

5.2.1.2 WAC FM MTF CALIBRATION RESULTS

As reported in Reference 5.2.1.2-1

Reference 5.2.1.2-1 - IOM 388-PAG-CCA97-13,"WAC FM Calibration Results: MTF", C. Avis, October 1, 1997

5.2.1.2.1 INTRODUCTION

The Wide-angle Flight Model thermal/vacuum testing included the acquisition of images for characterizing the system MTF. Because a collimator was used to project the target into the camera, the analysis really characterizes the camera/collimator/window combination. Further analysis is required to remove the contribution of the collimator and chamber window.

Image data were taken at temperature of -10° , $+5^{\circ}$ and $+25^{\circ}$ C in all gain and summation modes. Full-resolution Gain 2 data were acquired with all useful filter combinations. The light projected by the collimator was supplied by a flash lamp to eliminate any effects of vibration during exposures. Antibooming was 'OFF' in all images. At the -10° and 5° C temperatures, various numbers of layers of Kaydry sheets were used to attenuate the light for the CL1/CL2 data sets.

No images were acquired in this configuration with the target removed (i.e., flat-field images).

5.2.1.2.2 METHOD

Image areas containing the appropriate edges were selected. For the Bar targets, all corners and the center provided areas. For the Focus target, only the center region provided useful edges.

These image areas were supplied to the VICAR program OTF1 for characterization of the system MTF. For this analysis, no shading correction was applied before the MTF analysis because no images were acquired without the MTF target.

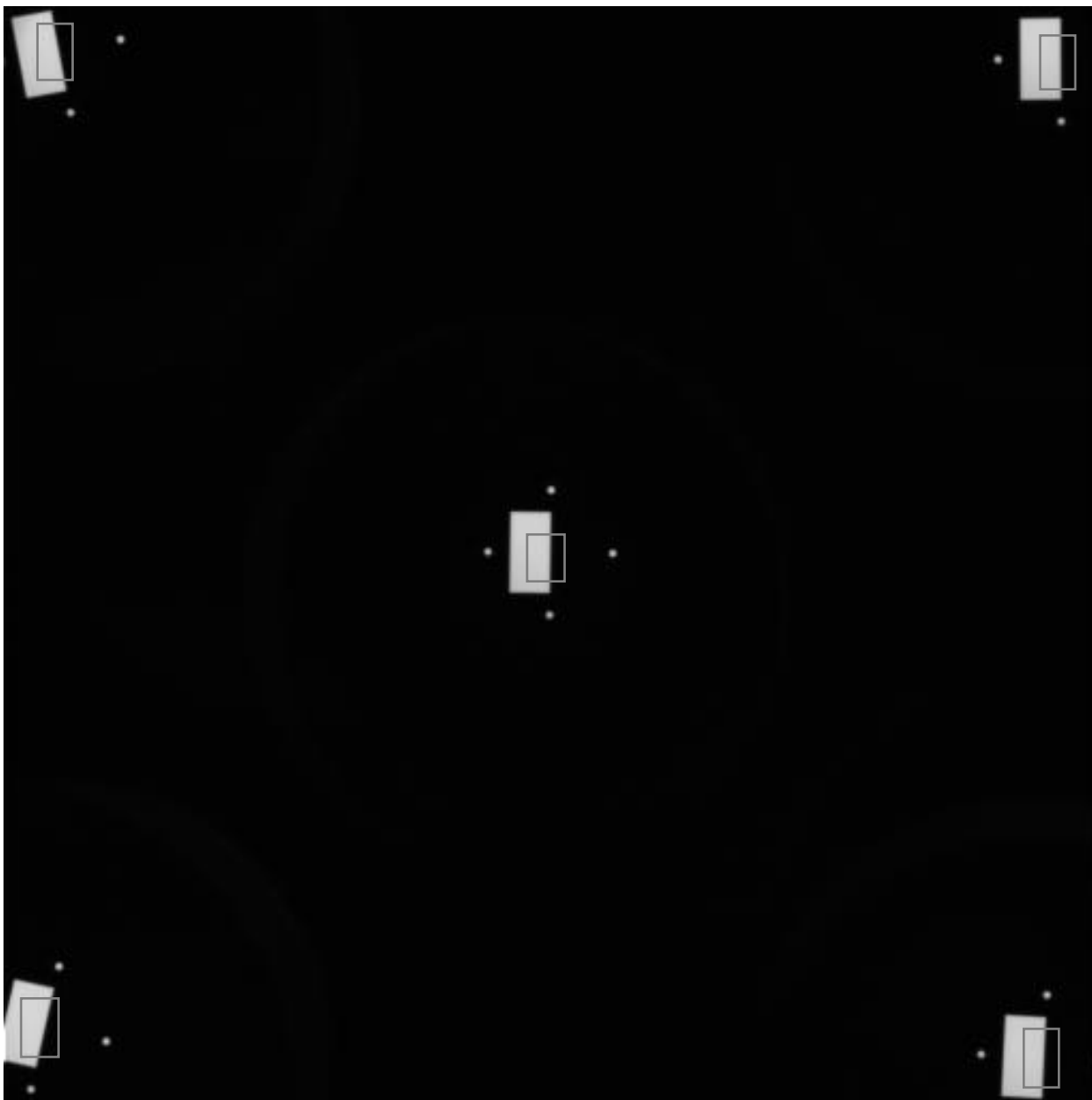
The algorithm proceeds through the following steps:

- For each line (or column) passing across the bar, the DN values are differentiated to form Line Spread Function (the peak of the resulting values defines the exact edge of the bar).
- For each line (or column), the LSF is justified using the peak value, resampled by the Sampling Theorem to 256 points and the 1-d Fourier Transform is taken.
- The Real and Imaginary components of the FT for all lines (or columns) are accumulated giving both Real and Imaginary values as a function of spatial frequency.
- The Real and Imaginary components are used to derive the normalized amplitude at each frequency.

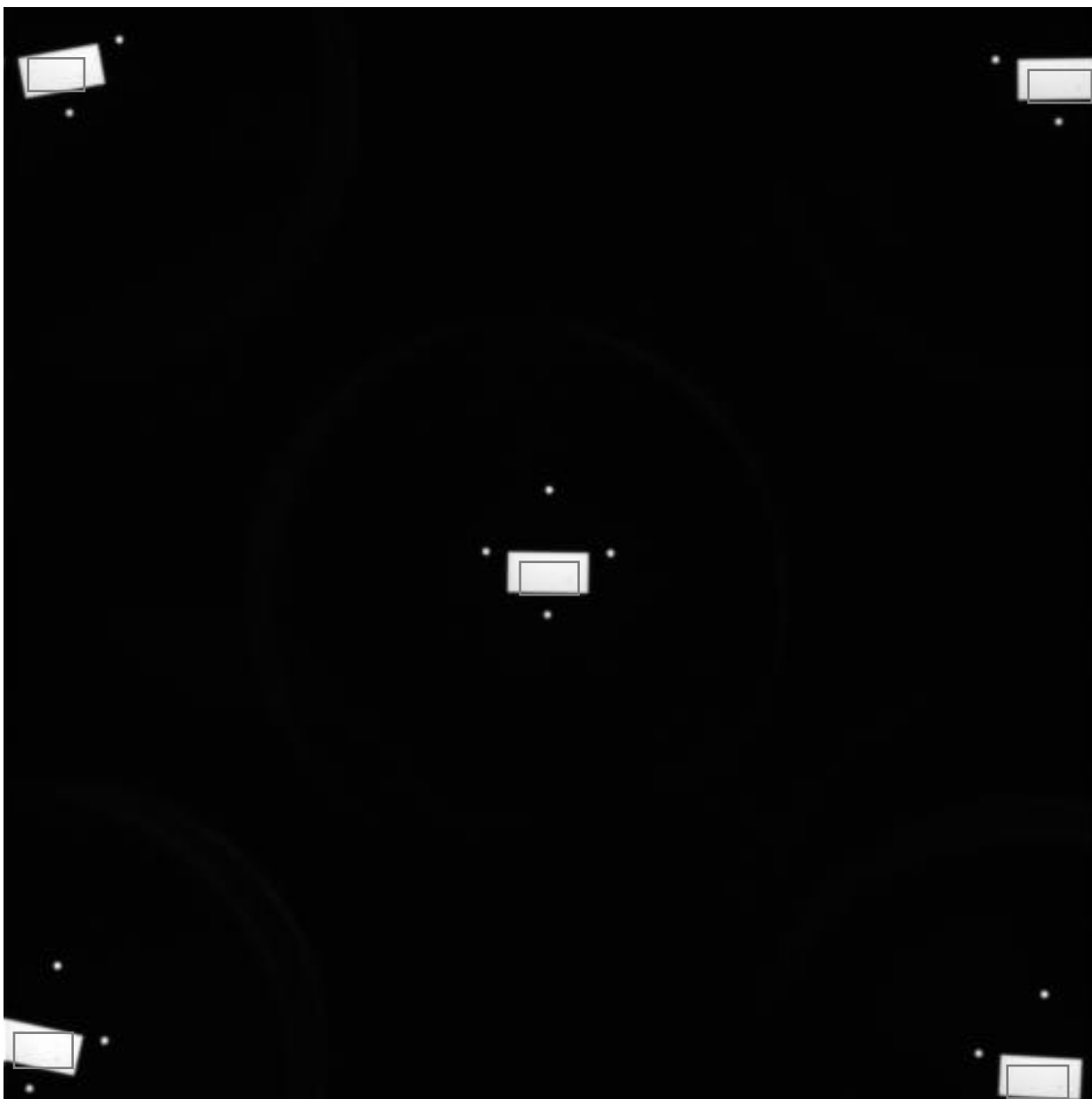
The edges which were used are described in the tables below as either:

- Ascending Horizontal Edge - An edge used to measure the Vertical MTF. A column of pixels passing across the edge from top to bottom goes from low DN's to high DN's.
- Descending Vertical Edge - An edge used to measure the Horizontal MTF. A line of pixels passing across the edge from left to right goes from high DN's to low DN's.
- Ascending Vertical Edge - An edge used to measure the Horizontal MTF. A column of pixels passing across the edge from top to bottom goes from low DN's to high DN's.

