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TECHNICAL PUBLICATION

PHOTOGRAPHIC EVALUATION REPORT MISSION 1108

WITH SPECIAL STUDY:

SO242 EVALUATION, MISSION 1108

[redacted]

JULY 1970

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59 PAGES

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TECHNICAL PUBLICATION

PHOTOGRAPHIC EVALUATION REPORT

MISSION 1108

JULY 1970

NATIONAL PHOTOGRAPHIC INTERPRETATION CENTER

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TABLE OF CONTENTS

INDEX OF PHOTOGRAPHIC EVALUATION REPORTS AND SPECIAL STUDIES

PER	DOCUMENT NUMBER	SPECIAL STUDY
1033	[redacted]	None
1034		None
1035		None
1037		None
1038		None
1039		None
1040		None
1041		Slant Range Computations Related to Universal Grid Coordinates for the J-1 Camera System
1042	[redacted]	None
1043		Scan Speed Deviation Analysis of the Forward Camera, Mission 1043
1044	[redacted]	Dual Gamma/Viscose Vs Conventional/Spray Processing Analysis (Mission 1044)
1045	[redacted]	None
1046		SO-230 Vs 3404 Evaluation
1047		None
1048		None
1049		Image Quality Comparison Mission 1102--Original Negative vs. Duplicate Positive
1050	[redacted]	None
1051		None
1052		SO-239 Second Generation Vs Third Generation Negative
1101	[redacted]	Slant Range Computations Related to Universal Grid Coordinates for the J-3 Camera System
1102	[redacted]	None
1103		None
1104		SO-180 Evaluation Mission 1104
1105		SO-121 Evaluation Mission 1105
1106	[redacted]	None
1107		MIP 1100 Series
1108		SO242 Evaluation, Mission 1108

GLOSSARY OF TERMS

ALTITUDE	Vertical distance from the vehicle to the Hough Ellipsoid at the time of exposure.
APOGEE	That point in an elliptical orbit of a satellite at which the distance is greatest between the orbiting body and the surface of the Hough Ellipsoid.
BINARY TIME WORD	Binary presentation of the accumulated system time.
DATE OF PHOTOGRAPHY	Day, month and year (GMT) that the photography was acquired.
DISIC	Dual Improved Stellar Index Camera.
ECCENTRICITY	A measure of the deviation of an ellipse from a true circle; expressed by dividing the distance between the foci of the ellipse by the length of its major axis.
EXPOSURE TIME	Time during which a light-sensitive material is subjected to the influence of light, expressed in this text in fractions of a second. Formula: $\text{Exposure time (sec)} = \frac{\text{slit width (in)}}{\text{scan rate (radians per sec)}}$
FIDUCIAL MARK	A standard geometrical reference point imaged within the frame of a photograph. The intersection of the primary fiducial marks usually defines the intersection of the principal ray with the focal plane.
FOCAL LENGTH (CALIBRATED)	Adjusted value of the equivalent focal length. Computed to distribute the effect of lens distortion over the entire field.
FOCAL LENGTH (EQUIVALENT)	Distance measured along the lens axis from the rear nodal point to the plane of best average definition over the entire field. Points other than the rear nodal point may be used but must

be specified for correct interpretation of data.

FOCAL PLANE — Plane perpendicular to the lens axis, in which images of points in the object field of the lens are focused.

FORMAT — The portion of the frame that contains imagery produced by the primary optical system of the camera.

FRAME* — A single exposure which contains the format and peripheral border information relevant to the format.

GENERATION — Number of reproductive steps by which a negative or positive photographic copy is separated from the original scene, ie., the original negative is generation one, a positive made from the original negative is generation two, etc.

GROUND RESOLUTION* — The minimum distance (expressed as bar plus space) between two adjacent linear features which can be detected by a photographic system, as determined from standard three bar resolution targets. A target is considered to be resolved when a grouping of three bars can be distinguished as three distinct lines.

HOUGH ELLIPSOID — A reference ellipsoid around the earth having a semi-major axis of 20,925,738.18 feet and a semi-minor axis of 20,855,588.20 feet.

IMAGE MOTION COMPENSATION (IMC) — A correction made to compensate for relative image motion at the camera focal plane.

INCLINATION — The angle between the orbital and equatorial planes measured counterclockwise from the equatorial plane to the orbital plane with the ascending node as the vertex.

INTERPRETABILITY (PHOTOGRAPHIC) — Suitability of the imagery with respect to answering requirements on a given type of target. Various factors such as halation, uncompensated image motion, poor contrast, incorrect focus,

improper film processing, atmospheric conditions (both natural and manmade), ground resolution, and insufficient natural or artificial lighting of the target affect interpretability. The 3 levels of interpretability are:

Poor (P) - Unsuitable for adequately answering requirements on a given type of target.

Fair (F) - Suitable for answering requirements on a given type of target but with only average detail.

Good (G) - Suitable for answering requirements on a given type of target in considerable detail.

INDEX CAMERA — A framing camera used to record terrain imagery. The product is used for relative orientation and mapping purposes.

LOCAL SUN TIME — Time of day computed from the position of the sun relative to the imaged terrain.

MATERIAL CHANGE DETECTOR (MCD) — A pre-exposed pre-processed film strip (approximately three feet long) that is detected by telemetry when it passes through the panoramic camera. This strip is generally spliced between two different film types to signal the film change.

NODAL TRACE — A continuous line imaged along the major axis of each frame to define the optical axis of the lens relative to any given instant of exposure.

PAN GEOMETRY DOTS — Images of the rail holes associated with the pan geometry calibration of the camera.

PANORAMIC CAMERA — Photographs a partial or complete panorama of the terrain in a transverse direction through a scanning motion of the lens system.

PASS — Photographic portion of an orbital revolution. A prefix "D" indicates the descending node, a prefix "A" indicates the ascending node, and a

	prefix "M" indicates a continuous camera operation from the ascending node through the descending node. An additional suffix "E" indicates that the associated photography was generated for engineering purposes.
PERIGEE	That point in an elliptical orbit of a satellite at which its distance is nearest the surface of the Hough Ellipsoid.
PERIOD	The time required for a satellite to complete one revolution about the earth.
PITCH	Rotation of the camera about its transverse axis. Positive pitch indicates nose up attitude.
PRINCIPAL RAY	That ray of light which emanates from a point in object space and passes undeviated through the centers of curvature of the lens surfaces. It is coincident with the optical axis of the lens.
RELATIVE ORIENTATION	The determining (analytically or in a photogrammetric instrument) of the position and attitude of one of a pair of overlapping photographs with respect to the other.
RESOLUTION	Measure, expressed in lines/mm, of the smallest array of point objects distinguishable as independent point images.
ROLL	Rotation of the camera about its longitudinal axis. Positive roll indicates left wing up attitude.
SOLAR ELEVATION	The angular distance to the sun measured from a plane tangent to the earth at the intersection of the principal ray of the camera and the earth.
STELLAR CAMERA	A framing camera which records stellar images. The product, in conjunction with the product of the Index camera, is used for attitude determination.
UNIVERSAL GRID	An X - Y coordinate system used to define image location on photographic formats.

VEHICLE GROUND TRACK AZIMUTH	Clockwise horizontal angle measured from the longitudinal meridian's intersection of the earth's surface to the vehicle's ground track.
VIGNETTING	Gradual reduction in density of parts of a photographic image due to the stopping of some of the rays entering the lens.
YAW	Rotation of the camera about its vertical axis. Positive yaw represents nose left attitude, as viewed from top of the camera.

* Defined differently than in the Glossary of NPIC Terminology.

SYNOPSIS

Mission 1108, a two-part satellite reconnaissance mission, was launched at 2138Z on 4 December 1969. The first capsule was recovered dry during rev 115 at 2355Z on 11 December 1969. The air catch of the second satellite reentry vehicle on rev 277 at 2300Z on 21 December 1969 terminated the mission. A total of 90 photographic passes was acquired by the 18-day mission.

The image quality of the foward-looking camera record is more variable than that of the aft-looking camera. Out of focus imagery (soft spots) and instances of image smear in the scan direction can be detected on the forward-looking camera material. In general, the image quality of the forward-looking camera record is fair, while the image quality of the aft-looking camera product is good. The imagery provided by the forward camera has a "soft" appearance at magnifications of 50X and above; however, the best imagery of the mission was selected from this record. An MIP rating of 105 and one of 100 are assigned to Missions 1108-1 and 1108-2 respectively.

Approximately 85 percent of the mission contains cloud free photography. The Dual Improved Stellar Index Camera failed to operate after frame 73 of pass 204. The mission carried an 811-foot tag end of film type SO-242 (aerial color film) on the aft camera supply. Detailed analysis of this color material is included in this report as a special study.

PART I. GENERAL SYSTEM INFORMATION

A. Camera Numbers

Forward-Looking Panoramic Camera	317
Aft-Looking Panoramic Camera	316
DISIC Camera	12

B. Launch and Recovery Dates

	(1108-1)	(1108-2)
Launch	4 Dec 69/2138Z	*
Recovery	11 Dec 69/2355Z	21 Dec 69/2300Z
Recovery Rev	115	277

C. Orbit Elements

Element	Actual** 1108-1 (Rev 9)	Actual** 1108-2 (Rev 113)	Photo Range
Period (min)	88.448	88.439	*
Perigee (nm)	82.423	94.969	81.169 (Pass D48)
Apogee (nm)	143.358	134.957	107.073 (Pass D14)
Eccentricity	0.00821	0.00520	*
Inclination (deg)	81.49	81.49	*
Perigee Latitude (Geod.)	27°25' N	34°17'N	*

* Not applicable

** This data reflects the orbital elements for only the indicated revolution, not the entire mission segment.

D. Photographic Operations

1. Panoramic Cameras:

Type	1108-1 Revs	1108-1 Frames	1108-2 Revs	1108-2 Frames	Total Revs	Total Frames
Operational						
Fwd	31	2,586	45	2,922	76	5,508
Aft	31	2,591	43	2,796	74	5,387
Operational/Domestic						
Fwd	3	183	1	44	4	227
Aft	3	184	2	70	5	254
Domestic						
Fwd	3	68	6	125	9	193
Aft	3	68	7	128	10	196
Engineering (no imagery)						
Fwd	0	0	1	6	1	6
Aft	0	0	1	6	1	6
TOTALS						
Fwd	37	2,837	53	3,097	90	5,934
Aft	37	2,843	53	3,000	90	5,843

2. Secondary Cameras:

Camera	Frames
Stellar (1108-1)	2,150 Starboard; 2,145 Port
Index (1108-1)	2,156
Stellar (1108-2)	2,013 Starboard; 2,007 Port
Index (1108-2)	2,025

E. Film Usage

Camera	Film Load (Total)	Pre-Flight Footage	Processed ** Footage	Film Type
Fwd-Looking (1108-1)	*16,300	538	8,005	3404
Aft-Looking (1108-1)	*15,200	540	8,018	3404
	800	Recovered with second bucket.		SO-242
Fwd-Looking (1108-2)	NA	NA	8,175	3404
Aft-Looking (1108-2)	NA	NA	7,088	3404
		NA	819	SO-242
Stellar (1108-1)	*2,000	53	637	3401
Stellar (1108-2)	NA	NA	542	3401
Index (1108-1)	*2,200	71	1,019	3400
Index (1108-2)	NA	NA	1,095	3400

* Total load for both buckets.
** Values include pre-flight footages.
NA - Not applicable.

