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PHOTOGRAPHIC EVALUATION REPORT MISSION 1104

WITH SPECIAL STUDY SO-180 EVALUATION MISSION 1104

[redacted]

DECEMBER 1968

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TECHNICAL PUBLICATION

PHOTOGRAPHIC EVALUATION REPORT

MISSION 1104

DECEMBER 1968

NATIONAL PHOTOGRAPHIC INTERPRETATION CENTER

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GLOSSARY OF TERMS

ABSOLUTE HEIGHT	Vertical distance from the vehicle to the mean ground level of the area being photographed.
ACUITY	Sharpness - Edge definition.
ACUTANCE	Measure of the ability of a lens to reproduce sharp images.
AIR BASE	Ground distance between 2 exposure stations.
ALTITUDE	Vertical distance from the vehicle to the Hough Ellipsoid at the time of exposure.
AZIMUTH OF THE PRINCIPAL RAY	Horizontal clockwise angle, measured from true north to the camera principal ray.
BASE HEIGHT RATIO	Ratio between the air base and the absolute altitude of a stereoscopic pair of photographs.
CAMERA NADIR	Geodetic latitude and longitude of a point vertically beneath the perspective center of the camera lens on the Hough Ellipsoid.
CONE ANGLE	Angle between the principal ray and the vehicle nadir.
COPY GENERATION	Number of reproductive steps by which a negative or positive photographic copy is separated from the original, i.e. the original negative is copy 1, a positive made from the original negative is copy 2, etc.
DATE OF PHOTOGRAPHY	Indicates the day, month, and year (GMT) that the photography was acquired.
EXPOSURE*	Total quantity of light received per unit area on a sensitized plate or film.

EXPOSURE DURATION	Time during which a light-sensitive material is subjected to the influence of light. Expressed in this text in fractions of a second. Formula: Exposure Time (sec) = $\frac{\text{Slit Width (in)}}{\text{Scan Rate (in per sec)}}$
EXPOSURE STATION	Position occupied by the camera lens at the moment of exposure.
FIDUCIAL MARK	A standard geometrical reference point imaged at the margin of a photograph. The intersection of the primary fiducial marks usually defines the principal point.
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.
FRAME	One of a series of full-format photographs comprising a roll of film.
GROUND RESOLUTION*	Resolved ground distance as determined from standard bar target resolution targets. A target is considered to be resolved when a grouping of 3 bars can be distinguished as 3 distinct lines. The lines need not have linear form.
HOLEY RAIL DOTS	Images of the rail holes associated with the pan geometry calibration of the camera.

IMC (Image Motion Compensation)	Correction for the forward motion of the vehicle while photographing the terrain.
ISODENSITOMETER	An instrument which is basically a microdensitometer with the capability of repeatedly scanning an image at pre-set intervals. Its output is in the form of a plot representing distance along 2 axes and density differences as code changes within each scan line.
LOCAL SUN TIME	Time of day computed from the position of the sun relative to the imaged terrain.
MICRODENSITOMETER	An instrument which measures the optical density of very small areas in an image. Its output is in the form of a continuous plot of density versus distance across an image. The microdensitometer used in NPIC can accurately measure distances as small as 1 micron and densities up to 5.0+.
NOD INDICATORS	A series of marks imaged in the border area of each frame for the purpose of defining the relative orientation of the optical axis and the ground scene.
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.
PANORAMIC CAMERA	Photographs a partial or complete panorama of the terrain in a transverse direction through a scanning motion of the lens system.
PARALLAX	Apparent displacement of the position of an object in relation to a reference point, caused by a change in the point of observation.
PASS	Operational portion of an orbital revolution. A suffix D indicates the descending node and a suffix A indicates the as-

	cending node. An additional suffix E indicates that the associated photography was generated for engineering purposes.
PITCH	Rotation of the camera about its transverse axis. Positive pitch indicates nose-up attitude.
PROCESSING LEVEL	Degree of development. Three levels of processing are currently employed: Primary, intermediate, and full.
PRINCIPAL RAY	That ray of light which emanates from a point in object space and passes undeviated through the lens to become imaged at the principal point of the camera system. It is co-incident with the optical axis of the lens.
RESOLUTION	Measure of the smallest array of point objects distinguishable as independent point images, expressed in lines/mm.
ROLL	Rotation of the camera about its longitudinal axis. Positive roll indicates left wing up attitude.
SHADOW FACTOR	A constant for each frame, used to calculate heights from shadow lengths.
SHRINKAGE MARKERS	Calibrated reference points used to calculate deformations of the photographic material.
SOLAR ELEVATION	Vertical angle measured from a plane (tangent to the surface of the earth at the point of intersection of the principal ray) to the sun, the vertex being at the center of the format.
STELLAR CAMERA	Used simultaneously with the index camera to photograph stars in order to determine vehicle attitude.
SYSTEM TIME LABEL	Binary presentation of the accumulative system time.

UNIVERSAL GRID	X, Y coordinate system used to locate images on photographic formats.
VEHICLE AZIMUTH	Clockwise horizontal angle measured from true north to the vehicle 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 the top of the camera.

*Defined differently than in the "Glossary of NPIC Terminology."

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PER	[redacted]	SPECIAL STUDY
1033		None
1034		None
1036		None
1037		None
1038		None
1039		None
1040		None
1041		Slant Range Computations Related to Universal Grid Coordinates for the KH4A Camera System
1042		None
1043		Scan Speed Deviation Analysis of the Forward Camera, Mission 1043
1044		Dual Gamma/Viscose Vs Conventional/Spray Processing Analysis (Mission 1044)
1045		None
1046		SO230 Vs 3404 Evaluation
1101		Slant Range Computations Related to Universal Grid Coordinates for the KH4B Camera System
1102		None
1103		None
1104		SO-180 Evaluation Mission 1104

SYNOPSIS

Mission 1104, a two part satellite reconnaissance mission, was launched at 2137Z on 7 August 1968. The first capsule was recovered dry on revolution 115 at 0004Z on 15 August 1968. The second capsule was recovered dry on revolution 244 at 2230Z on 22 August 1968, terminating the mission.

The best image quality of the fwd-looking camera record is considered to be better than any previous photography from this system. The image quality of the fwd-looking camera record is superior to that of the aft-looking camera record. In addition, the aft-camera imagery, exposed through the SF-05 filter, is of poor quality due to the use of a poor quality filter.

Approximately 80 percent of the mission contains cloud-free photography. The Dual Improved Stellar Index Cameras (DISIC) were operational throughout the mission. However, the binary time word image is intermittently degraded throughout the index camera record. The image quality of the index camera record is good and compares favorably with Mission 1103 index imagery.

PART I. GENERAL SYSTEM INFORMATION

A. Camera Numbers

Forward-Looking Panoramic Camera	309
Aft-Looking Panoramic Camera	308
DISIC Camera	7

B. Launch and Recovery Dates

	Mission 1104-1	Mission 1104-2
Launch	7 Aug 68	*
Recovery	15 Aug 68	22 Aug 68
Recovery Rev	115	244

C. Orbit Elements

Element	Planned	Actual 1104-1 (Rev 57)	Actual 1104-2 (Rev 164)	Photo Range
Period (min)	NA	88.564	88.578	*
Perigee (nm)	NA	83.723	81.084	80.047, 138D
Apogee (nm)	NA	141.581	151.007	129.224, 41D
Eccentricity	NA	0.00789	0.00953	*
Inclination (deg)	NA	82.10	82.11	*
Perigee Latitude	NA	14°15'N	32°17'N	*

NA - Not Available.
* - Not Applicable.

D. Photographic Operations

1. Panoramic Cameras

Type	Mission 1104-1 Revs	Mission 1104-1 Frames	Mission 1104-2 Revs	Mission 1104-2 Frames	Total Revs	Total Frames
Operational						
Fwd	39	2,821	34	2,787	73	5,608
Aft	39	2,814	36	2,853	75	5,667
Operational/Domestic						
Fwd	0	0	0	0	0	0
Aft	0	0	0	0	0	0
Domestic						
Fwd	6	123	6	153	12	276
Aft	7	141	7	180	14	321
Engineering (no imagery)						
Fwd	2	35	2	22	4	57
Aft	2	35	2	23	4	58
Totals						
Fwd	47	2,979	42	2,962	89	5,941
Aft	48	2,990	45	3,056	93	6,046

2. Secondary Cameras

Camera	Frames
Stellar (Mission 1104-1)	2,135 starboard, 2,135 port
Index (Mission 1104-1)	2,122
Stellar (Mission 1104-2)	2,566 starboard, 2,559 port
Index (Mission 1104-2)	2,465

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E. Film Usage

	Film-Load (Total)	Pre-Flight Footage	Processed Footage
Fwd-Looking (Mission 1104-1)	16,000*	**	8,182 of 3404
Aft-Looking (Mission 1104-1)	16,300*	**	8,208 of 3404
Fwd-Looking (Mission 1104-2)	NA	NA	6,999 of 3404 811 of SO-180
Aft-Looking (Mission 1104-2)	NA	NA	8,062 of 3404
Stellar (Mission 1104-1)	2,000*	**	625 of 3401
Stellar (Mission 1104-2)	NA	NA	691 of 3401
Index (Mission 1104-1)	2,000*	**	947 of 3400
Index (Mission 1104-2)	NA	NA	1,035 of 3400

*Total Load For Both Buckets.
** - Not Available.
NA - Not Applicable.

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PART II. IMAGE ANALYSIS

A. Fwd-Looking Panoramic Camera

1. Density: The density of the original negative on Mission 1104 is generally medium.

2. Contrast: In general, the imagery obtained by the fwd-looking camera is of medium contrast.

3. Acuity: The image quality of the fwd-looking camera record is good and better than that obtained on any previous mission of this system. The improvement in image quality can be partly attributed to the initial use of a third generation Petzval lens in the fwd-looking unit. The best ground resolution read from a mobile CORN target was four feet three point eight inches in the flight direction.

4. Imaged Degradations:

a. Light Leaks:

(1) Fog patterns are present on the seventh-from-last frame of most camera operations of Mission 1104-1 only. The patterns vary in density from thin to very heavy, commensurate with camera sit periods, and in some instances obscure imagery. This fog is attributed to a light leak in the vicinity of the Mission 1104-1 recovery system cover. (Graphic 1, page 9)

(2) On Mission 1104-2, fog is present on the second-from-last frame of some camera operations. Degradation to the imagery is minor. This fog is the result of an apparent light leak in the main barrel structure. (Graphic 2, page 9)

b. Static:

(1) Minor corona-type fog patterns are present near the take-up end of the first frame of most camera operations of Mission 1104-1 and on the first frame of a few camera operations of Mission 1104-2. In a few instances, many frames of an operation are affected.

(2) Another corona-type fog pattern is present on pass 169D, beginning on frame 24 and ending prior to the last two frames. This fog pattern has the appearance of pencil marks that run through the center of the format along the major axis of the material and branch out with extremely long, faint, plus density arms.

(3) Edge static is present along both film edges intermittently throughout the mission.

(4) Degradation to the imagery, resulting from the corona fogging and edge static mentioned above, is minor.

c. Other:

(1) The lens stowed in the center of the format at the end of pass A103E. As a result, only one-half of the last frame of pass A103E was exposed during this camera operation, while the remainder

of the frame was exposed at the start of operation on pass 103D.

(2) The level of performance of the fwd-looking lens (third generation) was sufficiently high to occasionally detect cross-track smear in the imagery. The most obvious example is the CORN display on pass 16D where bar target readings indicate five feet along track and eight feet across track.

5. Physical Degradation: None noted.

6. Product Quality: The overall quality of the fwd-looking camera record is good.

B. Aft-Looking Panoramic Camera

1. Density: Same as reported for the fwd-looking camera.

2. Contrast: Same as reported for the fwd-looking camera.

3. Acuity:

a. The best imagery of the aft-looking camera record is good but not equivalent to that of the fwd camera record.

b. Aft camera acquisitions exposed through the SF-05 filter are of poor quality. The imagery is severely degraded and of limited use for interpretation. This poor quality is attributed to imperfections in the filter and is not inherent in normal bicolor acquisitions. These filter imperfections were discovered prior to launch. Therefore, its use was limited to five camera operations.

4. Imaged Degradations:

a. Light Leaks: Fog patterns are present on the sixth-to-last frame of most camera operations of Mission 1104-1 only. The patterns vary in density from light to very heavy, commensurate with camera sit periods, and in some instances obscure imagery. This fog is attributed to a light leak in the vicinity of the Mission 1104-1 recovery system cover. (Graphic 3, page 9)

b. Static: Corona-type fog patterns are present near the take up end of the first frame of a few camera operations. Degradation to the imagery is minor.

c. Other: In many operations, the aft-camera performance was sufficient to identify cross track smear. In such instances, it was observed that the cross track smear recorded in the aft photography was less than that in the forward. This relationship is directly related to the shorter exposure time of the aft camera.

5. Physical Degradation: None noted.

6. Product Quality: The overall quality of the aft-looking camera record is good.

C. Stellar Camera

1. Density: The density of the material from both port and starboard stellar cameras is generally medium. However, the first port and star-

board frame of each camera operation are of heavy density and preclude the detection of stellar images. This anomaly is a system characteristic and will probably appear in future systems.

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

3. Image Shape: The stellar images generally appear as point type images.

4. Image per Frame: A total of 25 to 80 stellar images can be detected in both the port-and starboard-looking stellar camera records. The stellar field at which the cameras were looking contained Taurus and Orion.

5. Flare Level: Approximately ten percent of each port and starboard frame is affected by flare.

6. Imaged Degradations:

a. Light Leaks: Fog, in the form of equipment shadow graphs, is present on the 6th, 7th, and 8th frame before each port camera on. Associated with this fog is a plus density streak approximately 0.25 inch long and 0.1 inch wide near the center of the format of the second frame before most port camera ons. These fog patterns vary in density from thin to very heavy, commensurate with camera sit periods, and in some instances obscure imagery. The most likely cause of this anomaly appears to be a light leak through the "patio pin" hole. This hole is plugged by a screw prior to flight.

b. Static: Dendritic and corona-type fog patterns are present on the stellar camera record. In some instances, these fog patterns enter the format area. However, degradation to the imagery is minor.

c. Other:

(1) Characteristic pressure-induced fog patterns are present in the border area on both film edges throughout the mission.

(2) Both port and starboard camera frames contain repeated patterns of minus density spots which appear to be caused by dirt on the reseau plate. Degradation to the imagery is minor.

