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This document contains 13 pages

Analysis of Photographic Image to Evaluate System Performance Mission 1016-2

9 February 1965

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TITLE:

Summary of Microdensitometer Derived Image Quality Data Collected from Mission 1016-2

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 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. 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.

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

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SECTION II SUMMARY SHEET

Mission 1016-2

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

Arithmetic Mean	91.5 l/mm
Standard Deviation	16.1 l/mm
Coefficient of Dispersion	18%
Number of Edges	33
M.I.P. Frame	106 l/mm

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

Arithmetic Mean	9.8 μ
Standard Deviation	3.2 μ
Coefficient of Dispersion	32%
Number of Edges	33
M.I.P. Frame	7.6 μ

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SECTION IIA SUMMARY SHEET

Mission 1016-2

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	92.0 l/mm	90.8 l/mm
Standard Deviation	16.6 l/mm	16.1 l/mm
Coefficient of Dispersion	18%	18%
Number of Edges	19	14

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

	FWD Camera	AFT Camera
Arithmetic Mean	9.3 μ	10.4 μ
Standard Deviation	2.3 μ	4.1 μ
Coefficient of Dispersion	25%	39%
Number of Edges	19	14

SECTION III - MISSION 1016-2

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**	8.3	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%

*A 1 x 320 micron slit was used

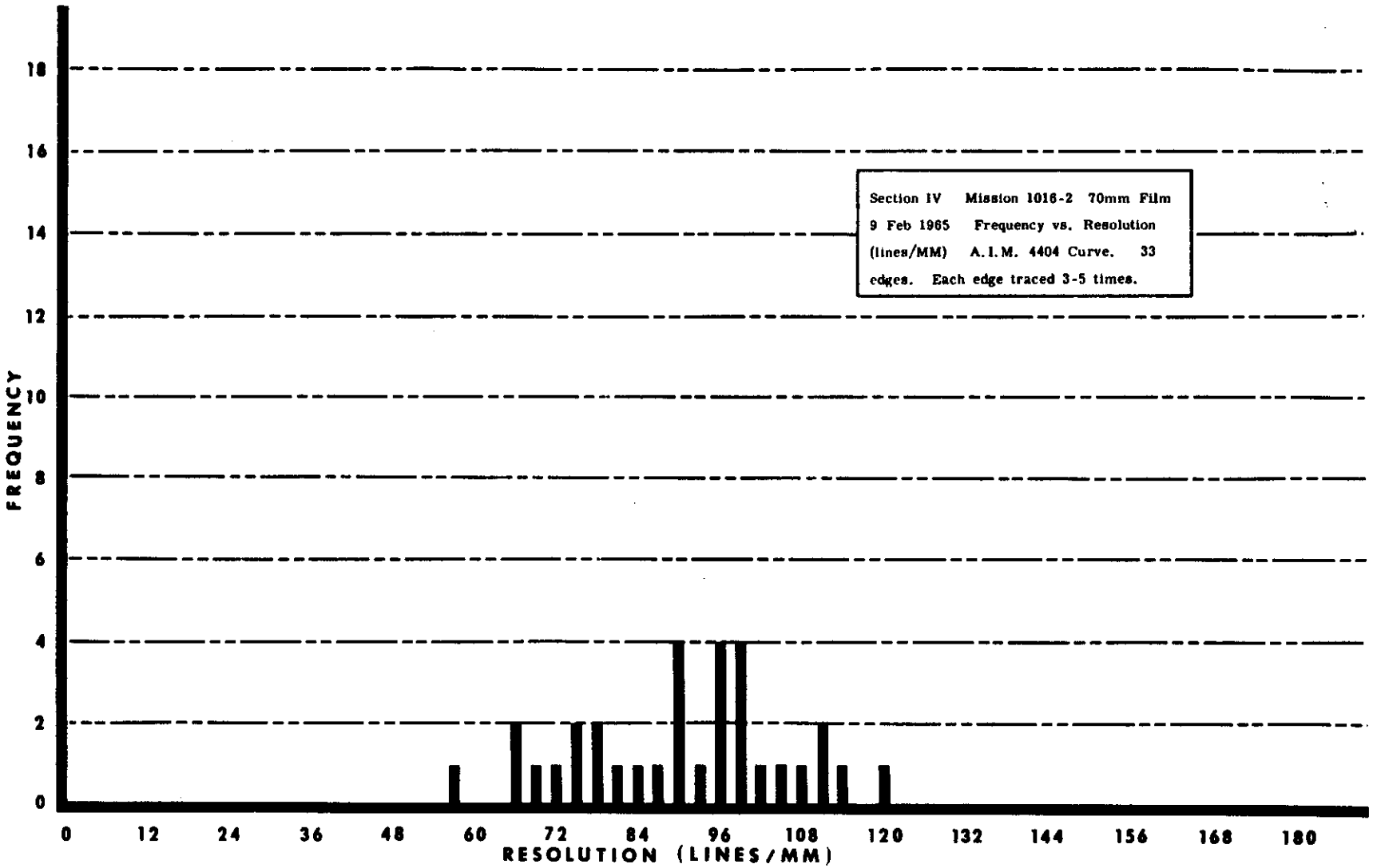
**Each edge was traced three or more times on the microdensitometer