PART II. CAMERA OPERATION

A. Fwd-Looking Panoramic Camera: Operational throughout.

B. Aft-Looking Panoramic Camera: Operational throughout.

C. Horizon Cameras: Operational throughout the mission; however, an extra port horizon image is present with frame 35 of pass D95. It is overlapped to a small extent with the starboard horizon image associated with frame 34 of pass D95. No fiducials are present with this extra horizon. This minor overlap condition does not interfere with normal horizon arc measurement.

D. Stellar Cameras: Failed to operate after frame 73, pass 204. This failure is apparently associated with a malfunction in the electronics system.

E. Index Camera: Failed to operate after frame 73, pass 204. This failure is apparently associated with a malfunction in the electronics system.

PART III. IMAGE ANALYSIS

A. Fwd-Looking Panoramic Camera

1. Density: Ranges from thin to heavy.

2. Contrast: Generally medium.

3. Image Quality: Variable. Instances of image smear in the scan direction and severe out-of-focus imagery are apparent intermittently throughout the mission. The image smear appears to be associated with exposure duration (slit width) and is more severe at the takeup end of the format than at the supply end. Image smear is not observable where terrain illumination level permitted the use of narrow exposing slits. The out-of-focus area is located approximately 10 inches from the takeup end of frames 3 and 4 of most passes. The amount of image degradation is directly associated with the length of sit time between passes. On passes with sit times of one revolution, the out-of-focus imagery is less severe and is difficult to detect. At least two revs between operates are necessary for consistent detection.

The cause of these out-of-focus areas is directly associated with small diameter rollers in the extended film path transport assembly and constant tension assembly. Extended inoperative periods tend to impress these rollers into the payload, causing the material to be deformed. This deformation is retained during the photographic scan resulting in out-of-focus imagery at these points.

In general, the imagery provided by this camera has a "soft" appearance at magnifications of 50X and above; however, the best imagery of the mission was selected from this camera record.

4. Imaged Degradations:

a. Light Leaks:

(1) A fog pattern is present on the fourth frame from the end of all camera operations. The density of this fog pattern is commensurate with camera sit periods. After a three-rev soak, fog density in the original negative measured 1.1 above base plus fog level. This light leak appears to originate in the camera drum and is imaged on the material at the camera exit roller (see Graphic #1, page 10).

(2) Two minor circular fog patterns are present near the takeup end of the first frame of some passes of the second-bucket material.

b. Static - Traces of dendritic static are present on both film edges intermittently throughout the second-bucket material.

c. Other - See image quality.

5. Physical Degradations:

a. Numerous comet-shaped minus density spots are present intermittently throughout the first part of the mission. This anomaly apparently occured in film manufacturing since the head/tail orientation of the comets reverse between manufacturing splices.

b. Several very fine, continuous emulsion scratches are present throughout the mission.

c. A minus density line with parallel plus density bands appears intermittently throughout both fwd and aft records of both buckets. These bands generally appear at a bias, are referenced to the film width, and extend across the width of the film. The bands sometimes have a brownish appearance, apparently associated with film manufacturing.

B. Aft-Looking Panoramic Camera

1. Density: Same as the fwd-looking panoramic camera record.

2. Contrast: Same as the fwd-looking panoramic camera record.

3. Image Quality: Although the best imagery of the mission was selected from the fwd-looking camera, the image quality of the aft-looking camera record is less variable. In general, the imagery can be viewed at 50X magnification without the noticeable loss of quality apparent on the fwd-looking record. The overall performance (image quality) of the aft-looking camera is rated as good.

4. Imaged Degradations:

a. Light Leaks - A minor, splash-like fog pattern is present on the first frame of passes acquired on the second bucket after an extended camera sit period (see Graphic #3, page 10).

b. Static - Traces of dendritic static are present on both film edges intermittently throughout the second bucket material.

c. Other - None noted.

5. Physical Degradation:

a. Several fine longitudinal emulsion scratches are present intermittently throughout the second bucket material.

b. See item c Section A5, p 7 (Panoramic Camera Physical Degradations).

c. A heavy diagonal crease with associated emulsion lifts and plus density marking extends approximately 15 inches into the format on frame 47, pass D199. Imagery in the area of the crease indicates this anomaly occurred after photographic scan and apparently during the defilming and presplice operations.

C. Stellar Cameras

1. Density: The density of the starboard stellar record is generally medium. The density of the port stellar record is also generally medium, but it is somewhat lower in density than the starboard camera record. The density of both the port and starboard records is adequate for the detection of stellar images.

2. Contrast: Adequate for the detection of stellar images.

3. Image Shape: Point-type star images were recorded on both stellar camera records.

4. Images Per Frame:

a. Mission 1108-1 - 6-10 (starboard), 8-15 (port)

b. Mission 1108-2 - 15-25 (starboard), 6-12 (port)

5. Imaged Degradations:

a. Light Leaks - None noted.

b. Static:

(1) Static marks apparently induced by the pressure plate appear in the format of many port frames throughout the mission.

(2) Severe dendritic and corona static traces are present at random throughout the last 50 feet of the first bucket and the entire second bucket stellar record.

c. Other:

(1) A plus density flare-type marking is present in some starboard formats from both mission segments. The marking affects approximately 8 percent of the format area. Star images are present within the flare area. This flare is apparently caused by a minor sunlight reflection during some operations and has not been observed on previous missions.

(2) Several minus density spots which appear to be caused by obstructions on the reseau plate are present on all port and starboard frames throughout the mission.

6. Physical Degradations: The characteristic skew bead roller markings are present on both film edges of the stellar record.

D. Index Camera

1. Density: The density of the index record ranges from thin to heavy with the major portion in the medium-to-heavy category.

2. Contrast: Generally medium.

3. Image Quality: The index photography is generally good and compares favorably with index photography from previous missions.

4. Imaged Degradations:

a. Light Leaks - None noted.

b. Static - Static traces appearing as wavering plus density lines are present intermittently throughout the second-bucket index record.

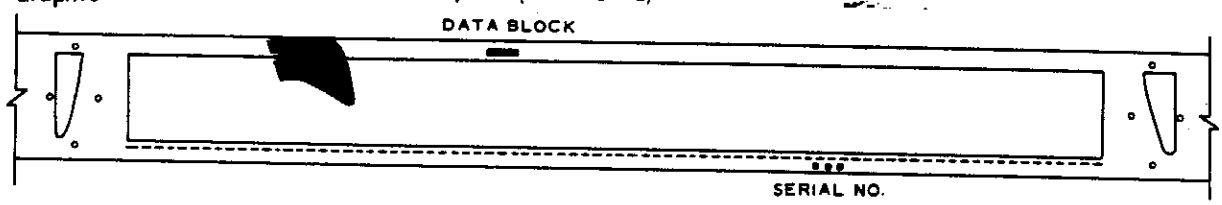
c. Other - Several minus density spots apparently caused by obstructions on the reseau plate are present throughout the mission.

5. Physical Degradations: The characteristic skew bead roller markings are present on both film edges of the index record.

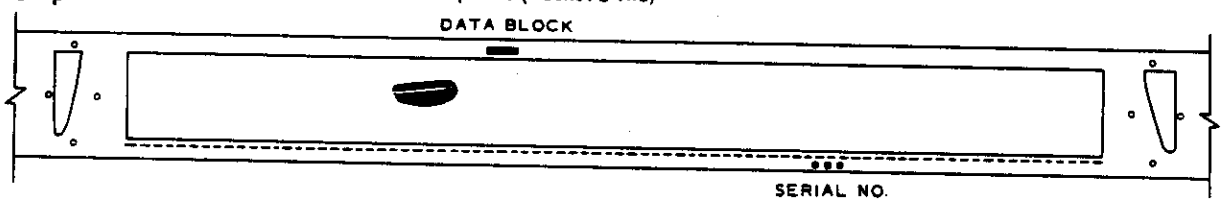
E. Graphic Display

The patterns illustrated below are referenced in the text of this report.

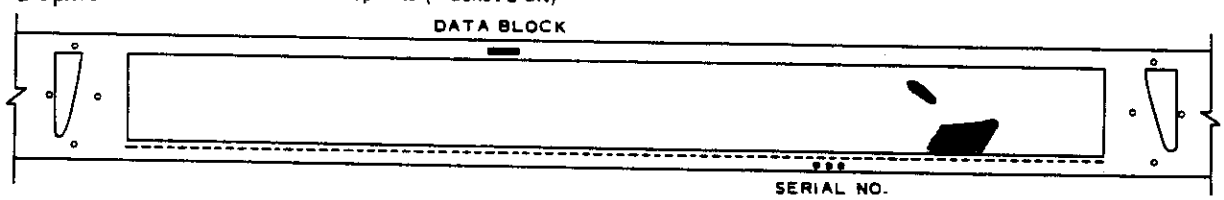
Graphic 1. Fourth frame from end of camera operate (Bucket 1 fwd)



Graphic 2. Fourth frame from end of camera operate (Bucket 2 fwd)



Graphic 3. First frame of camera operate (Bucket 2 aft)



PART IV. IMAGED AUXILIARY DATA

A. Fwd-Looking Panoramic Camera

1. Horizon Cameras:

a. Starboard-Looking:

(1) Imagery - Imaged properly.

(2) Fiducials - Sharp and well-defined.

b. Port-Looking:

(1) Imagery - Imaged properly.

(2) Fiducials - Sharp and well-defined.

2. Frequency Marks: Imaged properly.

3. Binary Time Word: Sharp and well-defined.

4. Camera Number: Readable.

5. Pan Geometry Dots: Sharp and well-defined.

6. Pan Geometry Traces: Sharp and well-defined.

B. Aft-Looking Panoramic Camera

1. Horizon Cameras:

a. Starboard-Looking:

(1) Imagery - Imaged properly.

(2) Fiducials - Sharp and well-defined.

b. Port-Looking:

(1) Imagery - Imaged properly.

