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Analysis of Photographic Image to Evaluate System Performance Mission 1016-1

29 January 1965

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TITLE:

Summary of Microdensitometer Derived Image Quality Data Collected from Mission 1016-1

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 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 or more 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 1016-1

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

Arithmetic Mean	88.0 l/mm
Standard Deviation	18.6 l/mm
Coefficient of Dispersion	21%
Number of Edges	31
M.I.P. Frame	113.6 l/mm

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

Arithmetic Mean	9.7 μ
Standard Deviation	2.3 μ
Coefficient of Dispersion	24%
Number of Edges	31
M.I.P. Frame	6.0 μ

Analysis of Photographic Image to Evaluate System Performance

SECTION IIA SUMMARY SHEET

Mission 1016-1

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	81.8 l/mm	93.9 l/mm	79.2 l/mm	89.7 l/mm
Standard Deviation	16.1 l/mm	19.3 l/mm	14.4 l/mm	19.0 l/mm
Coefficient of Dispersion	20%	21%	18.2 %	21%
Number of Edges	15	16	5.0	26

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

	FWD Camera	AFT Camera	Airfields	Buildings
Arithmetic Mean	10.2 μ	9.1 μ	10.5 μ	9.5 μ
Standard Deviation	2.1 μ	2.4 μ	2.1 μ	2.3 μ
Coefficient of Dispersion	20%	26%	20%	24%
Number of Edges	15	16	5.0	26

Analysis of Photographic Image to Evaluate System Performance

SECTION III - MISSION 1016-1

Summary of all C/M/J Missions Traced to Date

Mission Number	Number 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%

*A 1 x 320 micron slit was used

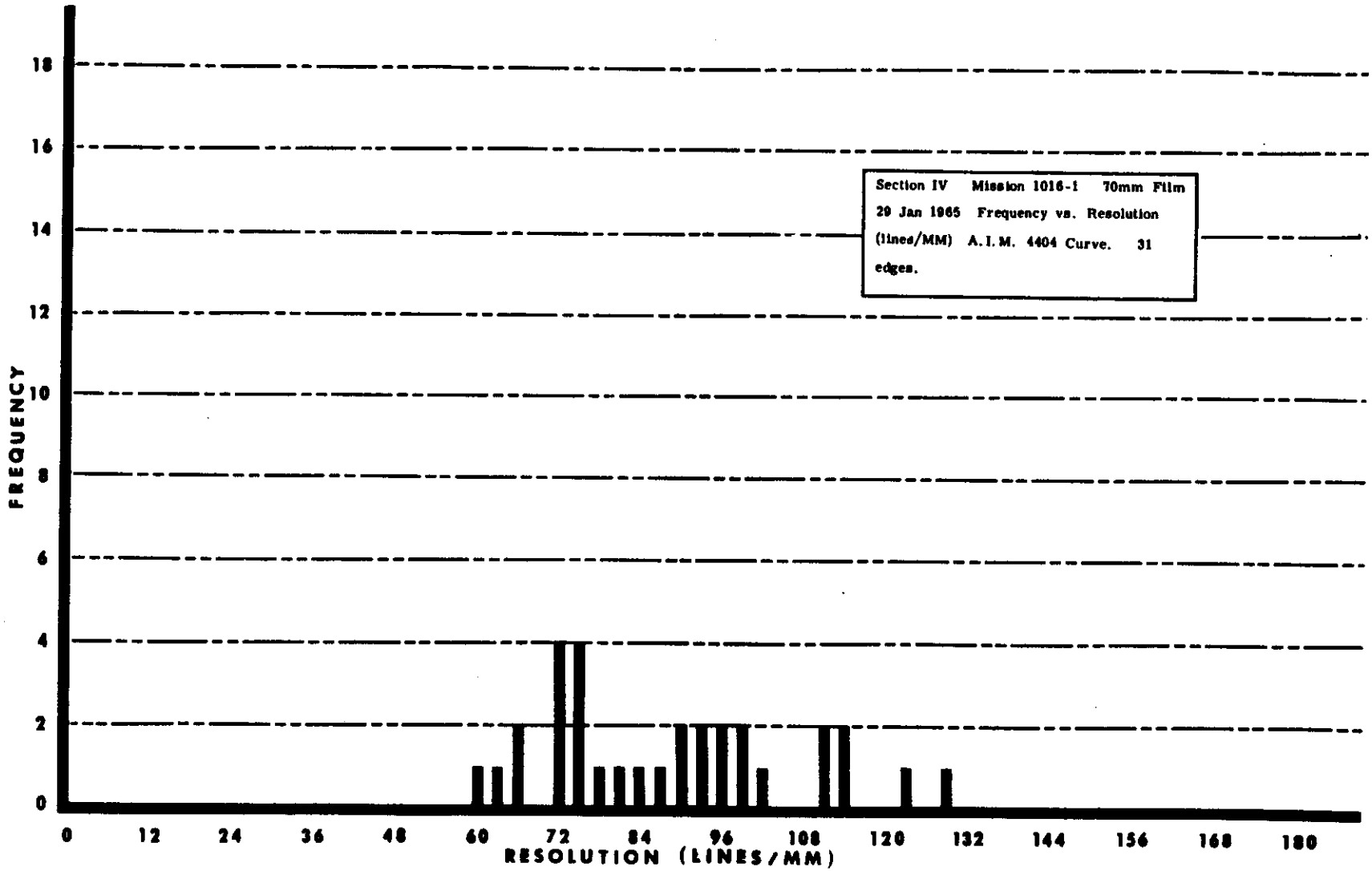
Analysis of Photographic Image to Evaluate System Performance