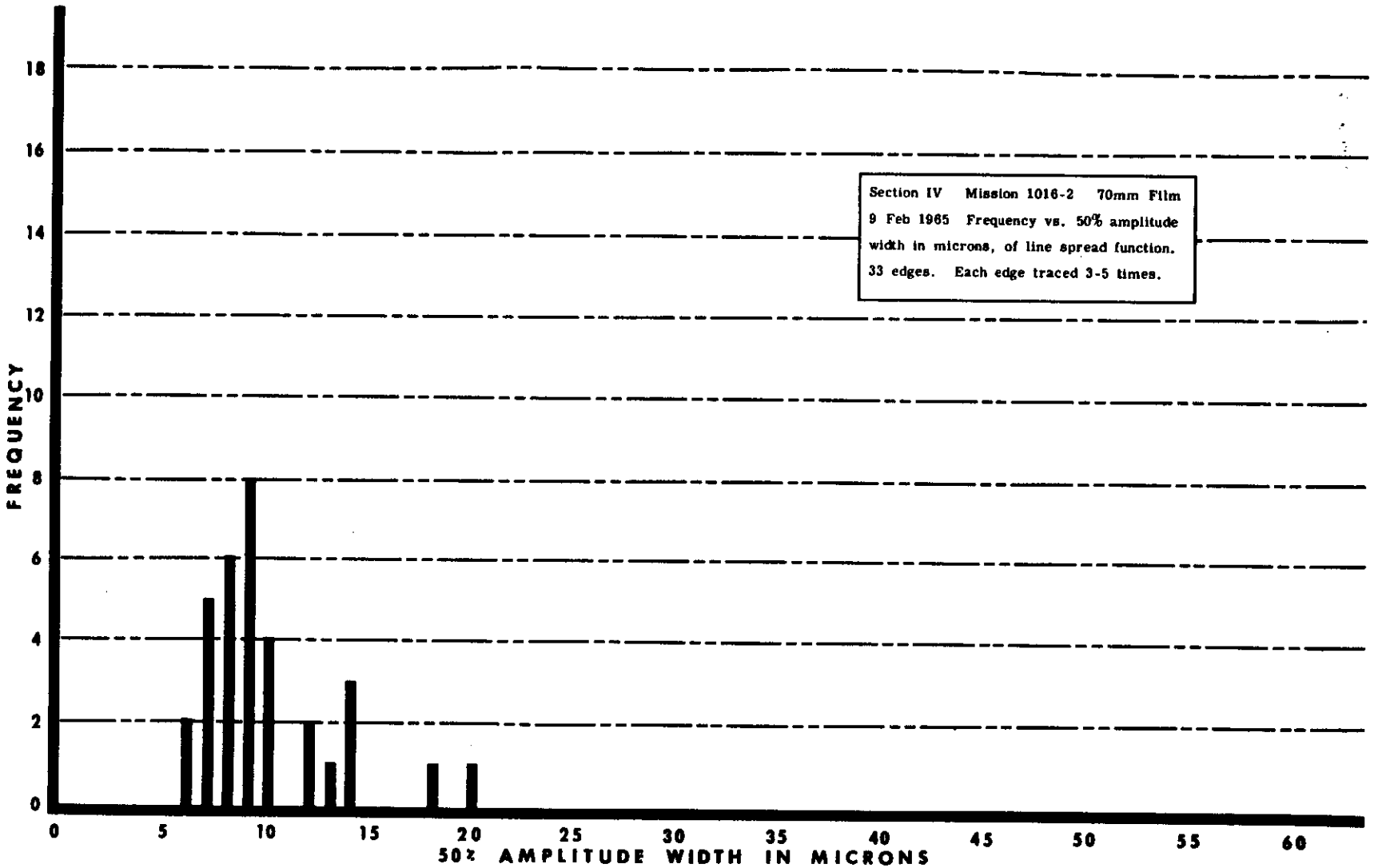
SECTION IIIA - MISSION 1016-2

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
1016-1	88.0 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 1016-2 70mm Film
9 Feb 1965 Frequency vs. Resolution
(lines/MM) A.I.M. 4404 Curve. 33
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 1016-2 70mm Film
9 Feb 1965 Frequency vs. 50% amplitude width in microns, of line spread function.
33 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

