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This document contains 21 pages

Analysis of Photographic Image to Evaluate System Performance Mission 1011-1

21 October 1964

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TITLE:

Summary of Microdensitometer Derived Image Quality Data Collected from Mission 1011-1

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 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

Mission 1011-1

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

Arithmetic Mean	76.3
Standard Deviation	15.1
Coefficient of Dispersion	20%
Number of Edges	116
M.I.P. Frame	106

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

Arithmetic Mean	10.9
Standard Deviation	3.9
Coefficient of Dispersion	36%
Number of Edges	116
M.I.P. Frame	4.0

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SECTION IIA SUMMARY SHEET

Mission 1011-1

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	73.6	78.7	74.0	85.7
Standard Deviation	16.7	13.1	15.5	8.7
Coefficient of Dispersion	23%	17%	21%	10%
Number of Edges	56	60	94	22

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

	FWD Camera	AFT Camera	Airfields	Buildings
Arithmetic Mean	11.9	9.9	11.3	9.0
Standard Deviation	4.5	2.9	4.1	1.8
Coefficient of Dispersion	38%	29%	36%	20%
Number of Edges	56	60	94	22

Analysis of Photographic Image to Evaluate System Performance

SECTION III - MISSION 1011-1
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%

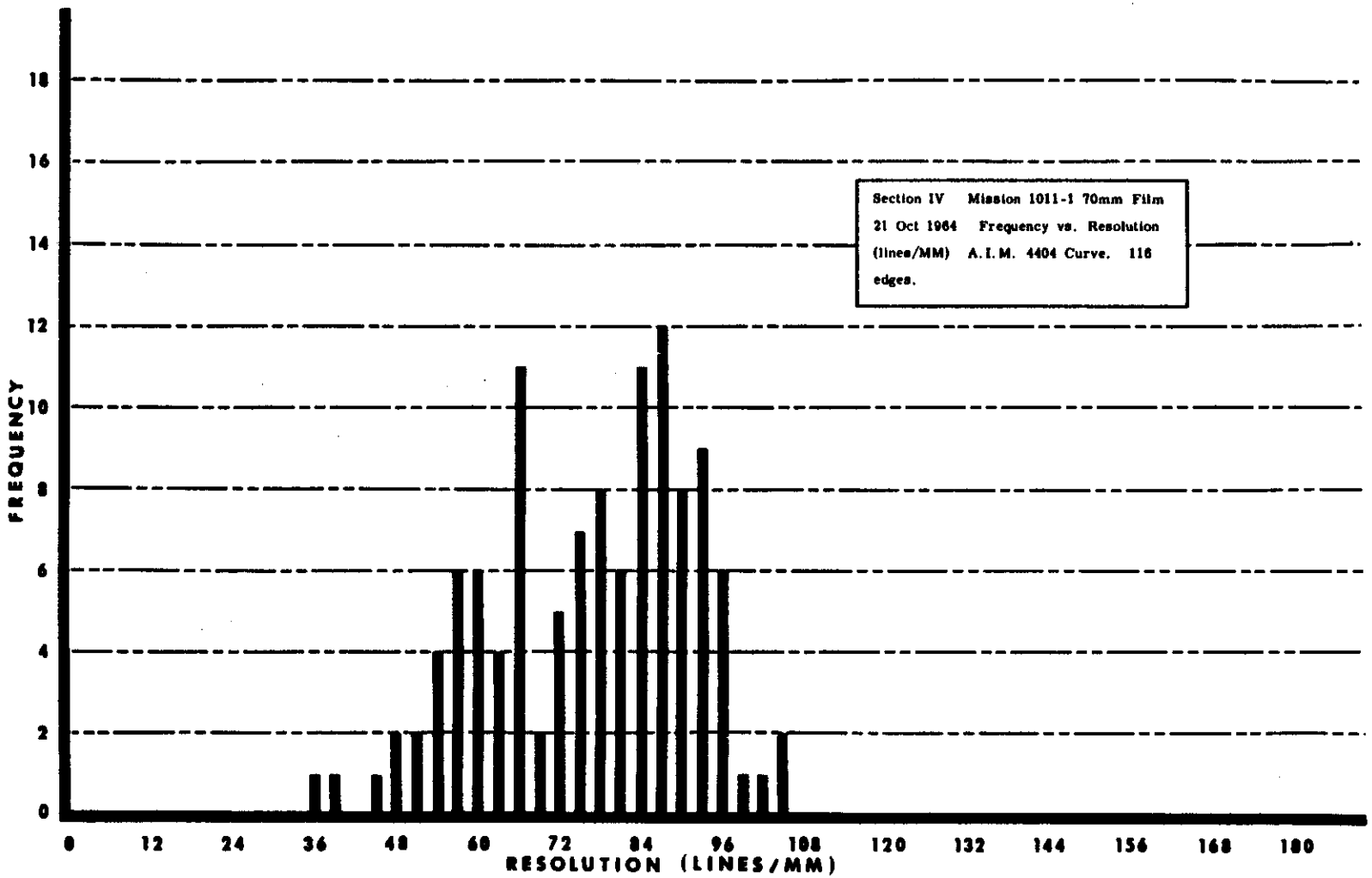
*A 1 x 80 micron slit was used.

