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This document contains 20 pages

Analysis of Photographic Image to Evaluate System Performance Mission 1012-2

6 November 1964

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TITLE:

Summary of Microdensitometer Derived Image Quality Data Collected from Mission 1012-2

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 for this mission is presented in Section II, giving the arithmetic mean, standard deviation, coefficient of dispersion, and number of edges. Section IIA is included to show a statistical breakdown of the

(a) forward and aft camera quality and

(b) the analysis of buildings and airfields used as scene objects.

Section III is a summary of all C/M/J Missions traced to date. Image Quality Ranking of all C/M/J Missions is listed in Section IIIA. Frequency plots of the spread function and resolving power data are presented as Section IV, to show the distribution of values. A tabulation of the location, description, and image quality data for each edge is presented as Section V.

Appendix A is included to show the edge orientation reference system and edge location grid. In use, the film is placed on an illuminator with the titling correct reading (i.e. emulsion down) with the camera take-up end at the right and the supply at the left. The orientation of an edge is described as 000 for longitudinal and 090 for transverse edges; the numbering system runs in a clockwise direction. The coordinate locator grid consists of centimeter squares numbered such that the center of the frame is given as X46.0, Y12.0. X numbers increase toward the take-up and Y numbers increase toward the title.

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. 7044 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.

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SECTION II SUMMARY SHEET

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

Arithmetic Mean	80.2 l/mm
Standard Deviation	13.1 l/mm
Coefficient of Dispersion	16%
Number of Edges	102
M.I.P. Frame	100 l/mm

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

Arithmetic Mean	10.0 μ
Standard Deviation	3.2 μ
Coefficient of Dispersion	32%
Number of Edges	102
M.I.P. Frame	6.1 μ

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SECTION IIA SUMMARY SHEET

Mission 1012-2

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

	FWD Camera	AFT Camera	Airfields	Buildings
Arithmetic Mean	79.6	80.8	78.0	84.3
Standard Deviation	15.1	10.7	13.5	11.5
Coefficient of Dispersion	19%	13%	17%	14%
Number of Edges	53	49	66	36

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

	FWD Camera	AFT Camera	Airfields	Buildings
Arithmetic Mean	10.3	9.7	10.7	8.8
Standard Deviation	3.7	2.6	3.4	2.3
Coefficient of Dispersion	35%	26%	32%	26%
Number of Edges	53	49	66	36

SECTION III - MISSION 1012-2

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%
1010-2*	111	9.8	3.2	33%	79.6	13.1	16%
1011-1*	116	10.9	3.9	36%	76.3	15.1	20%
1012-1*	95	10.1	3.7	36%	80.4	12.7	16%
1012-2*	102	10.0	3.2	32%	80.2	13.1	16%

