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This document contains 17 pages

Analysis of Photographic Image to Evaluate System Performance Mission 1010-1

25 September 1964

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TITLE:

Summary of Microdensitometer Derived Image Quality Data Collected from Mission 1010-1

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 80 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 0.420 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.

Analysis of Photographic Image to Evaluate System Performance

SECTION II SUMMARY SHEET

Mission 1010-1

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

Arithmetic Mean	98.5
Standard Deviation	25.1
Coefficient of Dispersion	26%
Number of Edges	94
M.I.P. Frame	135

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

Arithmetic Mean	10.7
Standard Deviation	3.1
Coefficient of Dispersion	29%
Number of Edges	94
M.I.P. Frame	7.3

Analysis of Photographic Image to Evaluate System Performance

Mission 1010-1

Section III

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M Resol
1	Fwd	D05	033	B-9	070	Dam	9.3	89
1A	Fwd	D05	033	B-9	070	Dam	7.3	108
2	Fwd	D05	033	C-9	100	Building	7.1	139
2A	Fwd	D05	033	C-9	100	Building	6.5	137
4	Fwd	D05	060	B-3	025	Airfield	8.0	112
4A	Fwd	D05	060	B-3	025	Airfield	9.5	91
5A	Fwd	D05	061	B-11	080	Airfield	7.4	118
6	Fwd	D05	062	C-5	110	Buildings next to airfield	9.0	98
7	Fwd	D05	080	C-8	160	Buildings above airfield	8.3	110
7A	Fwd	D05	080	C-8	160	Buildings above airfield	9.6	117
8	Fwd	D05	080	C-8	150	Airfield	7.7	133
8A	Fwd	D05	080	C-8	150	Airfield	9.4	93
10	Fwd	D05	085	B-10	075	Airfield	10.6	114
11A	Fwd	D07	027	C-9	155	Buildings	10.3	120
13	Fwd	D07	114	B-5	060	Small Dam	18.0	67
15	Fwd	D09	056	B-11	100	Airfield	9.5	113
15A	Fwd	D09	056	B-11	100	Airfield	7.6	117

