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Analysis of Photographic Image to Evaluate System Performance Mission 1007-2

29 July 1964

July 29, 1964

TITLE:

Summary of Microdensitometer Derived Image Quality Data Collected from Mission 1007-2

SECTION I: INTRODUCTION

Microdensitometer tracing of scene edges has been used as an objective technique for evaluating photographic system performance. In this report, the evaluation data is presented as spread function width in microns and resolving power in lines per millimeter. A statistical summary of the edge data is presented in Section II, giving the arithmetic mean, standard deviation, coefficient of dispersion, and number of edges. Section III is a tabulation of the location, description, and image quality data for each edge. Frequency plots of the spread function and resolving power data are presented as Section IV, to show the distribution of values. Summary of all C/M/J Missions traced to date is presented in Section V. Section VI is included to show the sensitometric data for this mission. A diagram of the reference system used in describing the orientation of an edge and a temporary coordinate system used to locate the edges within a frame are presented as Appendix A.

The image quality data was obtained from sharp scene edges in the original negative by scanning with a Kodak Model 5 microdensitometer. A 1 X 320 micron slit was used. The data reduction consisted of the following steps:

(a) hand smoothing of the microdensitometer strip chart recording,

(b) key punching of chart (density) values at sample distance increments of 0.277 microns,

(c) I.B.M. 1620 computer conversion of chart values to relative exposure values, and

(d) computer conversion of exposure data to line spread function and modulation transfer function by numerical methods.

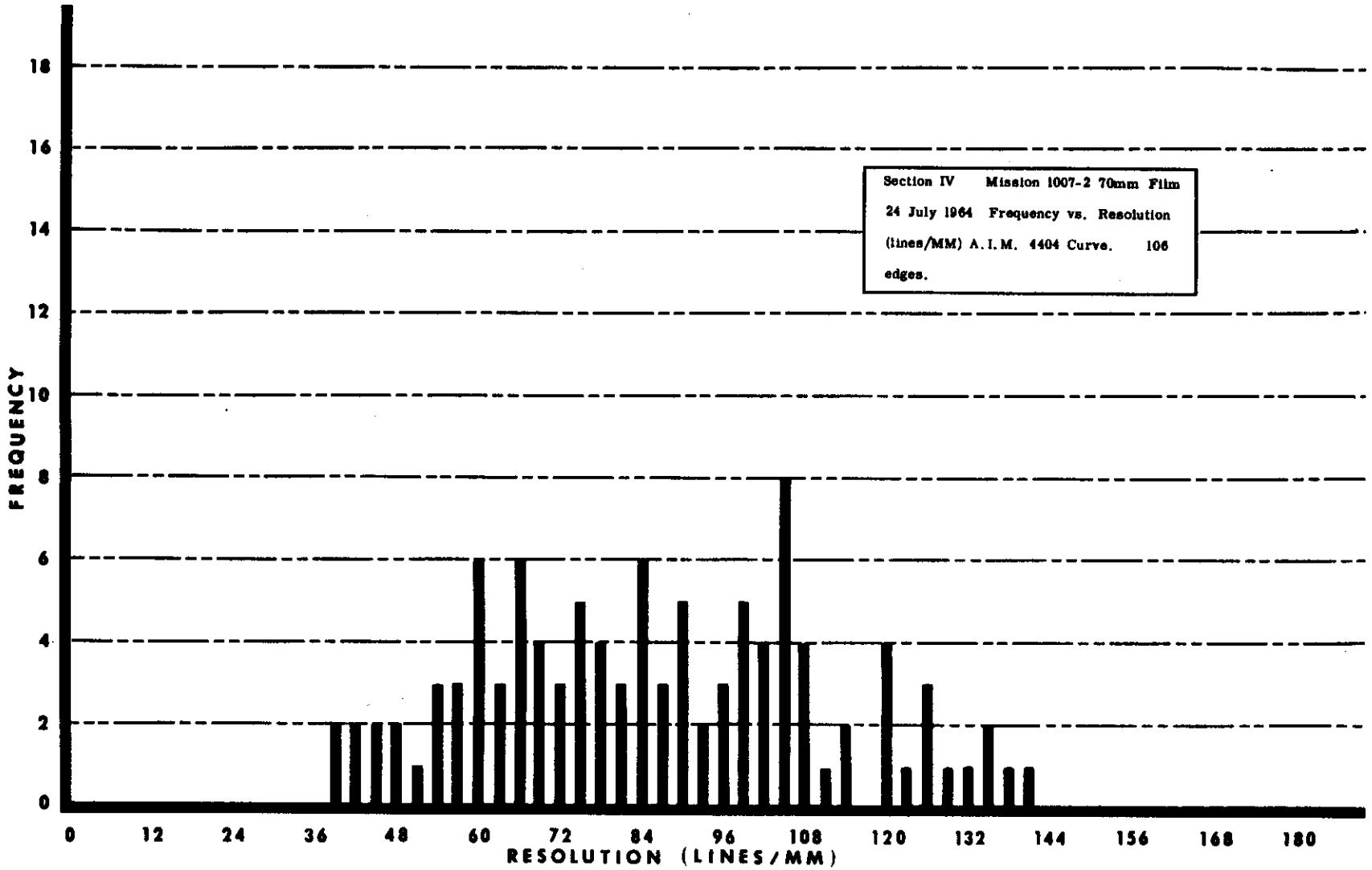
The edge resolving power was predicted graphically as the intersection of the MTF curve and the aerial image modulation curve for 4404 film at a test object contrast of 2:1. The spread function width was calculated from the first differences of relative exposure as the width at which the gradient became 50% of the maximum gradient.