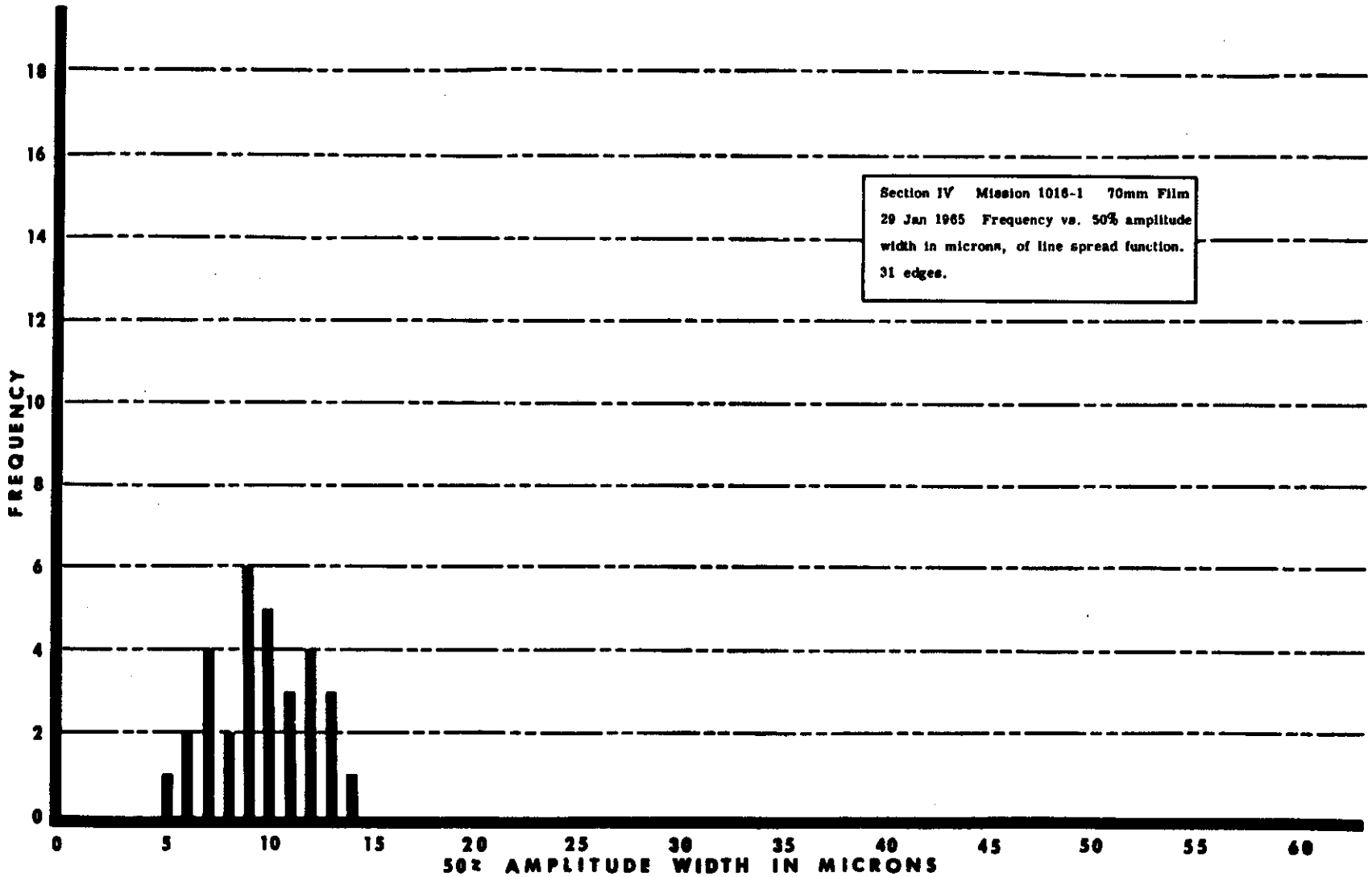
SECTION IIIA - MISSION 1016-1

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
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 1016-1 70mm Film
29 Jan 1965 Frequency vs. Resolution
(lines/MM) A.I.M. 4404 Curve. 31
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 1016-1 70mm Film
29 Jan 1965 Frequency vs. 50% amplitude width in microns, of line spread function.
31 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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Analysis of Photographic Image to Evaluate System Performance

Mission 1016-1
Section V

Forward Camera

Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A. I. M. Resolution
D-05	020	X35.3 Y14.3	035	Buildings	9.3	92
D-15	032	X67.3 Y11.8	050	Buildings	13.3	60
D-15	033	X64.5 Y11.5	055	Buildings	10.4	76
D-15	037	X61.9 Y10.2	080	Buildings	11.8	65
D-15	039	X61.2 Y11.2	065	Airfield	12.6	65
D-15	052	X67.6 Y11.6	070	Buildings	12.2	71
D-25	051	X48.7 Y10.3	098	Airfield	11.7	78
D-37	031	X31.0 Y12.4	160	Buildings	8.3	99
D-37	121	X34.3 Y11.8	165	Buildings	6.9	112
D-37	139	X53.8 Y14.3	155	Airfield	7.3	103
D-37	151	X19.2 Y11.5	020	Buildings	9.5	84
D-37	170	X46.5 Y10.3	110	Buildings	12.8	62
D-40	081	X29.8 Y13.6	030	Buildings	10.5	76
D-40	114	X53.1 Y14.6	020	Buildings	8.2	95

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Analysis of Photographic Image to Evaluate System Performance

