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Analysis of Photographic Image to Evaluate System Performance Mission 1015-1

12 January 1965

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TITLE:

Summary of Microdensitometer Derived Image Quality Data Collected from Mission 1015-1

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 that have been recomputed with the new SWRDR computer program. 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 at 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.

Each edge was traced three times on the microdensitometer, and the average of the computed spread function and resolution is presented in Section V.

Analysis of Photographic Image to Evaluate System Performance

SECTION II SUMMARY SHEET

Mission 1015-1

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

Arithmetic Mean	93.1 l/mm
Standard Deviation	16.5 l/mm
Coefficient of Dispersion	18%
Number of Edges	35
M.I.P. Frame	92 l/mm

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

Arithmetic Mean	8.8μ
Standard Deviation	2.3μ
Coefficient of Dispersion	26%
Number of Edges	35
M.I.P. Frame	8.6μ

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SECTION IIA SUMMARY SHEET

Mission 1015-1

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

	FWD Camera	AFT Camera	Airfields	Buildings
Arithmetic Mean	90.0 l/mm	96.9 l/mm	83.2 l/mm	95.2 l/mm
Standard Deviation	18.1 l/mm	14.0 l/mm	10.7 l/mm	16.9 l/mm
Coefficient of Dispersion	20%	14%	13%	18%
Number of Edges	19	16	6	29

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

	FWD Camera	AFT Camera	Airfields	Buildings
Arithmetic Mean	9.3μ	8.3μ	9.5μ	8.7μ
Standard Deviation	2.4μ	2.0μ	1.3μ	2.4μ
Coefficient of Dispersion	26%	24%	14%	28%
Number of Edges	19	16	6	29

SECTION III - MISSION 1015-1

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
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%

*A 1 x 320 micron slit was used

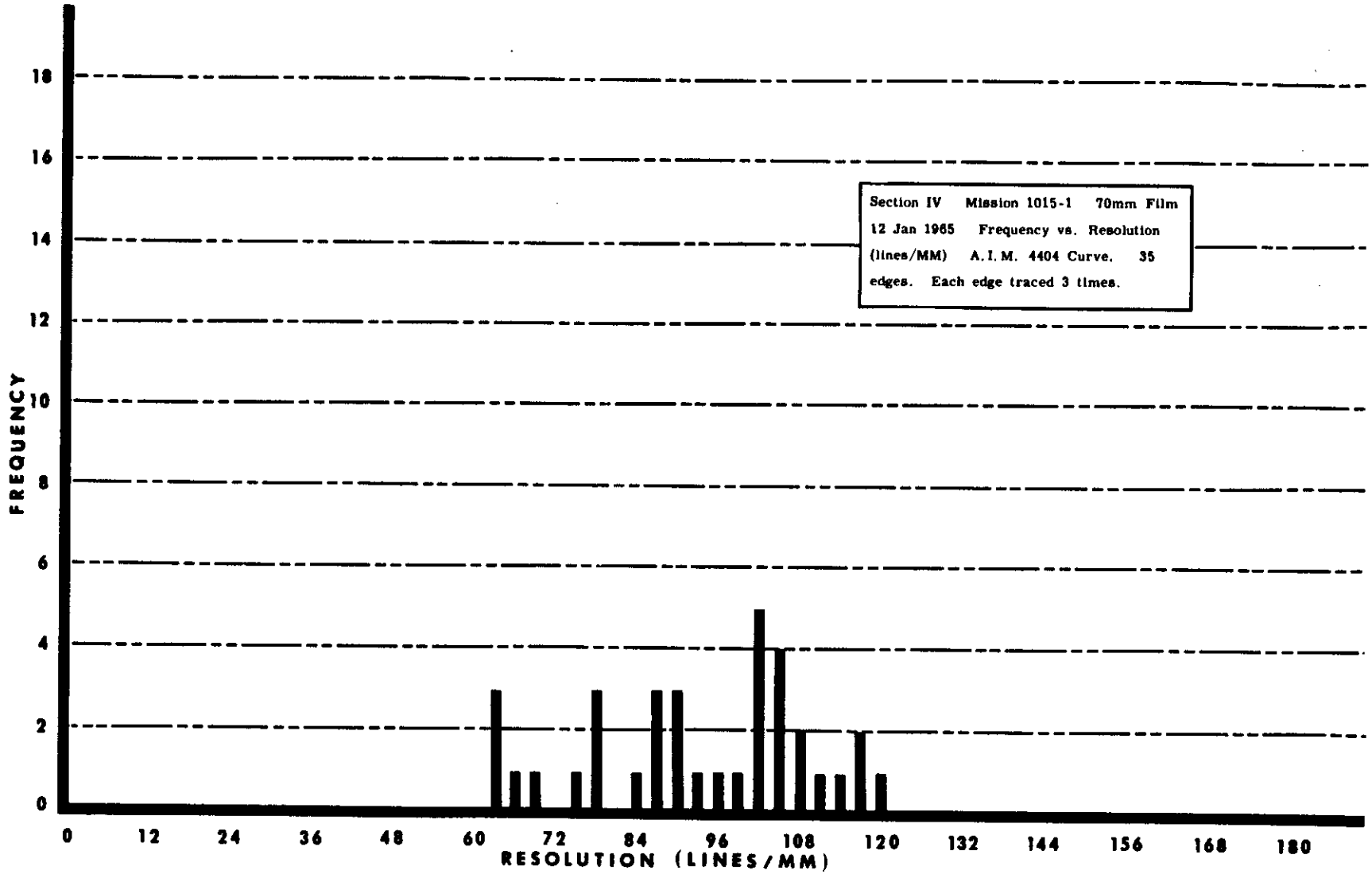
Analysis of Photographic Image to Evaluate System Performance

