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This document contains 17 pages

Analysis of Photographic Image to Evaluate System Performance Mission 1012-1

30 October 1964

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TITLE:

Summary of Microdensitometer Derived Image Quality Data Collected from Mission 1012-1

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 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 new 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. 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 1012-1

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

Arithmetic Mean	80.4	L/mm
Standard Deviation	12.7	L/mm
Coefficient of Dispersion	16%	
Number of Edges	95	
M.I.P. Frame	99	L/mm

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

Arithmetic Mean	10.1	μ
Standard Deviation	3.7	μ
Coefficient of Dispersion	36%	
Number of Edges	95	
M.I.P. Frame	7.1	μ

Analysis of Photographic Image to Evaluate System Performance

SECTION IIA SUMMARY SHEET

Mission 1012-1

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	79.1	82.0	79.0	81.4
Standard Deviation	14.3	10.4	14.2	11.5
Coefficient of Dispersion	18%	13%	18%	14%
Number of Edges	52	43	39	56

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

	FWD Camera	AFT Camera	Airfields	Buildings
Arithmetic Mean	10.7	9.5	10.7	9.7
Standard Deviation	4.4	2.4	4.8	2.6
Coefficient of Dispersion	41%	25%	45%	27%
Number of Edges	52	43	39	56

SECTION III - MISSION 1012-1

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%

*A 1 x 80 micron slit was used.

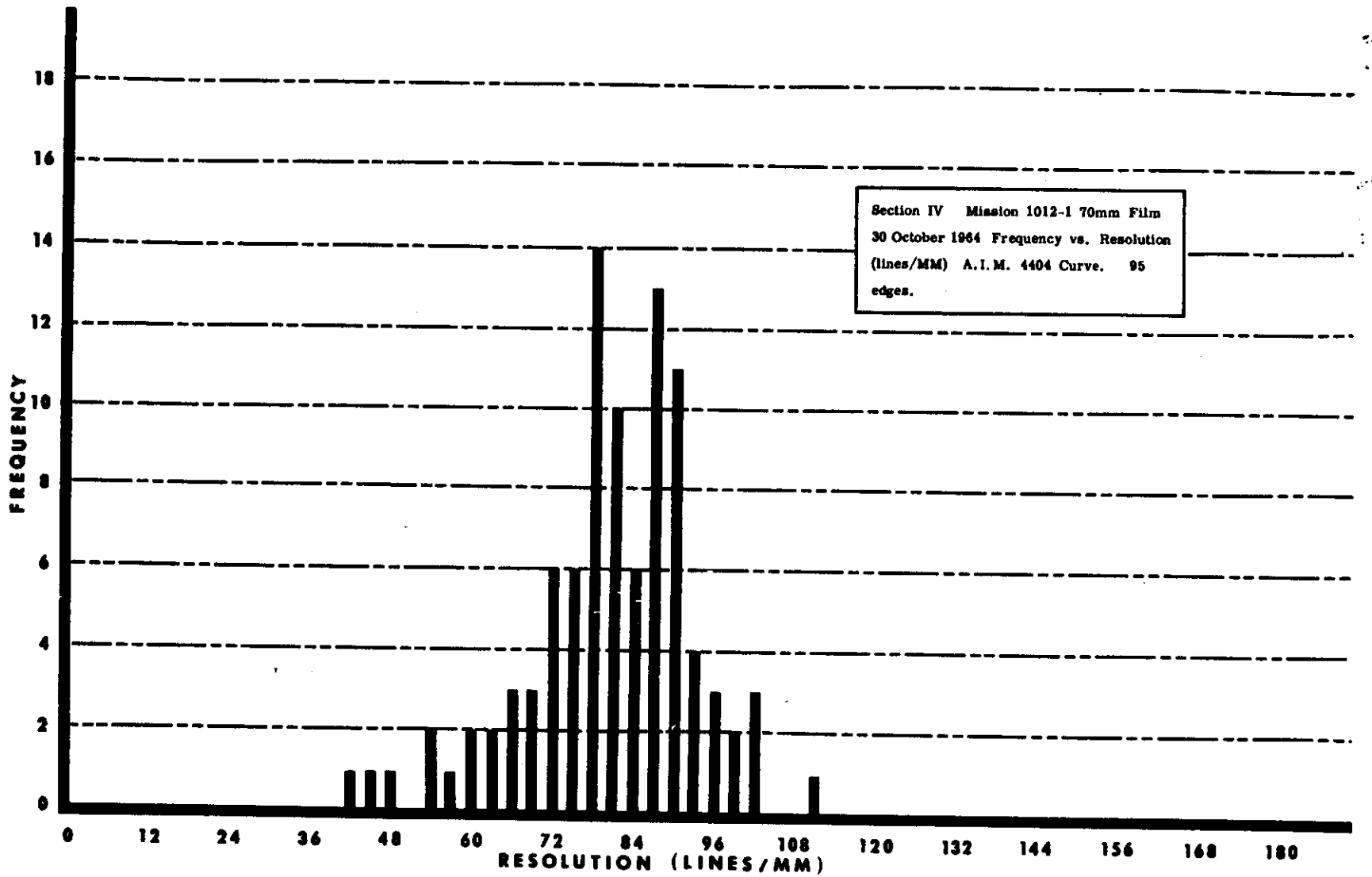
Analysis of Photographic Image to Evaluate System Performance