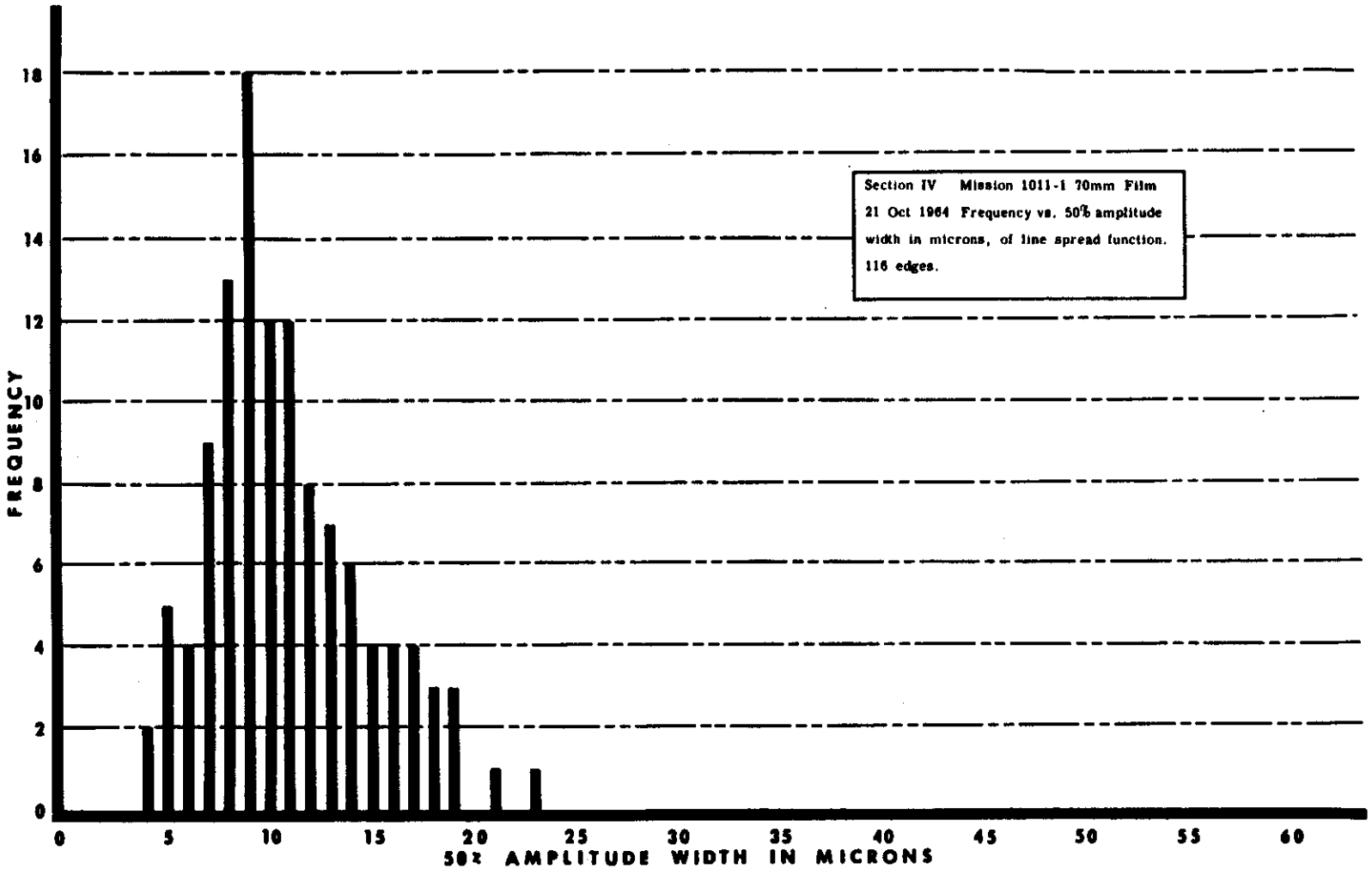
SECTION IIIA - MISSION 1011-1

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
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 1011-1 70mm Film
21 Oct 1964 Frequency vs. Resolution
(lines/MM) A.I.M. 4404 Curve. 116
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 1011-1 70mm Film
21 Oct 1964 Frequency vs. 50% amplitude
width in microns, of line spread function.
116 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	Aft	D-05	045	X29.0 Y11.8	105	Airfield	11.3	77
1A	Aft	D-05	045	X29.0 Y11.8	105	Airfield	13.7	63
2	Aft	D-05	055	X42.4 Y10.6	115	Airfield	9.5	81
2A	Aft	D-05	055	X42.4 Y10.6	115	Airfield	9.1	84
3	Aft	D-05	056	X42.0 Y 9.8	090	Buildings	9.7	83
3A	Aft	D-05	056	X42.0 Y 9.8	090	Buildings	9.9	88
3B	Aft	D-05	056	X42.0 Y 9.8	090	Buildings	9.7	84
4	Aft	D-06	039	X33.0 Y11.0	040	Buildings	7.8	88
