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Analysis of Photographic Image to Evaluate System Performance

Mission 1018-2

21 April 1965

Analysis of Photographic Image to Evaluate System Performance

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Mission 1018-2

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TITLE:

Summary of Microdensitometer Derived Image Quality Data Collected from Mission 1018-2.

SECTION I: INTRODUCTION

The normal quality evaluation of a photographic reconnaissance mission is based on a subjective judgment of the ground detail resolved on the film. In an attempt to find an objective measurement technique for image evaluation, the microdensitometer has been used to scan sharp scene edges present on the film. An illustration showing the conversion of a scene edge to M.T.F. and spread function is presented in Section IA.

Edges suitable for use in microdensitometer edge tracing should fulfill the criteria of the mathematical unit step function. In practice, the following restrictions are placed on the edges selected for tracing.

(1) The edge should appear sharp visually at 100X magnification. Additionally, the two density levels extending away from the edge should be uniform for several resolution widths (15 or more microns on each side of the edge).

The minimum length of an edge is 150 μ. The most common type of scene edge having these characteristics is found in the image of the roof of a large industrial building; ventilators, etc. must be avoided.

(2) The contrast of the edge must be high enough so that the edge can be readily aligned in the microdensitometer and yet not be of such high contrast that bleeding or halation is present.

(3) The subject must be free of cloud cover and cloud shadows and have a minimum amount of haze.

(4) The first 5 frames after each camera start up and the last 5 frames before shut down are avoided.

(5) Two inches from each end of the frame are not used.

(6) Subjects which occur in areas of soft spots or minus density are not used.

(7) Within acceptable portions of the frame there are no limitations nor restrictions on the location or orientation of the edge.

Three or more separate random sections of each edge are traced. Multiple tracings are made without changing focus or edge alignment.

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 forward and aft camera quality.

Section III is a summary of all C/M/J Missions that have been recomputed with the new SWRDR computer program. Image Quality Ranking of all C/M/J Missions is listed in Section IIIA. A summary of the P.I. rating and the computed values for the M.I.P. frame is listed in Section IIIB. 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 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 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

Each edge was traced three to five times on the microdensitometer The computed spread function widths and resolutions of the individual tracings and the averaged values for each edge are presented in Section V.

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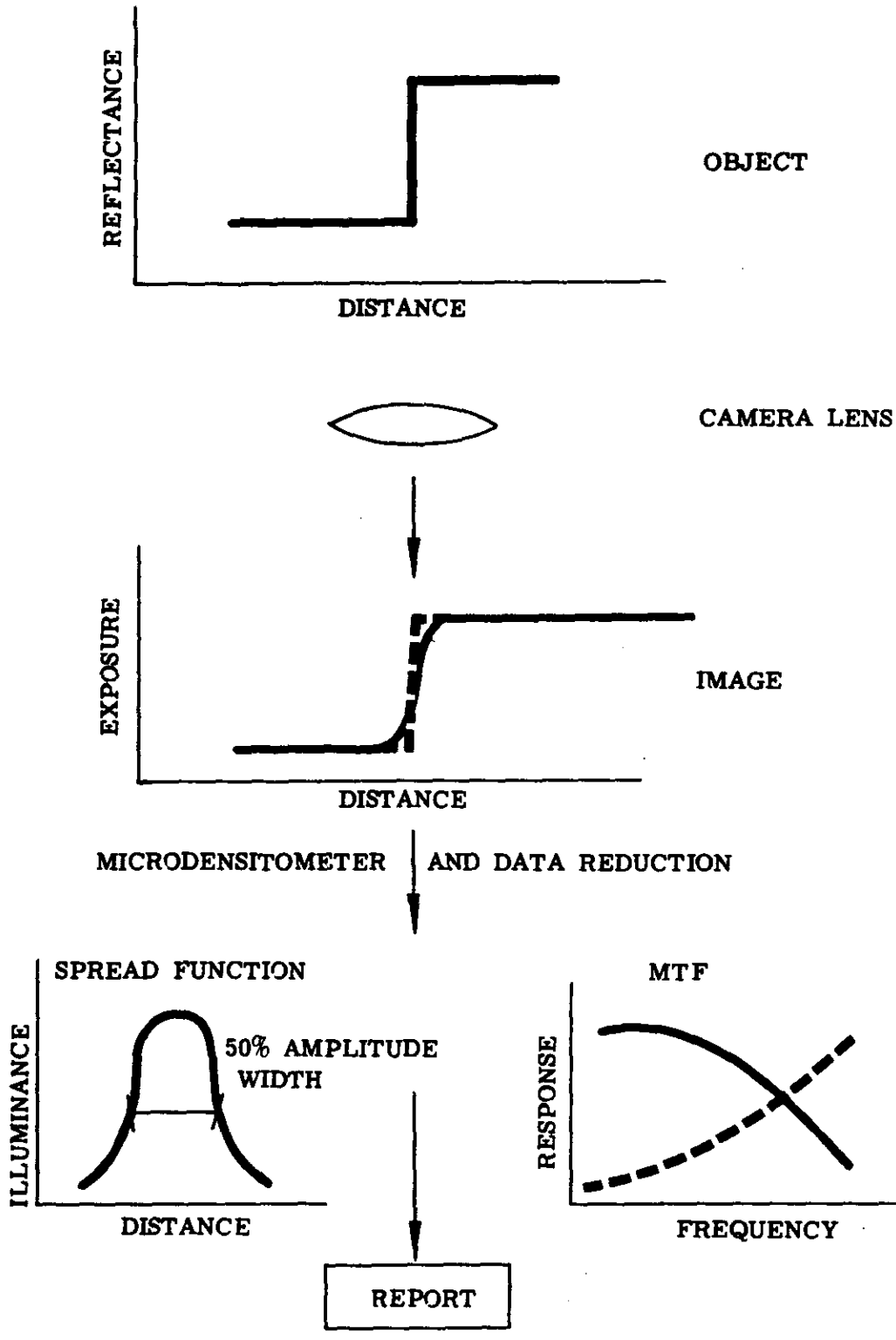
SECTION IA