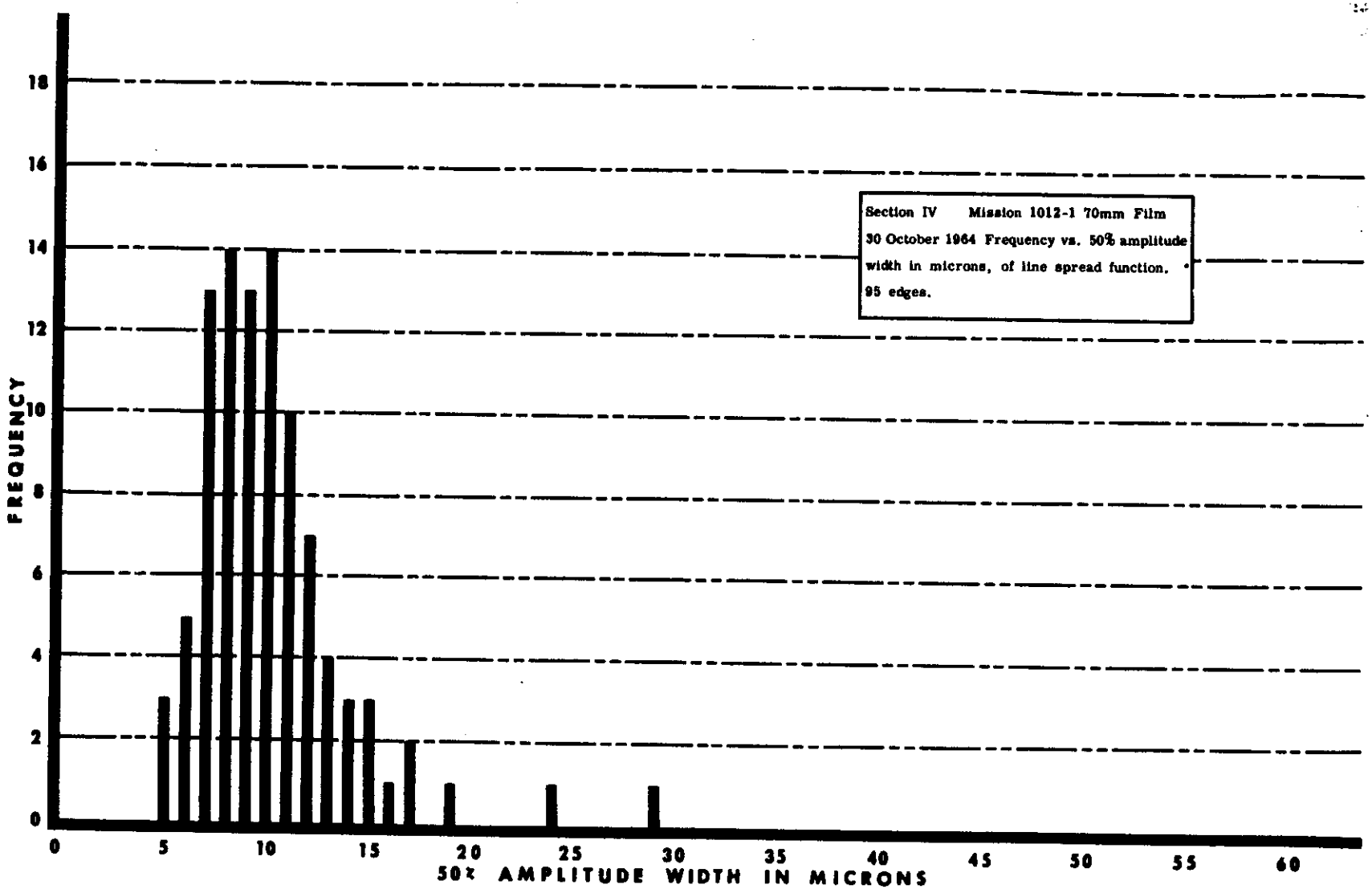
SECTION IIIA - MISSION 1012-1

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
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 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 1012-1 70mm Film
30 October 1964 Frequency vs. Resolution
(lines/MM) A.I.M. 4404 Curve. 95
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 1012-1 70mm Film
30 October 1964 Frequency vs. 50% amplitude width in microns, of line spread function.
95 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