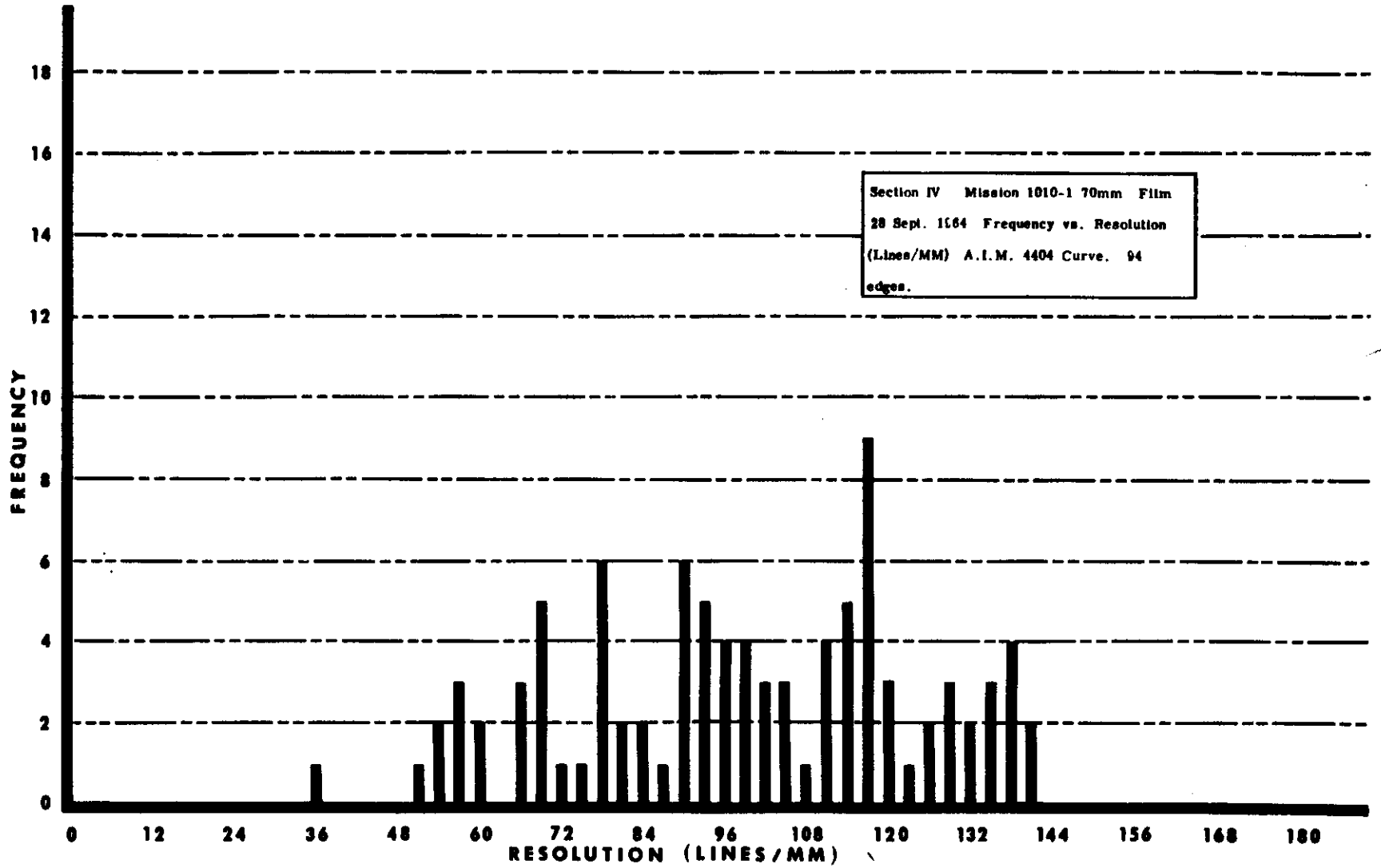
Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
16	Fwd	D09	084	A-8	075	Airfield	9.1	118
16A	Fwd	D09	084	A-8	075	Airfield	6.8	140
17	Fwd	D09	087	C-6	080	Airfield	10.0	92
17A	Fwd	D09	087	C-6	080	Airfield	15.7	58
18	Fwd	D09	097	C-3	092	Break-water	26.0	37
19	Fwd	D09	111	B-9	120	Airfield	10.5	90
19A	Fwd	D09	111	B-9	120	Airfield	9.0	102
21	Fwd	D21	114	A-9	100	Airfield	13.9	80
23	Fwd	D41	086	A-8	065	Airfield	10.4	114
23A	Fwd	D41	086	A-8	065	Airfield	8.0	111
24	Fwd	D56	137	A-8	105	Buildings next to Airfield	10.0	80
26	Fwd	D56	127	B-6	085	Airfield	11.8	70
26A	Fwd	D56	127	B-6	085	Airfield	11.8	85
27	Fwd	D41	090	A-2	075	Airfield	10.3	77
27A	Fwd	D41	090	A-2	075	Airfield	10.4	75
29	Fwd	D56	122	B-9	020	Airfield	7.6	118
29A	Fwd	D56	122	B-9	020	Airfield	8.3	118
30	Fwd	D56	105	B-11	085	Airfield	15.0	56
30A	Fwd	D56	105	B-11	085	Airfield	13.0	71
31	Fwd	D56	093	C-4	030	Airfield	13.1	65
31A	Fwd	D56	093	C-4	030	Airfield	17.8	50