Analysis of Photographic Image to Evaluate System Performance

Mission 1016-2
Section V

Forward Camera

Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
D-84	044	X19.8 Y12.2	020	Buildings	8.6	96
D-84	051	X54.0 Y11.1	175	Buildings	7.9	90
D-85	059	X39.5 Y12.1	010	Buildings	7.5	107
D-86	047	X42.6 Y14.4	030	Buildings	6.6	112
D-93	016	X45.2 Y13.9	135	Buildings	13.9	74
D-93	028	X48.6 Y11.3	045	Bridge	6.0	121
D-93	030	X49.6 Y13.0	180	Buildings	8.0	99
D-93	031	X37.3 Y11.5	035	Buildings	12.1	77
D-93	032	X77.8 Y13.1	045	Buildings	8.4	97
D-110	012	X41.0 Y13.6	015	Buildings	10.2	74
D-110	019	X36.2 Y12.0	015	Buildings	10.5	98
D-110	020	X50.1 Y13.9	015	Buildings	13.6	58
D-110	024	X38.6 Y12.3	170	Buildings	8.8	91
D-126	005*	X39.8 Y10.3	040	Buildings	7.6	106
D-126	010	X54.5 Y10.2	015	Buildings	10.1	79
D-126	011	X57.0 Y13.5	010	Buildings	8.5	96
D-126	012	X55.8 Y13.3	015	Buildings	7.4	111
D-126	013	X35.1 Y12.6	020	Buildings	9.0	95
D-134	058	X36.0 Y12.3	170	Buildings	12.7	67

*M.I.P. Frame

Analysis of Photographic Image to Evaluate System Performance

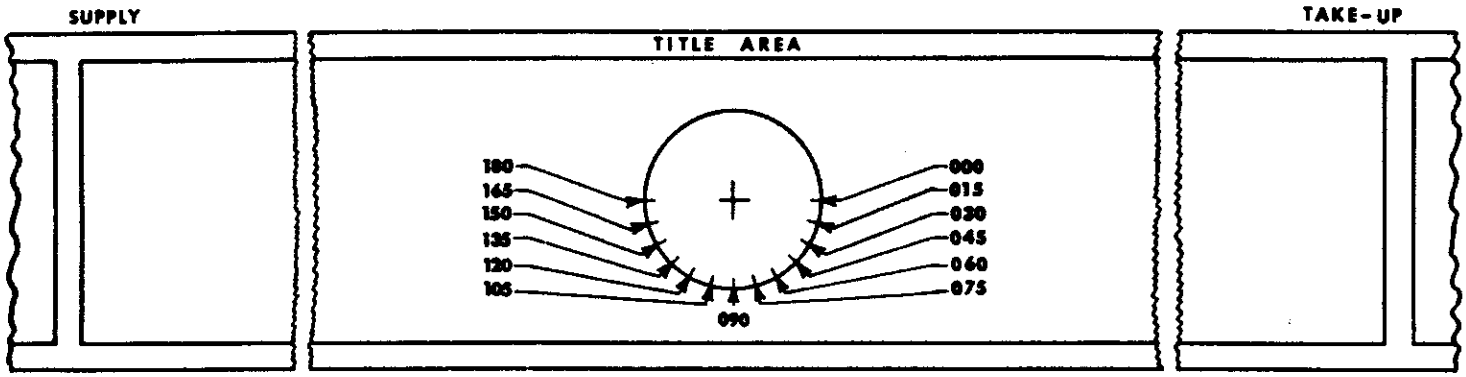
Mission 1016-2
Section V

Aft Camera

Pass	Frame	Location		Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
D-84	049	X71.3	Y14.1	025	Buildings	8.5	98
D-84	057	X36.0	Y10.0	180	Buildings	9.3	90
D-93	021	X44.8	Y11.7	160	Buildings	9.8	86
D-93	021	X44.8	Y11.7	050	Airfield	8.8	93
D-93	034	X24.7	Y11.2	020	Buildings	9.3	91
D-93	035	X40.4	Y12.4	180	Buildings	19.6	68
D-93	054	X36.5	Y12.5	090	Dock	12.0	82
D-110E	023	X49.5	Y13.5	030	Dam	13.7	66
D-126	009	X51.1	Y10.5	055	Buildings	7.4	103
D-126	011	X42.6	Y10.9	040	Buildings	7.0	100
D-126	015	X29.8	Y13.7	020	Buildings	6.1	120
D-126	016	X21.4	Y12.8	085	Dam	9.2	85
D-151	012	X60.6	Y12.7	025	Bridge	7.1	115
D-151	015	X56.3	Y11.8	045	Canal	18.0	72

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