Conversion of Scene Edge to MTF and Spread Function



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SECTION II SUMMARY SHEET

Mission 1018-2

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

Arithmetic Mean	84.8 l/mm
Standard Deviation	17.4 l/mm
Coefficient of Dispersion	21%
Number of Edges	44
M.I.P. Frame	90

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

Arithmetic Mean	10.1 μ
Standard Deviation	2.4 μ
Coefficient of Dispersion	23%
Number of Edges	44
M.I.P. Frame	9.7 μ

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SECTION IIA SUMMARY SHEET

Mission 1018-2

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

	FWD Camera	AFT Camera
Arithmetic Mean	77.8 l/mm	90.6 l/mm
Standard Deviation	16.7 l/mm	16.0 l/mm
Coefficient of Dispersion	21%	18%
Number of Edges	20	24

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

	FWD Camera	AFT Camera
Arithmetic Mean	11.2 μ	9.2 μ
Standard Deviation	2.3 μ	2.0 μ
Coefficient of Dispersion	21%	22%
Number of Edges	20	24

SECTION III - MISSION 1018-2

Summary of all C/M/J Missions Traced and Computed
With the New SWRDR Computer Program

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
1007-2*	106	12.2	3.9	32%	71.0	18.0	25%
1008-1*	103	10.6	3.2	30%	83.0	21.1	25%
1008-2*	123	10.2	3.9	38%	84.3	21.0	25%
1009-1	80	11.7	4.2	36%	75.3	19.9	26%
1009-2	110	13.0	5.0	39%	74.1	21.7	29%
1010-1	119	9.8	3.3	33%	89.4	22.7	25%
1010-2	110	9.8	3.2	32%	84.3	21.4	25%
1011-1	115	10.9	3.8	35%	80.5	21.6	27%
1012-1	94	10.1	3.7	36%	86.1	20.4	24%
1012-2	100	10.2	3.1	31%	84.0	21.4	26%
1013-1	49	10.8	4.1	38%	83.3	27.3	33%
1014-1	92	10.8	4.5	41%	83.0	24.7	30%
1014-2	90	11.7	3.9	34%	74.2	20.1	27%
1015-1	35**	8.8	2.3	26%	93.1	16.5	18%
1015-2	40**	9.2	2.3	25%	89.7	17.8	20%
1016-1	31**	9.7	2.3	24%	88.0	18.6	21%
1016-2	33**	9.8	3.2	32%	91.5	16.1	18%
1017-1	42**	10.2	3.5	34%	86.6	18.8	22%
1017-2	45**	11.4	3.6	31%	82.2	17.8	22%
1018-1	34**	9.6	2.5	26%	88.7	18.3	21%
1018-2	44**	10.1	2.4	23%	84.8	17.4	21%