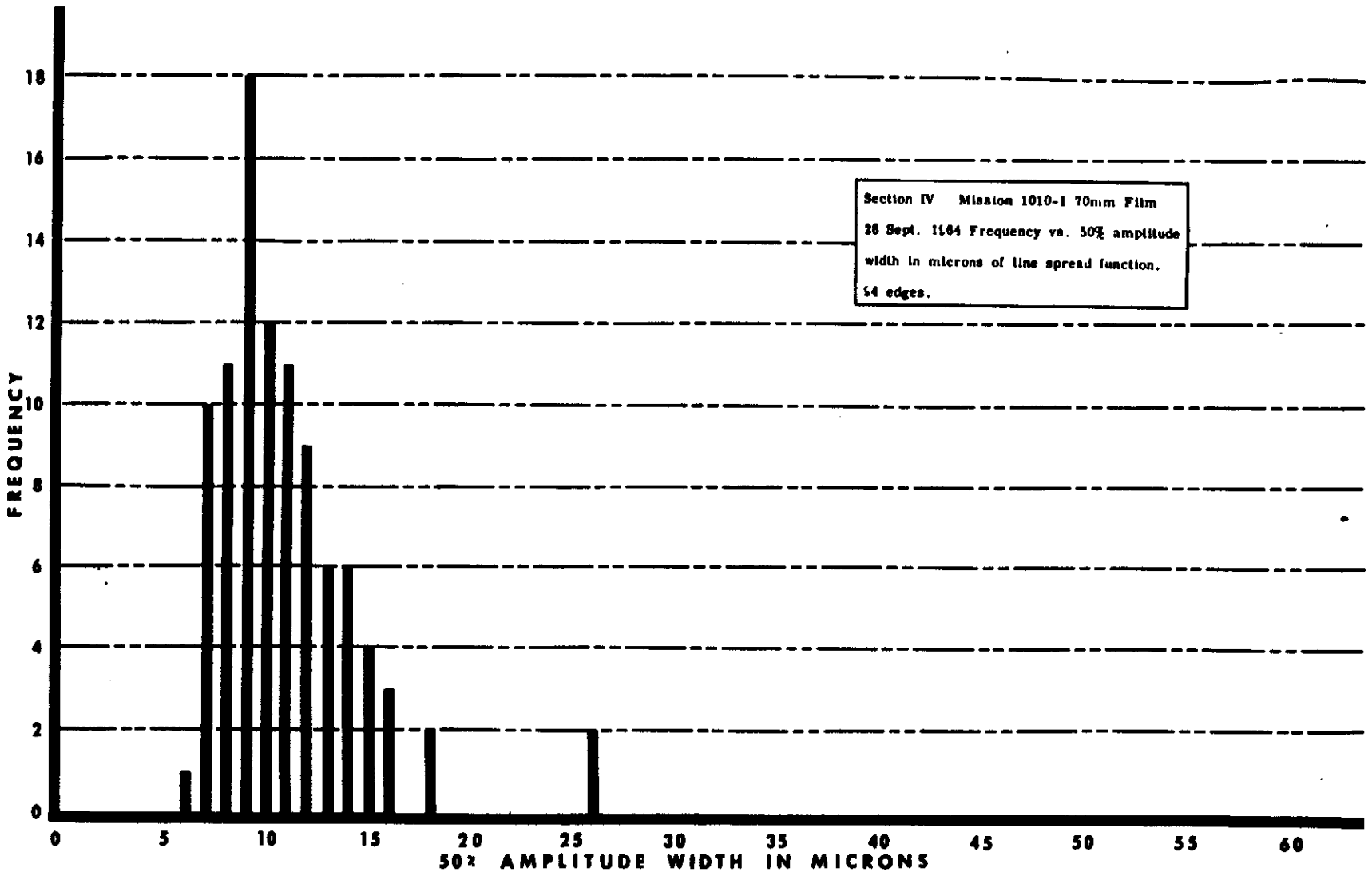
Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolutic
32	Fwd	D56	087	B-3	170	Airfield	14.3	59
32A	Fwd	D56	087	B-3	170	Airfield	11.5	67
33	Fwd	D56	065	C-6	075	Airfield	9.4	98
33A	Fwd	D56	065	C-6	075	Airfield	9.7	87
34A	Fwd	D56	127	B-6	085	Airfield	7.8	116
35A	Fwd	D56	066	A-8	100	Building next to airfield	6.9	134
*36	Fwd	D56	067	C-8	050	Airfield	9.9	79
*36A	Fwd	D56	067	C-8	050	Airfield	7.3	135
*37A	Fwd	D56	067	C-6	170	Airfield	14.6	118
38	Fwd	D56	072	B-3	075	Airfield	10.7	89
39	Aft	D05	073	B-5	155	Airfield	10.5	94
39A	Aft	D05	073	B-5	155	Airfield	11.3	128
40	Aft	D05	069	A-7	100	Airfield	10.8	83
41	Aft	D05	067	A-9	130	Buildings next to Airfield	14.5	106
41A	Aft	D05	067	A-9	130	Buildings next to Airfield	13.8	61
42	Aft	D05	066	B-4	065	Airfield	7.0	120
43	Aft	D05	065	B-11	030	Airfield	12.2	77
43A	Aft	D05	065	B-11	030	Airfield	15.0	56
44	Aft	D05	065	B-12	110	Buildings	6.8	137