7. Physical Degradations: None noted.

8. Product Quality: The overall quality of the stellar record is good and adequate for attitude determination.

E. Index Camera

1. Density: The density of the index camera record is generally heavy.

2. Contrast: The contrast of the index camera record is generally medium.

3. Acuity: The image quality of the index camera record is good and compares favorably with Mission 1103 index imagery.

4. Imaged Degradations:

a. Light Leaks: None noted.

b. Static: Dendritic and corona-type fog patterns are present occasionally throughout the index camera record, primarily toward

the end of Mission 1104-2. In some instances, these static markings are present near center format. Degradation to the imagery is minor.

c. Other: Characteristic pressure-induced fog patterns are present in the border area on both film edges throughout the mission. All index camera frames contain repeated patterns of minus density spots, which appear to be caused by dirt on the reseau. Degradation to the imagery is minor.

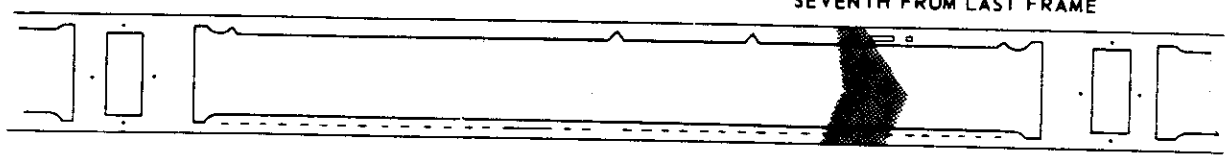
5. Physical Degradations: None noted.

6. Product Quality: The overall quality of the index camera record is good and adequate for attitude determination.

E. Graphic Display

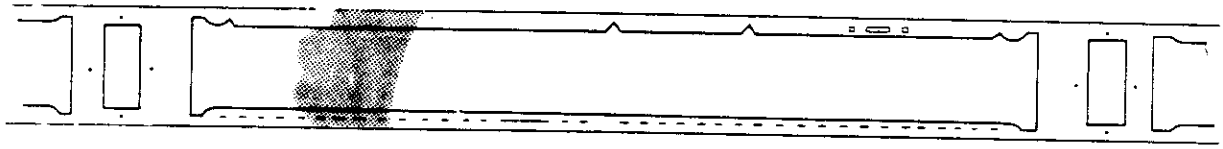
The patterns illustrated below are referenced in the text of this report.

Graphic 1



Graphic 2

Graphic 3



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PART III. IMAGED AUXILIARY DATA

A. Fwd-Looking Panoramic Camera

1. Horizon Cameras
   a. Starboard-looking:
      (1) Imagery: Imaged properly. However, the starboard horizon shutter failed to close during film transport on frame 66, pass 74D and frame 29, pass 155D. The result is heavy fogging of two pan camera frames for each occurrence.
      (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. Nodal Traces: Sharp and well defined.
7. Nod Indicators: Sharp and well defined. Mission 1104 is the first mission to have the nod indicators imaged.

B. Aft-Looking Panoramic Camera

1. Horizon Cameras
   a. Starboard-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. Nodal Traces: Sharp and well defined.
7. Nod Indicators: Sharp and well defined. Mission 1104 is the first mission to have nod indicators imaged.

C. Stellar Camera

1. Grid Image Quality: Sharp and well defined.
2. Binary Time Word: Imaged properly for the system. Automatic reduction of the time word was accomplished without problems.
3. Lens Serial Number Legibility: Good.

D. Index Camera

1. Grid Image Quality: Sharp and well defined.
2. Binary Time Word: The index time word image varies in density

from normal to nonexistent and in most cases is difficult to read visually. This anomaly was caused by an intermittent and improper seating of the data block head during exposure, which probably resulted from a variation in the data block cable position. Data provided on the stellar record were machine readable throughout the mission. Since index data are redundant to stellar data, no stellar/terrain set is missing time data.

4. Camera Number Legibility: Good.

PART IV. MENSURATION QUALITY

A. Fwd-Looking Panoramic Camera: There were 93 requests for mensuration on this mission. No problems were encountered. The image quality is considered to be good for mensuration purposes.

B. Aft-Looking Panoramic Camera: Same as above.

PART V. FILM PROCESSING

A. Processing Machines and Process Gamma

Film	Part: Machine	Entire Mission Gamma	Film Type
Fwd (Mission 1104-1)	Yardleigh	1.70	3404
Aft (Mission 1104-1)	Yardleigh	1.69	3404
Fwd (Mission 1104-2)	Yardleigh	1.76	3404
	Grafton	NA	SO-180
Aft (Mission 1104-2)	Yardleigh	1.83	3404
Stellar (Mission 1104-1)	Trenton	2.10	3401
Stellar (Mission 1104-2)	Trenton	2.10	3401
Index (Mission 1104-1)	Drape	1.52	3400
Index (Mission 1104-2)	Drape	1.66	3400

NA - Not Available.

B. Processing Levels

1. Panoramic Cameras

The black and white portions of both panoramic camera records were processed using the dual gamma process which uses a modified Yardleigh processor to provide single level viscous development.

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. Fwd-Looking Camera

a. Capsule De-Filming:

(1) Mission 1104-1: Received at the processing site, from the West Coast, in suitcases.

(2) Mission 1104-2: No problems encountered.

b. Pre-Processing Inspection: No problems encountered.

c. Manufacturing Splices:

(1) Mission 1104-1: Frame 99, pass 39D; frame 93, pass 58D, frame 51, pass 74D; frame 29, pass 102D.

(2) Mission 1104-2: Frame 83, pass 106D; frame 222, pass 121D; frame 34, pass 145D; frame 8, pass 169D. The fwd-camera material contained a pre-exposed, pre-processed indicator strip (approximately three feet in length) to indicate the film type

change from 3404 to SO-180. Part of frame 18, all of frame 19, and a small segment of frame 20 of pass 199D were exposed on this non-sensitive strip and lost. A blank piece of film was inserted for frame 19 and titled accordingly.

d. Processing Splices: None other than normal.
e. Manufacturing Defects: None noted.
f. Processing Anomalies: None.
g. Breakdown: No problems encountered.

2. Aft-Looking Camera
   a. Capsule De-Filming:
      (1) Mission 1104-1: Received at the processing site, from the West Coast, in suitcases.
      (2) Mission 1104-2: No problems encountered.
   b. Pre-Processing Inspection: No problems encountered.
   c. Manufacturing Splices:
      (1) Mission 1104-1: Frame 17, pass 52D.
      (2) Mission 1104-2: Frame 24, pass 106D; frame 115, pass 169D.
   d. Processing Splices: None other than normal.
   e. Manufacturing Defects: None noted.
   f. Processing Anomalies: None.
   g. Breakdown: No problems encountered.
3. Index Camera
   a. Capsule De-Filming:
      (1) Mission 1104-1: Received at the processing site, from the West Coast, in suitcases.
      (2) Mission 1104-2: No problems encountered.
   b. Pre-Processing Inspection: No problems encountered.
   c. Manufacturing Splices: None.
   d. Processing Splices: None.
   e. Manufacturing Defects: None noted.
   f. Processing Anomalies: None.
   g. Breakdown: No problems encountered.
4. Stellar Cameras:
   a. Capsule De-Filming:
      (1) Mission 1104-1: Received at the processing site, from the West Coast, in suitcases.
      (2) Mission 1104-2: No problems encountered.
   b. Pre-Processing Inspection: No problems encountered.
   c. Manufacturing Splices: None.
   d. Processing Splices: None other than normal.
   e. Manufacturing Defects: None noted.
   f. Processing Anomalies: None.
   g. Breakdown: No problems encountered.

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D. Timetable

Film	Recovered	Received at Processing Site	Priority 1A at NPIC Recd
Fwd (Mission 1104-1)	15 Aug 68/0004Z	NA	18 Aug 68/1356 local time
Aft (Mission 1104-1)	"	"	"
Stellar (Mission 1104-1)	"	"	"
Index (Mission 1104-1)	"	"	"
Fwd (Mission 1104-2)	22 Aug 68/2230Z	"	26 Aug 68/0713 local time
Aft (Mission 1104-2)	"	"	"
Stellar (Mission 1104-2)	"	"	"
Index (Mission 1104-2)	"	"	"

NA - Not Available.
No Special Shipment Received at NPIC.

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PART VI. PI SUITABILITY

A. Definition of Photographic Interpretation (PI) Suitability

The PI suitability is an assessment of the information content of photographic reconnaissance material and its interpretability. A number of interrelated factors are involved, such as the quality of the photography, the extent of target coverage, scale, and weather limitations. However, the fundamental criteria for assigning a PI suitability rating may be reduced to (a) the scope of the photographic coverage and (b) the degree to which a photographic interpreter may extract useful and reliable information from the material.

PI suitability ratings are categorized as Excellent, Good, Fair, Poor, and Unuseable. These ratings refer to the overall interpretive value of the photography obtained from a particular reconnaissance mission. Individual targets may also be assigned PI suitability ratings. The standards that determine assignment of the various ratings are:

Excellent: The photography is free of degradations by camera malfunctions or processing faults and the weather conditions are favorable throughout. The imagery contains sharp, well-defined edges and corners with no unusual distortions. Contrast is optimum and shadow details, as well as details in the highlight areas, are readily detectable. Observation of small objects and a high order of mensuration are made possible by the consistently good quality of the photography.

Good: The photography is relatively free of degradation or limiting atmospheric conditions. Edges and corners are well defined. No unusual distortions are present. Detection and accurate mensuration of small objects are feasible, but to a lesser degree than in material rated as "Excellent."

Fair: Degradation is present and the acuity of the photography is less than optimum. Edges and corners are not crisply defined and there is loss of detail in shadow and/or highlight areas. Detection and identification of small objects are possible, but accuracy of mensuration is reduced by the fall-off in image quality and the less-than-optimum contrast that prevails.

Poor: Camera-induced degradations and/or weather limitations severely reduce the effectiveness of the photography. Definition of edges and corners is not sharp. Only gross terrain features and culture may be detected or identified and distortion of form may exist. Accurate mensuration of even large objects is doubtful.

Unuseable: Degradation of photography completely precludes detection, identification, and mensuration of cultural details.

B. PI Statistics

1. Target Coverage

	Mission 1104-1	Mission 1104-2	Totals
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	88	88	168

2. PI Quality Appraisal

Rating	Missiles	Nuclear Energy	Air Facilities	Ports	Elect Commo	Military Activity	Complex	Bio/Chem Warfare
Good	17	1	7	11	1	0	3	0
Fair	72	8	13	2	0	10	5	1
Poor	38	4	11	6	0	7	7	0
Totals*	127	13	31	19	1	17	15	1

3. Summary of PI Quality Ratings

Good 40 or 17.9%
Fair 111 or 49.5%
Poor 73 or 32.6%

*A discrepancy exists between the total number of targets covered and the total PI reports because some targets are covered more repeatedly.

C. PI Comments

1. Atmospherics Attenuation: Listed below is the photo interpreter's report of weather conditions for priority 1 targets covered on this mission.

a.	Clear	125 or 55.8 percent
b.	Scattered Clouds	50 or 22.3 percent
c.	Heavy Clouds	23 or 10.3 percent
d.	Haze	25 or 11.2 percent
e.	Cloud Shadow	1 or 0.4 percent

2. Terrain Conditions: The terrain conditions were considered good for interpretation purposes.

3. Product Interpretability: The photo interpretability of Mission 1104 is generally good with the best of the forward camera record being rated very good. The best of the aft camera photography is also good but not equivalent to that of the forward. The aft camera imagery, exposed through the SF-05 filter, is of poor quality. In addition, the overall cloud cover estimate of 20 percent fails to reflect the percentage of cloud cover or degrading atmospherics in the prime target areas. There is generally a high incidence of cloud cover in the areas of intelligence interest.

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PART VII. RESOLUTION TARGET DATA

Target Designator	A		B
Camera (Looking)	Fwd	Aft	Aft
Pass	14D	14D	16D
Frame	6	12	6
Date of Photography	8 Aug 68	8 Aug 68	8 Aug 68
Universal Grid Coordinates	36.4-1.3	39.0-4.4	43.1-2.2
Geographic Coordinates of Format Center	41-34N 74-02W	41-34N 74-07W	34-50N 117-38W
Altitude (ft)	567,220	564,897	546,381
Camera			
Pitch (deg)	14°48'	-15°36'	-15°43'
Roll (deg)	-0°10'	-0°12'	-0°13'
Yaw (deg)	-1°59'	-2°4'	-2°21'
Local Sun Time	1320	1320	1324
Solar Elevation (deg)	58°49'	58°51'	62°39'
Solar Azimuth (deg)	140	140	130
Exposure (sec)	1/371	1/492	1/367
Processing Level	Dual Gamma	Dual Gamma	Dual Gamma
Vehicle Azimuth (deg)	171°58'	172°8'	173°18'
Filter (Wratten)	W/25	W/21	SF05
Target Type	51/51 T-Bar	51/51 T-Bar	B2
Target Contrast	5:1	5:1	25:1
Weather Conditions	Clear	Clear	Clear

GROUND RESOLUTION IN FEET AS DETERMINED FROM THE ORIGINAL NEGATIVE

	A				B		
	Along Track		Across Track			Along Track	Across Track
	Fwd	Aft	Fwd	Aft		Aft	Aft
Observer 1	7'1.5"	8'	12'	8'	Observer 1	8'11.6"	10'1"
Observer 2	7'1.5"	7'1.5"	7'1.5"	8'	Observer 2	8'11.6"	8'11.6"
Observer 3	7'1.5"	7'1.5"	7'1.5"	8'	Observer 3	8'11.6"	10'1"

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Target Designator	C		D	
Camera (Looking)	Fwd	Aft	Fwd	Aft
Pass	16D	16D	129D	129D
Frame	6	12	10	16
Date of Photography	8 Aug 68	8 Aug 68	15 Aug 68	15 Aug 68
Universal Grid Coordinates	44.5-3.1	30.8-2.6	50.9-3.5	24.5-1.7
Geographic Coordinates of Format Center	34-02N 117-26W	34-02N 117-31W	36-38N 115-49W	36-38N 115-54W
Altitude (ft)	546,390	544,516	495,733	495,988
Camera				
Pitch (deg)	14°41'	-15°45'	15°0'	-15°24'
Roll (deg)	-0°9'	-0°11'	-0°1'	-0°3'
Yaw (deg)	-2°10'	-2°14'	-2°6'	-2°10'
Local Sun Time	1325	1325	1223	1223
Solar Elevation (deg)	62°58'	63°0'	66°44'	66°45'
Solar Azimuth (deg)	130	130	167	167
Exposure (sec)	1/387	1/367	1/422	1/400
Processing Level	Dual Gamma	Dual Gamma	Dual Gamma	Dual Gamma
Vehicle Azimuth (deg)	173°18'	173°25'	172°53'	173°0'
Filter (Wratten)	W/25	SF05	W/25	SF05
Target Type	51/51 T-Bar	51/51 T-Bar	B	B
Target Contrast	5:1	5:1	8.8:1	8.8:1
Weather Conditions	Clear	Clear	Clear	Clear

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GROUND RESOLUTION IN FEET AS DETERMINED FROM THE ORIGINAL NEGATIVE

	C				D				
	Along Track		Across Track			Along Track		Across Track	
	Fwd	Aft	Fwd	Aft		Fwd	Aft	Fwd	Aft
Observer 1	6'4.2"	--	10'1"	--	Observer 1	6'1"	--	8'7.3"	--
Observer 2	6'4.2"	--	10'1"	11'3.6"	Observer 2	5'5"	--	8'7.3"	--
Observer 3	6'4.2"	--	10'1"	11'3.6"	Observer 3	6'1"	--	8'7.3"	--

--No Reading Possible.