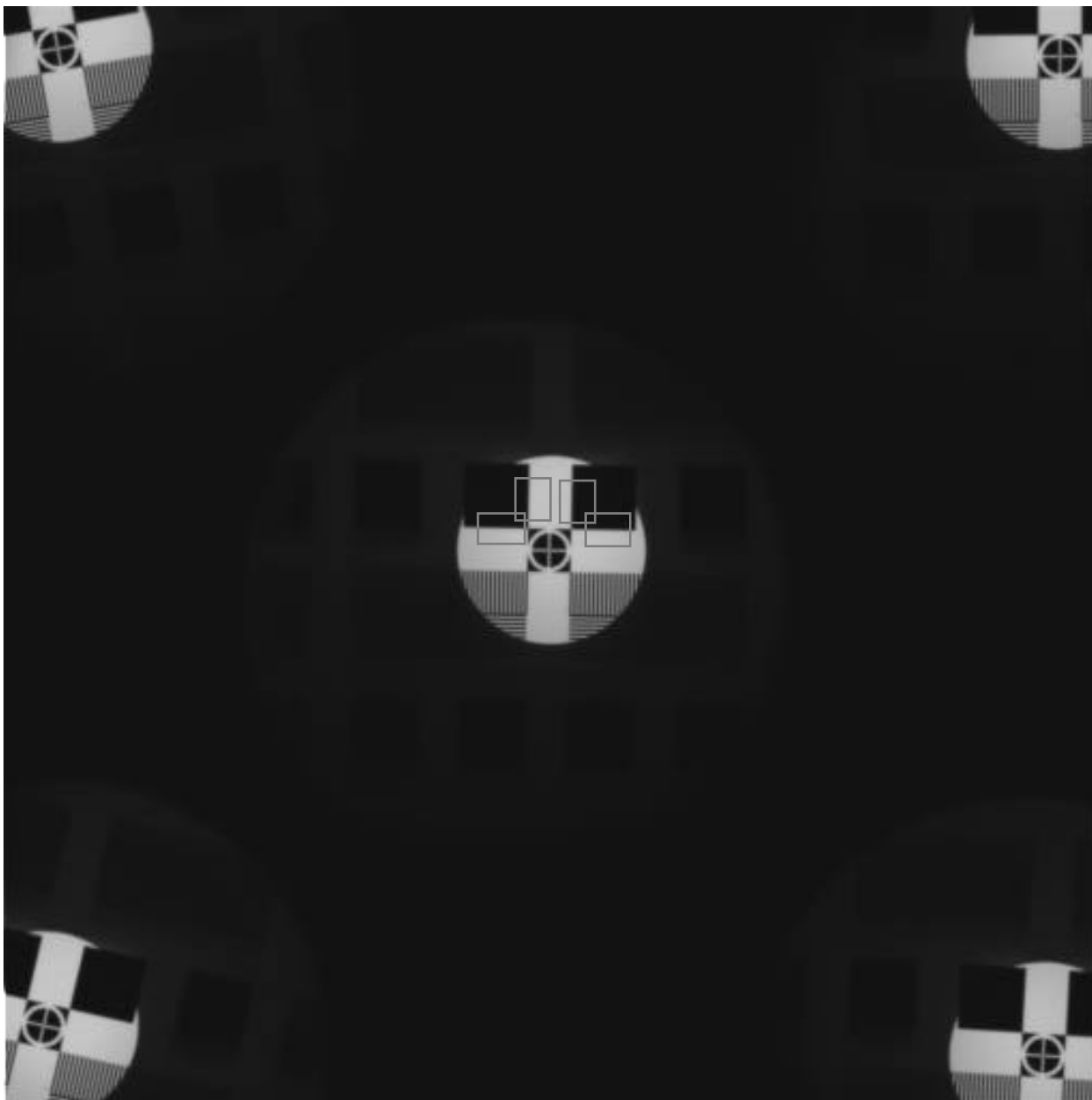
The WAC collimator projected targets into each corner and the image center simultaneously. Examples of the resulting images are shown below. The approximate regions of analysis are indicated as rectangular outlines in the images.



Vertical bright bar (-10° and 5° C)