(2) Fiducials - Sharp and well-defined.

2. Frequency Marks: Imaged properly.

3. Binary Time Word: Approximately 35 percent of the data bits on the aft-looking camera record are bloomed with each data block exposure throughout the mission. The data bits are within size specification; however, no attempt was made to automatically read the time words since the tape recorder data provided all necessary time correlation. The data block is used only if a tape recorder failure occurs.

4. Camera Number: Readable.

5. Pan Geometry Dots: Sharp and well-defined.

6. Pan Geometry Traces: Sharp and well-defined.

C. Stellar Cameras

1. Grid Image Quality: Sharp and well-defined.

2. Binary Time Word: Imaged properly.

3. Lens Serial Number Legibility: Good.

D. Index Camera

1. Grid Image Quality: Sharp and well-defined.

2. Binary Time Word: Imaged properly.

3. Camera Number Legibility: Good.

PART V. MENSURATION QUALITY

The image quality of Mission 1108 is considered good for mensuration purposes. There were 68 requests for mensuration on this mission. No problems were encountered.

PART VI. FILM PROCESSING

A. Processing Machines and Process Gamma

Camera	Machine	Average Gamma	Film Type
Fwd (1108-1)	Yardleigh	1.87	3404
Aft (1108-1)	Yardleigh	1.98	3404
Fwd (1108-2)	Yardleigh	1.86	3404
Aft (1108-2)	Yardleigh	1.92	3404
	Grafton	N/A	SO-242
Stellar (1108-1)	Trenton	2.15	3401
Stellar (1108-2)	Trenton	2.24	3401
Index (1108-1)	Drape	1.79	3400
Index (1108-2)	Drape	1.80	3400

N/A - Not available.

B. Processing Techniques

1. Panoramic Cameras: The black and white portion of both panoramic camera records were processed using the Yardleigh dual gamma process. The color portion was processed in the Grafton machine.

2. Secondary Cameras:

a. Stellar Cameras - The stellar camera records were processed with a Trenton processor at a single level of development.

b. Index Camera - The index camera records were processed with a Drape processor at a single level of development.

C. Film Handling Summary

1. Primary Cameras:

a. Capsule Defilming - The primary camera records were defilmed on the West Coast and received at the processing site in suitcases.

b. Pre-processing Inspection - No major problems were encountered; however, the West Coast labels for the bucket one main camera suitcases caused some confusion. The problem was rectified on the second bucket.

c. Manufacturing Splices:

Fwd-Looking Camera	Aft-Looking Camera
Pass D39, fr 152	Pass D37, fr 73
Pass D71, fr 14	Pass D89, fr 85
Pass D151, fr 109	Pass D167, fr 98
Pass D176, fr 21	Pass D199, fr 52
Pass D216, fr 23	Pass D242, fr 27 & 28*

d. Processing Anomalies - None

e. Breakdown - No problems encountered.

3. Secondary Cameras (Stellar and Index):

a. Capsule Defilming - The secondary camera records were defilmed on the West Coast and received at the processing site in suitcases.

b. Pre-processing Inspection - No problems encountered.

c. Manufacturing Splices - Rev 138, fr 8 on the index camera record only (ultrasonic splice).

d. Processing Anomalies - None

e. S/I Correlation - No problems encountered.

* Material-change detector splices.

D. Timetable

Film	Recovered	Received at Processing Site	Spec Shipment at NPIC	Priority 1A at NPIC
Fwd (1108-1)	11 Dec 69/ 2138Z	12 Dec 69/ 1950Z	None	14 Dec 69/ 2100Z
Aft (1108-1)	"	"	"	"
Stellar (1108-1)	"	"	"	"
Index (1108-1)	"	"	"	"
Fwd (1108-2)	21 Dec 69/ 2300Z	22 Dec 69/ 1855Z	"	25 Dec 69/ 0057Z
Aft (1108-2)	"	"	"	"
Stellar (1108-2)	"	"	"	"
Index (1108-2)	"	"	"	"

PART VII. PI SUITABILITY

A. PI Statistics

1. Target Coverage:

	1108-1	1108-2	Total
Priority 1 Targets Programmed	No specific priority 1 targets were programmed on this mission although specific areas were selected for initial readout.		
Priority 1 Targets Covered	144	177	321

2. Photographic Interpretability Ratings:

Rating	Missiles	Nuclear Energy	Airbase Facilities	Ports	Industry	Ground force Facilities	Logistics	Miscellaneous
Good	13	7	19	0	2	18	0	6
Fair	65	8	44	15	17	63	13	26
Poor	31	0	18	23	11	17	5	4
TOTALS*	109	15	81	38	30	98	18	36

3. Summary of PI Ratings (percentage):

Good 65 or 15%
Fair 251 or 59%
Poor 109 or 26%

* A discrepancy can exist between the total number of targets covered and the total PI reports because some targets are covered more than once.

B. PI Comments

1. Atmospheric Attenuation: Listed below is the photointerpreters' report of weather conditions for Priority 1 targets covered on this mission.

a.	Clear	366	or 86.1%
b.	Scattered Clouds	19	or 4.5%
c.	Heavy Clouds	4	or 0.9%
d.	Haze	34	or 8.0%
e.	Cloud Shadow	2	or 0.5%

2. Product Interpretability:

The PI suitability of the black and white record ranges from fair to good. The reduction in scale because of higher-than-normal mission altitude after Pass D40 reduced the effectiveness of this mission. The PI suitability of the color record is poor (see SO-242 Special Study in this report).

PART VIII. RESOLUTION TARGET DATA

There were no Resolution Targets used during this mission.

PART IX. MISSION 1108 DATA

	Forward-Looking			Aft-Looking			Stellar		Index
	▲ Pan	Takeup Horizon	Supply Horizon	● Pan	Takeup Horizon	Supply Horizon	Port	Starboard	
Camera Number	317	*	*	316	*	*	12		12
Reseau Number	*	*	*	*	*	*	14P	15	109
Lens Serial Number	I-200	23780	23781	I-195	23773	23776	14P	15	109
Slit Position/ Slit Widths (in.)	1/0.141 2/0.214 3/0.274 4/0.334 FS/0.237	*	*	1/0.084 2/0.140 3/0.185 4/0.289 FS/0.154	*	*	*		*
Aperture	*	F/8.0	F/6.3	*	F/6.3	F/8.0	F/2.8	F/2.8	F/6.3
Exposure Time (sec)	Variable	1/100	1/100	Variable	1/100	1/100	1.5	1.5	1/500
Filter (Wratten) Primary	W-25	W-25	W-25	W-21	W-25	W-25	None	None	W-12
Alternate	W-25	*	*	W-2B	*	*	*	*	*
Focal Length (mm)	609.752	54.82	55.88	609.638	54.93	NA	76.2	76.2	76.2
Film Length (ft)	16,300	*	*	15,200/800	*	*	2,000		2,200
Splices	5	*	*	6	*	*	None		1
Emulsion	443-1/2-11-9	*	*	444-6-11-9/SO-242-2-1	*	*	319-6-6-9		202-4-4-9
Film Type	3404	*	*	3404 / SO-242	*	*	3401		3400
Resolution Data (L/mm)	- - -	209R/187T	207R/209T	- - -	148R/132T	187R/166T	NA	NA	122R/108T
Static									
High Contrast	292	NA	NA	248	NA	NA	NA	NA	NA
Low Contrast	186	NA	NA	148	NA	NA	NA	NA	NA
Dynamic									
I High Contrast	284	NA	NA	224	NA	NA	NA	NA	NA
I Low Contrast	188	NA	NA	139	NA	NA	NA	NA	NA
P High Contrast	277	NA	NA	239	NA	NA	NA	NA	NA
P Low Contrast	188	NA	NA	132	NA	NA	NA	NA	NA

NA - Not Available.
* - Not Applicable.
R - Radial Resolution on Axis.
T - Tangential Resolution on Axis.
▲ - Resolution Tested using a W-25 filter.
● - Resolution Tested using a W-21 filter.

PART X. MISSION INFORMATION POTENTIAL (MIP) HISTORY, 1100 SERIES

Mission	MIP#	Pass	Frame	Universal Grid Coord	
1101	85	D159	2 fwd	39.0	1.5
*1102	90	D16	22 fwd	26.8	1.3
1103	90	D79	15 fwd	41.8	3.8
*1104	115	D16	6 fwd	33.1	4.1
*1105	95	D16	20 aft	47.3	1.2
*1106	110	D32	8 fwd	17.9	1.8
1107-1	95	D122	30 aft	43.7	2.4
1107-2	95	D170	20 aft	42.1	2.9
1108-1	105	D30	20 fwd	28.7	0.5
*1108-2	100	D242	20 fwd	33.3	2.3