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Target Designator	E		F	
Camera (Looking)	Fwd	Aft	Fwd	Aft
Pass	129D	129D	129D	129D
Frame	12	18	13	19
Date of Photography	15 Aug 68	15 Aug 68	15 Aug 68	15 Aug 68
Universal Grid Coordinates	30.5-0.1	44.9-5.2	30.3-5.2	44.7-0.2
Geographic Coordinates of Format Center	36-24N 115-47W	36-23N 115-51W	36-17N 115-46W	36-16N 115-50W
Altitude (ft)	496,482	495,751	496,358	495,633
Camera				
Pitch (deg)	15°0'	-15°24'	15°0'	-15°24'
Roll (deg)	-0°1'	-0°3'	-0°1'	-0°2'
Yaw (deg)	-2°5'	-2°11'	-2°4'	-2°11'
Local Sun Time	1223	1223	1223	1223
Solar Elevation (deg)	66°57'	66°58'	67°4'	67°5'
Solar Azimuth (deg)	167	167	167	167
Exposure (sec)	1/422	1/400	1/422	1/400
Processing Level	Dual Gamma	Dual Gamma	Dual Gamma	Dual Gamma
Vehicle Azimuth (deg)	172°56'	173°3'	172°57'	173°4'
Filter (Wratten)	W/25	SF05	W/25	SF05
Target Type	C	C	C	C
Target Contrast	9.7:1	9.7:1	9.7:1	9.7:1
Weather Conditions	Clear	Clear	Clear	Clear

GROUND RESOLUTION IN FEET AS DETERMINED FROM THE ORIGINAL NEGATIVE

	E					F			
	Along Track		Across Track			Along Track		Across Track	
	Fwd	Aft	Fwd	Aft		Fwd	Aft	Fwd	Aft
Observer 1	6'10"	--	6'10"	12'2.3"	Observer 1	4'3.8"	12'2.3"	5'5"	10'10.3"
Observer 2	6'1"	--	6'1"	12'2.3"	Observer 2	4'3.8"	12'2.3"	6'10"	10'10.3"
Observer 3	7'8"	--	6'10"	12'2.3"	Observer 3	4'3.8"	12'2.3"	4'10"	10'10.3"

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Target Designator	G Fwd	Aft
Camera (Looking)		
Pass	145D	145D
Frame	32	38
Date of Photography	16 Aug 68	16 Aug 68
Universal Grid Coordinates	30.1-1.7	45.1-3.6
Geographic Coordinates of Format Center	33-29N 111-47W	33-28N 111-52W
Altitude (ft)	498,617	498,485
Camera		
Pitch (deg)	14°59'	-15°25'
Roll (deg)	0°5'	0°2'
Yaw (deg)	-2°16'	-2°21'
Local Sun Time	1218	1218
Solar Elevation (deg)	69°48'	69°50'
Solar Azimuth (deg)	166	166
Exposure (sec)	1/421	1/556
Processing Level	Dual Gamma	Dual Gamma
Vehicle Azimuth (deg)	173°23'	173°29'
Filter (Wratten)	W/25	W/21
Target Type	51/51 T-Bar	51/51 T-Bar
Target Contrast	5:1	5:1
Weather Conditions	Clear	Clear

GROUND RESOLUTION IN FEET AS DETERMINED FROM THE ORIGINAL NEGATIVE

	G Along Track		Across Track	
	Fwd	Aft	Fwd	Aft
Observer 1	8'	7'1.5"	12'	12'
Observer 2	8'	7'1.5"	7'1.5"	7'1.5"
Observer 3	8'	7'1.5"	7'1.5"	7'1.5"

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PART IX. ENGINEERING EXPERIMENTS

A. Mission 1104 Experiments: All proposed engineering experiments on Mission 1104 were accomplished as scheduled. However, the bicolor experiment was somewhat limited due to a poor quality SF-05 filter. A description of each experiment is presented below.

1. "Bi-spectral Test": A combination of a Wratten 25 (red filter) and a SF05 (green filter) was used on five passes to obtain conjugate imagery suitable for bicolor presentation.

2. SO-180 Film Type Test: Eight hundred feet of color infrared film (SO-180) was placed at the tail of the fwd-looking camera record.

B. Analysis of Experiments:

1. A detailed analysis on the bi-spectral test performed on Mission 1104 will be included as a special study in a future PER.

2. A detailed report on the Mission 1104, SO-180 Film Type Test is included as a special study in this PER.

C. Scheduled Future Experiments

Mission 1105 Tentative Experiments	SO-121	High Resolution Color Film
Mission 1106 & 1107	Polorizer Through Focus	Winter, Proper Azimuths Stepped Glass Filter

FIGURE 1. BEST IMAGE QUALITY
Image quality comparable to the best of this mission.

FIGURE 2. CORRESPONDING COVERAGE
Corresponding coverage as imaged by the aft-looking camera.

[redacted]

	FIGURE 1	FIGURE 2
Camera	309	308
Pass	16D	16D
Frame	6	12
Date of Photography (GMT)	8 Aug 68	8 Aug 68
Universal Grid Coordinates	33.1-4.1	42.1-1.6
Enlargement Factor	20X	20X
Geographic Coordinates	34-02N 117-26W	34-02N 117-31W
Altitude (ft)	546,390	544,516
Camera Attitude:		
Pitch (deg)	14°41'	-15°45'
Roll (deg)	-0°9'	-0°11'
Yaw (deg)	-2°10'	-2°14'
Local Sun Time	1325	1325
Solar Elevation (deg)	62°58'	63°0'
Solar Azimuth (deg)	130°	130°
Exposure (sec)	1/387	1/367
Vehicle Azimuth (deg)	173°18'	173°25'
Processing Level	Dual Gamma	Dual Gamma

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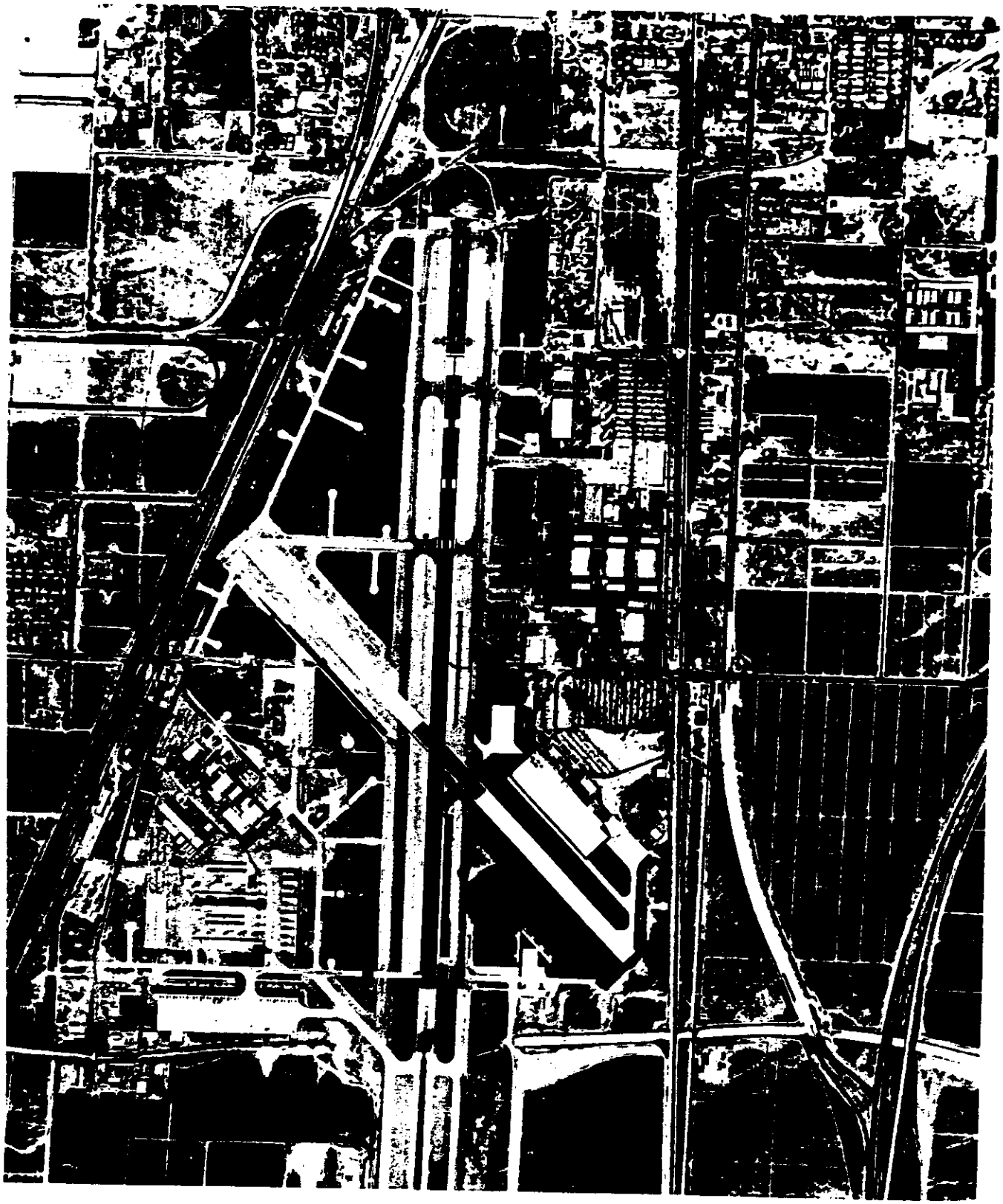

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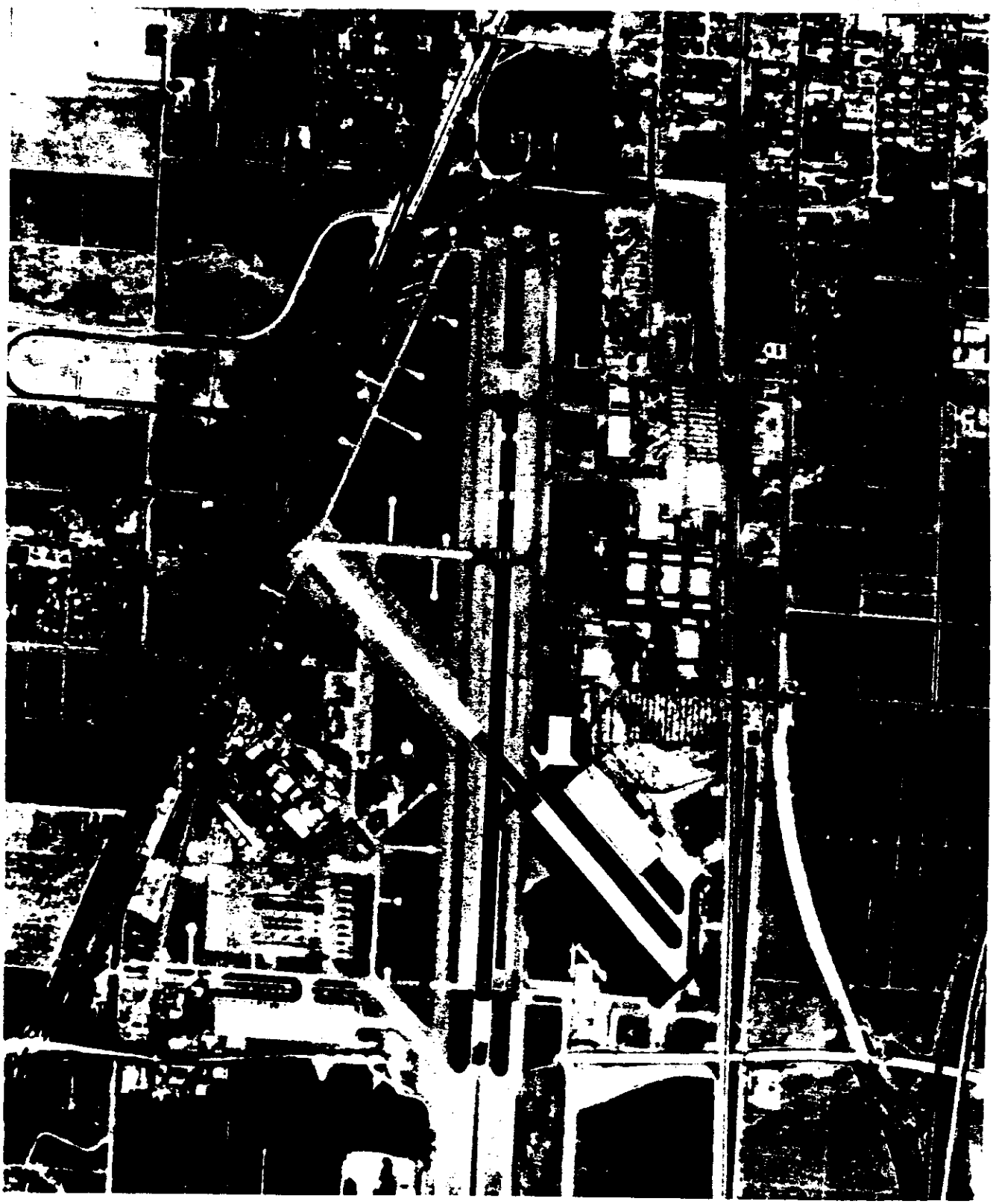

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FIGURE 3. STELLAR FORMAT (MISSION 1104-1)

FIGURE 4. STELLAR FORMAT (MISSION 1104-2)

	FIGURE 3	FIGURE 4
Mission Number	1104-1	1104-2
Pass	70	105
Frames	23P, 29S, 24P	22P, 28S, 23P
Date of Photography	12 Aug 68	12 Aug 68
Enlargement Factor	2.5	2.5
Exposure (sec)	1.5	1.5