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M Resolu
45	Aft	D05	038	A-6	070	Dam	6.8	10
45A	Aft	D05	038	A-6	070	Dam	12.3	9
46	Aft	D05	077	A-5	055	Dam	7.4	12
46A	Aft	D05	077	A-5	055	Dam	9.1	11
47	Aft	D05	077	B-C-2	060	Airfield	14.0	5
47A	Aft	D05	077	B-C-2	060	Airfield	9.9	10
47C	Aft	D05	077	B-C-2	060	Airfield	12.4	7
48	Aft	D05	085	A-7	140	Buildings near Airfield	12.2	12
49	Aft	D05	086	B-5	045	Airfield	11.2	7
49A	Aft	D05	086	B-5	045	Airfield	14.4	6
50	Aft	D07	036	C-8	110	Buildings near Airfield nearer lake	7.5	12
51	Aft	D09	061	B-4	090	Airfield	11.6	13
52	Aft	D09	066	A-B 3-4	110	Airfield	9.2	9
52A	Aft	D09	066	A-B 3-4	110	Airfield	7.7	13
53	Aft	D09	116	B-5	110	Airfield	9.5	12
53A	Aft	D09	116	B-5	110	Airfield	8.6	9
54	Aft	D09	112	C-2	115	Airfield	11.7	9
54A	Aft	D09	112	C-2	115	Airfield	16.0	5

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolutio
55	Aft	D09	093	B-3	075	Airfield	13.2	68
55A	Aft	D09	093	B-3	075	Airfield	12.6	98
56	Aft	D09	089	B-7	065	Airfield	12.7	79
56A	Aft	D09	089	B-7	065	Airfield	9.3	125
57	Aft	D25	116	C-6	085	Airfield	11.4	70
58A	Aft	D25	116	B-7	120	Building	9.7	104
59A	Aft	D25	109	B-9	105	Airfield	13.4	90
60	Aft	D25	089	A-6	095	Airfield	9.0	112
60A	Aft	D25	089	A-6	095	Airfield	10.0	89
61A	Aft	D25	073	C-3	090	Airfield	11.1	128
*62	Aft	D56	073	A-B-9	175	Airfield	9.4	101
63	Aft	D56	073	B-6	040	Airfield	8.1	116
63A	Aft	D56	073	B-6	040	Airfield	9.2	137
64	Aft	D56	085	C-7	165	Building	9.5	113
65	Aft	D56	093	B-11	165	Airfield	11.8	93
65A	Aft	D56	093	B-11	165	Airfield	16.1	68
66	Aft	D56	099	A-10	050	Airfield	8.5	140
66A	Aft	D56	099	A-10	050	Airfield	13.6	100
67	Aft	D56	111	A-3	075	Airfield	8.9	93