4A	Aft	D-06	039	X33.0 Y11.0	040	Buildings	9.7	83
5	Aft	D-06	105	X70.5 Y13.5	150	Airfield	9.3	88
5A	Aft	D-06	105	X70.5 Y13.5	150	Airfield	9.3	88
6	Aft	D-06	166	X66.6 Y13.0	065	Airfield	9.7	77

Mission 1011-1

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
6A	Aft	D-06	166	X66.6 Y13.0	065	Airfield	12.4	64
7	Fwd	D-05	040	X61.6 Y12.6	060	Airfield	17.2	49
7A	Fwd	D-05	040	X61.6 Y12.6	060	Airfield	17.1	54
8	Fwd	D-05	047	X64.6 Y13.5	130	Airfield	13.7	66
8A	Fwd	D-05	047	X64.6 Y13.5	130	Airfield	15.3	57
9	Fwd	D-05	050	X48.0 Y11.0	115	Airfield	7.7	93
9A	Fwd	D-05	050	X48.0 Y11.0	115	Airfield	9.3	87
10	Fwd	D-05	051	X48.3 Y12.3	090	Buildings	10.5	79
10A	Fwd	D-05	051	X48.3 Y12.3	090	Buildings	12.2	66
10B	Fwd	D-05	051	X48.3 Y12.3	090	Buildings	11.0	78
11	Fwd	D-06	034	X33.3 Y13.2	075	2 long Bldgs.	11.3	92
11A	Fwd	D-06	034	X33.3 Y13.2	075	2 long Bldgs.	7.9	97