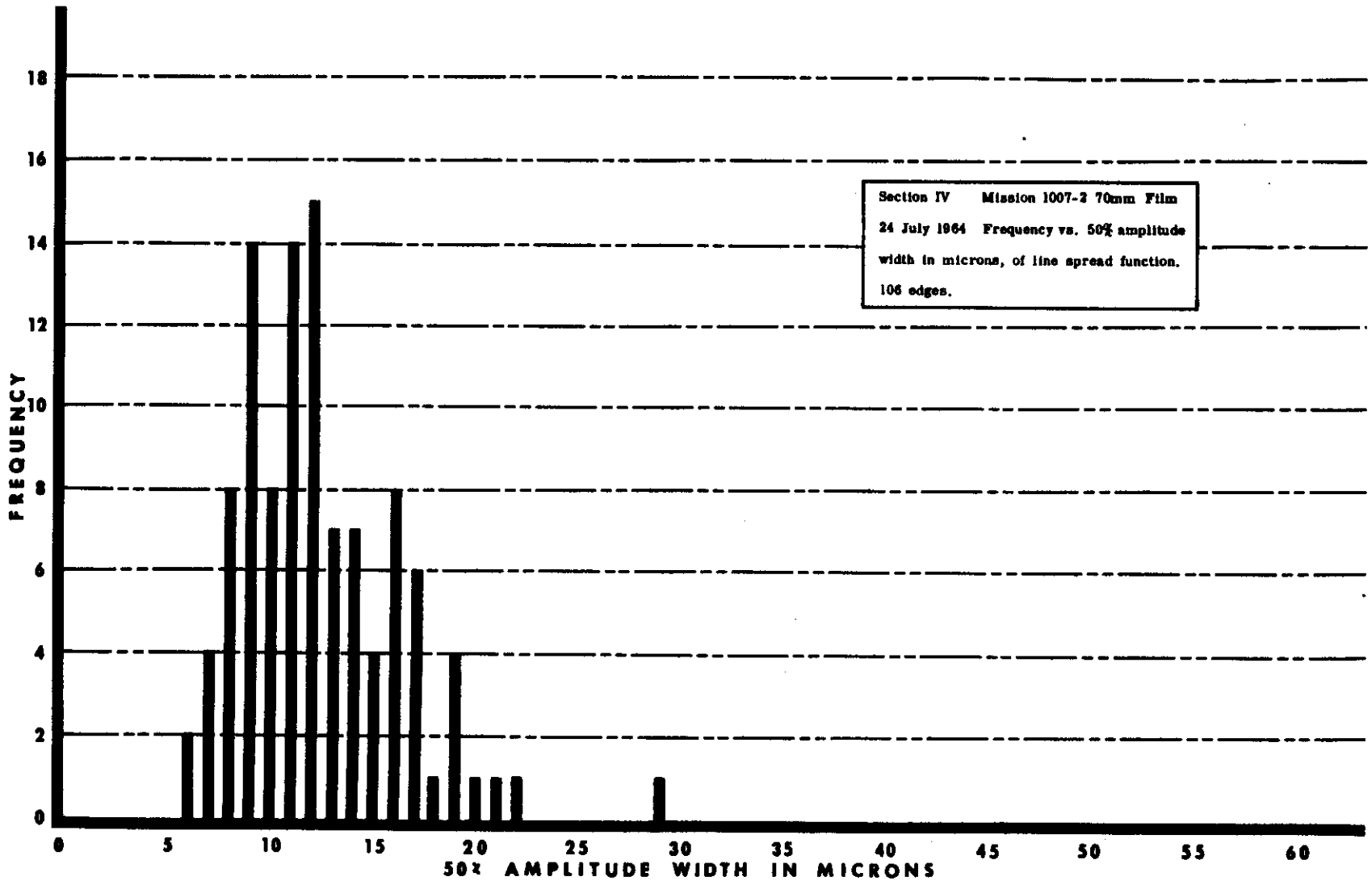
Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
11A	Aft	D72	058	A-11	175	Airfield	8.0	120
12	Aft	D72	057	A-6	160	Airfield	11.5	76
12A	Aft	D72	057	A-6	160	Airfield	5.8	140
13	Aft	D72	051	C-8	180	Airfield	7.3	119
13A	Aft	D72	051	C-8	180	Airfield	11.8	77
14	Aft	D72	112	B-10	020	Airfield	12.4	66
14A	Aft	D72	112	B-10	020	Airfield	18.7	48
15	Aft	D72	110	C-11	050	Airfield	13.2	60
15A	Aft	D72	110	C-11	050	Airfield	7.0	137
16	Aft	D72	095	A-9	080	Airfield	9.5	105
16A	Aft	D72	095	A-9	080	Airfield	10.7	84
17	Aft	D72	090	A-5	150	Airfield	10.3	108
17A	Aft	D72	090	A-5	150	Airfield	7.1	136
18	Aft	D72	090	A-12	125	Airfield	14.4	73
18A	Aft	D72	090	A-12	125	Dam	13.9	100
19	Aft	D72	087	A-8	090	Dam	11.7	85
19A	Aft	D72	087	A-8	090	Dam	11.8	87
20	Aft	D72	078	C-6	090	Airfield	10.7	103
20A	Aft	D72	078	C-6	090	Airfield	9.3	100
21	Aft	D88	023	A-4	045	Airfield	11.0	90
21A	Aft	D88	023	A-4	045	Airfield	12.6	65
22	Aft	D88	011	B-8	160	Airfield	13.1	66
22A	Aft	D88	011	B-8	160	Airfield	11.4	85