Analysis of Photographic Image to Evaluate System Performance

Mission 1012-1

Section V

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
1	Fwd	D-04	057	X24.0 Y10.5	045	Airfield	13.5	60
1A	Fwd	D-04	057	X24.0 Y10.5	045	Airfield	5.4	89
2	Fwd	D-05	067	X18.1 Y10.6	089	Airfield	8.8	86
2A	Fwd	D-05	067	X18.1 Y10.6	089	Airfield	7.5	88
3	Fwd	D-05	066	X18.3 Y11.6	125	Airfield	11.8	71
3A	Fwd	D-05	066	X18.3 Y11.6	125	Airfield	6.0	96
4	Fwd	D-05	054	X13.8 Y11.3	110	Airfield	7.4	88
4A	Fwd	D-05	054	X13.8 Y11.3	110	Airfield	9.9	74
5	Fwd	D-05	054	X13.8 Y10.8	120	Buildings	12.6	71
5A	Fwd	D-05	054	X13.8 Y10.8	120	Buildings	7.9	91
6	Fwd	D-05	053	X74.5 Y11.0	110	Airfield	23.7	55
6A	Fwd	D-05	053	X74.5 Y11.0	110	Airfield	12.7	72

Mission 1012-1

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
7	Fwd	D-05	035	X69.0 Y13.0	070	Airfield	16.9	68
7A	Fwd	D-05	035	X69.0 Y13.0	070	Airfield	29.0	41
7B	Fwd	D-05	035	X69.0 Y13.0	070	Airfield	7.2	91
8	Fwd	D-05	029	X29.8 Y12.8	030	Buildings	11.2	67
8A	Fwd	D-05	029	X29.8 Y12.8	030	Buildings	7.6	91
8B	Fwd	D-05	029	X29.8 Y12.8	030	Buildings	6.0	103
8C	Fwd	D-05	029	X29.8 Y12.8	030	Buildings	5.3	111
8D	Fwd	D-05	029	X29.8 Y12.8	030	Buildings	10.3	79
9	Fwd	D-05	014	X42.8 Y12.1	110	Bridge	13.6	76
9A	Fwd	D-05	014	X42.8 Y12.1	110	Bridge	12.3	62
10	Aft	D-04	063	X67.8 Y13.3	045	Airfield	8.2	87
10A	Aft	D-04	063	X67.8 Y13.3	045	Airfield	12.3	73

Mission 1012-1

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
11	Aft	D-05	035	X61.3 Y10.3	030	Buildings	11.2	74
11A	Aft	D-05	035	X61.3 Y10.3	030	Buildings	9.1	79
11B	Aft	D-05	035	X61.3 Y10.3	030	Buildings	8.4	94
11C	Aft	D-05	035	X61.3 Y10.3	030	Buildings	8.7	85
12	Aft	D-05	041	X22.7 Y10.0	055	Airfield	9.0	89
12A	Aft	D-05	041	X22.7 Y10.0	055	Airfield	8.1	81
13	Aft	D-05	059	X16.8 Y12.6	110	Airfield	14.0	61
13A	Aft	D-05	059	X16.8 Y12.6	110	Airfield	11.5	69
14	Aft	D-05	060	X78.0 Y12.3	120	Airfield	7.2	89
14A	Aft	D-05	060	X78.0 Y12.3	120	Airfield	9.6	75
15	Aft	D-05	060	X70.7 Y12.5	090	Buildings	10.7	82
15A	Aft	D-05	060	X70.7 Y12.5	090	Buildings	6.4	86

Mission 1012-1

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
16	Aft	D-05	064	X42.2 Y13.3	080	Buildings	12.0	79
16A	Aft	D-05	064	X42.2 Y13.3	080	Buildings	9.2	88
17	Aft	D-05	072	X73.2 Y11.5	120	Airfield	8.5	89
17A	Aft	D-05	072	X73.2 Y11.5	120	Airfield	6.8	92
18	Aft	D-05	073	X73.7 Y12.7	097	Airfield	5.5	90
18A	Aft	D-05	073	X73.7 Y12.7	097	Airfield	11.2	78
19	Fwd	D-06	038	X41.8 Y 9.4	060	Airfield	10.4	83
19A	Fwd	D-06	038	X41.8 Y 9.4	060	Airfield	8.3	88
20	Fwd	D-47E	007	X45.3 Y12.2	060	Buildings	9.9	77
20A	Fwd	D-47E	007	X45.3 Y12.2	060	Buildings	9.2	83
*21	Fwd	D-47E	008	X40.5 Y13.5	135	Airfield	8.5	88
*21A	Fwd	D-47E	008	X40.5 Y13.5	135	Airfield	7.1	99