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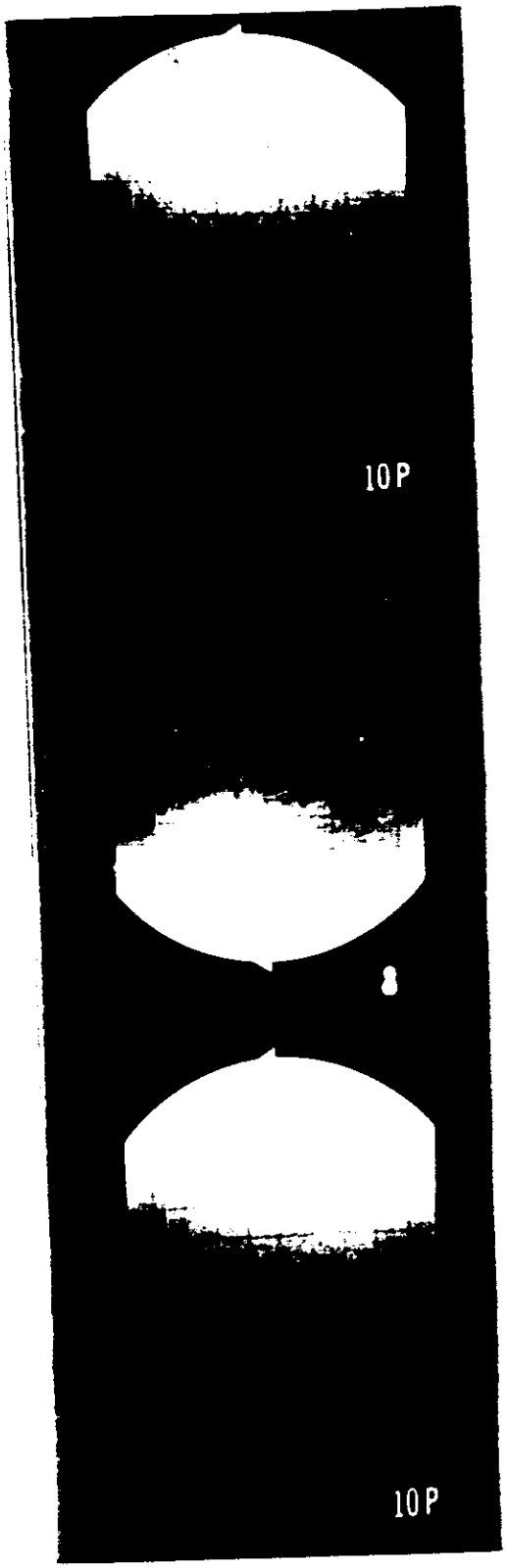

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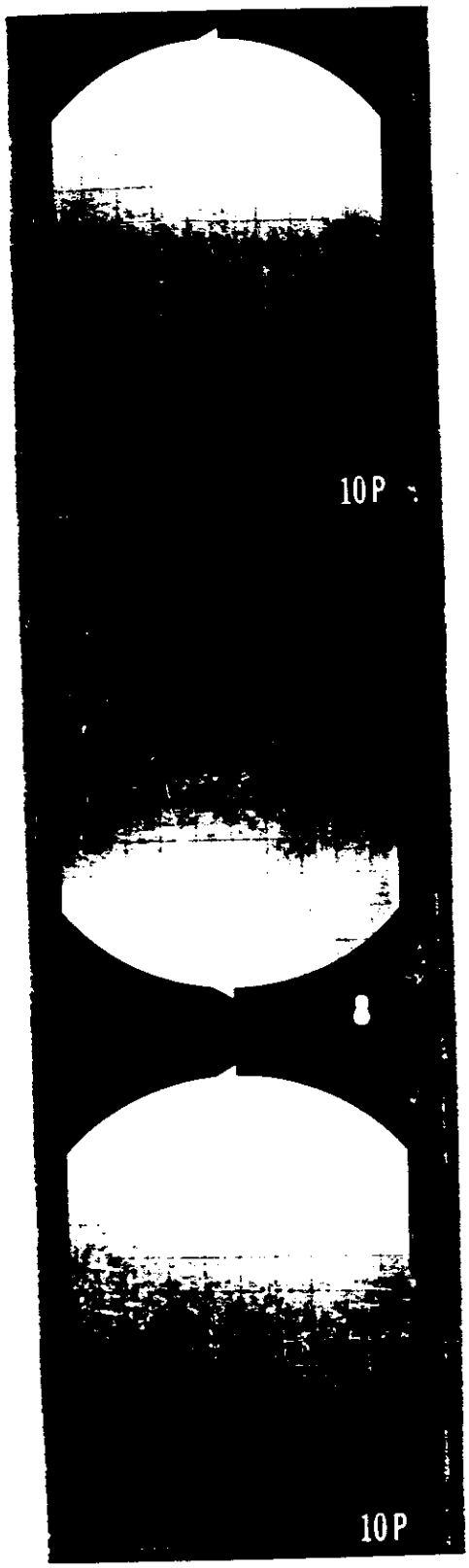

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SPECIAL STUDY

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SO-180 Evaluation

Mission 1104

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I INTRODUCTION

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SO-180 EVALUATION

MISSION 1104

I. INTRODUCTION

Extrachrome infrared color film (SO-180) was used in an engineering test at orbital altitudes for the first time during Mission 1104-2. This report presents a comprehensive analysis of the test with regard to the film's characteristics, image quality, and its potential from a technical standpoint.

A. Test Description:

The last 800 feet (301 frames) of the fwd-looking camera film record was SO-180 Ektachrome infrared color film. The SO-180 film was spliced to the end of type 3404 black and white material. It was exposed during acquisitions 20 through 28 of pass 199D, all of passes 200D, 201D, 203D, 210D, 211D, 220D, and frames 1 through 31 of pass 236D. Duplicate area coverage was provided by the aft-looking camera black and white record. Because of the increase in film thickness of SO-180 compared to 3404, (the base thickness of SO-180 is 5.2 mils compared to 2.5 mils for 3404) photographic coverage during passes 215D and 217D was obtained by the aft camera only.

Prior to processing, the time-track edge of the color film was flashed with filtered light to decrease the density along the film edge. This allowed the standard edge titling technique to be used while retaining the auxiliary data. The color film was processed in the Grafton machine without incident. Reproductions of the original were made on SO-271 duplicate color stock and disseminated to customers according to standard requirements.

B. Characteristics of SO-180

SO-180 film is an infrared sensitive, false color, reversal color material. The spectral sensitivity, contrast, and dye composition are designed for detection of reflected infrared radiations, such as from live vegetation. The film will generally differentiate between green painted objects and live green plant life: This it is used for camouflage detection or assessment of crop vigor, and so forth. The following is a cross-sectional design of the film:

Infrared Sensitive Layer - Cyan Positive Image
Green Sensitive Layer - Yellow Positive Image
Red Sensitive Layer - Magenta Positive Image
Base

Note: All photographic emulsions are sensitive to blue radiation which necessitates the use of techniques to control this sensitivity. A yellow filter normally included in reversal color films, to filter out unwanted blue light, is not included in SO-180 film; however, compensation is made by using a yellow filter in the camera lens optical path.

C. System/Film Compatability

The engineering test proved the compatability of SO-180 film with this camera system. However, the increased sensitivity of SO-180 compared to 3404 film causes it to be more susceptible to extraneous light. Because of the prevailing environment at orbital altitudes, corona static will occur during camera operations unless the pressure is maintained at a proper level. To create the needed pressure, a pressure make-up (PMU) unit is used within the orbiting vehicle. During this mission, the regulator on the PMU system malfunctioned. As a result, corona static occurred, causing extensive fogging. The degradation to the color material is severe and is described in detail in PART II of this report.

This test proved not only that SO-180 film is compatable with this camera system but also that the film (in this quantity) can be processed, reproduced, and disseminated on a priority basis. The knowledge made possible from this engineering test can be applied to the state-of-the art in planning for present and future systems.

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II FILM
DEGRADATIONS

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II. FILM DEGRADATIONS

A. Physical Degradations

Longitudinal base and emulsion scratches are present intermittently throughout the SO-180 material. These scratches are slightly more pronounced than those present on the 3404 film; however, little degradation results. Emulsion lifts are prominent along the titled edge of the film and, at times, are present in the format. Splices and associated handling marks are located within frame 66, pass 203D, and frame 4, pass 210D.

B. Imaged Degradations

The faster speed of SO-180 as compared to 3404 makes it more susceptible to fog in association with extraneous light. Therefore, fog patterns associated with camera-off periods are more pronounced on the SO-180 film than on the 3404 film.

The most pronounced degradation to the SO-180 is a red cast of fog of varying saturation, attributed to corona static. This fog is of definite concern in that it adds to the already existing problems in interpreting the imaged information. Warm colors are exaggerated by the fog whereas the saturation of cold colors is reduced. The tonal range and the degree of hue separation is especially limited in the more severely affected areas.

The entire SO-180 record was viewed frame-by-frame to determine the quantity of degradation caused by corona static. All frame formats and their respective percentage of fog degradation are listed in the following table. The percentage figures represent subjective estimates and should be used accordingly. The "E" in the percent column refers to the area outside the format and simply infers that fog is also present in that area.

Pass	Frame	Corona Fog (Percent)
199	20	75E
	21	75E
	22	65E
	23	60E
	24	25E
	25	10
	26	7E
	27	3
	28	3
200	1	0
	2	2
	3	2
	4	10
	5	5
	6	5
	7	E
	8	E
	9	E
	10	E
	11	E
	12	E
	13	E
	14	E
	15	E
	16	E
	17	E
	18	E
	19	E
	20	E
	21	E
	22	E
	23	5
	24	2
	25	1
	26	15
	27	10
	28	10
	29	E
	30	E
	31	E
	32	E
	33	E
	34	E

Pass	Frame	Corona Fog (Percent)
	35	E
	36	E
	37	E
	38	E
	39	E
	40	E
	41	E
201	1	E
	2	5
	3	2
	4	10
	5	15
	6	10
	7	10
	8	5
	9	5
	10-41	0
	42	10
	43	10
	44	10
	45	5
	46	5
	47	30
	48	30
	49	30
	50	25
	51	20
	52	15
	53	10
	54	5
	55	5
	56	5
	57	10
	58	10
	59	5
	60	10
	61	15
	62	15
	63	15
	64	10
	65	15
	66	10
	67	5

Pass	Frame	Corona Fog (Percent)	Pass	Frame	Corona Fog (Percent)
	68	5		40	0
	69	5		41	3
	70	0		42	3
	71	0		43	30
203	1	E		44	30
	2	7		45	25
	3	2		46	15
	4	7		47	15
	5	10		48	12
	6	10E		49-63	10
	7	5E		64	5
	8	5E		65	10
	9	5E		66	5
	10	5E		67	10
	11	5E		68	10
	12	7E		69	15
	13	5E	210	1	5E
	14	2E		2	15E
	15	2E		3	2
	16	2E		4	5E
	17	2E		5	5
	18	5E		6	25E
	19	2E		7	30E
	20	2E		8	35E
	21	5E		9	35E
	22	E		10	55E
	23	E		11	55E
	24	E		12	60E
	25	E		13	60E
	26	E		14	50E
	27	E		15	50E
	28	E		16	50E
	29	E		17	50E
	30	E		18	45E
	31	E		19	45E
	32	E		20	60E
	33	E		21	50E
	34	E		22	60E
	35	10E		23	60E
	36	E		24	60E
	37	15		25	70E
	38	5	211	1	50E
	39	0		2	50E

Pass	Frame	Corona Fog (Percent)	Pass	Frame	Corona Fog (Percent)
	3	50		38	60E
	4	70E		39	60E
	5	45E		40	E
	6	30E	236	1	60E
	7	20E		2	20
	8	25E		3	C
	9-16	10E		4	0
	17	10		5	5
	18	2		6	5
	19	2		7	20
	20	0		8	20
220	1	0		9	30
	2	2		10	40
	3	0		11	50
	4	5		12	70E
	5	15		13	60E
	6	20		14	70E
	7	20		15	75E
	8	20		16	60E
	9	25		17	60E
	10	30		18	50E
	11	40E		19	55E
	12	45E		20	70E
	13	65E		21	60E
	14	70E		22	60E
	15	80E		23	90E
	16	90E		24	85E
	17	85E		25	85E
	18	90E		26	70E
	19	70E		27	70E
	20	80E		28	85E
	21-35	85E		29	90E
	36	80E		30	65
	37	70E		31	75

FIGURE 1a. EFFECT OF CORONA STATIC ON SO-180

The following is a representative sample of an area which is severely affected by corona static. Interpretation is extremely difficult because of decreased tonal separation and the overall red cast of fog. The information recorded in the infrared sensitive layer is contaminated by the fog.

FIGURE 1a

Camera	Fwd
Pass	199D
Frame	21
Date of Photography (GMT)	20 Aug 68
Universal Grid Coordinates	61.6-1.1
Enlargement Factor	10X
Geographic Coordinates	40-07N 123-40E
Altitude (ft)	499,488
Camera Attitude:	
Pitch (deg)	15°04'
Roll (deg)	0°04'
Yaw (deg)	-2°04'
Local Sun Time	1146
Solar Elevation (deg)	62°39'
Solar Azimuth (deg)	173°20'
Exposure (sec)	1/426
Vehicle Azimuth (deg)	172°16'