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
23	Aft	D102	270	9-C	000	Airfield With Aircraft	9.0	96
23A	Aft	D102	270	9-C	000	Airfield With Aircraft	11.0	75
24	Aft	D87	047	A-3	045	Airfield	14.9	56
25	Aft	D87	038	C-7	130	Airfield	9.3	125
26	Fwd	D72	086	A-10	165	Airfield	9.0	94
26A	Fwd	D72	086	A-10	165	Airfield	14.4	92
27	Fwd	D72	087	B-1	045	Dam	16.0	56
27A	Fwd	D72	087	B-1	045	Dam	18.6	43
28	Fwd	D72	091	A-5	080	Airfield	12.2	80
29	Fwd	D72	106	A-3-4	025	Airfield	19.8	61
29A	Fwd	D72	106	A-3-4	025	Airfield	17.3	65
30	Fwd	D72	107	C-4	020	Airfield	22.2	40
30A	Fwd	D72	107	C-4	020	Airfield	17.2	83
31	Fwd	D88	005	C-7	165	Airfield	9.0	104
31A	Fwd	D88	005	C-7	165	Airfield	15.5	79
32	Fwd	D88	038	B-2	150	Airfield	19.2	45
32A	Fwd	D88	038	B-2	150	Airfield	29.1	38
33	Fwd	D88	042	B-3	135	Airfield	10.4	100
33A	Fwd	D88	042	B-3	135	Airfield	10.8	82
34	Fwd	D87	042	B-12	045	Airfield	15.3	102
34A	Fwd	D87	042	B-12	045	Airfield	11.0	120