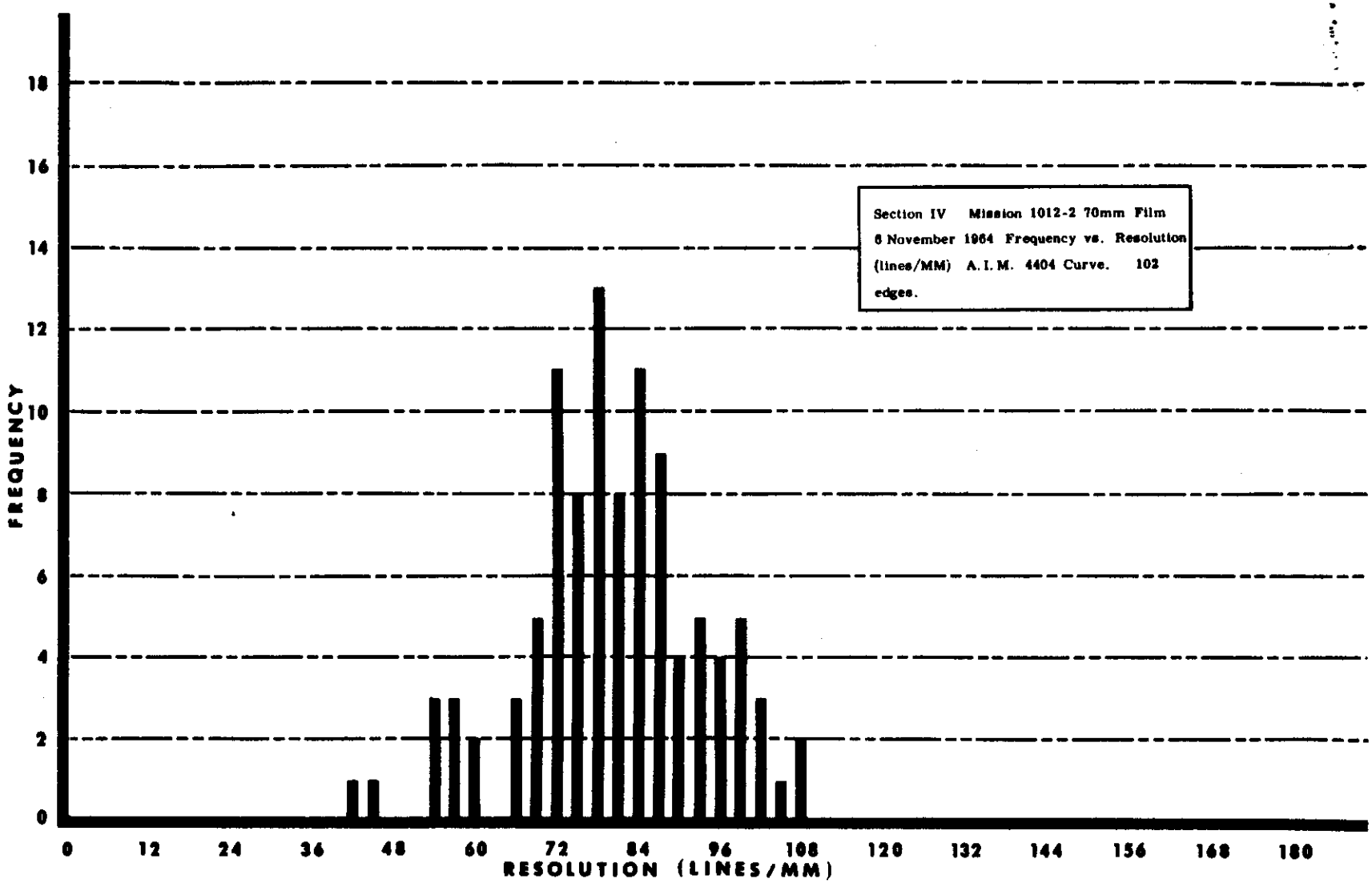
*A 1 x 80 micron slit was used.