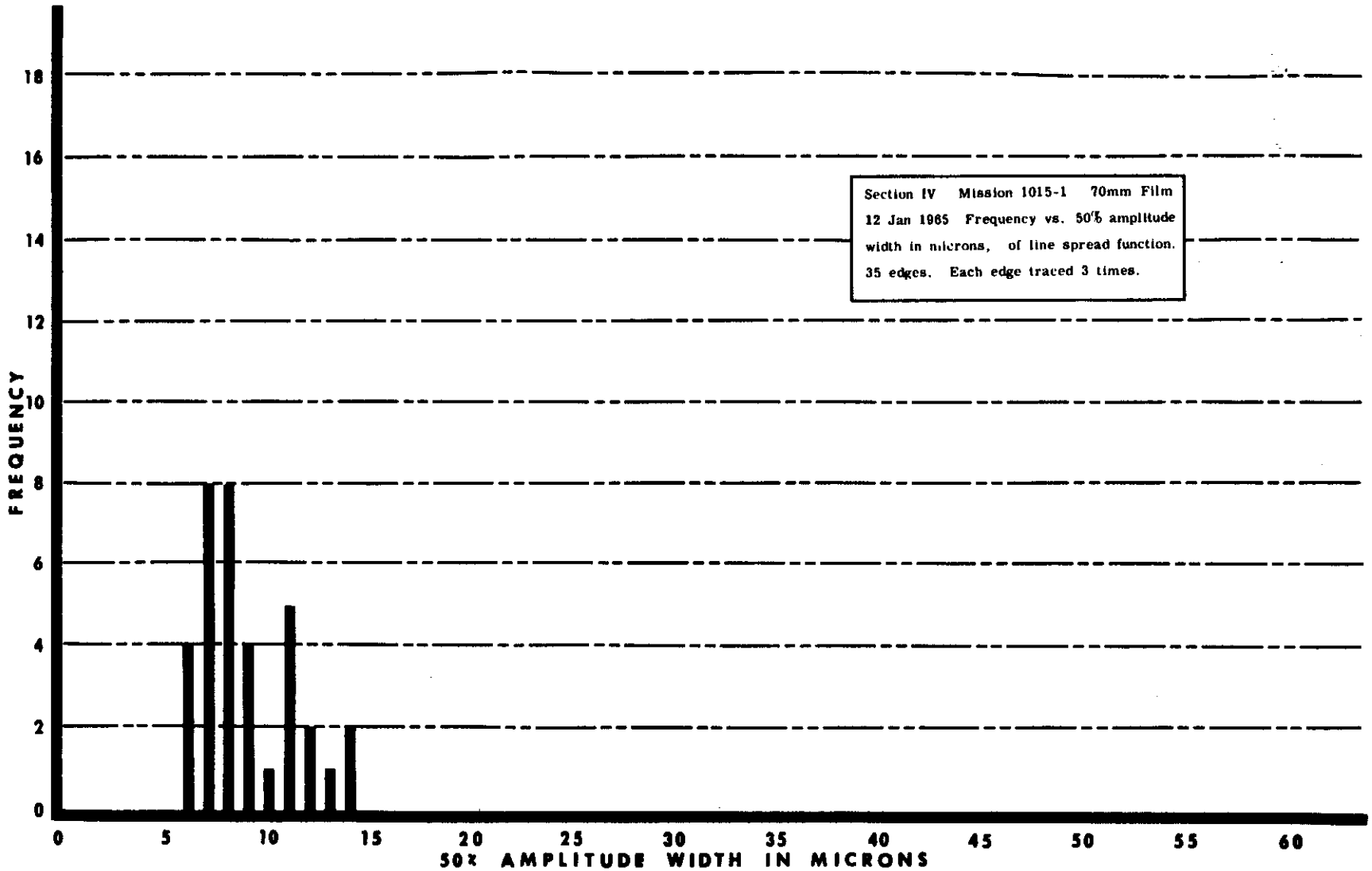
SECTION IIIA - MISSION 1015-1

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
1015-1	93.1 l/mm
1010-1	89.4 l/mm
1012-1	86.1 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
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. The quality rating of current missions may have a slightly different basis than earlier missions, which could affect the quality ranking.