* - Standards

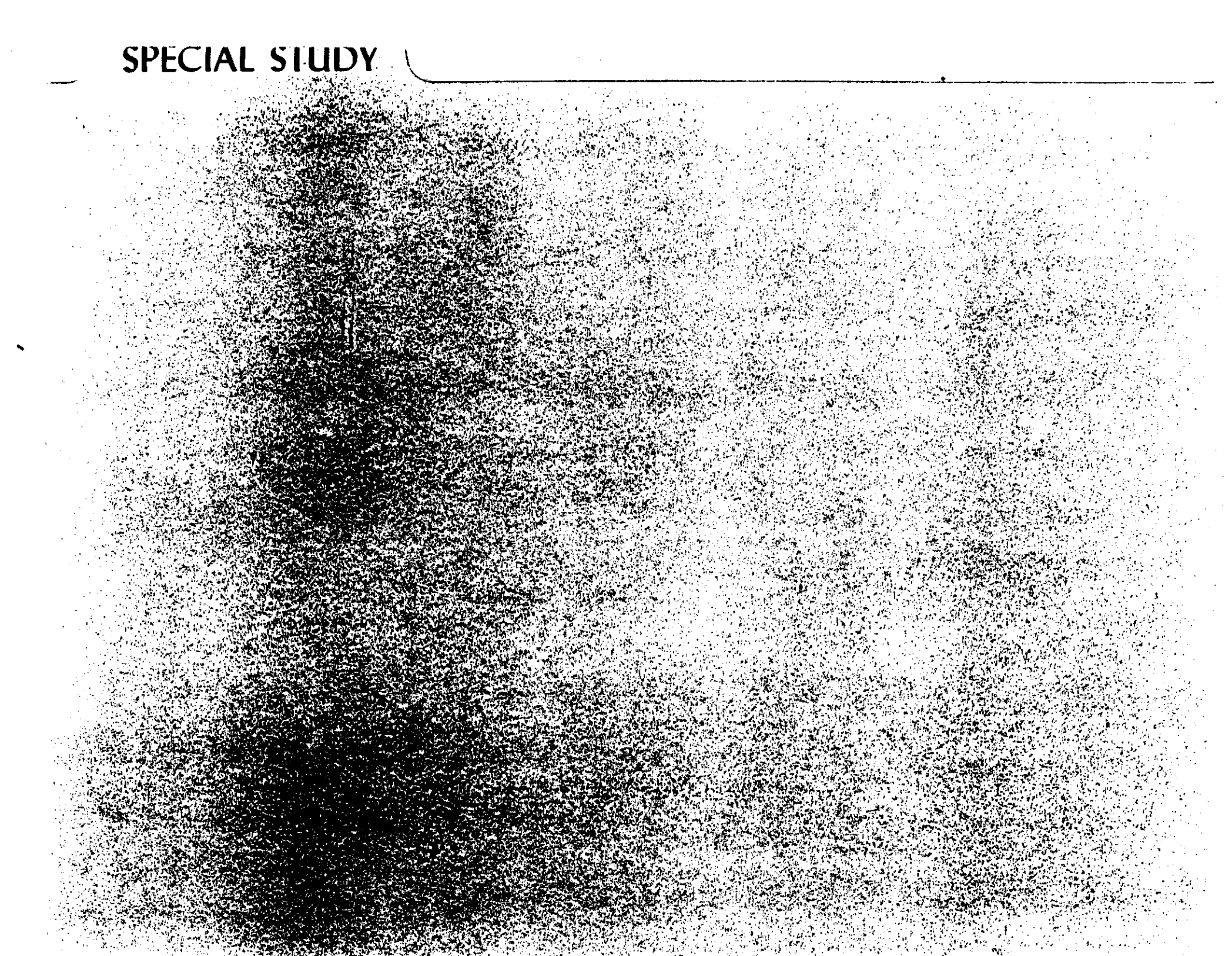


TABLE OF CONTENTS

GRAPHIC ILLUSTRATIONS

I. INTRODUCTION

The goal of this satellite reconnaissance program is to provide the customers with the best possible photographic information base available. Thus far in the program black/white film has served to meet this objective. However, recent advancements in color technology certainly indicate that additional benefits may be realized above and beyond those provided by black/white photography. For example, substantial improvements have been incorporated into the manufacture of SO-242 color film.

The film load of Mission 1108-2 was partially composed of SO-242 color material in addition to the regular black/white film supply. Two reasons for using the color were (a) to investigate the capabilities of SO-242 with respect to this system, and (b) to satisfy a specific intelligence requirement. This report presents some of the technical considerations of the experiment and attempts to clarify the National Photographic Interpretation Center's position from an interpretation standpoint on the utility of color photography in this system.

II. EXPERIMENT CHARACTERISTICS AND CONSIDERATIONS

The following sections present mission coverage data, characteristics of SO-242, and comparisons of SO-242 with SO-121 and 3404 films.

A. Mission Profile

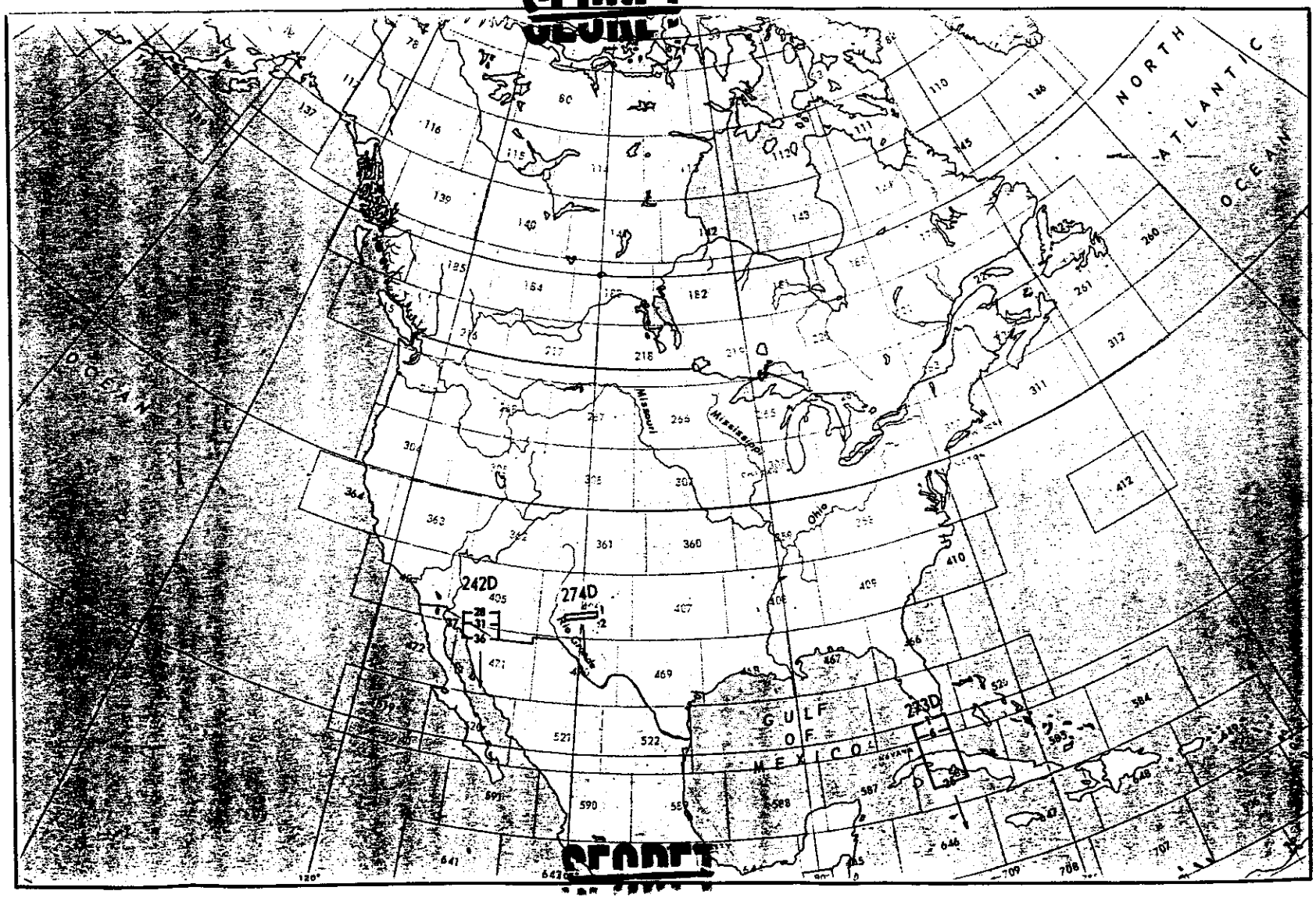
The last 811 feet (312 frames) of the aft-looking camera film record of Mission 1108 was SO-242 Ektachrome color film. The SO-242 was spliced to the end of the type 3404 black/white material. A material/film change device was used to signal the availability of the color material for exposure and a Wratten 2B filter was automatically inserted into the aft-looking camera optical path. The color was exposed during acquisitions from frame 28 of pass D242 through frame 2 of pass D274 (end of mission). Duplicate black/white coverage through frame 18 of pass D268 was provided by the forward-looking camera. Pertinent information pertaining to the color portion of the mission and color coverage plots follows.