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
35	Fwd	D87	032	C-7	135	Airfield	10.9	109
35A	Fwd	D87	032	C-7	135	Airfield	13.6	105
36A	Fwd	D72	073	A-9	085	Airfield	11.4	87
37	Fwd	D72	069	B-10	000	Airfield	8.9	106
37A	Fwd	D72	069	B-10	000	Airfield	8.7	105
38	Fwd	D72	045	C-7	000	Airfield	11.1	77
38A	Fwd	D72	045	C-7	000	Airfield	14.6	61
39	Fwd	D71	021	C-1	040	Airfield	7.8	104
39A	Fwd	D71	021	C-1	040	Airfield	15.6	54
40	Aft	D71	027	C-13	040	Airfield	8.0	110
40A	Aft	D71	027	C-13	040	Airfield	10.4	90
41	Aft	D117	030	B-1	000	Airfield	11.7	69
41A	Aft	D117	030	B-1	000	Airfield	16.1	51
42	Aft	D117	030	B-1	080	Airfield	18.0	47
42A	Aft	D117	030	B-1	080	Airfield	21.3	43
43	Aft	D119	123	A-7	160	Airfield	9.9	104
43A	Aft	D119	123	A-7	160	Airfield	17.1	66
44	Aft	D119	118	B-2-3	010	Airfield	11.4	85
44A	Aft	D119	118	B-2-3	010	Airfield	9.4	101
45	Aft	D119	116	C-3	000	Airfield	16.5	75
45A	Aft	D119	116	C-3	000	Airfield	11.9	90
46	Fwd	D120	062	B-2	085	Airfield	12.1	75
46A	Fwd	D120	062	B-2	085	Airfield	8.6	98

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
47	Fwd	D120	058	B-1	120	Airfield	13.8	60
47A	Fwd	D120	058	B-1	120	Airfield	17.0	46
48	Fwd	D120	058	C-5	115	Airfield	12.0	77
48A	Fwd	D120	058	C-5	115	Airfield	12.1	95
49	Fwd	D120	057	B-1	115	Airfield	9.6	98
49A	Fwd	D120	057	B-1	115	Airfield	14.1	55
50	Fwd	D120	056	C-7	110	Airfield	11.4	75
50A	Fwd	D120	056	C-7	110	Airfield	13.0	60
51	Fwd	D120	043	C-6	015	Airfield	16.4	62
51A	Fwd	D120	043	C-6	015	Airfield	13.0	89
52	Fwd	D120	039	B-13	130	Airfield	13.2	71
52A	Fwd	D120	039	B-13	130	Airfield	17.1	59
53	Fwd	D120	033	A-7	160	Airfield With Aircraft	14.7	64
53A	Fwd	D120	033	A-7	160	Airfield With Aircraft	14.4	67
54	Fwd	D120	025	B-3	070	Airfield	9.1	90
54A	Fwd	D120	025	B-3	070	Airfield	16.5	53
55	Fwd	D120	012	A-4	000	Airfield	18.8	70
55A	Fwd	D120	012	A-4	000	Airfield	11.7	80


Section IV Mission 1007-2 70mm Film
24 July 1964 Frequency vs. Resolution
(lines/MM) A.I.M. 4404 Curve. 106
edges.
FREQUENCY
0
2
4
6
8
10
12
14
16
18
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
RESOLUTION (LINES/MM)


Section IV Mission 1007-2 70mm Film
24 July 1964 Frequency vs. 50% amplitude
width in microns, of line spread function.
106 edges.
FREQUENCY
0
2
4
6
8
10
12
14
16
18
0
5
10
15
20
25
30
35
40
45
50
55
60
50% AMPLITUDE WIDTH IN MICRONS