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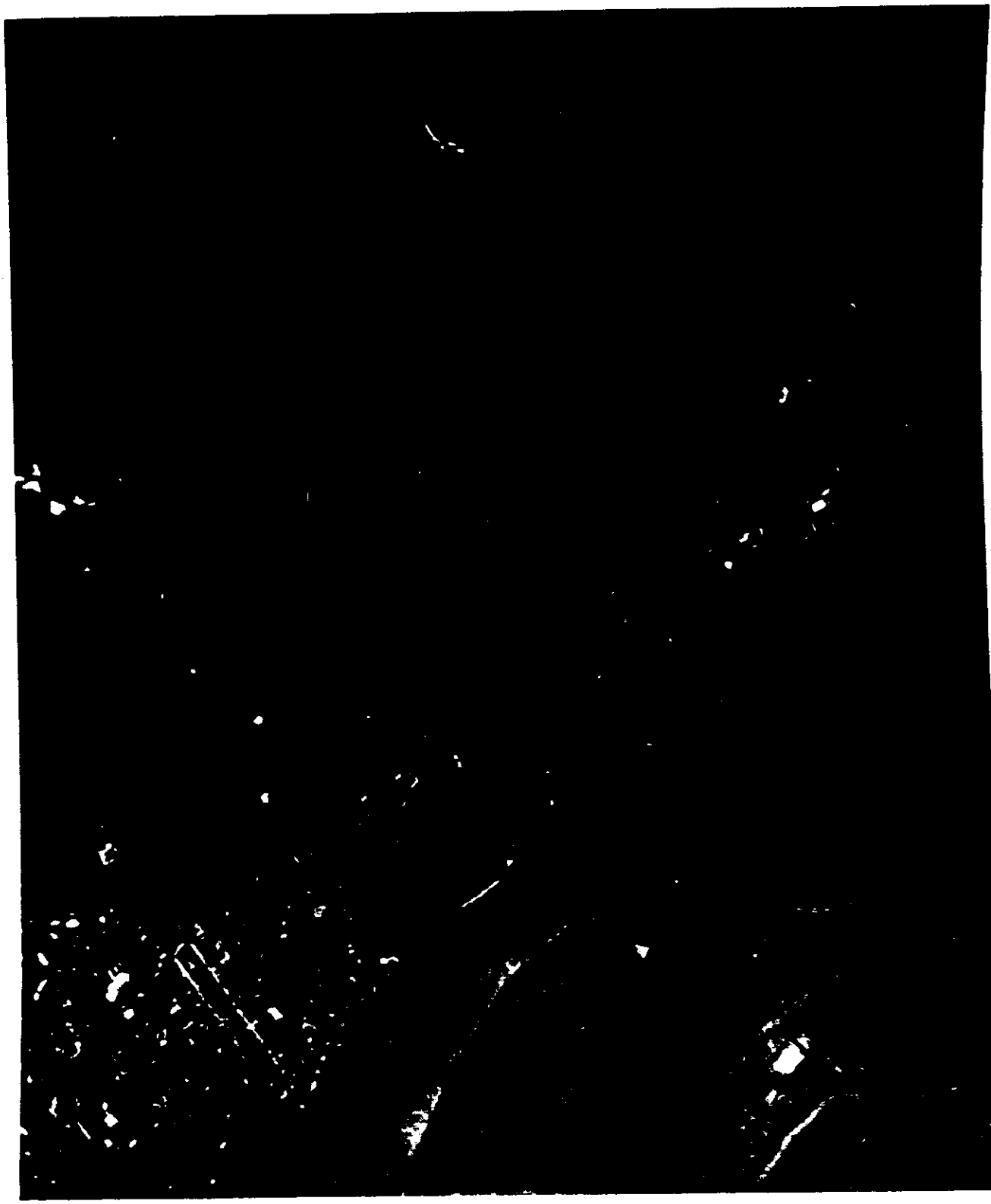

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III IMAGE QUALITY

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III. IMAGE QUALITY

A. Resolution (Theoretical)

A dynamic system's resolution of 163 l/mm was reported for the fwd-looking camera of Mission 1104, using 3404 film at 2:1 Total Overall Contrast (TOC). This equates to a theoretical ground resolution of approximately 6 feet at 100 nautical miles (nm). The best ground resolution as determined from a 9.7:1 TOC Controlled Range Network (CORN) target for the fwd-looking camera is approximately 4.4 feet along track and 5.8 feet across track, recorded at 82 nm. Unfortunately, there were no resolution targets photographed with the SO-180 film, nor was the system resolution reported using SO-180 film. Theoretical system resolution values using SO-180 film were developed at this facility using the following computations:

Data and Calculations

Given: 1. Resolving power of SO-180 film at 2:1 TOC - 42 l/mm
2. Resolving power of 3404 film at 2:1 TOC - 230 l/mm
3. Dynamic system resolution of the fwd-looking camera using 3404 film at 2:1 TOC - 163 l/mm.

Using 1, 2, and 3 above and the formula $\frac{1}{R_s} = \frac{1}{R_l} + \frac{1}{R_f}$ (where R_s is the resolving power of the system, R_l is the resolving power of the lens, and R_f is the resolving power of the film) the system resolution of the fwd-looking camera using SO-180 film is computed to be approximately 39 l/mm at 2:1 TOC.

By applying the scale formula $S = \frac{H}{300\,FR}$ (where S is the ground resolution in feet, H is the altitude in feet, F is the focal length in feet, R is the resolving power of the system, and 300 is the conversion factor)

The theoretical ground resolution of SO-180 film in the fwd-looking camera is computed to be approximately 26 feet at an altitude of 100 nm.

Note: The above formulas do not take into account image motion parameters or atmospherics. A confidence limit of plus or minus four feet is a reasonable allowance for error.

The formula $\frac{1}{R_s^2} = \frac{1}{R_l^2} + \frac{1}{R_f^2}$ has been suggested as a more accurate descriptor of the system performances but the difference is included in the confidence limit of 4 feet.

Resolution Comparison

Film resolving power (Cycles per millimeter, c/mm):

TOC	3404 c/mm	SO-180 c/mm
1.5:1	190	30
1.7:1	196	35
2:1	230	42

6.4:1	455	67
1000:1	651	95

System Resolution

TOC	3404	SO-180
2:1	163 l/mm ≡ 6 feet	39 l/mm ≡ 26 feet

B. Resolution (Subjective)

In theory, a resolution trade-off of approximately 4:1 is evident in favor of the 3404 film. The same is true subjectively. Objects approximately the size of automobiles can easily be identified on the 3404 film, whereas on the SO-180 film objects this size can barely be detected. The loss of detailed intelligence because of the poorer resolution of the SO-180 film is significant and of pronounced importance when considering mono photography. However, this system minimizes but does not eliminate the loss of detailed intelligence because of its stereo configuration. The high resolution of the 3404 film is maintained by the aft camera but is not complimented by the poor resolution of SO-180 in the fwd camera. The advantage of using SO-180 film must be realized from additional tonal information. When the two materials are viewed in stereo, a loss of detail and a gain in tonal information is realized. Whether the advantages outweigh the disadvantages depends upon the specific target and the type of information needed.

C. Color Quality

Proper color balance of the SO-180 film is critical for optimum hue discrimination and highly dependent upon the environmental conditions and age of the film. The infrared sensitive layer (cyan dye layer) tends to decrease in speed as the film ages and the speed of the green sensitive layer (yellow dye layer) increases slightly. Also the color balance shifts toward cyan. However, these problems can be minimized through proper storage techniques.

It is evident from the SO-180 film on this mission that the orbital environment had a profound effect on portions of the film. The fog patterns resulting from corona static constitute the most significant degradation to the color quality of the original and the subsequent reproductions. A change in color balance is also evident from the beginning to the end of an operation with the first four frames exhibiting a shift toward cyan. These frames were subjected to the environment of the camera system during the "off period" between camera operations. As a result, the infrared sensitive layer decreased in sensitivity, and little infrared information is recorded. After the first four frames, more information is recorded in the infrared sensitive layer and the color balance is improved. It should be noted, however, that generally the quantity and or quality of information in the infrared layer does not appear to be representative of the potential of the film.

Part of the aforementioned color shift can be attributed to changes in exposure conditions, i.e. terrain conditions, scan rate, solar elevation, and in particular the relationship between the principal ray of the camera lens and the solar azimuth. These effects are also exhibited on single frames such as at the beginning of scan versus the end of scan.

FIGURES 2a AND 3a. SO-180 AND 3404 QUALITY COMPARISON

The following photographs are comparisons from SO-180 and type 3404 films. The scene is one of the less fog contaminated cultural areas covered with SO-180 during the mission. It is evident that a significant infrared signature is provided by the SO-180 whereas the 3404 photographs provide much more detailed information.

	FIGURE 2a	FIGURE 3a
Camera	Fwd	Aft
Pass	210D	210D
Frame	8	14
Date of Photography (GMT)	20 Aug 68	20 Aug 68
Universal Grid Coordinates	38.5-3.5	36.8-2.4
Enlargement Factor	10X	10X
Geographic Coordinates	35-16N 120-39W	35-16N 120-43W
Altitude (ft)	491,585	491,370
Camera Attitude:		
Pitch (deg)	15°01'	-15°21'
Roll (deg)	-0°06'	-0°08'
Yaw (deg)	-2°16'	-2°22'
Local Sun Time	1144	1144
Solar Elevation (deg)	67°11'	67°12'
Solar Azimuth (deg)	170°24'	170°24'
Exposure (sec)	1/428	1/573
Vehicle Azimuth (deg)	173°07'	173°14'

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FIGURES 4a AND 5a. SO-180 AND 3404 TONAL COMPARISON

Following are photographs of the Dead Sea area from SO-180 and 3404 film. Although an extended range of tones is exhibited by both photographs, the SO-180 appears to have an advantage. From a resolution and image sharpness standpoint, the 3404 is definitely superior.

	FIGURE 4a	FIGURE 5a
Camera	Fwd	Aft
Pass	203D	203D
Frame	46	52
Date of Photography (GMT)	20 Aug 68	20 Aug 68
Universal Grid Coordinates	22.5-2.8	52.5-2.8
Enlargement Factor	4X	4X
Geographic Coordinates	31-07N 35-52E	31-07N 35-47E
Altitude (ft)	493,476	493,433
Camera Attitude:		
Pitch (deg)	14°56'	-15°27'
Roll (deg)	0°04'	0°03'
Yaw (deg)	-2°36'	-2°39'
Local Sun Time	1151	1151
Solar Elevation (deg)	71°37'	71°37'
Solar Azimuth (deg)	173°42'	173°42'
Exposure (sec)	1/428	1/573
Vehicle Azimuth (deg)	173°43'	173°48'

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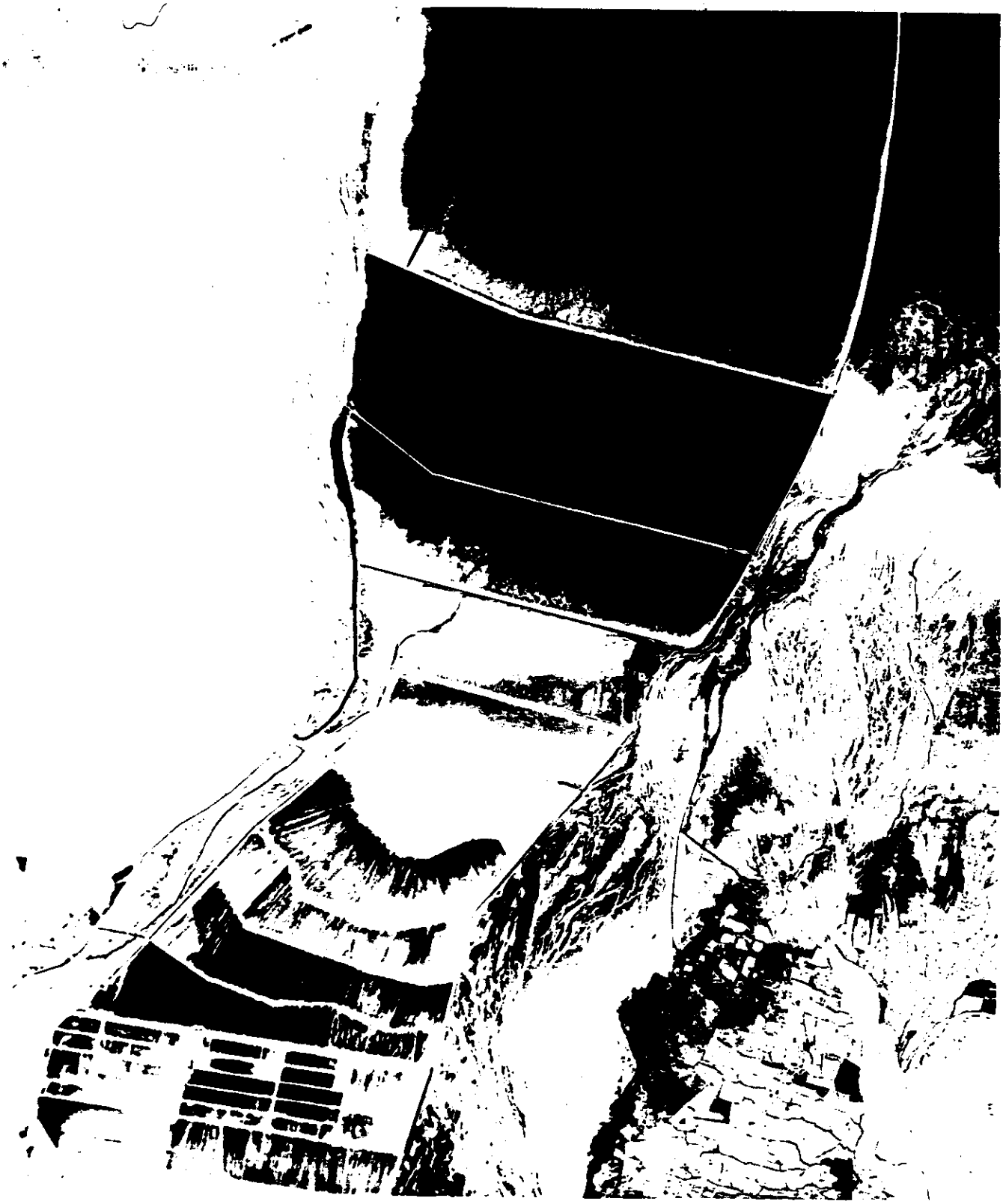

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IV SENSITOMETRY

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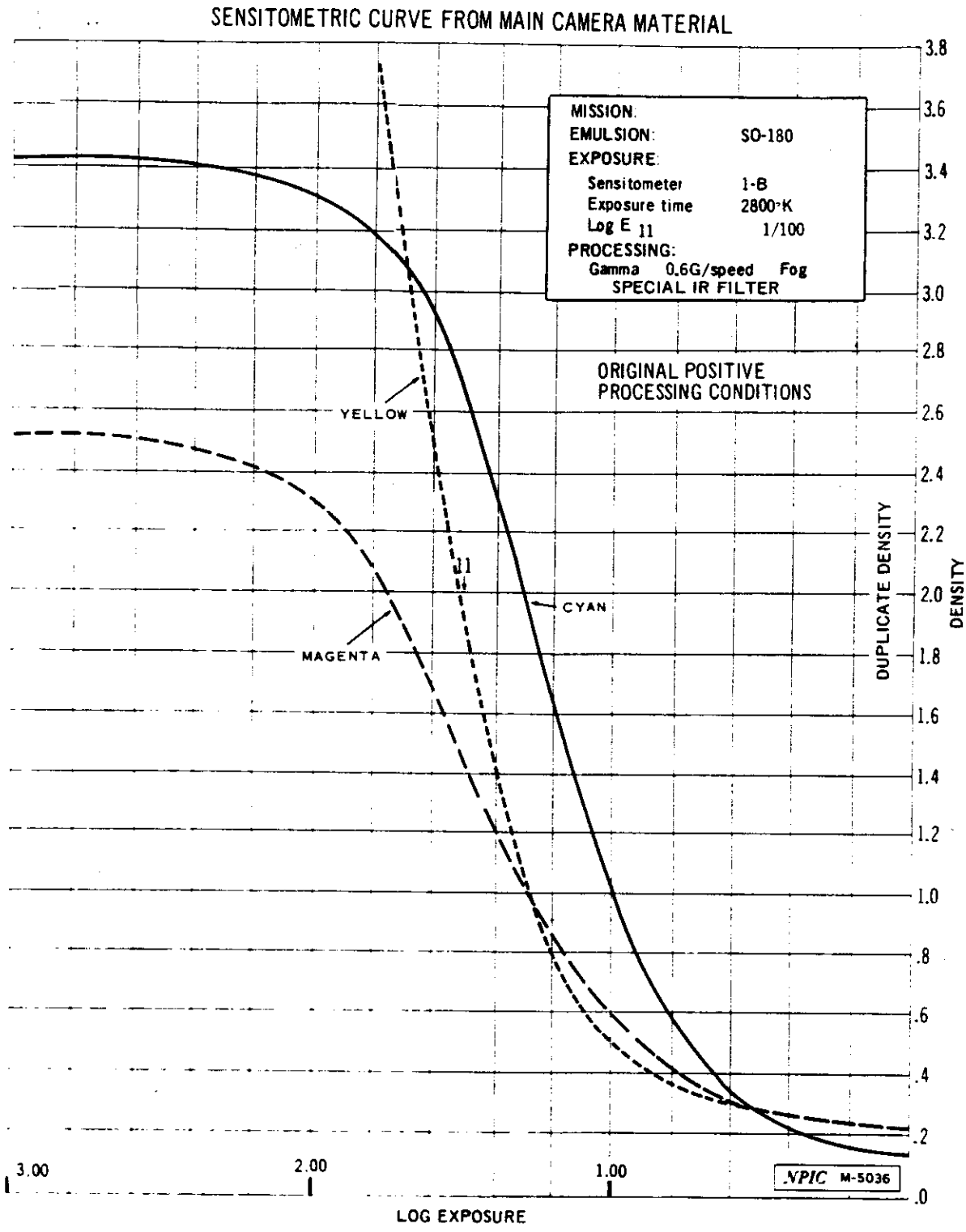
IV. SENSITOMETRY