*A 1 x 320 micron slit was used

**Each edge was traced three or more times on the microdensitometer

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SECTION IIIA - MISSION 1018-2

Image Quality Ranking of C/M/J Missions

Mission Number	Average Resolution in lines/mm for A.I.M. 4404 Curve
1015-1	93.1 l/mm
1016-2	91.5 l/mm
1015-2	89.7 l/mm
1010-1	89.4 l/mm
1018-1	88.7 l/mm
1016-1	88.0 l/mm
1017-1	86.6 l/mm
1012-1	86.1 l/mm
1018-2	84.8 l/mm
1008-2	84.3 l/mm
1010-2	84.3 l/mm
1012-2	84.0 l/mm
1013-1	83.3 l/mm
1008-1	83.0 l/mm
1014-1	83.0 l/mm
1017-2	82.2 l/mm
1011-1	80.5 l/mm
1009-1	75.3 l/mm
1014-2	74.2 l/mm
1009-2	74.1 l/mm
1007-2	71.0 l/mm

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. Caution is advised in making system comparisons based on lines per millimeter resolution or spread function width until better methods become available for calibration of the edge tracing technique.

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SECTION IIIB M.I.P. SUMMARY SHEET
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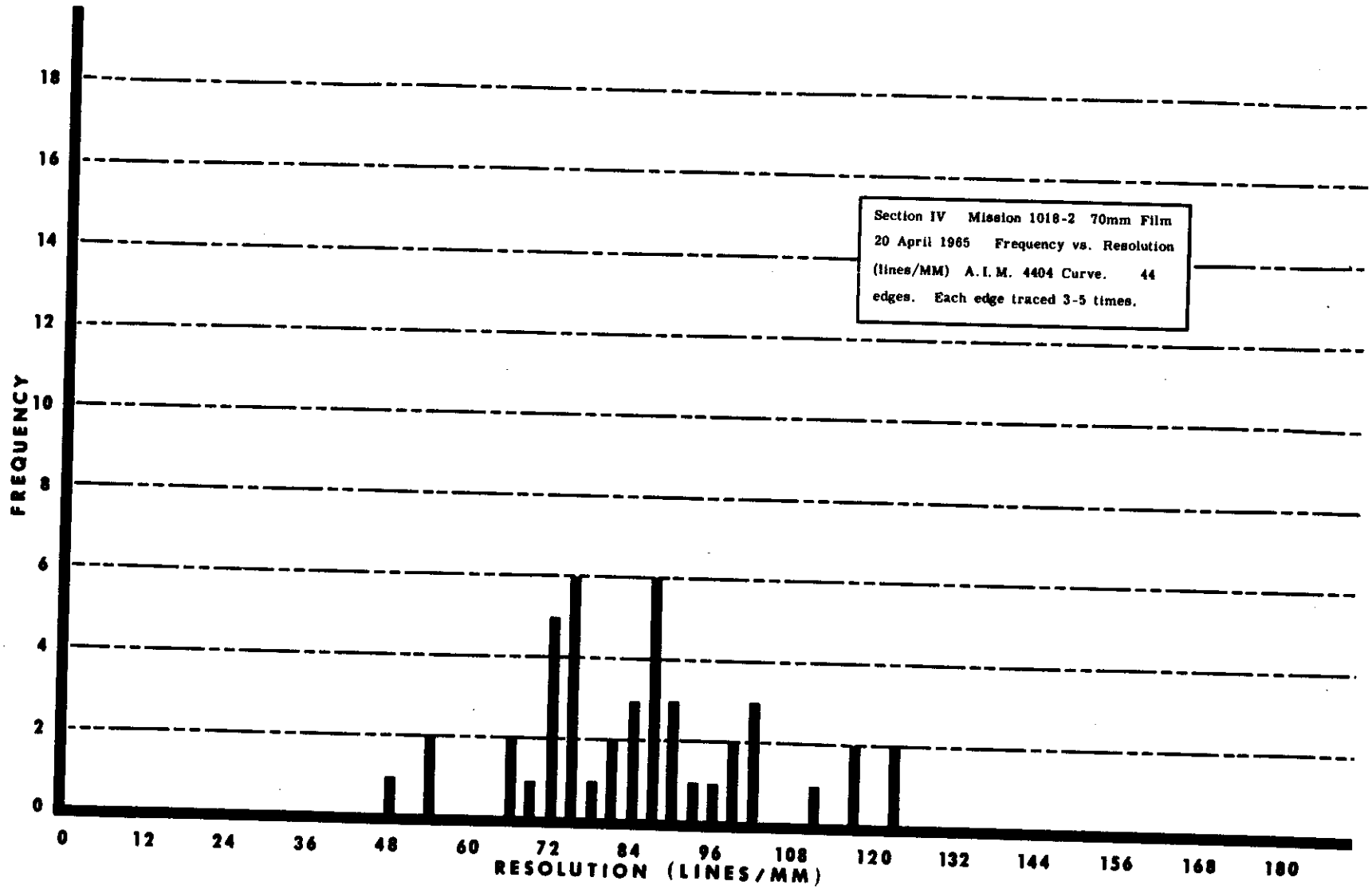
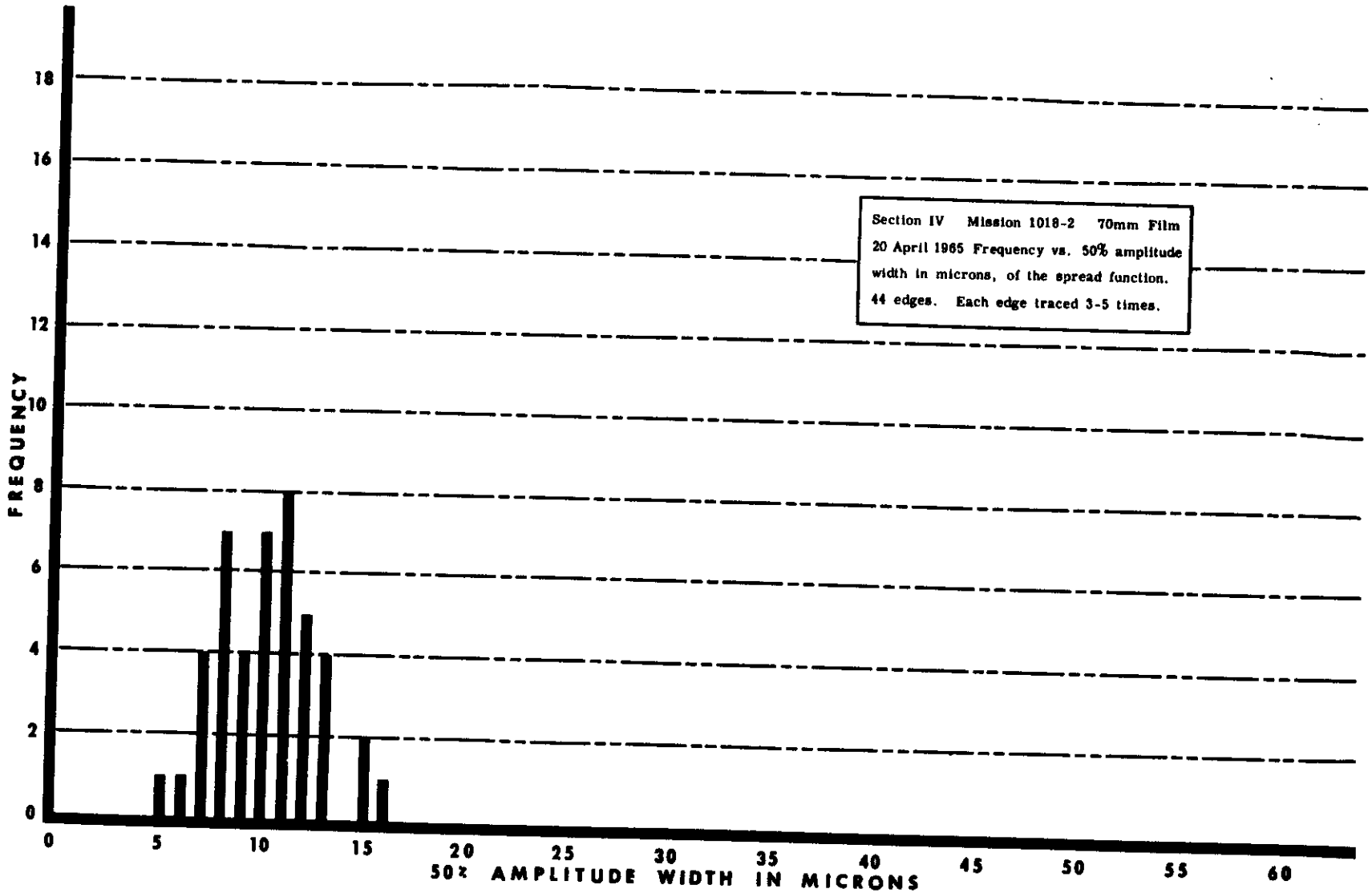
Mission Number	PI M.I.P. Rating	Resolution in lines/mm	Spread Function
1009-1	85	112 l/mm	7.3 μ
1009-2	85	---	---
1010-1	85	134 l/mm	5.3 μ
1010-2	85	136 l/mm	5.0 μ
1011-1	85	113 l/mm	6.3 μ
1012-1	85	120 l/mm	6.7 μ
1012-2	85	117 l/mm	5.0 μ
1013-1	85	95 l/mm	9.2 μ
1014-1	80	109 l/mm	5.6 μ
1014-2	80	---	---
1015-1	85	92 l/mm	8.6 μ
1015-2	85	86 l/mm	8.4 μ
1016-1	85	114 l/mm	6.0 μ
1016-2	85	106 l/mm	7.6 μ
1017-1	---	112 l/mm	7.6 μ
1017-2	---	97 l/mm	8.6 μ
1018-1	85	78 l/mm	9.9 μ
1018-2	---	90 l/mm	9.7 μ