SECTION V
Summary of all C/M/J Missions Traced to Date

Mission	Number of	Spread Function Width at 50% Amplitude in Microns, Computer Calculations			Resolution in lines/mm from A.I.M. 4404 Curve, Computer Calculations		
Number	Edges	Arithmetic Mean	Standard Deviation	Coefficient of Dispersion	Arithmetic Mean	Standard Deviation	Coefficient of Dispersion
9054	12	14.3	4.6	32%	81.7	27.9	34%
9057	35	12.0	4.1	34%	81.3	30.2	37%
9062	69	12.0	4.5	37%	89.4	30.3	34%
1001	117	25.6	11.3	44%	45.9	16.8	37%
1004	60	10.1	5.6	56%	115.7	38.8	34%
1004-2	69	12.6	4.9	39%	84.6	31.3	37%
1006-1	93	12.0	4.3	36%	85.3	26.4	31%
1006-2	109	11.4	3.3	29%	85.5	22.1	26%
1007-1	107	11.9	3.6	30%	89.7	22.2	25%
1007-2	106	12.3	3.9	31%	85.8	25.1	29%

Sensitometric Data

Mission 1007-2

Film Manufacturer: Eastman Kodak Company

Exposure Date: May 26, 1964

Emulsion No.: 4404-42

Lamp No.: 1903

Exposure Time: 1/25 second

Wedge No.: 711-15

Filter: Daylight

Development Conditions:

Primary: P-693, 2' 15", 74°F

Intermediate: Primary Development Plus 12DX90, 25", 67°F

Full: Primary Development Plus 12DX90, 1' 41", 67°F

Absolute Log E 11th Step: $\bar{1}$.30 M.C.S.

Sensitometric Data

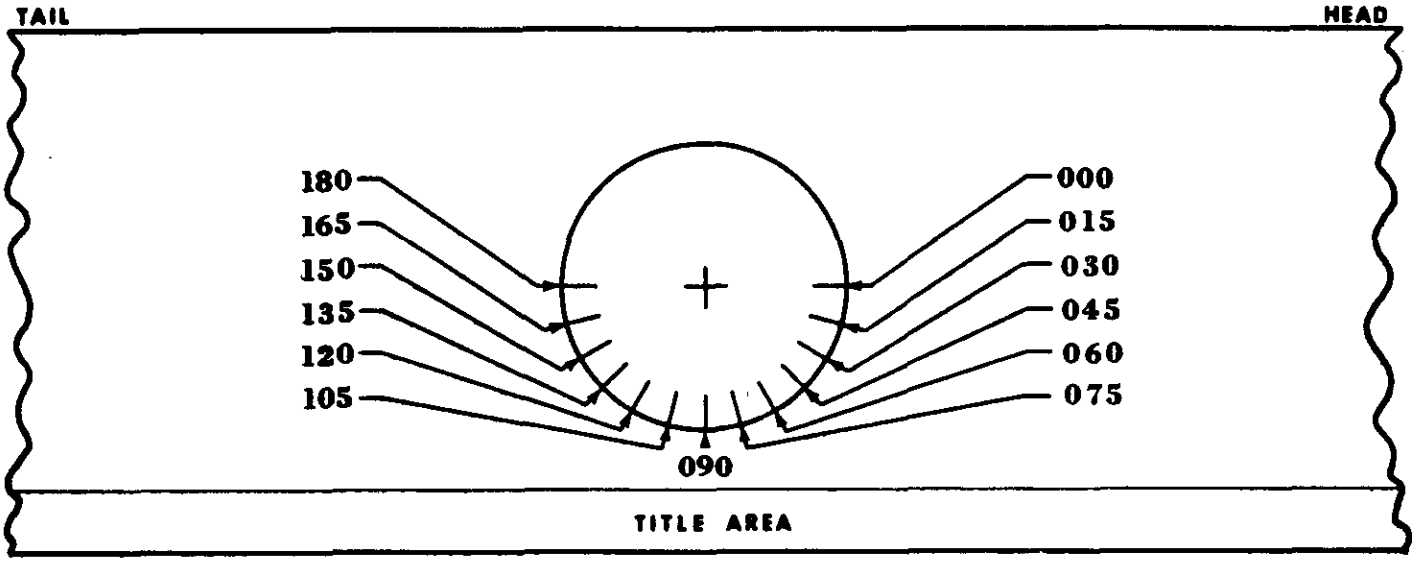
	Process Control Standard			Start Up		
	Primary	Intermed.	Full	Primary	Intermed.	Full
Fog	.08	.10	.19	.07	.09	.19
1						
2						
3						
4						.20
5			.19			.21
6		.10	.20		.10	.22
7	.08	.12	.23	.09	.11	.25
8	.10	.14	.27	.10	.14	.30
9	.12	.18	.34	.12	.20	.40
10	.16	.26	.50	.17	.29	.58
11	.24	.42	.79	.26	.43	.82
12	.38	.67	1.10	.42	.70	1.13
13	.62	1.03	1.43	.66	1.04	1.44
14	.93	1.40	1.72	.96	1.42	1.74
15	1.26	1.71	1.95	1.30	1.74	1.98
16	1.55	1.95	2.13	1.62	1.98	2.16
17	1.83	2.10	2.24	1.88	2.16	2.30
18	2.04	2.22	2.30	2.08	2.29	2.40
19	2.17	2.29	2.35	2.22	2.36	2.44
20	2.25	2.34	2.39	2.30	2.40	2.46
21	2.30	2.37	2.43	2.35	2.42	2.48
γ	2.15	2.38	2.20	2.06	2.34	2.13
0.6G/Speed	$\bar{1}$.48	$\bar{1}$.30	$\bar{1}$.13	$\bar{1}$.10	$\bar{1}$.33	$\bar{1}$.47