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
12	Fwd	D-06	034	X53.4 Y10.3	040	Buildings	7.7	91
12A	Fwd	D-06	034	X53.4 Y10.3	040	Buildings	9.3	86
13	Fwd	D-06	102	X20.7 Y11.3	145	Airfield	7.4	95
13A	Fwd	D-06	102	X20.7 Y11.3	145	Airfield	7.1	96
14	Fwd	D-06	165	X24.0 Y12.6	065	Airfield	12.3	66
14A	Fwd	D-06	165	X24.0 Y12.6	065	Airfield	7.3	94
15	Fwd	D-09	010	X63.5 X12.2	015	Airfield	13.8	59
15A	Fwd	D-09	010	X63.5 Y12.2	015	Airfield	16.3	50
16	Fwd	D-09	026	X67.2 Y13.5	075	Airfield	18.2	60
16A	Fwd	D-09	026	X67.2 Y13.5	075	Airfield	17.0	65
17	Fwd	D-09	027	X64.3 Y12.2	065	Airfield	11.8	71
17A	Fwd	D-09	027	X64.3 Y12.2	065	Airfield	14.8	57

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Altitude Spread Function Width (Microns)	A.I.M. Resolution
18	Fwd	D-09	029	X25.3 Y10.8	070	Airfield	16.7	71
18A	Fwd	D-09	029	X25.3 Y10.8	070	Airfield	8.5	86
19	Fwd	D-09	030	X64.0 Y14.0	135	Airfield	6.3	90
19A	Fwd	D-09	030	X64.0 Y14.0	135	Airfield	9.0	83
20	Fwd	D-09	046	X50.0 Y10.5	125	Airfield	16.2	60
20A	Fwd	D-09	046	X50.0 Y10.5	125	Airfield	11.1	76
21	Fwd	D-09	047	X33.8 Y13.2	105	Airfield	9.2	76
21A	Fwd	D-09	047	X33.8 Y13.2	105	Airfield	8.4	90
22	Fwd	D-09	050	X17.4 Y11.0	115	Airfield	7.3	86
22A	Fwd	D-09	050	X17.4 Y11.0	115	Airfield	4.7	99
23	Fwd	D-24	070	X40.8 Y10.4	060	Airfield	19.4	59
23A	Fwd	D-24	070	X40.8 Y10.4	060	Airfield	8.9	84

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
*24	Fwd	D-24	071	X41.7 Y13.4	100	Airfield	10.8	87
24A	Fwd	D-24	071	X41.7 Y13.4	100	Airfield	10.1	78
*25	Fwd	D-24	071	X47.0 Y11.8	025	Airfield	12.3	94
25A	Fwd	D-24	071	X47.0 Y11.8	025	Airfield	7.7	88
26	Fwd	D-24	077	X19.4 Y10.3	055	Airfield	8.9	66
26A	Fwd	D-24	077	X19.4 Y10.3	055	Airfield	19.3	58
27	Aft	D-09	031	X56.5 Y10.6	130	Airfield	6.8	89
27A	Aft	D-09	031	X56.5 Y10.6	130	Airfield	8.2	97
28	Aft	D-09	034	X65.6 Y12.5	070	Airfield	9.4	76
28A	Aft	D-09	034	X65.6 Y12.5	070	Airfield	10.8	75
29	Aft	D-09	048	X25.5 Y11.5	055	Airfield	18.5	44
29A	Aft	D-09	048	X25.5 Y11.5	055	Airfield	12.8	74
30	Aft	D-09	049	X36.5 Y14.5	100	Airfield	9.2	81

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A. I. M. Resolution
30A	Aft	D-09	049	X36.5 Y14.5	100	Airfield	14.8	59
31	Aft	D-09	051	X56.5 Y13.6	115	Airfield	9.1	78
31A	Aft	D-09	051	X56.5 Y13.6	115	Airfield	5.4	95
32	Aft	D-09	055	X73.4 Y10.5	135	Airfield	11.8	64
32A	Aft	D-09	055	X73.4 Y10.5	135	Airfield	14.1	54
*33	Aft	D-24	074	X48.8 Y12.9	105	Airfield	17.8	58
33A	Aft	D-24	074	X48.8 Y12.9	105	Airfield	5.7	90
*34	Aft	D-24	074	X43.5 Y14.5	140	Airfield	6.3	93
34A	Aft	D-24	074	X43.5 Y14.5	140	Airfield	4.0	106
35	Aft	D-24	081	X71.5 Y10.5	035	Airfield	13.8	64
35A	Aft	D-24	081	X71.5 Y10.5	035	Airfield	9.1	80
36	Fwd	D-40	055	X67.5 Y13.5	095	Airfield	15.1	50