The M.I.P. rating is an arbitrary figure assigned by the PI to indicate the quality of the best photography obtained in a particular mission. The pass and frame is selected by the PI and the target to be traced is selected by the Microdensitometer operator.


Section IV Mission 1018-2 70mm Film
20 April 1965 Frequency vs. Resolution
(lines/MM) A.I.M. 4404 Curve. 44
edges. Each edge traced 3-5 times.
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 1018-2 70mm Film
20 April 1965 Frequency vs. 50% amplitude
width in microns, of the spread function.
44 edges. Each edge traced 3-5 times.
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

Forward Camera

Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)		A.I.M. Resolution	
D-71	146	X30.1	020	Buildings	9.8	11.6	92	71
		Y14.2			11.9		58	
					13.2		63	
D-72	193	X39.8	015	Buildings	6.8	8.6	91	84
		Y09.8			8.4		83	
					10.7		77	
D-73	123	X29.9	165	Buildings	9.4	12.5	55	54
		Y10.6			11.5		60	
					16.6		48	
D-73	133	X15.4	045	Buildings	14.3	11.7	57	71
		Y12.2			12.2		68	
					8.7		89	
D-75	009	X45.3	140	Buildings	12.6	11.6	60	69
		Y10.2			10.9		72	
					11.2		74	
D-75	045	X34.0	050	Buildings	6.3	7.4	111	96
		Y12.0			7.0		102	
					9.0		75	
D-75	047	X35.7	160	Buildings	13.4	11.8	60	77
		Y12.9			9.9		88	
					12.0		84	
D-75	051	X36.4	165	Buildings	11.2	11.0	68	82
		Y09.3			11.0		96	
					10.8		81	
D-75	052	X36.6	075	Buildings	8.3	8.6	86	87
		Y13.9			7.2		106	
					10.4		69	