	Head and Tail Forward Camera		Head and Tail Aft Camera		Mission
	Head	Tail	Head	Tail	Mat'l
Fog					None Received
1					
2					
3					
4	.20	.20	.19	.19	
5	.21	.21	.21	.21	
6	.22	.23	.22	.22	
7	.25	.25	.23	.23	
8	.30	.30	.29	.28	
9	.40	.41	.39	.38	
10	.57	.58	.55	.55	
11	.82	.84	.80	.81	
12	1.12	1.14	1.11	1.12	
13	1.46	1.48	1.44	1.44	
14	1.74	1.75	1.72	1.71	
15	1.98	1.99	1.95	1.94	
16	2.16	2.15	2.11	2.12	
17	2.29	2.30	2.24	2.24	
18	2.39	2.39	2.36	2.35	
19	2.42	2.42	2.40	2.39	
20	2.45	2.46	2.45	2.42	
21	2.46	2.48	2.48	2.45	
$\bar{y}$	2.07	2.06	2.15	2.11	
0.6G/Speed	$\bar{1}$.12	$\bar{1}$.12	$\bar{1}$.12	$\bar{1}$.13	

APPENDIX "A"

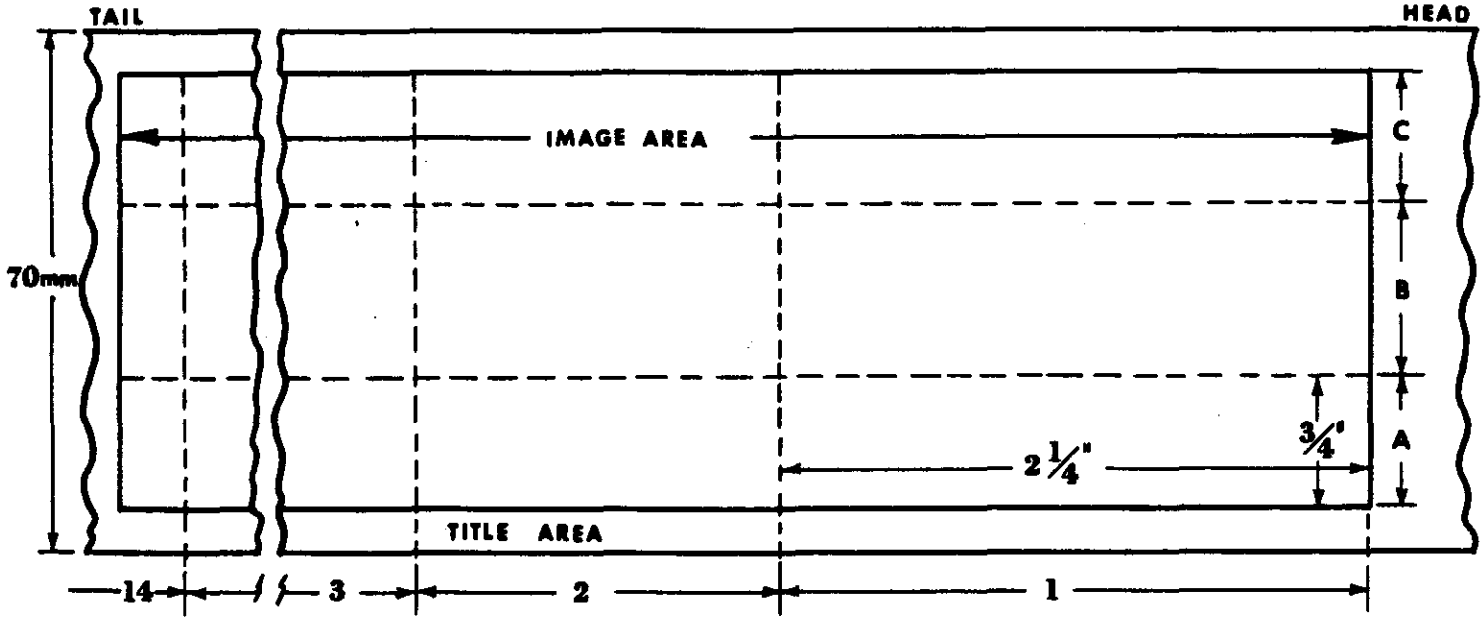
Reference System For Orientation Of C/M/J Mission Edges

original negative - - emulsion up



Grid For Position Of C/M/J Mission Edges

original negative - - emulsion up



Analysis of Photographic Image to Evaluate System Performance

SECTION II SUMMARY SHEET

Mission 1007-2

Resolution in lines/mm based on the aerial image modulation - 4404 curve from edge trace data reduced by computer techniques.

Arithmetic Mean	85.8
Standard Deviation	25.1
Coefficient of Dispersion	29%
Number of edges	106