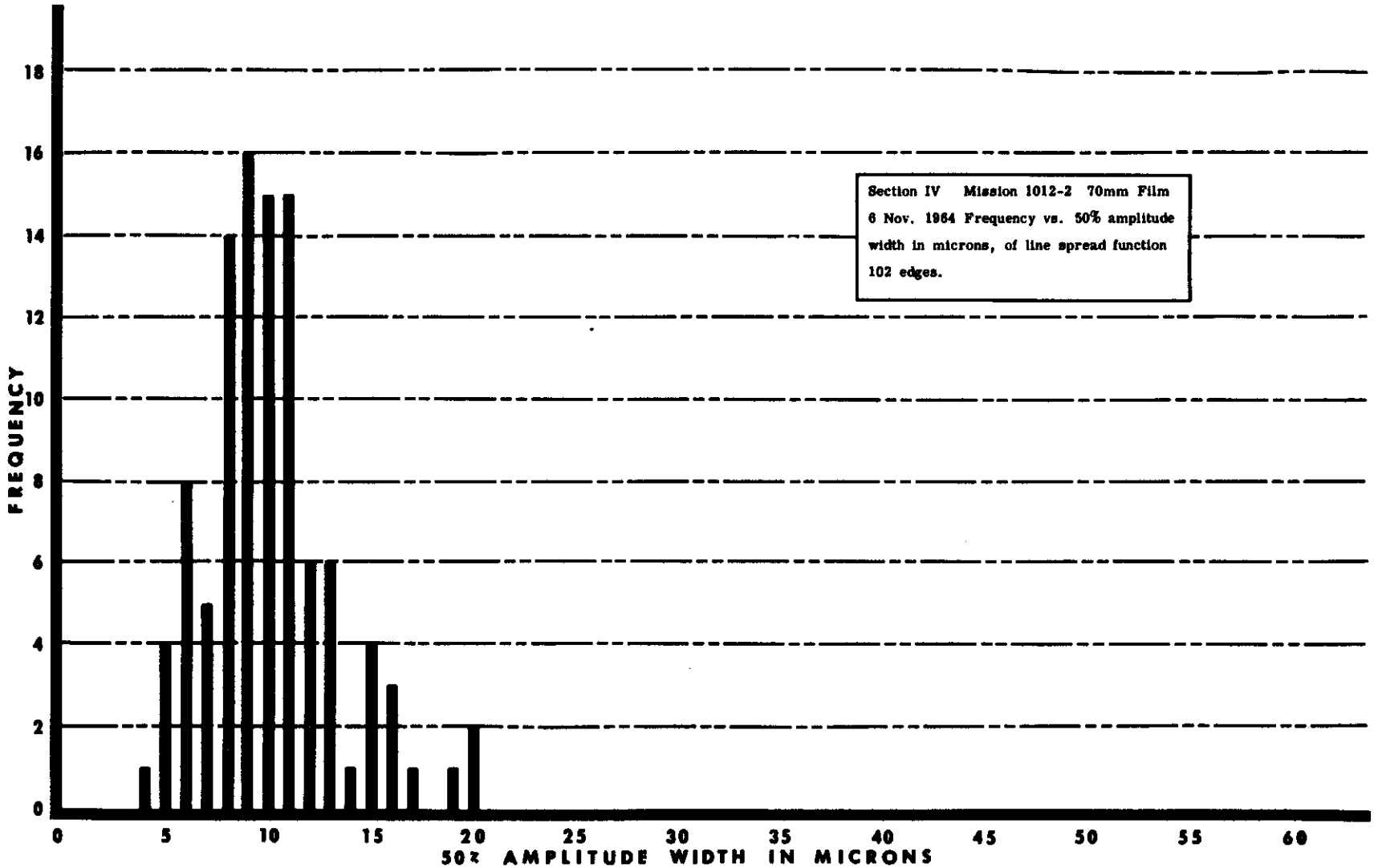
SECTION IIIA - MISSION 1012-2

Image Quality Ranking of all C/M/J Missions Traced to Date

Mission Number	Average Resolution in lines/mm for A.I.M. 4404 Curve
1004-1	115.7
1010-1	98.5
1008-2	97.7
1008-1	96.3
1009-1	92.2
1007-1	89.7
9062	89.4
1007-2	85.8
1006-2	85.5
1006-1	85.3
1004-2	84.6
1009-2	83.5
9054	81.7
9057	81.3
1012-1	80.4
1012-2	80.2
1010-2	79.6
1011-1	76.3
1001	45.9

NOTE: Since this is a research and development effort, modifications and improvements are continually being made in the methods of collecting edge data and in the computer data reduction. The quality rating of current missions may have a slightly different basis than earlier missions, which could affect the quality ranking.