Forward Camera

Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)		A.I.M. Resolution	
D-79	012	X44.6 Y14.2	170	Buildings	8.4 5.7 5.9	6.7	101 134 138	124
D-87	080	X51.8 Y11.1	175	Buildings	7.8 9.0 13.2	10.0	98 85 68	84
D-87	081	X50.1 H14.3	080	Buildings	10.1 10.8 10.5	10.5	62 65 73	67
D-87	118	X43.3 Y13.8	040	Buildings	9.2 11.5 12.2	11.0	92 84 89	88
D-91	141	X44.0 Y11.2	020	Buildings	16.3 13.8 16.4	15.5	46 56 44	49
D-91	144	X45.3 Y13.3	035	Buildings	9.8 11.3 10.7	10.6	68 90 71	76
D-95	029	X41.9 Y11.2	005	Buildings	11.7 11.4 10.5	11.2	98 103 73	91
D-95	030	X43.3 Y11.3	080	Buildings	14.5 14.3 14.8	14.5	55 56 54	55
D-95	030	X41.6 Y12.4	070	Buildings	11.6 12.3 15.6	13.2	105 55 53	71
D-95	031	X14.3 Y11.5	050	Buildings	12.5 11.8 14.3	12.9	73 94 60	76

Forward Camera

Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)		A.I.M. Resolution	
D-95	032	X33.2 Y12.3	030	Buildings	16.5 13.3	14.9	72 77	75

Aft Camera

Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)		A.I.M. Resolution	
D-71	152	X61.6 Y10.7	030	Buildings	10.8 11.7 17.4	13.3	80 72 45	66
D-72	200	X51.6 Y11.1	020	Buildings	8.2 8.2 6.8	7.7	105 107 98	103
D-73	129	X62.2 Y14.4	170	Buildings	8.6 11.4 12.9	11.0	88 77 59	75
D-73	138	X46.9 Y13.7	090	Buildings	12.0 13.2 11.0	12.1	66 78 79	74
D-75	015	X46.5 Y14.2	140	Buildings	9.5 5.3 9.1	8.0	86 104 113	101
D-75	051	X45.4 Y12.2	020	Buildings	9.0 8.3 7.6	8.3	87 97 111	98
D-75	053	X56.3 Y12.3	165	Buildings	5.1 6.2 5.1	5.5	131 112 111	118
D-87	086	X41.1 Y14.0	175	Buildings	11.0 13.5 9.1	11.2	73 59 80	71
D-87	124	X48.5 Y11.7	040	Buildings	6.5 7.2 7.5	7.1	112 96 99	102
D-91	143	X75.3 Y11.2	045	Buildings	12.3 8.4 9.2	10.0	65 88 106	86

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Aft Camera

Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)		A.I.M. Resolution	
D-91	145	X67.1 Y14.2	100	Buildings	7.3 8.5 8.4	8.1	94 84 84	87
D-91	146	X47.2 Y13.8	045	Buildings	8.3 10.9 6.7	8.6	86 70 113	90
D-91	146	X47.3 Y13.8	045	Buildings	5.7 5.8 6.1	5.9	128 121 120	123
D-91	147	X47.7 Y13.8	025	Buildings	6.2 10.0 7.7	8.0	132 96 101	110
D-91	150	X46.5 Y11.7	035	Buildings	10.3 8.4 11.4	10.0	74 90 94	86
D-95	031	X41.5 Y14.2	160	Buildings	10.5 9.7 12.6	10.9	73 80 71	75
*D-95	031	X48.5 Y13.2	095	Buildings	12.5 8.8 7.7	9.7	79 93 99	90
D-95	034	X51.5 Y10.9	040	Buildings	11.6 9.4 10.1	10.4	67 74 74	72
D-95	035	X49.9 Y13.3	010	Buildings	9.8 10.6 11.0	10.5	81 78 75	78
D-95	036	X49.0 Y12.2	088	Buildings	13.6 11.1 10.5	11.7	59 74 115	83