Spread function width at 50% amplitude in microns from edge trace data reduced by computer techniques.

Arithmetic Mean	12.3
Standard Deviation	3.9
Coefficient of Dispersion	31%
Number of Edges	106

Analysis of Photographic Image to Evaluate System Performance

Mission 1007-2

Section III

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
1	Aft	D57	048	B-4	135	Airfield	12.5	69
1A	Aft	D57	048	B-4	135	Airfield	12.0	70
2	Aft	D57	045	C-7	135	Airfield	8.8	130
2A	Aft	D57	045	C-7	135	Airfield	9.2	107
3	Aft	D57	044	A-9	172	Airfield	10.5	88
3A	Aft	D57	044	A-9	172	Airfield	7.7	125
4	Fwd	D73	047	B-2	015	Airfield	9.6	106
4A	Fwd	D73	047	B-2	015	Airfield	8.9	109
5	Fwd	D73	032	A-5	165	Airfield	8.5	114
5A	Fwd	D73	032	A-5	165	Airfield	6.3	125
6	Fwd	D73	016	C-12	165	Airfield	7.8	135
6A	Fwd	D73	016	C-12	165	Airfield	15.6	64
7	Fwd	D73	014	A-13	005	Airfield	8.0	120
7A	Fwd	D73	014	A-13	005	Airfield	11.4	102
8	Aft	D72	074	B-4	002	Airfield	10.6	96
8A	Aft	D72	074	B-4	002	Airfield	11.8	73
9	Aft	D72	071	C-3	050	Airfield	6.9	124
9A	Aft	D72	071	C-3	050	Airfield	7.8	132
10	Aft	D72	066	B-3	160	Airfield	15.6	84
10A	Aft	D72	066	B-3	160	Airfield	13.5	58
11	Aft	D72	058	A-11	175	Airfield	7.6	113

Distribution List