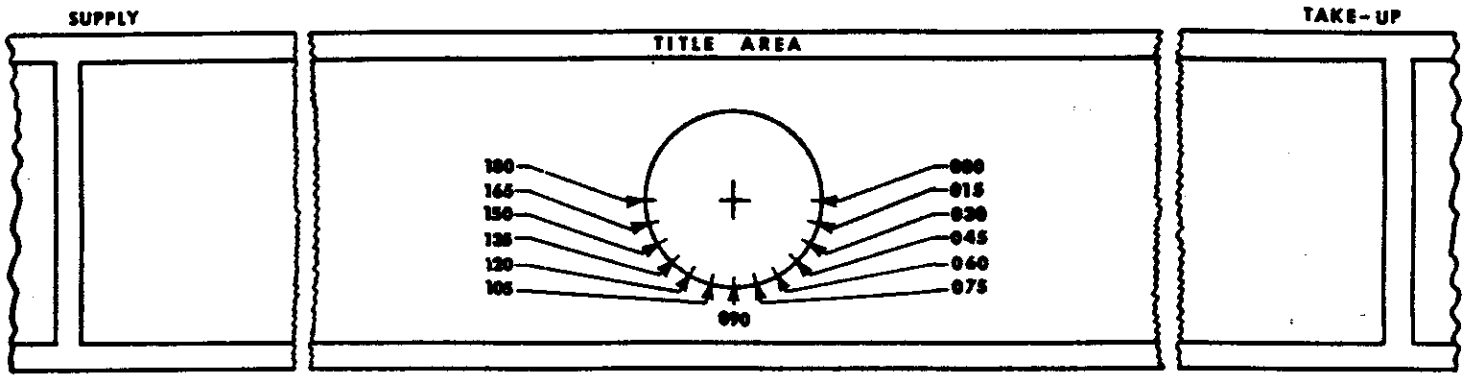
Mission 1016-1
Section V

AFT Camera

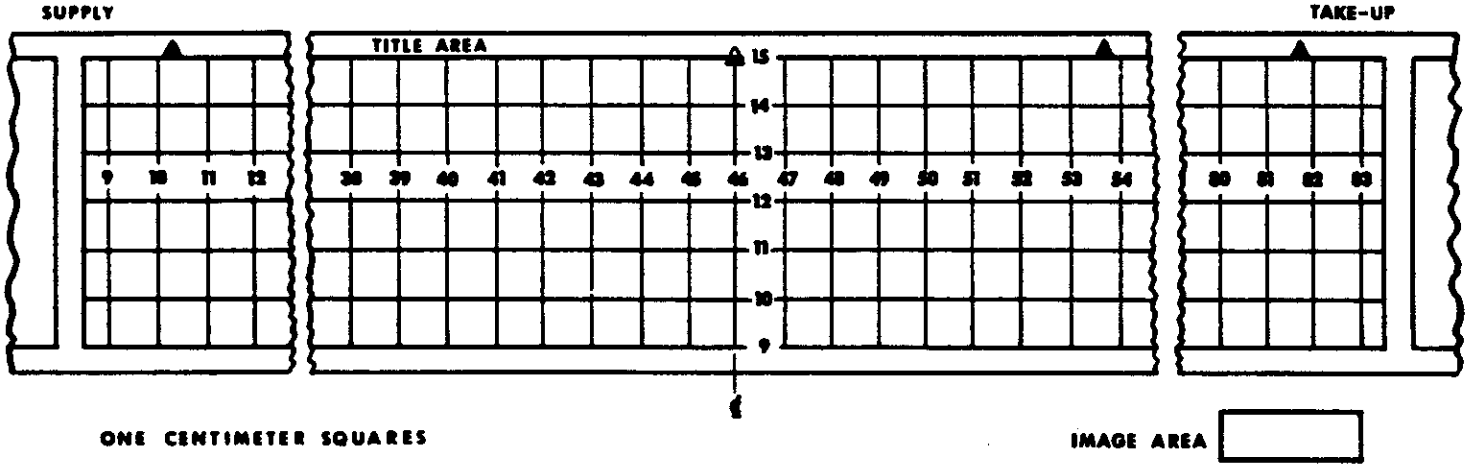
Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
D-05	025	X55.0 Y11.5	040	Buildings	6.7	122
D-05	062	X50.3 Y10.2	020	Buildings	7.1	110
D-05	063	X64.1 Y13.7	088	Buildings	10.4	73
D-15	037	X22.7 Y14.4	040	Buildings	9.1	90.6
D-15	038	X23.5 Y10.5	015	Buildings	6.1	115
D-15	043	X27.7 Y11.1	075	Buildings	5.5	130
D-15	045	X28.5 Y10.2	065	Airfield	9.7	73
D-24	010	X71.0 Y13.0	015	Buildings	9.3	80