Section IV Mission 1012-2 70mm Film
6 November 1964 Frequency vs. Resolution
(lines/MM) A.I.M. 4404 Curve. 102
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 1012-2 70mm Film
6 Nov. 1964 Frequency vs. 50% amplitude
width in microns, of line spread function
102 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

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Section V

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
1	Fwd	D-54	036	X38.7 Y14.2	035	Buildings	6.3	98
1A	Fwd	D-54	036	X38.7 Y14.2	035	Buildings	8.1	83
2	Fwd	D-56	069	X34.2 Y10.0	110	Airfield	19.9	68
2A	Fwd	D-56	069	X34.2 Y10.0	110	Airfield	14.8	60
3	Fwd	D-56	066	X29.5 Y13.5	035	Airfield	8.5	97
3A	Fwd	D-56	066	X29.5 Y13.5	035	Airfield	12.7	66
4	Fwd	D-56	061	X36.8 Y11.7	105	Airfield	15.8	57
4A	Fwd	D-56	061	X36.8 Y11.7	105	Airfield	12.1	67
5	Fwd	D-56	054	X68.5 Y12.3	130	Airfield	16.4	56
5A	Fwd	D-56	054	X68.5 Y12.3	130	Airfield	13.4	76
6	Fwd	D-56	052	X35.2 Y10.7	165	Airfield	9.0	82
6A	Fwd	D-56	052	X35.2 Y10.7	165	Airfield	11.3	68

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
7	Fwd	D-56	047	X49.4 Y11.2	085	Airfield	14.9	60
7A	Fwd	D-56	047	X49.4 Y11.2	085	Airfield	12.5	73
8	Fwd	D-63	017	X65.1 Y12.7	025	Buildings	5.2	108
8A	Fwd	D-63	017	X65.1 Y12.7	025	Buildings	8.6	85
9	Fwd	D-63	015	X58.0 Y12.3	025	Buildings	9.0	86
9A	Fwd	D-63	015	X58.0 Y12.3	025	Buildings	8.1	83
10	Fwd	D-63	014	X13.7 Y13.8	035	Buildings	7.7	87
10A	Fwd	D-63	014	X13.7 Y13.8	035	Buildings	6.4	103
*11	Fwd	D-63	011	X49.7 Y10.5	075	Airfield	5.0	98
*11A	Fwd	D-63	011	X49.7 Y10.5	075	Airfield	6.1	100
*12	Fwd	D-63	011	X46.1 Y11.7	065	Buildings	8.0	97
13	Fwd	D-63	010	X35.7 Y11.0	070	Airfield	5.8	97
13A	Fwd	D-63	010	X35.7 Y11.0	070	Airfield	12.5	71

*M.I.P. Frame

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
14	Fwd	D-63	010	X35.9 Y12.9	030	Buildings	6.6	97
14A	Fwd	D-63	010	X35.9 Y12.9	030	Buildings	6.8	101
15	Fwd	D-63	009	X46.4 Y14.3	025	Buildings	10.8	86
15A	Fwd	D-63	009	X46.4 Y14.3	025	Buildings	9.9	75
16	Fwd	D-63	008	X14.0 Y10.2	085	Airfield	6.8	88
16A	Fwd	D-63	008	X14.0 Y10.2	085	Airfield	8.2	93
17	Aft	D-63	022	X27.2 Y13.2	055	Buildings	10.7	80
17A	Aft	D-63	022	X27.2 Y13.2	055	Buildings	10.5	79
18	Aft	D-63	021	X32.5 Y11.5	120	Buildings	11.6	76
18A	Aft	D-63	021	X32.5 Y11.5	120	Buildings	16.7	54
*19	Aft	D-63	017	X40.5 Y13.5	070	Airfield	11.6	70
*19A	Aft	D-63	017	X40.5 Y13.5	070	Airfield	8.3	81
*19B	Aft	D-63	017	X40.5 Y13.5	070	Airfield	9.3	75