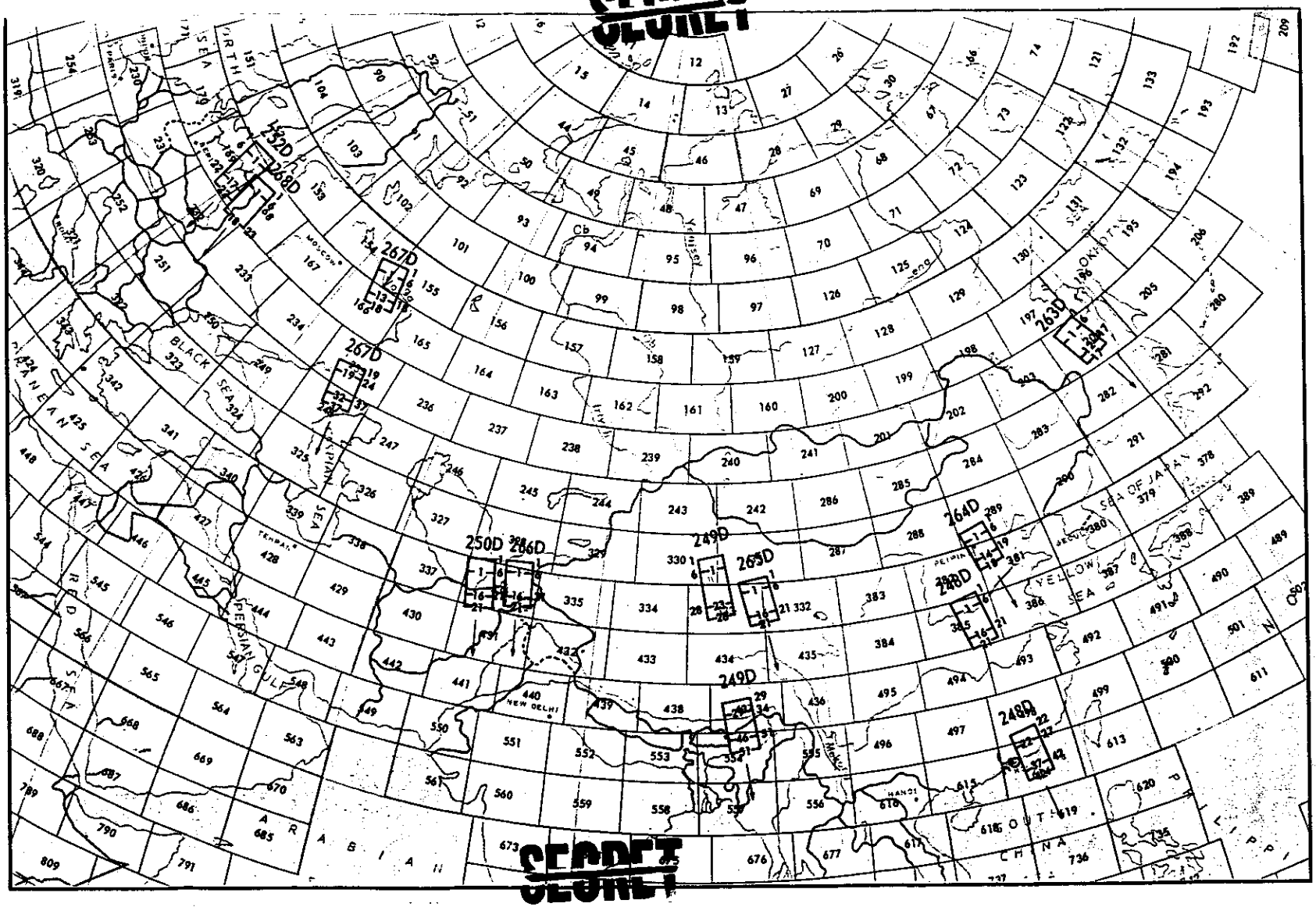
COLOR PROFILE DATA

Pass	Frame	Date	Solar Elevation Range (degrees)	Exposure Range (seconds)	Cloud Cover (Percentage)	Area Photographed (Remarks)
D242	26	19 Dec 69	-	-	-	Last black/white frame
	27	"	-	-	-	Mission change detector
	28-37	"	32.8 - 33.8	1/450 - 1/451	0	USA
D248	1-21	20 Dec 69	29.5 - 32.4	1/823 - 1/826	45	China
	22-42	"	40.7 - 43.5	1/831 - 1/832	5	China
D249	1-28	"	23.3 - 27.2	1/814 - 1/819	15	China
	29-51	"	34.9 - 38.0	1/828 - 1/830	30	China, Bhutan
D250	1-21	"	25.4 - 28.3	1/491 - 1/493	25	USSR, Afghanistan
D252	1-22	"	8.6 - 11.7	1/359 - 1/362	50	USSR, Poland
D263	1-17	21 Dec 69	13.2 - 15.4	1/815 - 1/819	25	USSR
D264	1-19	"	24.1 - 26.5	1/513 - 1/515	0	China
D265	1-21	"	24.9 - 27.7	1/500 - 1/502	0	China
D266	1-21	"	24.9 - 27.6	1/500 - 1/502	10	USSR, Pakistan, Afghanistan
D267	1-17	"	6.8 - 9.2	1/367 - 1/369	25	USSR
	18-37	"	15.1 - 17.6	1/371 - 1/373	20	USSR
D268	1-23	"	9.7 - 12.9	1/370 - 1/372	5	USSR, Poland
D273	1-26	"	40.7 - 44.1	1/845 - 1/846	25	USA, Cuba
D274	1- 2	"	31.9	1/841	-	USA (end of mission)

A summary of the Color Profile Data given on the preceding page is presented below:

Passes: 13
Frames: 312
Photographic Days: 3
Solar Elevation Range: 6.8° - 44.1°
Exposure Range: 1/359 - 1/846 second
Average Cloud Cover Percentage: 20 percent
Scale Range: 1/301463 - 1/323062
Altitude Range: 95.6 - 102.5 nm


SECRET
NORTH ATLANTIC OCEAN
PACIFIC OCEAN
GULF OF MEXICO
242D
274D
233D
SECRET


SECRET
SECRET
252D
268D
267D
267D
263D
264D
250D
266D
249D
263D
248D
249D
248D
BLACK SEA
CASPIAN SEA
PERSIAN GULF
ARABIAN SEA
YELLOW SEA
SEA OF JAPAN
MOSCOW
NEW DELHI
HANOI
CHINA

B. SO-242 Characteristics

SO-242 is a color ektachrome reversal film specifically designed for high altitude reconnaissance acquisitions. Three emulsion layers are deposited on a 2.5 mil estar standard thin base with a protective filter overcoat (transmission characteristics equivalent to a Wratten 2B filter) and a clear gel backing. The arrangement of the individual emulsion layers is unique; ie the green sensitive layer is on top, the red sensitive layer in the middle, and the blue sensitive layer on the bottom (see graphics and microtome illustrations on pages 8A and 9A).

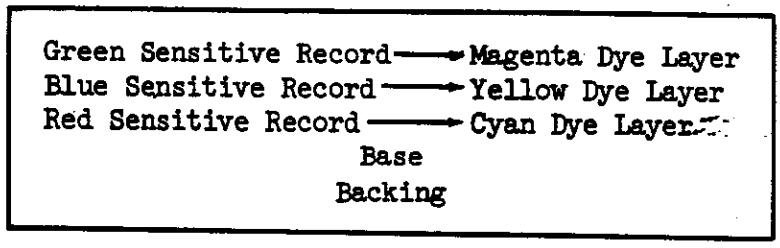
The development of SO-242 with the blue sensitive emulsion layer beneath the red and green layers represents an important departure from conventional techniques of color film manufacture. A drawback to this arrangement is the sensitivity of all silver halide emulsions to blue radiation. To circumvent this sensitivity characteristic, the blue recording emulsion layer is usually placed on top. A blue absorption filter is included above the red and green emulsion layers to restrict penetration of the blue radiation to these emulsions. In SO-242, the sensitivity of the red and green emulsion layers to blue radiation has been restricted sufficiently so the blue sensitive layer can be placed on the bottom.

This layer arrangement attempts to optimize the composite characteristics of the film, eye, camera optics, and atmosphere. For example, (a) since the sensitivity and discriminativity of the human eye peak in the green region of the electromagnetic spectrum, it is desirable to record green information where minimal image degradation occurs. This is accomplished with SO-242 by placing the green sensitive emulsion layer on top where light dispersion during exposure and viewing is minimized; (b) the camera optics are designed for best performance in the red and green region of the spectrum; therefore, it is desirable to record the information included within this region where minimal image degradation is encountered; and (c) the atmosphere scatters the short blue wavelengths more than it does the longer green and red wavelengths; therefore, the potential information content within the blue region is not as great as that in the corresponding green and red regions.

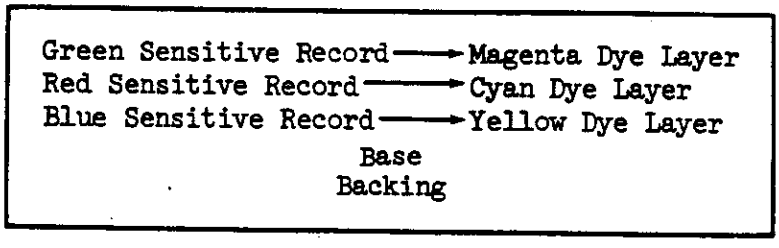
The resolution capability of SO-242 is significantly improved over that of its predecessor, SO-121 (resolution data is listed for SO-242, SO-121 and 3404 on page 10A). This improvement is primarily the result of the more optimum arrangement of the emulsion layers, better dye homogeneity, and a sacrifice in film speed as compared to SO-121. The decreased film speed is most compatible with the system since a faster film speed

GRAPHIC 3a. CROSS SECTIONS OF SO-121 AND SO-242

SO-121



SO-242



GRAPHIC 4a. MICROTOMES OF SO-121 AND SO-242

The microtomes on the following photograph pictorially illustrate the arrangement of the emulsion layers of SO-121 (top) and SO-242 (bottom). The film base of both materials is toward the bottom.

The layer irregularity present in the SO-121 Microtome is a result of the cut. Note the relative placement and thickness of the yellow dye layer compared to the magenta and cyan layers of SO-121 and SO-242.

The magnification factor is approximately 1850X.

would require the use of a neutral density filter when mixed film loads are used. This was the case on Missions 1105 and 1106.

FILM DATA COMPARISON*

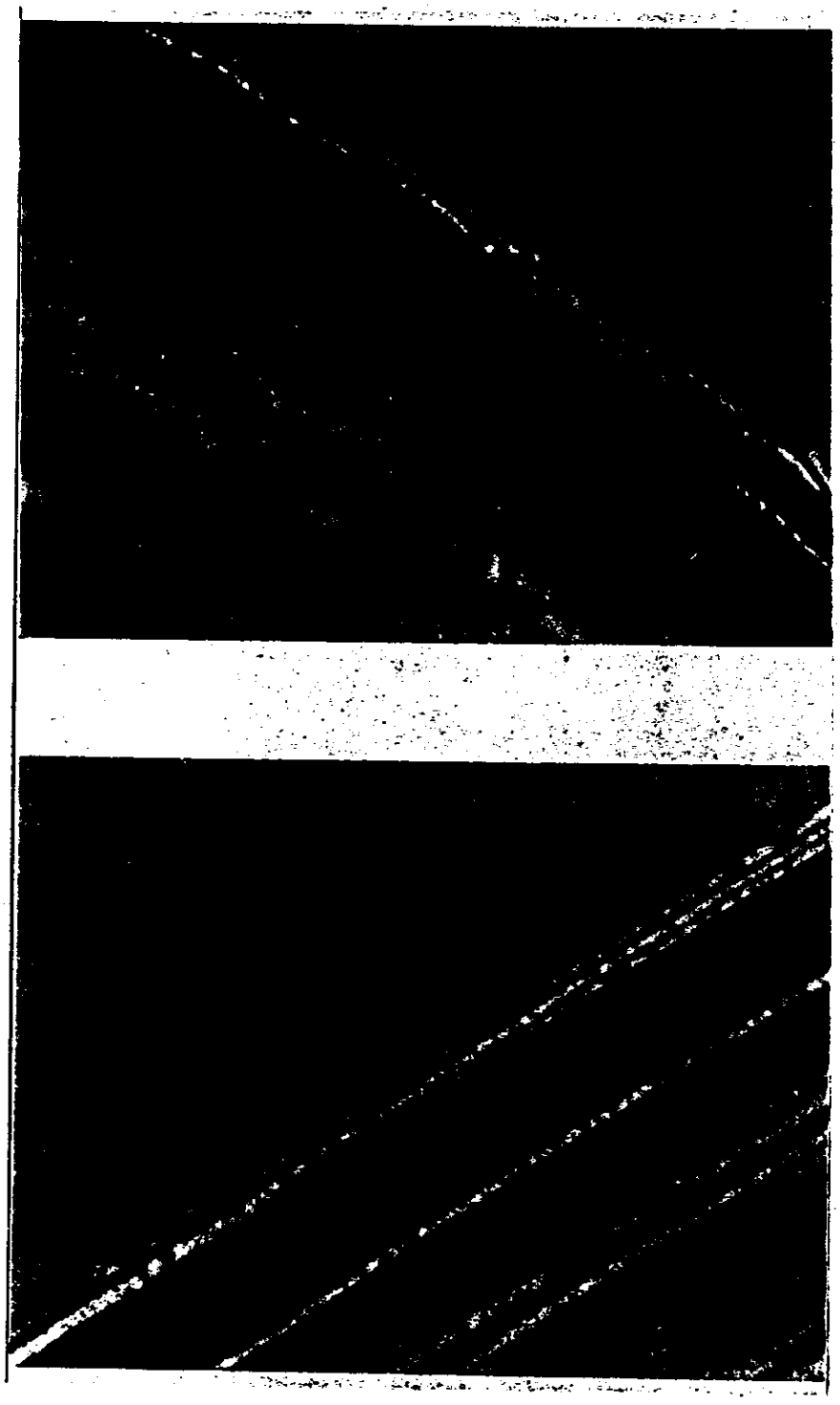
Film	Resolving Power (c/mm) 1.7:1	100:1	AEI	Thickness base	total	RMS Granularity**
SO-242	111	205	3.8	2.5	3.5	38.0
3404	220	680	3.5	2.5	3.0	22.3
SO-121	75	154	12.0	2.5	3.5	78.7