Section IV Mission 1015-1 70mm Film
12 Jan 1965 Frequency vs. Resolution
(lines/MM) A.I.M. 4404 Curve. 35
edges. Each edge traced 3 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 1015-1 70mm Film
12 Jan 1965 Frequency vs. 50% amplitude
width in microns, of line spread function.
35 edges. Each edge traced 3 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
50x AMPLITUDE WIDTH IN MICRONS

Analysis of Photographic Image to Evaluate System Performance
Mission 1015-1
Section V

Forward Camera

Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
D-21	068	X65.3 Y14.6	020	Buildings	7.1	113
D-21	069	X59.7 Y13.8	010	Buildings	6.5	106
D-21	076	X60.3 Y12.7	020	Buildings	10.4	77
D-22	078	X69.2 Y13.5	085	Buildings	7.4	104
D-24	019	X57.4 Y09.4	045	Dock	13.5	64
D-24	024	X17.6 Y11.5	065	Canal Bank	13.2	63
D-24	030	X42.8 Y13.8	020	Buildings	6.2	118
D-24	052	X29.3 Y13.7	065	Buildings	8.1	103
D-30	041	X52.0 Y13.3	160	Buildings	7.4	96
D-30	042	X74.8 Y09.9	080	Dock	12.0	88
D-37	074	X56.2 Y14.0	105	Airfield	10.5	76
D-47E	009	X29.7 Y13.3	155	Buildings	9.4	83
D-47E	010	X25.5 Y14.7	135	Airfield	7.9	98
D-63	008	X75.3 Y12.3	100	Settling Basins	12.4	63
D-63	009	X75.8 Y10.0	100	Airfields	11.0	70
D-63	010	X28.3 Y12.3	150	Buildings	11.1	90
D-63	011	X69.6 Y12.5	020	Buildings	8.9	87
D-63	011	X69.6 Y12.5	020	Buildings	5.9	120
D-63	012	X34.4 Y11.8	020	Buildings	8.1	91

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Section V

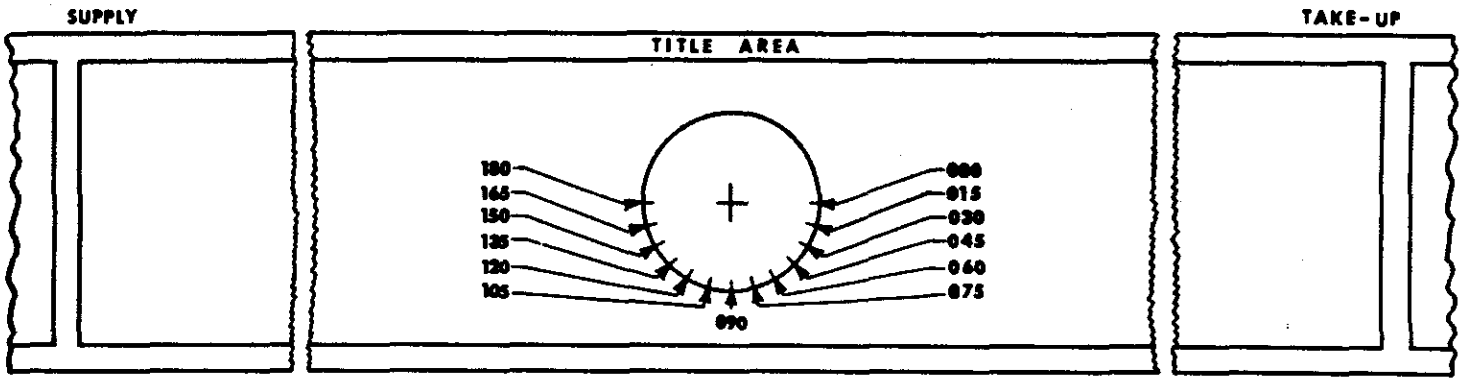
AFT Camera

Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
D-06	164	X57.6 Y12.0	015	Bridge	6.4	108
D-21	071	X25.6 Y10.4	020	Buildings	7.1	106
D-21	072	X30.9 Y11.1	010	Buildings	8.1	91
D-21	079	X30.3 Y11.6	010	Buildings	6.7	110
D-22	082	X21.5 Y13.0	060	Buildings	7.5	101
D-24	025	X32.6 Y12.6	045	Buildings	7.0	104
D-24	029	X74.4 Y14.4	070	Canal Bank	14.2	66
D-24	035	X48.6 Y11.6	025	Buildings	6.4	109
D-30	047	X15.6 Y11.3	075	Dock	7.3	117
D-37	078	X34.4 Y10.8	100	Airfield	10.6	77
D-47E	013	X61.4 Y12.4	160	Buildings	7.8	101
D-47E*	014	X65.5 Y10.6	140	Airfield	8.6	92
D-63	015	X14.6 Y10.7	090	Airfield	8.5	86
D-63	016	X60.7 Y10.7	120	Dock	7.9	102
D-63	016	X20.8 Y13.3	020	Buildings	10.5	78
D-63	017	X56.5 Y14.3	020	Buildings	7.8	102

*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