* M.I.P. Frame


Section IV Mission 1010-1 70mm Film
28 Sept. 1964 Frequency vs. Resolution
(Lines/MM) A.I.M. 4404 Curve. 94
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 1010-1 70mm Film
28 Sept. 1164 Frequency vs. 50% amplitude
width in microns of line spread function.
54 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	Number of Edges	Spread Function Width at 50% Amplitude in Microns, Computer Calculations			Resolution in lines/mm from A.I.M. 4404 Curve, Computer Calculations		
		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%
1004-1	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%
1008-1	95	10.8	3.1	29%	96.3	25.4	26%
1008-2	114	10.5	3.8	36%	97.7	24.8	25%
1009-1*	74	11.5	3.5	30%	92.2	25.2	27%
1009-2*	101	13.4	5.3	40%	83.5	26.3	31%
1010-1*	94	10.7	3.1	29%	98.5	25.1	26%

*A 1 x 80 micron slit was used.

Sensitometric Data

Mission 1010-1

Film Manufacturer: Eastman Kodak Company

Exposure Date: August 26, 1964

Emulsion No.: 4404-42

Lamp No.: 1961

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

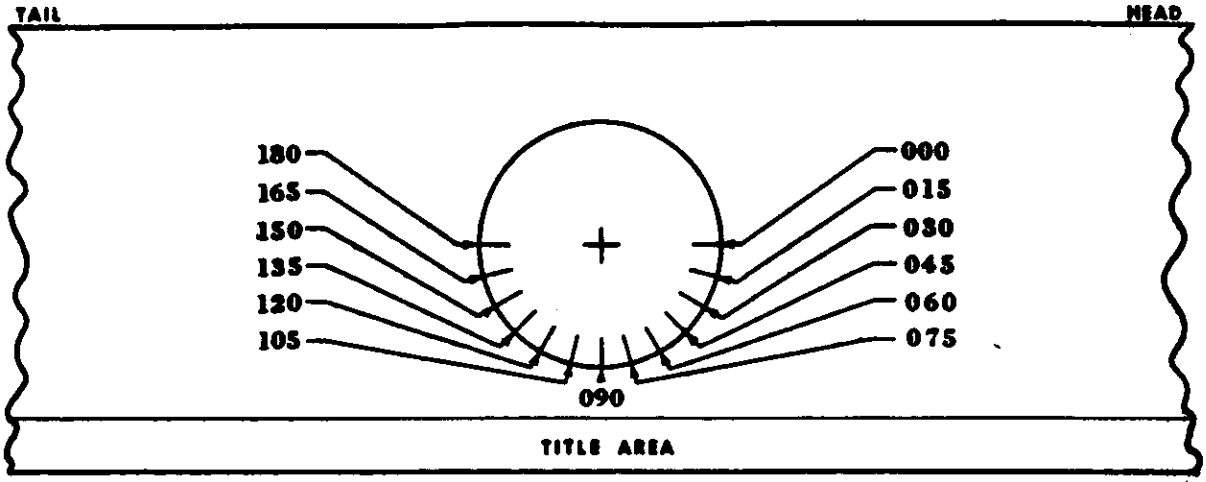
	Process Control Standard			Start Up		
	Primary	Intermed.	Full	Primary	Intermed.	Ful
Fog	.08	.10	.19	.09	.12	.1
1						
2						
3						
4						.2
5			.19		.12	.2
6		.10	.20		.13	.2
7	.08	.12	.23	.09	.14	.2
8	.10	.14	.27	.11	.16	.2
9	.12	.18	.34	.13	.20	.3
10	.16	.26	.50	.17	.28	.5
11	.24	.42	.79	.25	.41	.7
12	.38	.67	1.10	.38	.66	1.1
13	.62	1.03	1.43	.61	.98	1.4
14	.93	1.40	1.72	.89	1.34	1.7
15	1.26	1.71	1.95	1.20	1.67	1.9
16	1.55	1.95	2.13	1.51	1.91	2.1
17	1.83	2.10	2.24	1.78	2.10	2.2
18	2.04	2.22	2.30	1.98	2.23	2.3
19	2.17	2.29	2.35	2.13	2.31	2.3
20	2.25	2.34	2.39	2.24	2.37	2.4
21	2.30	2.37	2.43	2.31	2.40	2.4
∫	2.15	2.38	2.20	2.01	2.24	2.0
0.6G/Speed	1.48	1.30	1.13	1.47	1.34	1.1