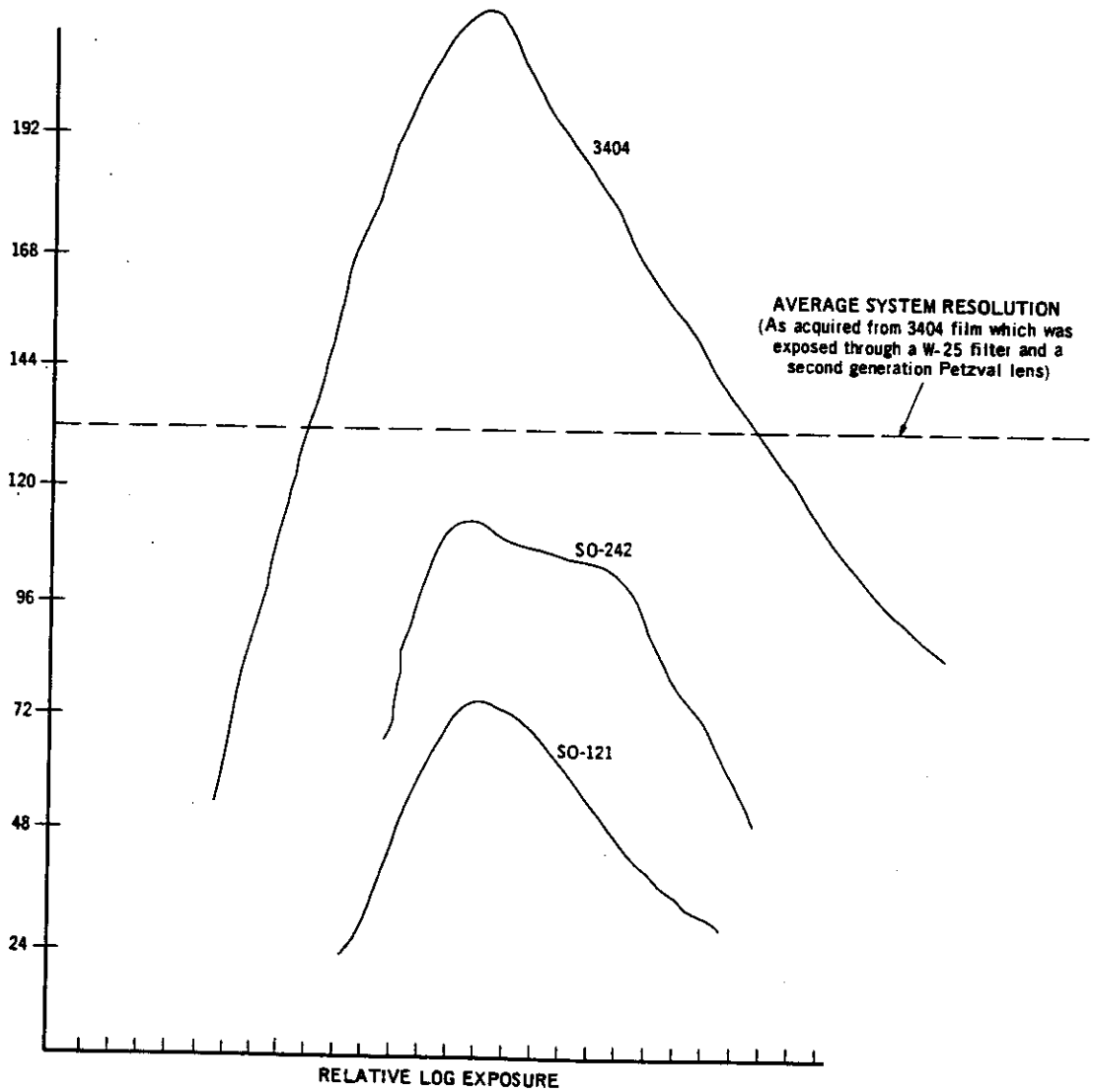
It was previously stated that SO-242 substantially reduced the resolution gap that exists between color and black/white film. The fact remains however that the resolution restrictions of color film are a limiting factor with respect to its utilization in this system even though the camera optics are not specifically designed for color acquisitions. The resolution capabilities of SO-242, SO-121 and 3404 are compared to the average system resolution of a second generation Petzval lens in the illustration on page 11A.

The sensitivity of the individual emulsion layers of SO-242 and SO-121 are compared in Graphic 7a (page 13A). Notice particularly the sensitivity within the green region of SO-242. Note the absence in this emulsion layer of an extended sensitivity within the blue and near ultra-violet region as compared to the green sensitive emulsion layer of SO-121.

* - Data obtained from film manufacturer's specification sheets and pertinent reports.

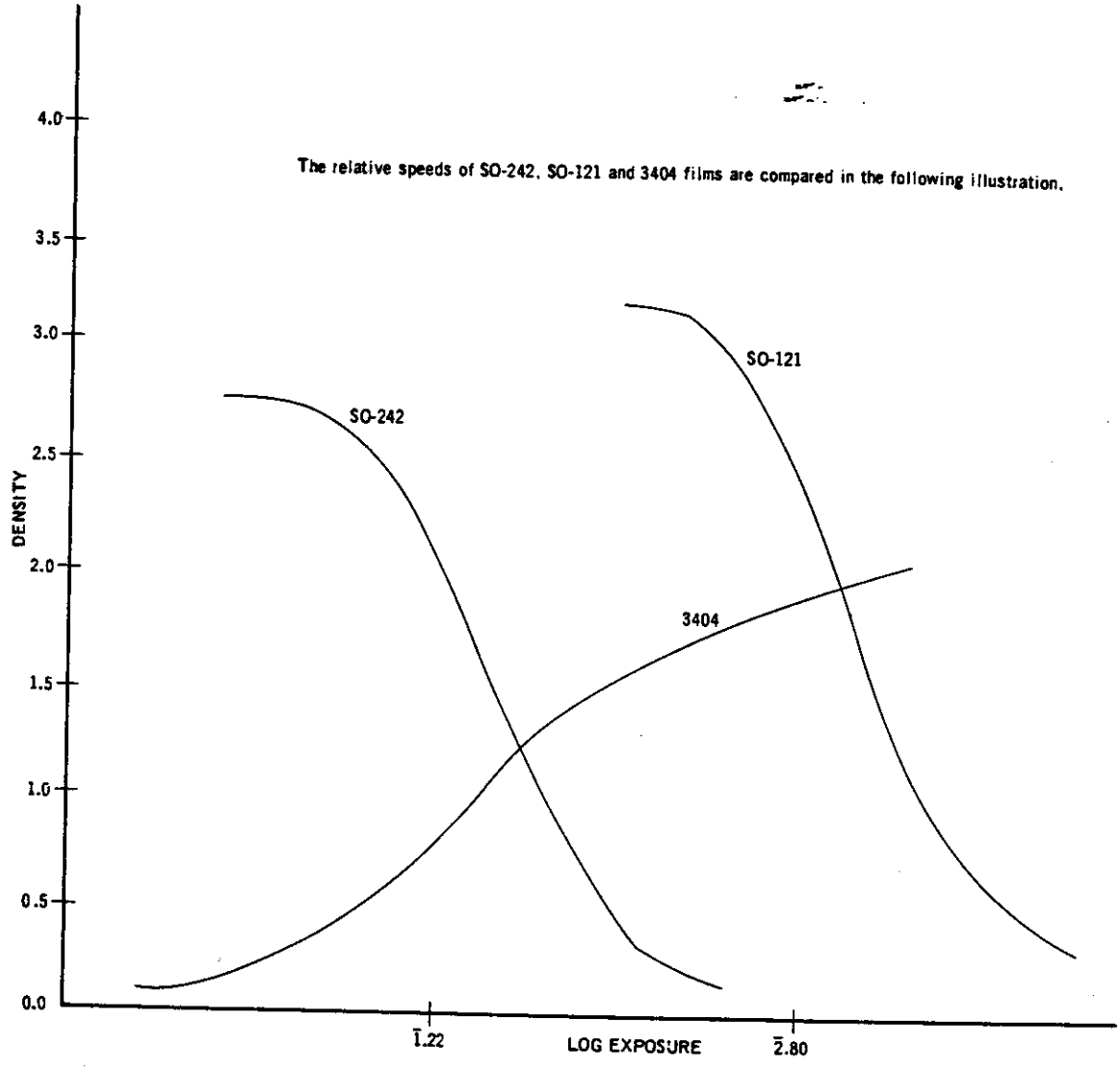
** - At 1.0 gross density, 12.7 micron aperture, 45X viewing magnification.