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
36A	Fwd	D-40	055	X67.5 Y13.5	095	Airfield	13.4	57
37	Fwd	D-40	053	X32.0 Y12.5	028	Airfield	16.0	53
37A	Fwd	D-40	053	X32.0 Y12.5	028	Airfield	6.3	87
38	Fwd	D-40	049	X13.5 Y15.8	115	Airfield	12.2	67
38A	Fwd	D-40	049	X13.5 Y15.8	115	Airfield	12.5	66
39	Fwd	D-40	047	X50.3 Y10.8	115	Airfield	15.6	53
39A	Fwd	D-40	047	X50.3 Y10.8	115	Airfield	8.7	86
40	Fwd	D-40	045	X18.5 Y13.5	035	Large Bldg.	10.0	80
41	Fwd	D-40	039	X43.0 Y11.5	030	Airfield	23.5	37
41A	Fwd	D-40	039	X43.0 Y11.5	030	Airfield	21.5	47
42	Fwd	D-40	034	X23.3 Y12.6	150	Airfield	19.3	39
42A	Fwd	D-40	034	X23.3 Y12.6	150	Airfield	5.5	90
43	Fwd	D-40	031	X25.5 Y11.3	090	Airfield	4.5	93

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Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
43A	Fwd	D-40	031	X25.5 Y11.3	090	Airfield	10.1	80
44	Aft	D-25	023	X66.0 Y13.4	092	Airfield	12.8	66
44A	Aft	D-25	023	X66.0 Y13.4	092	Airfield	7.0	91
45	Aft	D-25	025	X68.5 Y12.5	092	Airfield	13.1	66
45A	Aft	D-25	025	X68.5 Y12.5	092	Airfield	7.3	93
46	Aft	D-25	042	X44.0 Y12.8	080	Airfield	8.1	83
46A	Aft	D-25	042	X44.0 Y12.8	080	Airfield	14.0	56
47	Aft	D-25	043	X70.8 Y13.7	055	Airfield	11.2	70
47A	Aft	D-25	043	X70.8 Y13.7	055	Airfield	8.8	89
48	Aft	D-30	045	X55.5 Y12.5	015	Bridge	4.9	102
48A	Aft	D-30	045	X55.5 Y12.5	015	Bridge	8.7	84
49	Aft	D-30	043	X66.6 Y13.2	130	Bridge	8.3	84
49A	Aft	D-30	043	X66.6 Y13.2	130	Bridge	10.8	84

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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-30	038	X46.8 Y12.2	070	Buildings	7.5	88
51	Aft	D-30	025	X45.8 Y12.3	065	Buildings	9.2	75
51A	Aft	D-30	025	X45.8 Y12.3	065	Buildings	8.5	77
51B	Aft	D-30	025	X45.8 Y12.3	065	Buildings	5.1	104
52	Aft	D-30	021	X54.2 Y13.9	130	Airfield	11.2	71
52A	Aft	D-30	021	X54.2 Y13.9	130	Airfield	8.4	73
53	Aft	D-30	011	X61.3 Y14.4	145	Airfield	10.4	81
53A	Aft	D-30	011	X61.3 Y14.4	145	Airfield	13.2	67
54	Aft	D-40	052	X40.2 Y11.2	110	Airfield	11.2	69
54A	Aft	D-40	052	X40.2 Y11.2	110	Airfield	6.9	92
55	Aft	D-40	049	X72.7 Y13.3	035	Large Bldgs.	8.9	93
56	Aft	D-40	046	X40.2 Y11.6	090	Airfield	9.5	74
56A	Aft	D-40	046	X40.2 Y11.6	090	Airfield	7.4	95

