. Examination of the samples of the ~~orginal~~ imagery provided, ~~for evaluation of polarizer for use in oblique aerial photography~~ support the conclusions of the report.

6.0 The study concludes that on a clear day with the polarizer properly orientated ~~and the camera orientation is~~ correct for maximum polarization, a camera with a polarizer

will provide better oblique photography than a camera without a polarizer.

7. This study is not relevent to our present reconnaissance systems. The altitudes are vastly different, AND ~~the~~ affects of polarization at higher altitudes is not necessarily the same as at lower altitudes. The second, and MORE important POINT, is

That a very small portion of a reconnaissance mission will have the polarizer properly oriented, ~~and the proper~~ unless a highly sophisticated system of polarizer inflight adjustment orientation ~~of the camera~~ for is available maximum ~~polarization~~. It should be noted that when the polarizer is not orientated properly and/or the camera orientation is not correct for maximum polarization the benefit of the ~~effect~~ of polarization is ~~are~~

greatly reduced. A drawback to the polarizer is the loss in effective film speed. A polarizer requires approximately 0.9 log exposure (3 f/stops) more exposure. The trade-off of effective film speed versus the small percentage of photography a polarizer ~~would help~~ COULD IMPROVE would be a prime factor of consideration. ~~with todays reconnaissance systems.~~ It must also be recognized that ~~some~~ image forming energy is [illegible] by the polarizer. Hence, imagery is obscured

1. The first six pages is a resumé of what he, in fact, told us. Why repeat it.

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There are two boxes of "chips" in the file cabinet in addition to the chips in the envelopes in this folder.

Basically OSA wants to know whether to invest additional monies in polarizer testing.

I informed [redacted] STATINTL of the EXIT Report. He is going to read it but would still like our opinion on the [redacted] Yes V. STATINTL

Roll 8 Run 3 Cross Hatch

POLARIZER + No 12 D.P

W-011-B-1

ROLL 8 RUN 4 CROSS HIGH

NO 12 & 0.6 N.D. D.P.

W-011-B-2

ROLL 12 RUN 2 CROSS LOW
POLARIZER & NO 12 D.P.

W-011-B-3

ROLL 12 RUN 3 CROSS LOW

NO 12 & 0.6 ND D.P.

W-011-53-1