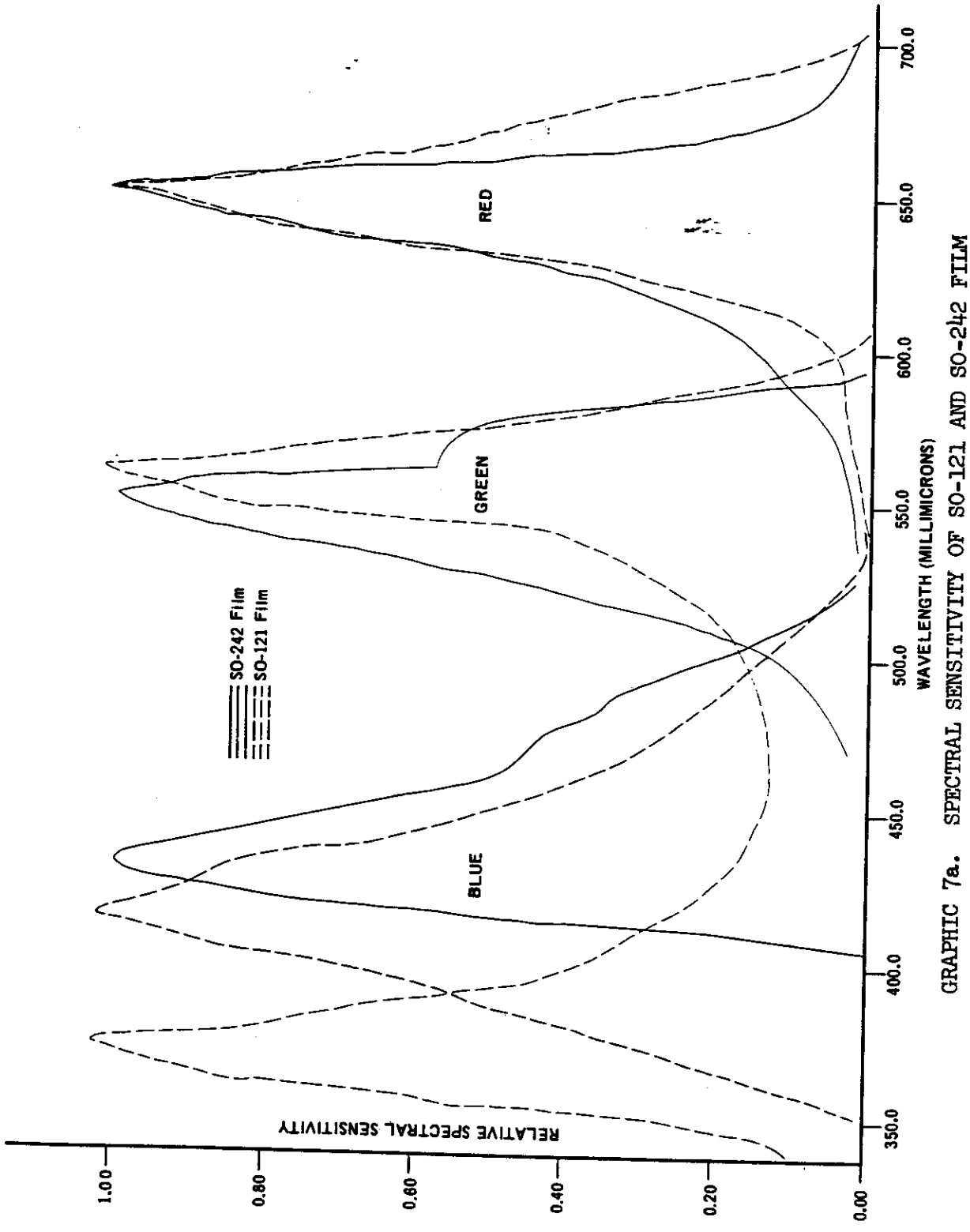


Graphic 5a. FILM/SYSTEM RESOLUTION CAPABILITY (1.7:1 Contrast Ratio)

The relative speeds of SO-242, SO-121 and 3404 films are compared in the following illustration.

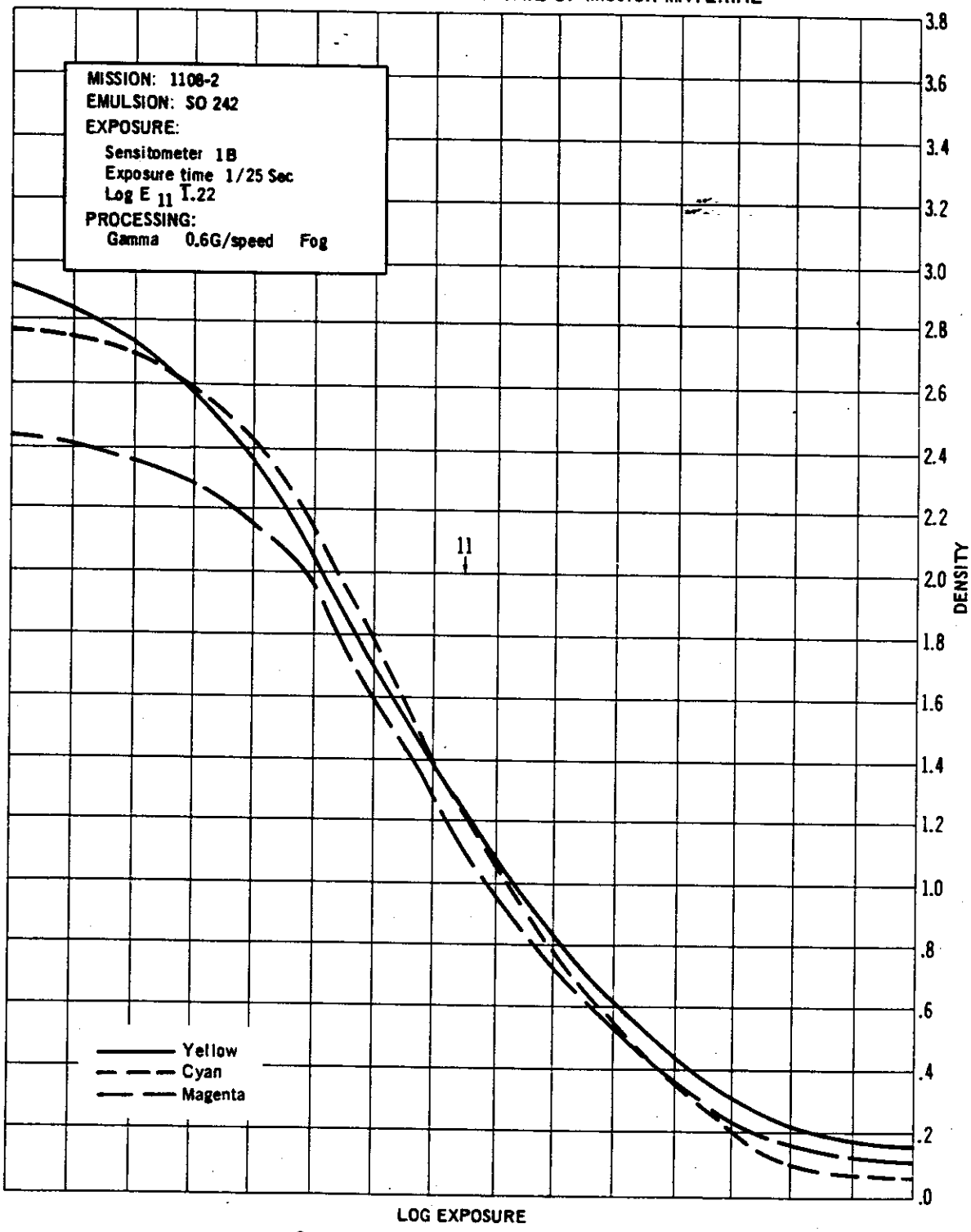


GRAPHIC 6a. FILM SENSITIVITY COMPARISON



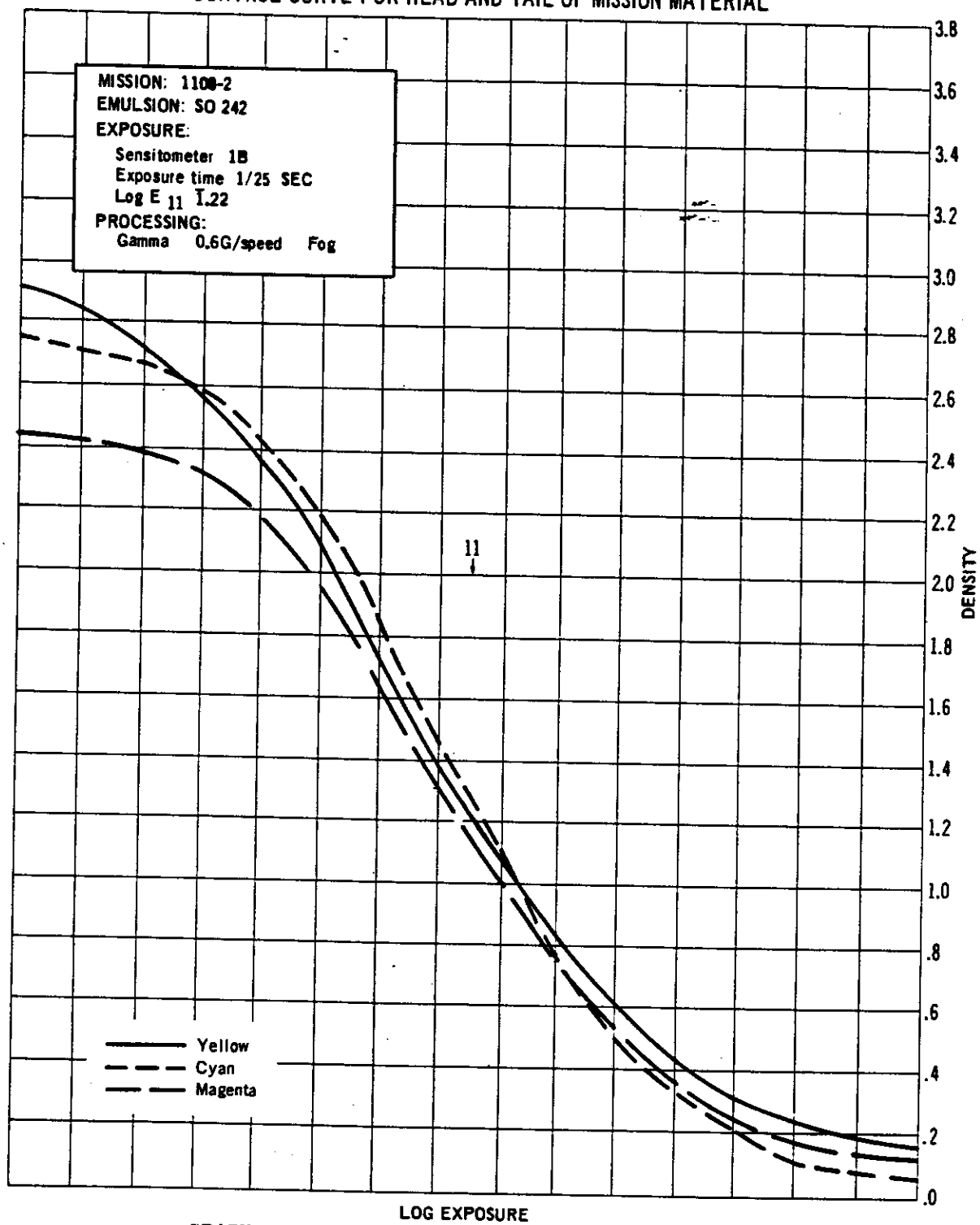
GRAPHIC 7a. SPECTRAL SENSITIVITY OF SO-121 AND SO-242 FILM

CONTROL CURVE FOR HEAD AND TAIL OF MISSION MATERIAL



GRAPHIC 8a. PROCESS CONTROL CURVES (HEAD)

CONTROL CURVE FOR HEAD AND TAIL OF MISSION MATERIAL



GRAPHIC 9a. PROCESS CONTROL CURVES (TAIL)

III. PHOTOINTERPRETATION REPORT

A. First Phase Readout Analysis

The first phase readout of Mission 1108-2 was initiated by the National Photographic Interpretation Center Photointerpreters (NPIC/PIs) at 0745 on 29 December 1969. This readout was completed two days later. Throughout this period, the PIs were solicited for their opinions concerning the use of color with respect to their specific functions. The PIs stated that the overwhelming disadvantage of the color is its severe fall-off in ground resolution as compared to the black/white material. Some complaints from the PIs are:

> "Planes identified on black/white cannot be located on color."
>
> "Small villages present on black/white cannot be detected on color."
>
> "Mountain peaks appear jagged and distinct on black/white but are rounded and smooth on color."