*M.I.P. Frame

Mission 1012-1

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. (Resolution)
22	Fwd	D-47E	008	X40.5 Y14.1	100	Buildings	10.8	78
22A	Fwd	D-47E	008	X40.5 Y14.1	100	Buildings	8.9	83
23	Fwd	D-47E	009	X48.6 Y12.1	020	Buildings	9.1	82
23A	Fwd	D-47E	009	X48.6 Y12.1	020	Buildings	7.8	88
24	Aft	D-47E	011	X45.3 Y11.3	070	Buildings	10.4	78
24A	Aft	D-47E	011	X45.3 Y11.3	070	Buildings	6.3	91
*25	Aft	D-47E	012	X49.8 Y10.0	140	Airfield	10.8	81
*25A	Aft	D-47E	012	X49.8 Y10.0	140	Airfield	14.6	55
*26	Aft	D-47E	012	X50.5 Y 9.8	100	Buildings	7.3	87
27	Aft	D-47E	013	X41.9 Y11.5	020	Buildings	9.3	77
27A	Aft	D-47E	013	X41.9 Y11.5	020	Buildings	11.2	82
28	Aft	D-47E	025	X44.3 Y14.3	080	Buildings	6.8	103

*M.I.P. Frame

Mission 1012-1

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
29	Aft	D-47E	034	X67.3 Y13.3	150	Airfield	14.6	59
29A	Aft	D-47E	034	X67.3 Y13.3	150	Airfield	9.0	77
30	Fwd	D-37	130	X38.6 Y13.4	110	Buildings	10.0	79
30A	Fwd	D-37	130	X38.6 Y13.4	110	Buildings	11.0	80
30B	Fwd	D-37	130	X38.6 Y13.4	110	Buildings	7.4	95
31	Fwd	D-37	128	X38.0 Y10.0	115	Bridge	7.6	86
31A	Fwd	D-37	128	X38.0 Y10.0	115	Bridge	19.4	47
32	Aft	D-07	101	X33.9 Y12.9	178	Buildings	7.3	89
32A	Aft	D-07	101	X33.9 Y12.9	178	Buildings	7.4	95
32B	Aft	D-07	101	X33.9 Y12.9	178	Buildings	10.1	79
33	Aft	D-07	094	X40.2 Y13.2	130	Buildings	6.6	93
33A	Aft	D-07	094	X40.2 Y13.2	130	Buildings	9.9	82
33B	Aft	D-07	094	X40.2 Y13.2	130	Buildings	9.0	78

Mission 1012-1

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
34	Fwd	D-07	079	X58.5 Y11.5	050	Buildings	17.4	46
34A	Fwd	D-07	079	X58.5 Y11.5	050	Buildings	15.8	76
35	Fwd	D-07	087	X41.3 Y12.2	110	Buildings	11.5	66
35A	Fwd	D-07	087	X41.3 Y12.2	110	Buildings	9.0	82
35B	Fwd	D-07	087	X41.3 Y12.2	110	Buildings	9.7	82
36	Fwd	D-07	088	X51.3 Y10.5	110	Buildings	12.0	73
36A	Fwd	D-07	088	X51.3 Y10.5	110	Buildings	10.3	80
36B	Fwd	D-07	088	X51.3 Y10.5	110	Buildings	10.3	75
37	Fwd	D-07	095	X57.3 Y10.7	178	Buildings	8.1	93
37A	Fwd	D-07	095	X57.3 Y10.7	178	Buildings	11.5	69
37B	Fwd	D-07	095	X57.3 Y10.7	178	Buildings	8.5	90
38	Fwd	D-08	043	X38.6 Y11.4	075	Buildings	8.3	79
38A	Fwd	D-08	043	X38.6 Y11.4	075	Buildings	9.7	84