	Head and Tail Forward Camera		Head and Tail Aft Camera	
	Head	Tail	Head	Tail
Fog	.19	.19	.20	.19
1				
2				
3	.19		.20	
4	.20	.19	.21	
5	.21	.20	.22	.19
6	.22	.21	.23	.20
7	.25	.23	.25	.23
8	.29	.27	.29	.27
9	.37	.36	.37	.34
10	.53	.50	.52	.50
11	.77	.75	.76	.74
12	1.08	1.04	1.05	1.04
13	1.41	1.38	1.38	1.36
14	1.69	1.65	1.64	1.64
15	1.93	1.88	1.88	1.87
16	2.10	2.06	2.06	2.05
17	2.24	2.19	2.21	2.18
18	2.33	2.29	2.31	2.28
19	2.38	2.34	2.37	2.36
20	2.42	2.38	2.40	2.38
21	2.43	2.40	2.41	2.40
$\bar{x}$	2.16	2.08	2.05	2.10
0.6G/Speed	$\bar{1}.15$	$\bar{1}.16$	$\bar{1}.14$	$\bar{1}.15$

APPENDIX "A"

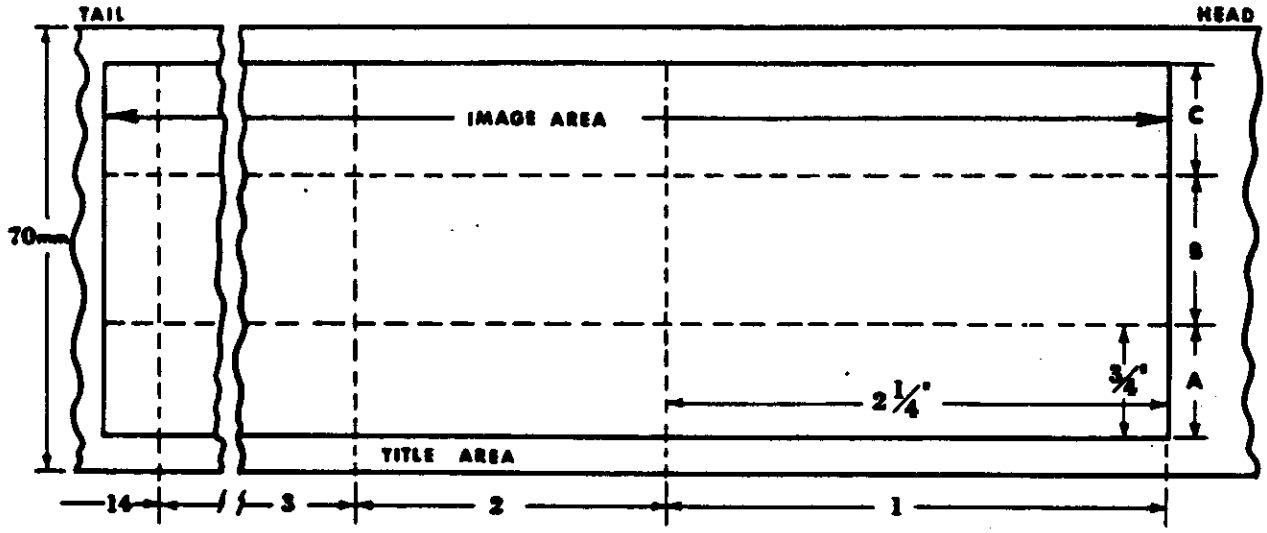
Reference System For Orientation Of C/M/J Mission Edges

original negative - - emulsion up



Grid For Position Of C/M/J Mission Edges

original negative - - emulsion up



Distribution List

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