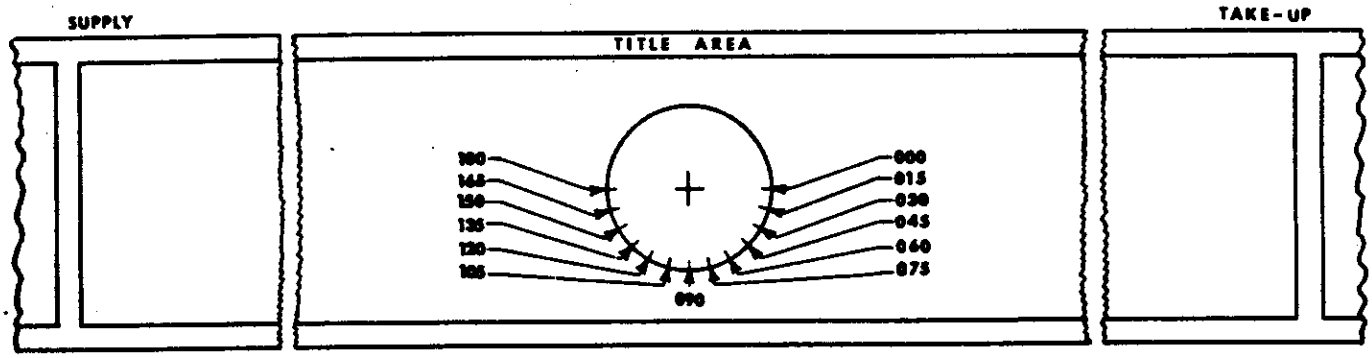
Mission 1011-1

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width Microns	A.I.M. Resolution
57	Aft	D-40	039	X67.5 Y10.5	145	Airfield	12.7	59
57A	Aft	D-40	039	X67.5 Y10.5	145	Airfield	10.6	71
58	Aft	D-40	036	X65.1 Y12.3	095	Airfield	8.4	84
58A	Aft	D-40	036	X65.1 Y12.3	095	Airfield	11.7	66

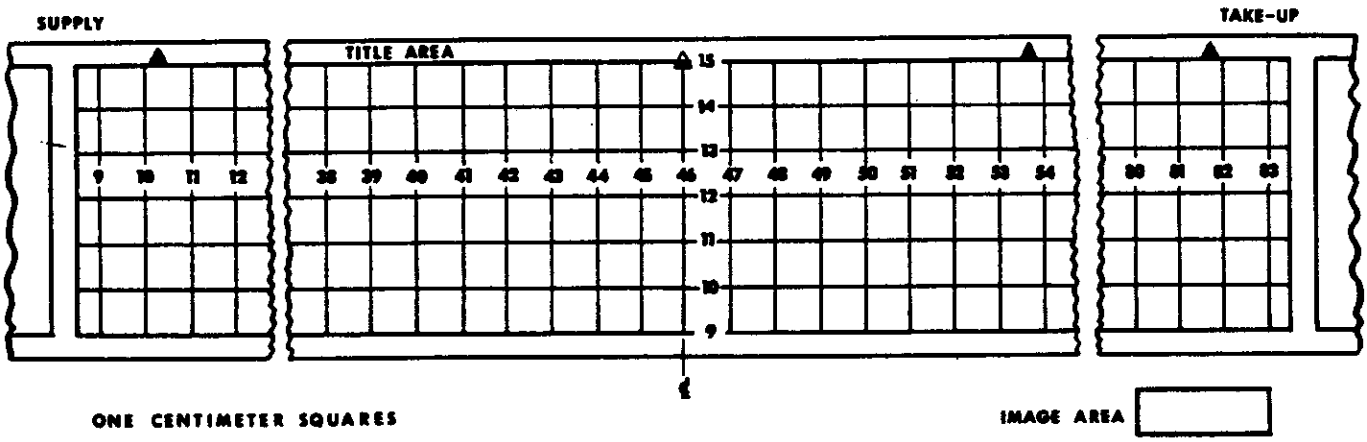
*M.I.P. Frame

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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