D-37	036	X59.8 Y14.6	165	Buildings	10.5	92
D-37	125	X46.8 Y10.2	055	Buildings	14.3	75
D-37	155	X71.5 Y13.3	025	Buildings	9.2	87
D-37	174	X43.3 Y13.5	105	Buildings	9.2	98
D-61	011	X38.8 Y13.6	135	Dock	10.4	96
D-61	013	X55.5 Y11.3	070	Airfield	11.0	76
D-61	013	X55.7 Y12.7	025	Buildings	6.0	114
D-61	017	X45.3 Y13.3	100	Dock	11.8	71

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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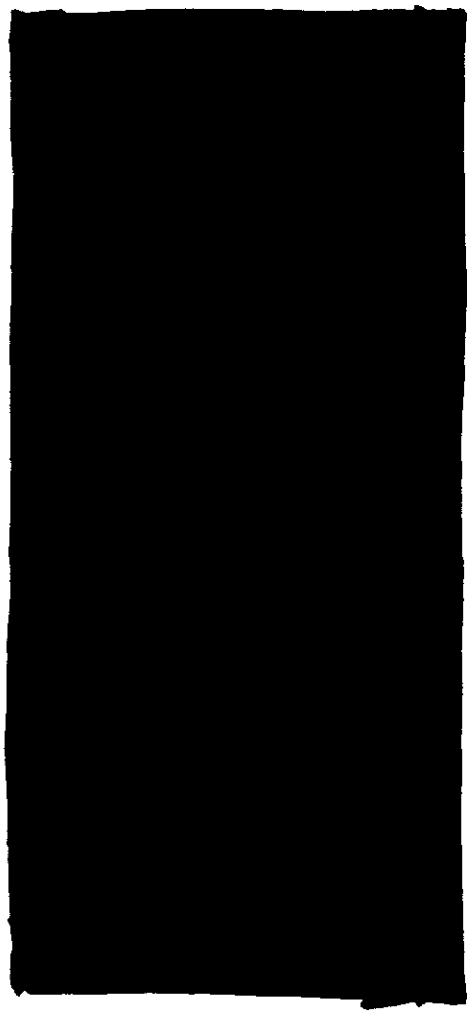

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