The H and D sensitometric curves of SO-180 film indicate that the speed of the infrared sensitive layer (cyan dye layer) is slower than the red sensitive layer (magenta dye layer) and green sensitive layer (yellow dye layer). The original (flight) film also indicates a loss of speed in the infrared sensitive layer in relation to the red and green sensitive layers. As a result, the infrared information is not only recorded at a higher cyan density level but is placed on the non-linear portion of the H and D curve, resulting in vastly reduced contrast. The original film was densitometrically sampled and adjustments were made in the reproduction process to improve the color balance. The sensitometric control patches attached to the reproduction idents and the printer tone reproduction curves represent the color change.

The speed of SO-180 is approximately six times that of 3404 (Aerial Exposure Index of 10 for SO-180 versus 1.7 for 3404 film) and is designed to efficiently accommodate a scene contrast range of 4.7:1 compared to 2.7:1 for 3404 film. The sensitivity of SO-180 extends into the near infrared to about 850 millimicrons. Its sensitivity to short wavelength radiation necessitates the use of a yellow filter (a wratten 15 filter with a 0.9 ND was used with the SO-180 film in this mission).

The following set of curves represent the sensitometric characteristics of the original process as generated by a 1B sensitometer, and the transfer of densities from the original to the duplicate via the printer and duplicate process system. The density transfer information for each pass is represented by a particular set of curves which indicates the printing conditions for each pass. Note: The curves and above data were obtained from the processing contractor. The printer dye transfer curves are based on reconstructed data and are the best approximation to the actual printing conditions.


SENSITOMETRIC CURVE FROM MAIN CAMERA MATERIAL
MISSION:
EMULSION: SO-180
EXPOSURE:
Sensitometer 1-B
Exposure time 2800°K
Log E 11 1/100
PROCESSING:
Gamma 0.6G/speed Fog
SPECIAL IR FILTER
ORIGINAL POSITIVE
PROCESSING CONDITIONS
YELLOW
11
CYAN
MAGENTA
DUPLICATE DENSITY
DENSITY
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
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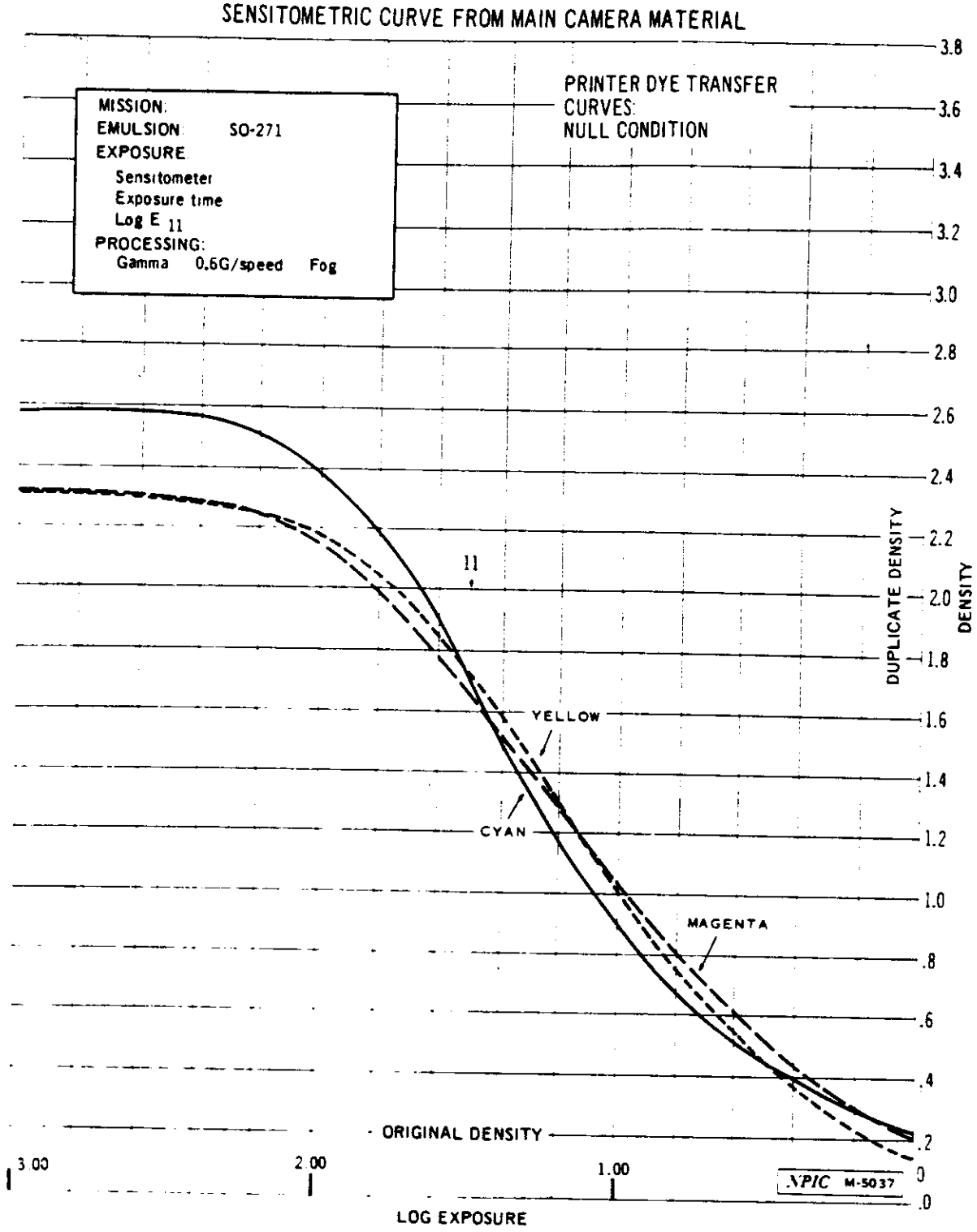
.8
.6
.4
.2
.0
3.00
2.00
1.00
NPIC M-5036
LOG EXPOSURE


SENSITOMETRIC CURVE FROM MAIN CAMERA MATERIAL
MISSION:
EMULSION: SO-271
EXPOSURE:
Sensitometer
Exposure time
Log E 11
PROCESSING:
Gamma 0.6G/speed Fog
PRINTER DYE TRANSFER CURVES: NULL CONDITION
11
YELLOW
CYAN
MAGENTA
ORIGINAL DENSITY
DUPLICATE DENSITY
DENSITY
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
.0
3.00
2.00
1.00
LOG EXPOSURE
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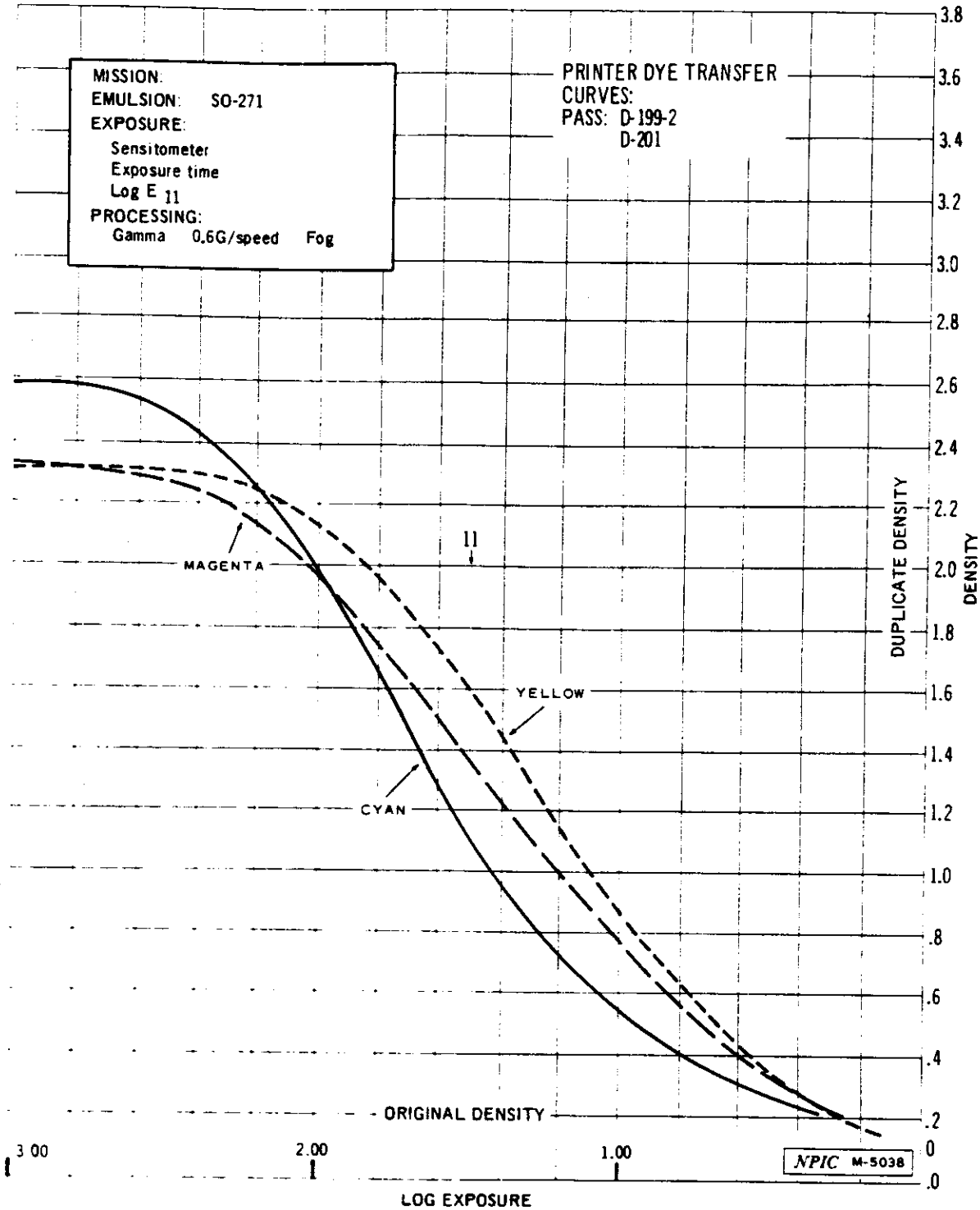
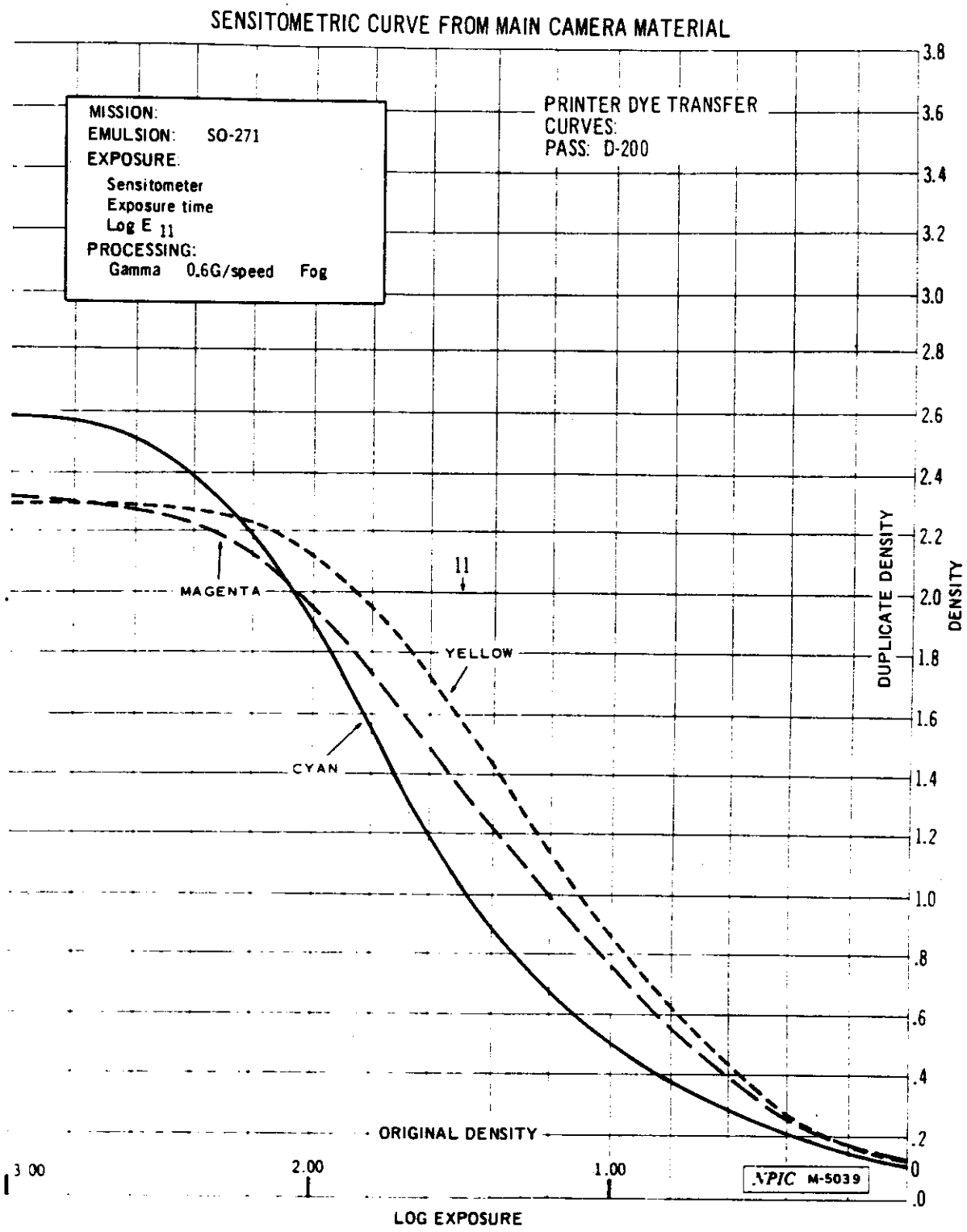
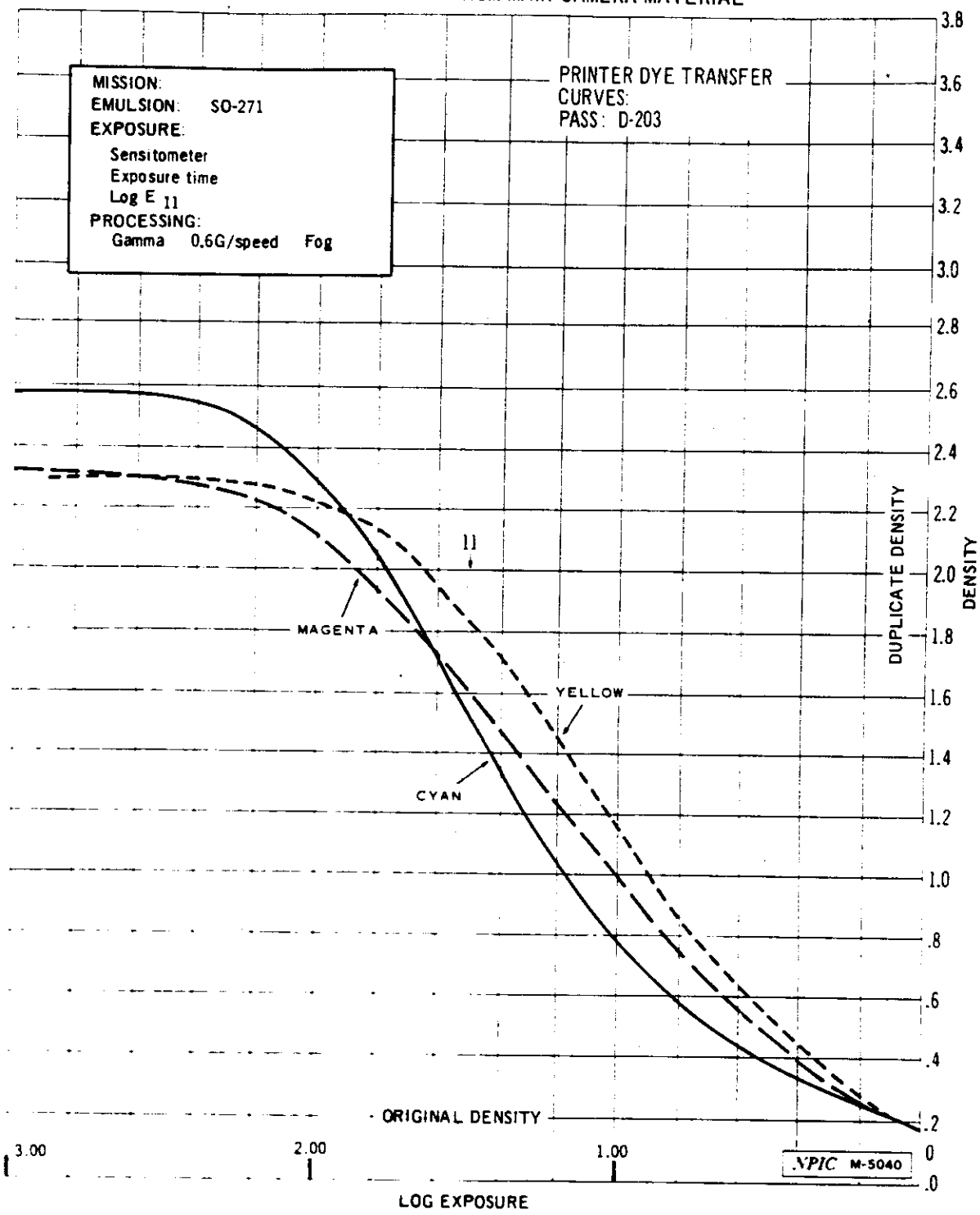
SENSITOMETRIC CURVE FROM MAIN CAMERA MATERIAL