*M.I.P. Frame

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
*20	Aft	D-63	017	X44.3 Y11.8	045	Buildings	8.1	84
*20A	Aft	D-63	017	X44.3 Y11.8	045	Buildings	10.7	78
21	Aft	D-63	016	X54.8 Y12.6	070	Airfield	6.5	94
21A	Aft	D-63	016	X54.8 Y12.6	070	Airfield	6.6	101
22	Aft	D-63	016	X54.6 Y10.7	025	Buildings	8.2	81
22A	Aft	D-63	016	X54.6 Y10.7	025	Buildings	9.8	77
23	Aft	D-63	014	X77.5 Y13.4	095	Airfield	9.6	79
23A	Aft	D-63	014	X77.5 Y13.4	095	Airfield	11.3	78
23B	Aft	D-63	014	X77.5 Y13.4	095	Airfield	10.3	83
23C	Aft	D-63	014	X77.5 Y13.4	095	Airfield	15.4	54
24	Aft	D-63	008	X53.4 Y12.5	045	Buildings	8.7	78
24A	Aft	D-63	008	X53.4 Y12.5	045	Buildings	8.6	86

*M.I.P. Frame

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
25	Aft	D-52	079	X50.0 Y13.8	092	Airfield	4.2	94
25A	Aft	D-52	079	X50.0 Y13.8	092	Airfield	8.5	82
26	Aft	D-52	077	X50.7 Y11.3	090	Buildings	8.8	75
26A	Aft	D-52	077	X50.7 Y11.3	090	Buildings	5.6	99
27	Aft	D-52	070	X70.2 Y 9.8	080	Buildings	7.7	84
27A	Aft	D-52	070	X70.2 Y 9.8	080	Buildings	11.0	72
28	Aft	D-54	041	X52.3 Y14.6	045	Buildings	8.9	89
28A	Aft	D-54	041	X52.3 Y14.6	045	Buildings	9.2	78
29	Aft	D-68	072	X22.0 Y14.4	100	Airfield	9.6	90
29A	Aft	D-68	072	X22.0 Y14.4	100	Airfield	10.9	58
30	Aft	D-68	083	X42.8 Y11.8	105	Airfield	6.3	99
30A	Aft	D-68	083	X42.8 Y11.8	105	Airfield	8.5	80

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
31	Aft	D-71	085	X29.0 Y13.0	140	Airfield	5.2	104
31A	Aft	D-71	085	X29.0 Y13.0	140	Airfield	15.9	73
32	Fwd	D-52	073	X41.6 Y10.0	093	Airfield	12.4	78
32A	Fwd	D-52	073	X41.6 Y10.0	093	Airfield	7.8	85
33	Fwd	D-52	071	X39.8 Y12.3	089	Buildings	12.9	65
33A	Fwd	D-52	071	X39.8 Y12.3	089	Buildings	11.4	71
34	Fwd	D-68	066	X68.0 Y10.0	130	Airfield	20.1	43
34A	Fwd	D-68	066	X68.0 Y10.0	130	Airfield	18.8	45
35	Aft	D-56	075	X56.5 Y13.6	130	Airfield	8.8	80
35A	Aft	D-56	075	X56.5 Y13.6	130	Airfield	11.4	78
36	Aft	D-56	072	X60.6 Y10.2	040	Airfield	9.2	83
36A	Aft	D-56	072	X60.6 Y10.2	040	Airfield	9.8	90
37	Aft	D-56	067	X53.8 Y11.4	130	Airfield	9.8	79

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
37A	Aft	D-56	067	X53.8 Y11.4	130	Airfield	11.5	82
38	Fwd	D-56	079	X55.1 Y10.2	080	Airfield	11.1	73
38A	Fwd	D-56	079	X55.1 Y10.2	080	Airfield	12.1	78
39	Fwd	D-56	090	X31.3 Y13.3	075	Buildings	8.1	83
39A	Fwd	D-56	090	X31.3 Y13.3	075	Buildings	7.1	87
40	Fwd	D-56	090	X59.4 Y13.2	035	Buildings	5.0	107
40A	Fwd	D-56	090	X59.4 Y13.2	035	Buildings	7.9	86
41	Fwd	D-56	091	X28.2 Y10.0	100	Airfield	10.2	76
41A	Fwd	D-56	091	X28.2 Y10.0	100	Airfield	9.6	77
42	Fwd	D-56	106	X21.9 Y10.9	075	Airfield	9.4	76
42A	Fwd	D-56	106	X21.9 Y10.9	075	Airfield	10.6	79
42B	Fwd	D-56	106	X21.9 Y10.9	075	Airfield	10.9	70
42C	Fwd	D-56	106	X21.9 Y10.9	075	Airfield	9.1	84