The PIs noted numerous instances where items of interest within high priority target areas are present on the black/white record but cannot be detected on the color. For example; tents, tent foundations, aircraft, missiles, missile facilities, fences, tracks, roads, tanks, trucks, pieces of armament and equipment, etc. can be detected and often identified on the black/white material but these objects cannot be detected or are recorded as blobs on the color material.

Forty-one high priority targets were photographed in color during this mission. The PIs readout these targets during the first phase analysis and assigned quality ratings to the coverage record. Analysis of these ratings indicates the importance of at least one high resolution record. Thirty-two targets are covered in stereo with twenty-two rated fair and the remaining ten rated poor. Nine additional targets are covered in mono (color only) and of these, eight are rated poor and one fair. These ratings should not be construed as an indicator of system performance with respect to color. However, they are representative of the degree or extent to which the photointerpreters are able to answer their requirements from the color record. Following is a list of the targets which were photographed in color. The respective quality ratings and weather/terrain conditions are also presented.

Target	Pass	Frame	Quality	Weather/Terrain Conditions
Missile Range	D267	29	Poor	Haze
Missile Range	D267	23-30	Poor	Haze
Deployed Strategic SSM Facilities	D268	21-22	Fair	Clear
" "	D268	12-15	Poor	Clear snowy
" "	D252	15-19	Poor	Clear snowy
" "	D268	2- 4	Poor	Scattered clouds snowy
" "	D252	14-18	Fair	Clear snowy
" "	D268	2- 3	Poor	Scattered clouds snowy
" "	D268	2- 4	Poor	Scattered clouds snowy
" "	D252	12-16	Fair	Clear snowy
" "	D268	1- 2	Poor	Scattered clouds snowy
" "	D268	10-13	Poor	Clear snowy
" "	D252	2- 6	Poor	Clear snowy
" "	D252	3- 7	Poor	Clear snowy
" "	D268	21-22	Fair	Haze snowy
" "	D268	17-21	Fair	Clear snowy
" "	D268	16-20	Fair	Clear snowy
" "	D252	6-10	Fair	Clear snowy
" "	D268	16-20	Fair	Clear snowy
" "	D268	7- 9	Fair	Clear snowy
" "	D252	12-16	Fair	Clear snowy
" "	D268	1- 2	Poor	Scattered clouds snowy

Target	Pass	Frame	Quality	Weather/Terrain Conditions
Deployed Strategic SSM Facilities	D252	12-16	Fair	Clear snowy
" "	D268	1- 2	Poor	Scattered clouds snowy
" "	D268	1- 4	Poor	Scattered clouds snowy
" "	D268	11-14	Poor	Clear snowy
" "	D267	9-14	Poor	Clear snowy
" "	D252	15-19	Fair	Clear snowy
Air Base Facilities	D268	13	Fair	Clear snowy
Logistics	D252	17	Fair	Clear snowy
Logistics	D268	4	Fair	Clear snowy
Logistics	D264	8	Fair	Clear
Nuclear Energy	D249	9-12	Fair	Scattered clouds haze
" "	D249	11	Fair	Scattered clouds haze
" "	D249	11	Fair	Scattered clouds haze
" "	D249	11	Fair	Scattered clouds haze
Weapons Facility	D248	12	Fair	Clear
" "	D264	12	Fair	Scattered clouds
" "	D264	18	Poor	Haze
" "	D264	16	Fair	Clear
" "	D264	18	Poor	Haze

B. Second Phase Readout Analysis

The second phase readout of Mission 1108-2 began immediately after the first phase was completed. Readout and quality reporting procedures for first and second phase are nearly identical except that the latter phase concerns targets of lower national priority. The photointerpreters' opinions were again solicited as to the effects of color on their requirements. Their statements and quality ratings correlate closely to the first phase results and directly reflect the poor resolution of the color when compared to the black/white material.

C. Third Phase Readout Analysis

Third phase readout is characterized by detailed analysis and reports. It usually involves a basic report on a specific target type and may

include a regional geographical or agricultural study. It is within this realm that color photography as provided by this system is expected to contain the greatest potential and application. This expectation is justified by the fact that almost all cloud free frames of the color material provide a tremendous range of tones and hues. The ecological data that could be derived from these clues by trained color analysts is substantial.

The NPIC PIs produce a large number of third phase reports; however, because of present-day time restrictions, no third phase work has been conducted with the color from this mission. In addition, the majority of the third phase reports are, by necessity, heavily oriented toward military/industrial complexes where the application of color photography at this resolution level and scale is limited. As requirements expand and color coverage increases, it is inevitable that the application of color will also increase. It is noteworthy that the color resolution limits are generally not as critical to this type of application as they are to first and second phase readouts.

D. Specific Intelligence Requirement

It was noted in the introduction that one reason for using SO-242 in this mission was to satisfy a specific intelligence requirement. Due to the sensitive nature of the requirement the specifics cannot be openly discussed. The requirement was not oriented to spatial resolution but dependent upon the assessment of the spectral characteristics of a particular geographical area. The color quality of the coverage was considered adequate to satisfy the requirement.

IV. QUALITY ANALYSIS

Mission 1108 provided the intelligence community with color photography which is superior to any other color photography which has been received from this system to date. The estimated ground resolution (GR = bar plus space) of the best color imagery is 12 to 15 feet. This compares favorably with the 15-foot ground resolution of Mission 1105 (obtained from SO-121 film) and 15- to 20-foot GR of Mission 1106 (also obtained from SO-121 film). Whereas these resolution figures are empirical estimates, a comparison of the color from Missions 1105, 1106, and 1108 readily illustrates the superiority of the Mission 1108 color.

The SO-242 color coverage acquired on this mission does not correspond geographically to the SO-121 color coverage of Missions 1105 or 1106. Therefore, comparisons of identical terrain images are not possible.

A. Color Quality

The color balance and color saturation of the original SO-242 material is adequate for exploitation purposes. A detailed comparison of the original material to the SO-360 reproduction illustrates a vivid loss of dye homogeneity and color distinction capability in the reproductions. This is not objectionable at low magnifications but becomes a real problem at enlargements greater than 20 diameters.

The material exposed under ideal weather conditions exhibits a multitude of hues and tonal variations. The objects recorded at "midtone" density level appear faithfully recorded. However, the "D-mins" representing ground-scene highlights often record slightly warm, whereas the "D-maxs" representing ground-scene shadows are shifted toward the cold end of the spectrum -- usually cyan. Most frames acquired during adverse weather conditions (dense haze and clouds) also exhibit a color shift toward cyan.

B. Density

The density of the original color material ranges from generally medium to slightly heavy. Low luminance levels attributed to insufficient solar elevation and unfavorable atmospherics were encountered on several passes. The density of the film from these passes suggests that an increase in exposure would have improved the product. The exposure range, solar elevation, and cloud cover percentage are listed in the Color Profile Section in Part II of this report.

The density level of the reproductions is improved over that of the original and is adequate for exploitation purposes.

C. Color Compared to Black/White

The difference in the ground resolution of the color when compared to the black/white material is approximately 2:1 in favor of the black/white. Although there were no resolution targets recorded, empirical estimates from the original film place the best ground resolution of the color at 12 - 15 feet and that of the black/white at 7 - 9 feet. The ground resolution estimates from the reproductions are 18 - 25 feet for the color and 8 - 10 feet for black/white. The result of this resolution difference is clearly apparent in the photointerpretation section (page 16A) of this report.

D. Color Original Compared to Reproductions

More than twenty percent loss in ground resolution and information content is evident in the color reproductions (SO-360) when compared to the SO-242 original. This quality difference is readily apparent on photomicrographs of the two materials. Minute detail, required for object separation and identification, is more apparent on the original--the original provides significantly more distinct geometrical information. This difference in quality places added restraints on color photography exploitation and therefore causes the current reproduction material to be unsatisfactory since the photointerpreter is dependent upon reproductions for all first phase and most second phase readout requirements. Because of the loss in image quality attributed to the color reproductions, specialized printing techniques are being investigated. It has been determined that black/white reproductions of the top two emulsion layers (green and red sensitive layers) either singularly or composited are superior from an image sharpness standpoint to the color reproductions. Additional experimentation within this area is being conducted, but the present results justify the following recommendation (considering NPIC's resolution oriented readout requirements) with respect to future color utilization in this system: The photointerpreter should be provided with an optimum quality black/white reproduction which has been selectively printed from the original color material, and all additional copies should be color reproductions. This combination will provide the interpreter with the best copy from a resolution standpoint, and will insure that any additional benefits which may be derived from color will also be available.

V. OBSERVATIONS AND CONCLUSIONS

1. The resolution capability and dye homogeneity of SO-242 are superior to those of SO-121

2. The sensitivity characteristics of the individual emulsion layers of SO-242 are improved over those of SO-121.

3. The film speed and exposure latitude of SO-242 are compatible with this system.

4. The primary constraint on using SO-242 in this system is the incompatibility between the intelligence community requirements and the spatial resolution afforded by SO-242 at this scale.

5. The difference in ground resolution between the color and black/white material is approximately 2:1 in favor of the black/white.

6. The current color reproduction material is unsatisfactory because of its loss in quality as compared to the original.

7. Except for its stereo contribution, the color material was of no apparent value to first or second phase analysis.

8. Color photography as provided by this system is expected to contribute most to regional, agricultural, and geological studies.

9. The quality of the color was adequate to satisfy the specific requirement for which it was intended.

10. The overall quality of the color material from this mission is superior to any other color photography that has been received from this system to date.

VI. RECOMMENDATIONS

Mindful of the National Photographic Interpretation Center's primary function, the design purpose of this system, and its scale and ground resolution capabilities, the following recommendations concerning the use of color photography in this system are submitted:

1. Color be utilized on an experimental basis only with reasonable assurance that the experiment benefits will outweigh the loss of intelligence information which may occur.

2. Color be utilized if there are direct color-oriented intelligence requirements which fall within the capabilities of the system.

3. Color be utilized if the ground resolution capabilities of the color are comparable to the black/white capabilities.

4. Color simulation experiments be conducted in high altitude aircraft missions where practical, unless one of the above conditions can be satisfied.