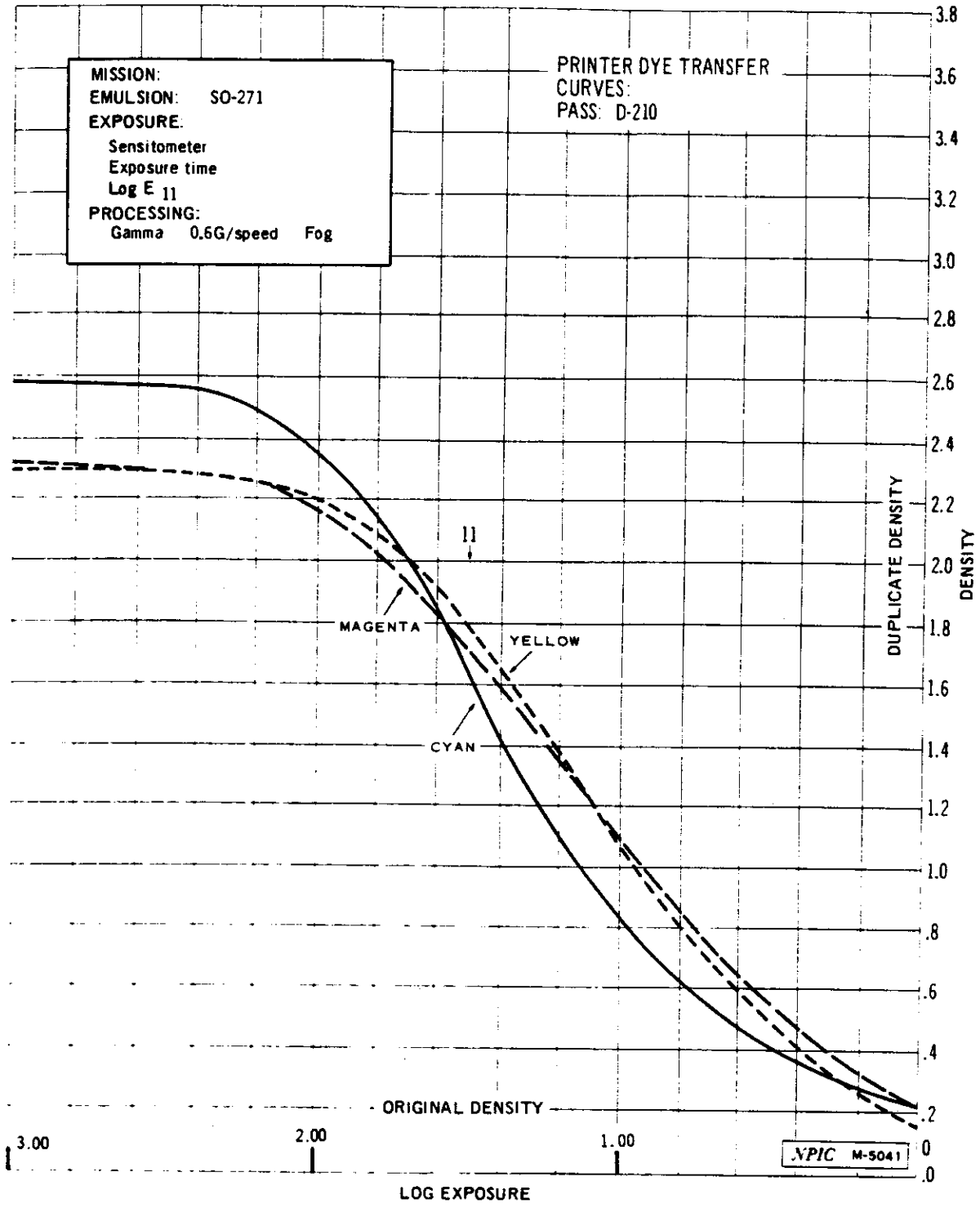



SENSITOMETRIC CURVE FROM MAIN CAMERA MATERIAL
MISSION:
EMULSION: SO-271
EXPOSURE:
Sensitometer
Exposure time
Log E 11
PROCESSING:
Gamma 0.6G/speed Fog
PRINTER DYE TRANSFER CURVES:
PASS: D-200
MAGENTA
YELLOW
CYAN
11
ORIGINAL DENSITY
DUPLICATE DENSITY
DENSITY
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
.0
3.00
2.00
1.00
LOG EXPOSURE
NPIC M-5039

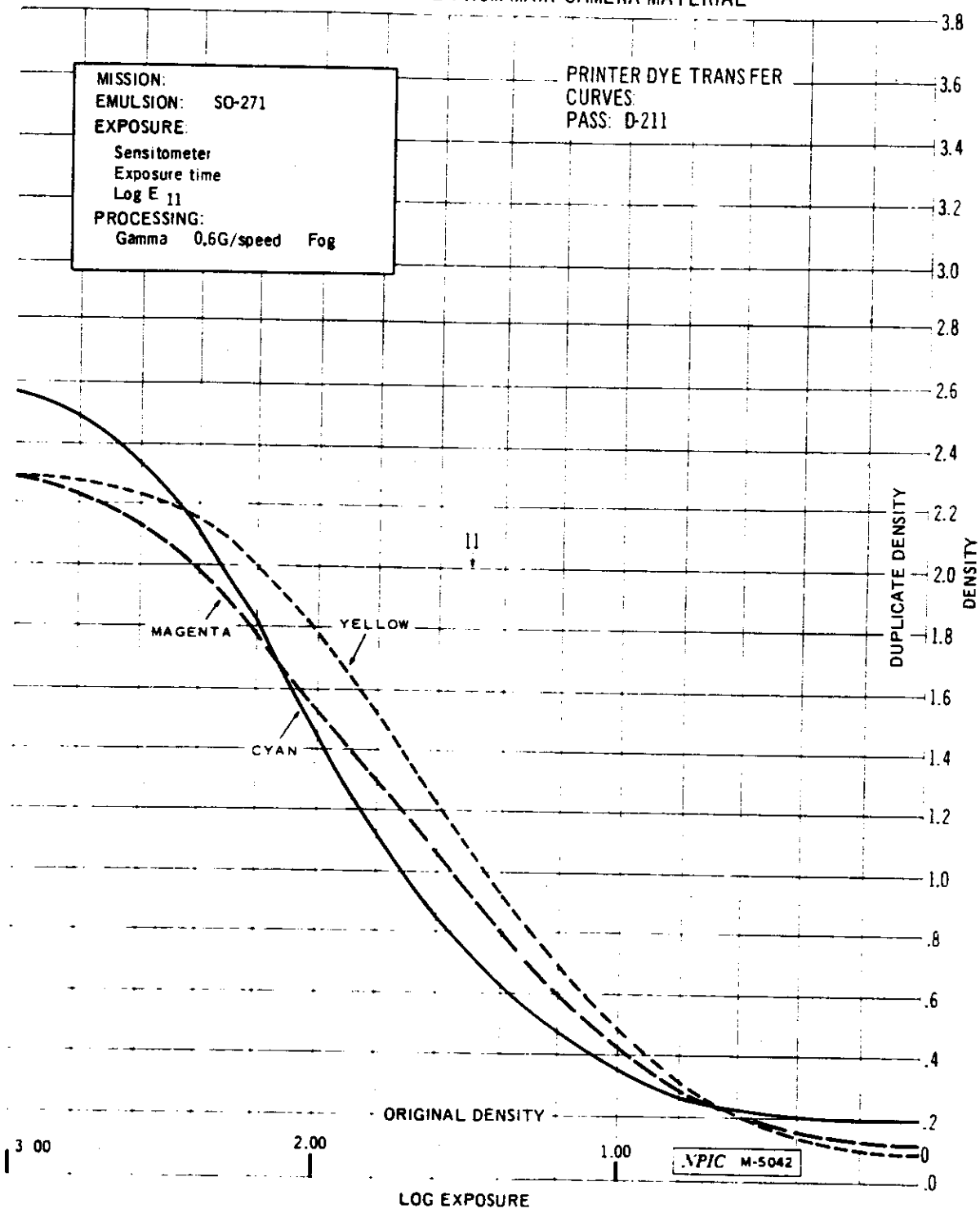
SENSITOMETRIC CURVE FROM MAIN CAMERA MATERIAL