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A. I. M. Resolution
43	Fwd	D-56	107	X17.8 Y13.1	075	Airfield	9.7	73
43A	Fwd	D-56	107	X17.8 Y13.1	075	Airfield	9.6	90
44	Fwd	D-56	111	X59.0 Y10.5	089	Airfield	15.3	55
44A	Fwd	D-56	111	X59.0 Y10.5	089	Airfield	11.3	72
45A	Aft	D-56	117	X31.1 Y13.5	080	Airfield	7.7	85
46	Aft	D-56	114	X78.3 Y11.8	091	Airfield	13.7	72
46A	Aft	D-56	114	X78.3 Y11.8	091	Airfield	13.2	94
47	Aft	D-56	112	X69.1 Y13.0	088	Airfield	10.6	68
47A	Aft	D-56	112	X69.1 Y13.0	088	Airfield	10.2	86
48	Aft	D-56	097	X62.5 Y13.7	100	Airfield	10.2	88
48A	Aft	D-56	097	X62.5 Y13.7	100	Airfield	10.5	72
49	Aft	D-56	096	X58.8 Y10.3	080	Buildings	9.5	75

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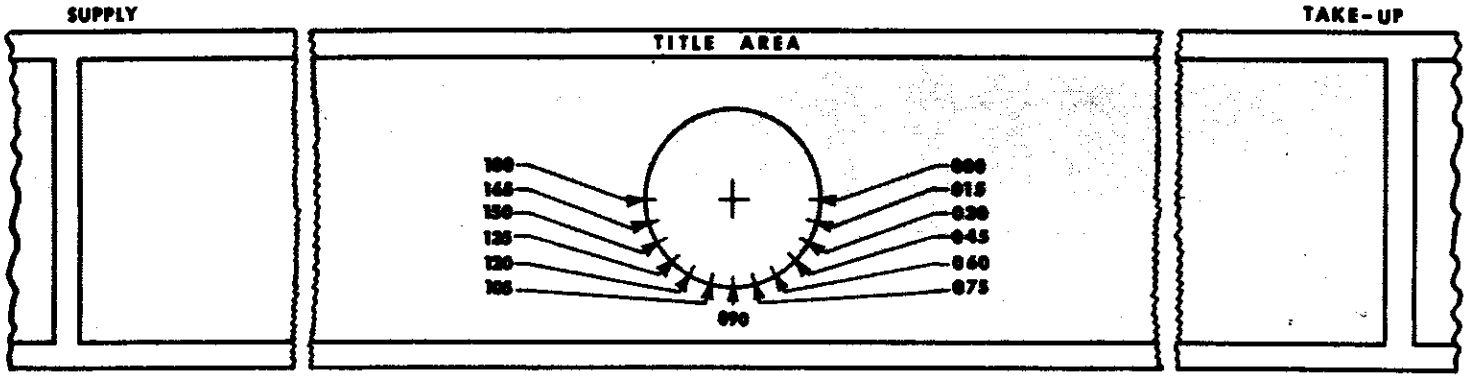
Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
50	Aft	D-56	085	X35.2 Y13.5	075	Airfield	5.9	93
50A	Aft	D-56	085	X35.2 Y13.5	075	Airfield	12.7	71

APPENDIX "A"

Reference System For Orientation Of C/M/J Mission Edges
original negative — emulsion down



Coordinate Locator Grid For C/M/J Mission Edges
original negative — emulsion down