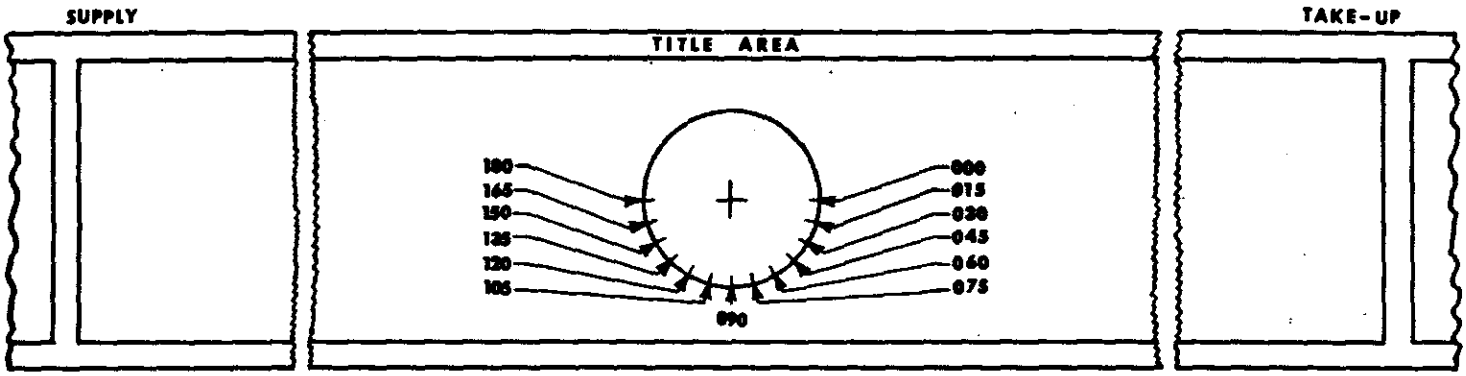
Aft Camera

Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)		A.I.M. Resolution	
D-95	036	X50.5	080	Buildings	4.8	6.6	139	116
		Y11.2			6.6		114	
					8.5		95	
D-95	038	X58.8	040	Buildings	8.7	8.3	89	92
		Y11.3			9.9		79	
					6.3		108	
D-95	038	X58.2	085	Buildings	7.3	8.0	99	99
		Y10.9			8.1		96	
					8.5		103	

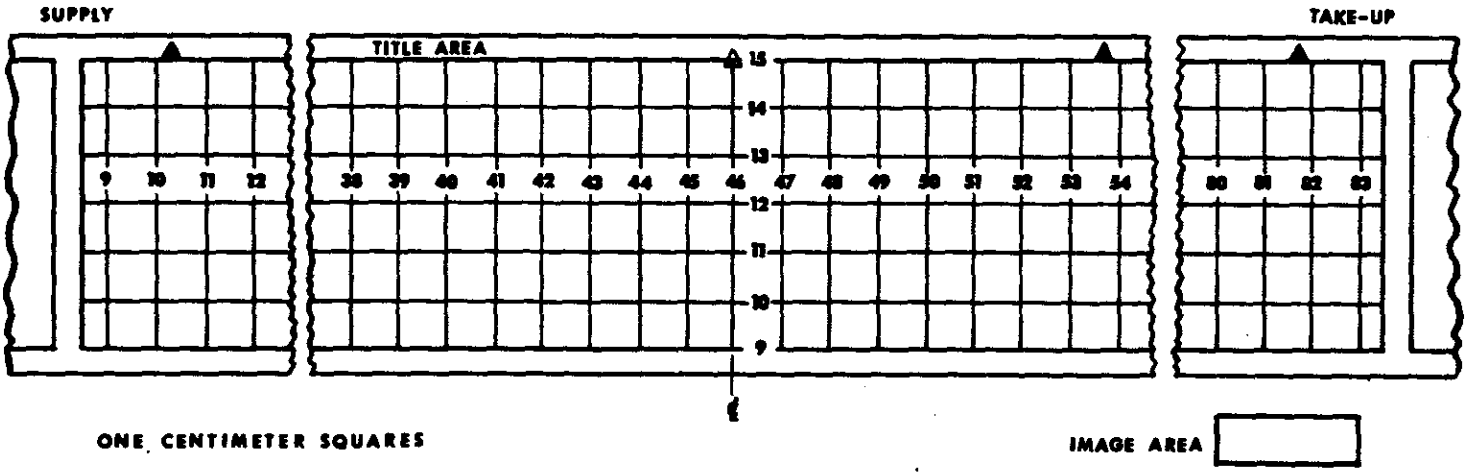
*M.I.P. Frame

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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