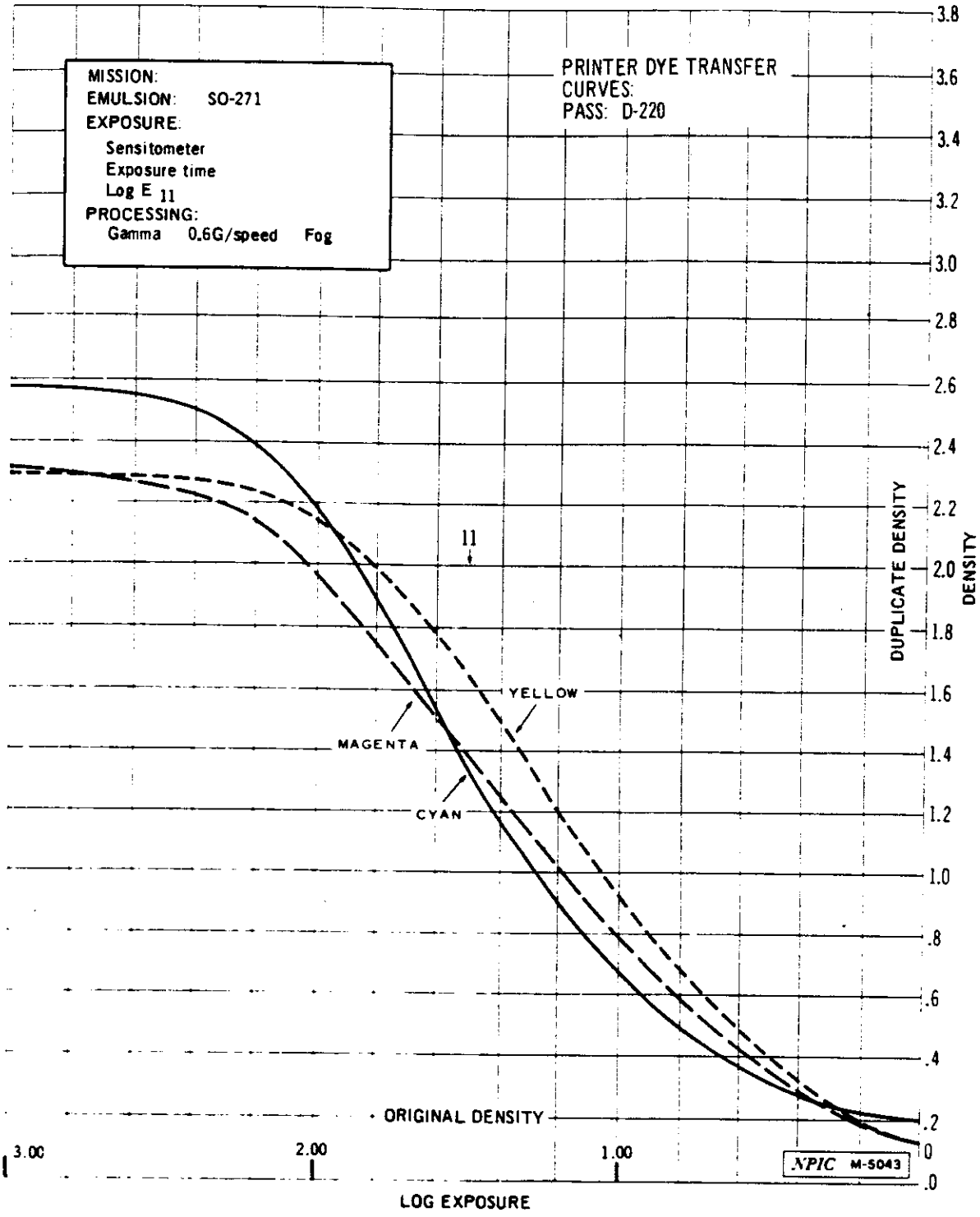
SENSITOMETRIC CURVE FROM MAIN CAMERA MATERIAL



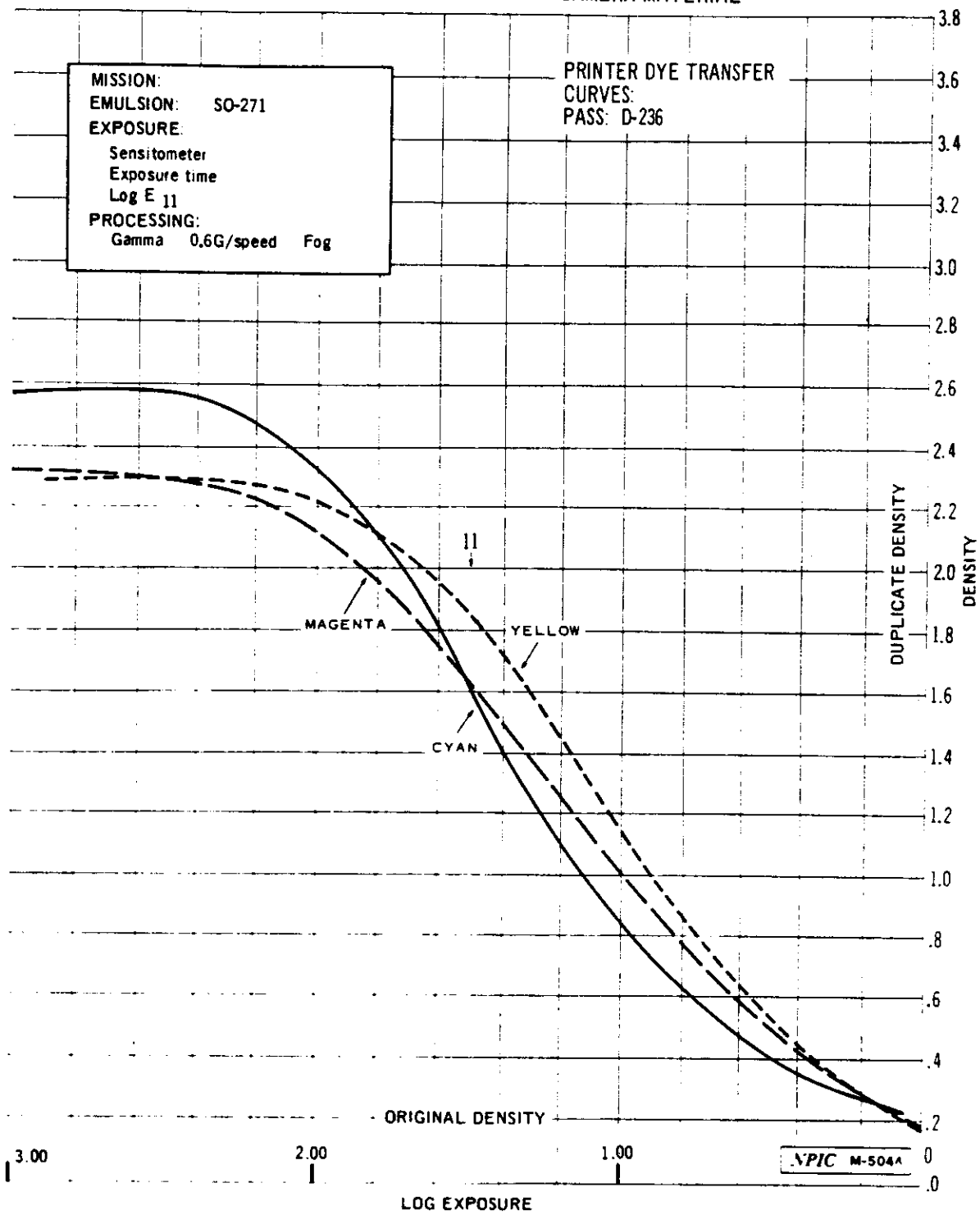
SENSITOMETRIC CURVE FROM MAIN CAMERA MATERIAL



SENSITOMETRIC CURVE FROM MAIN CAMERA MATERIAL



SENSITOMETRIC CURVE FROM MAIN CAMERA MATERIAL

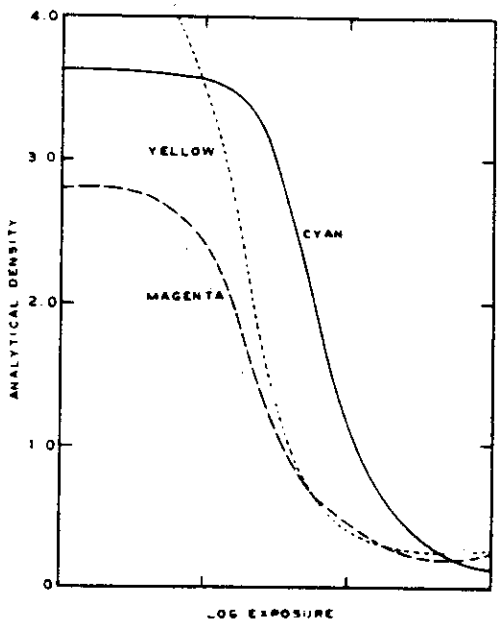


Following are density values obtained from the sensitometric control patches of the original and a reproduction as measured by a MacBeth Quantalog Densitometer with an EP-1000 attachment. Although the density values are relative, they represent the change in color balance from the original to the reproduction.

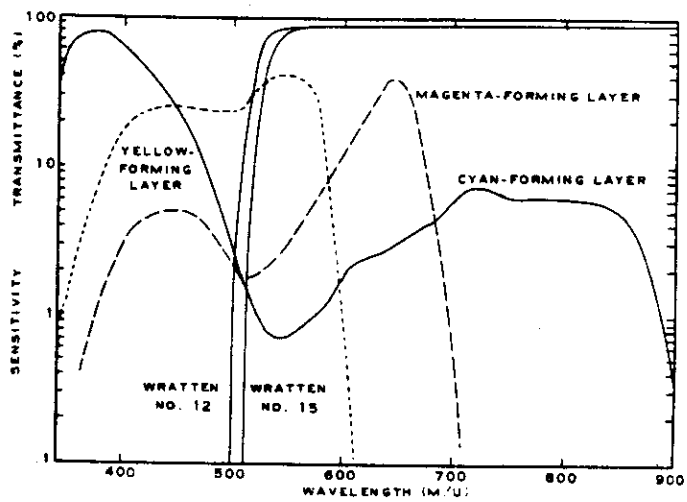
		Relative Density			
Film	Pass	Red	Green	Blue	Visual
Original	199	1.01	.89	1.01	.98
Reproduction	199	.62	.84	.98	.73
Original	200	1.00	.89	1.01	.96
Reproduction	200	.57	.89	.95	.73
Original	201	1.00	.89	1.01	.96
Reproduction	201	.53	.83	.98	.69
Original	203	1.04	.92	1.03	.98
Reproduction	203	.87	.99	1.13	.90
Original	210	1.04	.94	1.08	1.02
Reproduction	210	.98	1.09	1.10	.99
Original	211	.96	.85	.98	.91
Reproduction	211	.36	.51	.57	.47
Original	220	1.00	.89	1.00	.94
Reproduction	220	.70	.86	.94	.74
Original	236	.99	.88	1.00	.94
Reproduction	236	.91	1.00	1.12	.92

Figures:

The following curves were extracted from a publication issued by the processing contractor and are included to present to the reader the sensitometric and spectral sensitivity characteristics of SO-180 film. A Wratten 15 filter was used on this mission, and its characteristics and those of a Wratten 12 are illustrated with the spectral sensitivity curves.



SENSITOMETRIC CURVES



SPECTRAL SENSITIVITIES OF THE THREE FILM LAYERS
SPECTRAL TRANSMITTANCE OF KODAK
WRATTEN FILTERS AS INDICATED

NPIC M-5045

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V MENSURATION

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V. MENSURATION

It is empirically known that measurements made on tri-pack color films are more accurate if obtained from a single emulsion layer rather than from the total layers collectively. An attempt was made to determine which of the three layers of the SO-180 film used on this mission provided the most accurate dimensional data. The analysis described herein is of limited depth, and a more thorough examination of the mensuration qualities of SO-180 film should be undertaken for future use.

The site selected for the measurements is in Santa Maria, California. Two legs of a runway and two buildings were measured. Ground truth data of these were obtained to provide collateral support for this analysis. The measurements of the buildings from the photography and ground truth data correlate to a high degree. However, because of different indexing (measuring) points, the runway lengths and widths measured from the photography do not correlate with the reported ground truth data. As a result and because of previous experience with this system, the measurements from the 3404 film are assumed to be correct, allowing for a plus or minus 5 feet and plus or minus 5 percent error.

The targets were measured on 3404 and SO-180 film. Measurements from the SO-180 were made of all three layers collectively and each layer individually by using clear, blue, green, and red filtration. All building measurements were compared with ground truth data. The runway measurements from the SO-180 film were compared with those from the 3404 film.

Dimensional data for all targets is presented in the following table. It is evident from this data that a high degree of correlation exists between the measurements from the 3404 film and the ground truth. The data also indicates that the use of a green filter (magenta dye layer) provided the best dimensional results from the SO-180 film, although the differences are not significant. Users are cautioned that a more extensive investigation of the mensuration qualities of SO-180 film may give different results. Statistical computations, based on the data, proved to be inconclusive and therefore are not included.

SO-180

Target	Actual	3404	Clear	Blue*	Green*	Red*
Bldg 1	211	204	200	221	215	217
"	162	166	160	159	158	159
"	520	519	534	525	537	540
"	160	161	137	132	163	135
"	80	80	66	68	87	81
"	240	230	249	242	234	246
"	60	60	53	57	57	48
"	80	82	78	75	82	73
"	620	617	625	617	616	579
"	320	319	305	295	301	293
Bldg 2	120	118	100	98	119	102
"	160	158	171	169	172	170
Leg 1	**	5600	5615	5622	5605	5620
"	**	134	132	150	130	130
Leg 2	**	5190	5190	5170	5192	5192
"	**	150	135	150	158	144

*A blue filter is used to measure yellow dye information (green sensitive), a green filter is used to measure magenta dye information (red sensitive), and a red filter is used to measure cyan dye information (infrared sensitive).

**The SO-180 dimensional data of the runway was compared directly to the 3404 film data.

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VI OBSERVATIONS AND CONCLUSIONS

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VI. OBSERVATIONS AND CONCLUSIONS

A. Photo Interpreter Report

A separate report pertaining to the intelligence value of the SO-180 film of this mission will be issued by NPIC at a later date. However, it should be emphasized at this time that: 1) the coverage obtained was not over the intended areas, 2) portions of the material are severely degraded by fog from corona static, and 3) approximately 30 percent of the SO-180 film is obscured by clouds.

Regardless of these factors, portions of the SO-180 imagery obtained on this mission closely approximate the expectations of this lens/film combination. Some of the existing imagery contains significant added information from an intelligence standpoint, provided the analyst is allowed sufficient time to interpret it, has a working knowledge of the film characteristics, and is familiar with the infrared reflectivity of the various objects photographed.

VII. APPENDIX

It was previously stated that measurements made on tri-pack color films may be more accurate if obtained from a single emulsion layer rather than from the composite of all layers. Similarly, improvements may also be expected in the image quality of black and white reproductions made selectively from color film. It has been established that the quality of the imagery varies with filter/film combinations. Therefore, more information may be derived from one of the three layers than from either of the other two, and more than in all three viewed or printed as one. This phenomenon is more distinctly manifested in some areas than in others. Experiments were conducted on the corona fog-degraded areas (where the layer information differences are more pronounced) by making reproductions through red, green, and blue separation filters. The following combinations were used:

FILTER	FILM	PROCESS
W-92 (Red)	Dupont High Contrast Separation Film	Versamat A
W-99 (Green)	Dupont Medium Contrast Separation Film	Versamat B
W-98 (Blue)	Dupont Medium Contrast Separation Film	Versamat B

Reproductions from the fog-degraded* areas illustrate that the prints made through a W-92 (red) filter are unusable from an intelligence standpoint--practically all information is obscured with only gross terrain features detectable. The degree of information provided by the reproductions made through the W-98 (green) and W-98 (blue) filters is much superior, with the prints obtained through the green filter generally being the best. All reproductions are improved and more comparable with respect to each other as the fog from the corona static decreases. The value of this special printing technique as a salvage and enhancement operation is obvious.

Note: Prints illustrating the above conclusion are not available for this report but will be included in a subsequent PER.

*Corona Fog Imaged Red as Per Part II of This Report.