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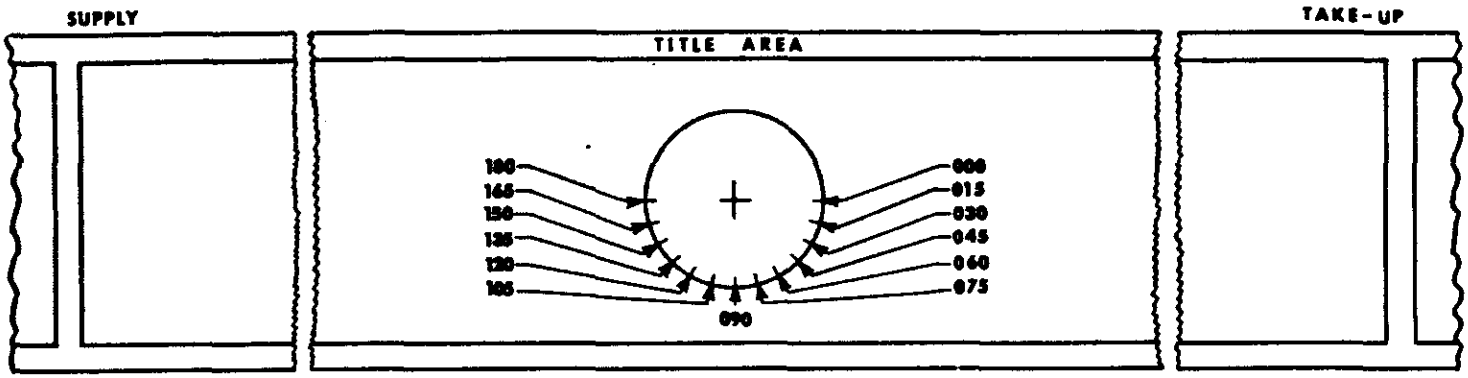
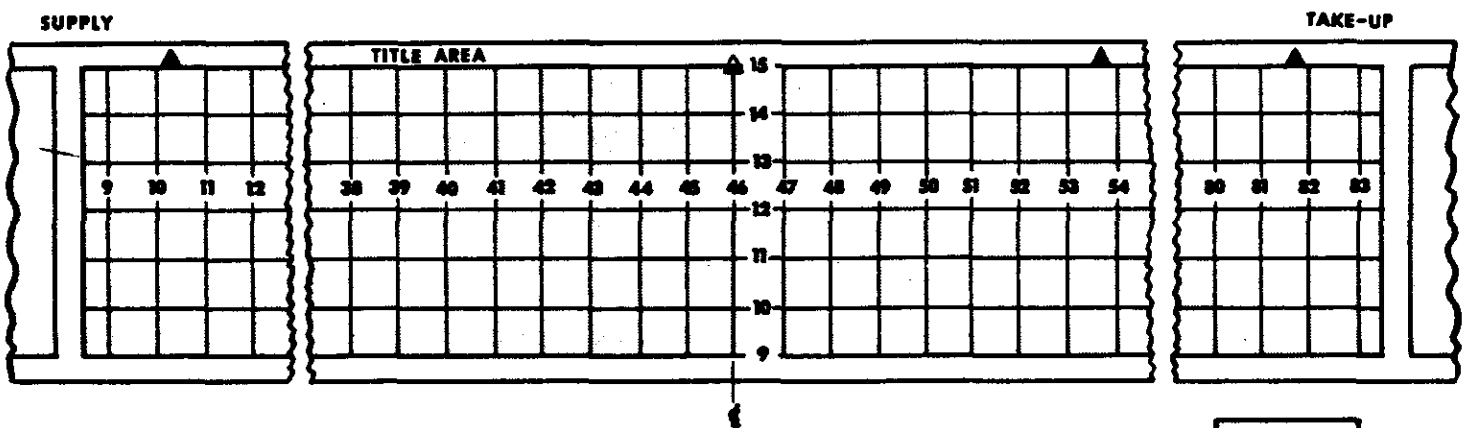
Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
39	Aft	D-06	044	X49.5 Y13.5	065	Airfield	5.9	102
39A	Aft	D-06	044	X49.5 Y13.5	065	Airfield	7.8	86
40	Aft	D-08	049	X52.3 Y11.5	080	Buildings	7.5	100
40A	Aft	D-08	049	X52.3 Y11.5	080	Buildings	11.0	72
41	Fwd	D-25	042	X80.2 Y13.6	160	Airfield	15.3	57
41A	Fwd	D-25	042	X80.2 Y13.6	160	Airfield	7.2	96
42	Aft	D-25	048	X35.0 Y12.5	030	Airfield	13.0	66
42A	Aft	D-25	048	X35.0 Y12.5	030	Airfield	13.5	63
43	Aft	D-37	127	X22.3	115	Dam	10.0	84

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



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