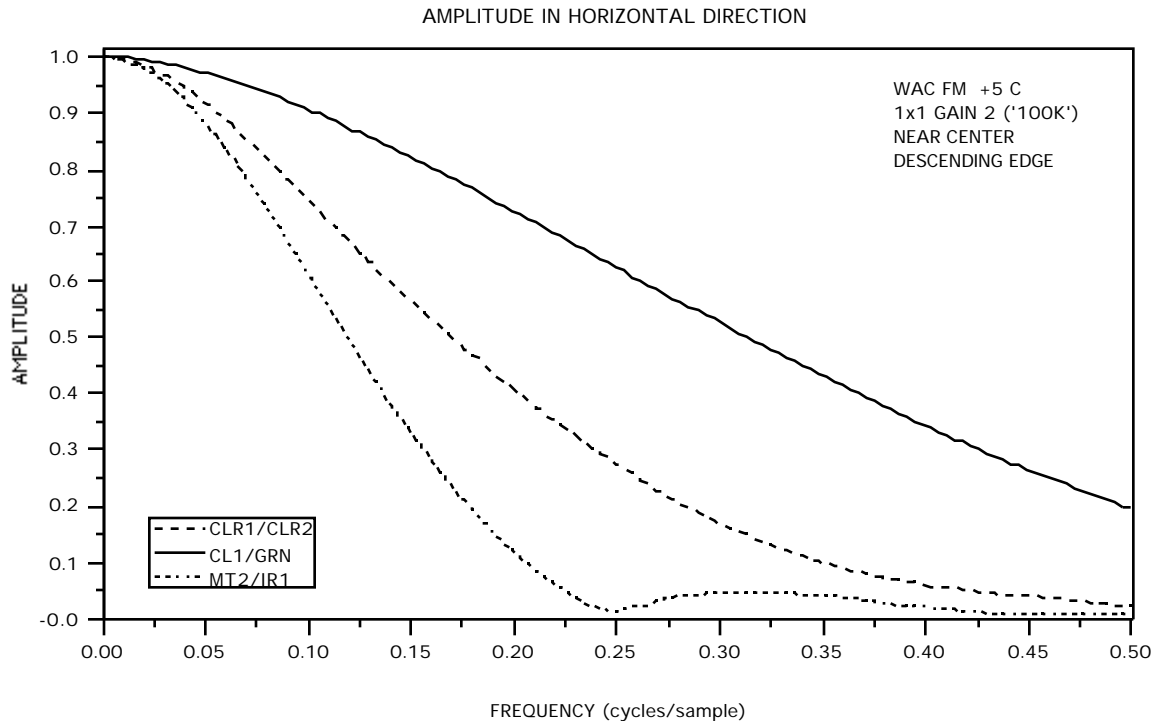


Horizontal bright bar (-10° and 5° C)



Focus Target (25° C only)

Below is a plot of example MTF curves showing CL1/CL2, CL1/GRN, and MT2/IR1 for a vertical edge near the image center.



5.2.1.2.3 RESULTS

Because of the number of filter combinations tested, all curves could not be plotted here. Thus, the following tables summarize the values of the System MTF in the various Gains, Modes, Filters and areas. Recall that the ISS Functional Requirements Document 699-205-4-2036 sets a performance requirement of System MTF 0.15 at 32 line-pairs/mm (corresponding to .38 cycles/sample). Therefore, all the tabulated values represent the MTF amplitude at this frequency.

CL1/CL2 frames were taken at high (~3000 DN), low (~800 DN) and, for Gain=2, medium exposures. These are indicated in the tables in the Mode column as FULL-H, FULL-L and FULL-M.

WAC MTF Tables

5.2.1.2.4 CONCLUSIONS

1. Low vs. high exposure didn't cause MTF changes for the CL1/CL2 cases where both exposures were available.
2. There was significant variation in MTF amplitude from corner to center for some filters. In particular, images using IR4, CB3, and MT3 show large variations, especially between the center and the bottom left.

3. The horizontal and vertical amplitudes agreed pretty well. However, the agreement was especially good for the +25° data. This is probably due to the fact that for the +25° data, horizontal and vertical measurements used the same image. The others required different targets at different times where conditions may not have been identical. To illustrate this, the list below shows the mean of the absolute value of (horizontal amplitude - vertical amplitude) for the center:
- -10° 0.020
 - +5° 0.022
 - +25° 0.007
4. Wide variation in filter MTF quality was expected because of focus tradeoffs in the design. The following table shows the filters sorted by the mean center amplitude (including both horizontal and vertical at +25° C). Even if the collimator/window contribution was removed, three of the filter combinations may not meet the 0.15 requirement.

FILTER 1	FILTER 2	Mean center value
IR2	IR1	0.030
MT2	IR1	0.052
CL1	CL2	0.080
CB3	CL2	0.121
MT3	CL2	0.123
MT3	IRP0	0.129
CB3	IRP0	0.131
MT3	IRP90	0.132
CB3	IRP90	0.133
CL1	VIO	0.135
IR2	IRP90	0.148
IR4	CL2	0.149
IR4	IRP0	0.151
IR2	CL2	0.155
IR2	IRP0	0.161

FILTER 1	FILTER 2	Mean center value
IR4	IRP90	0.161
CL1	IR1	0.162
IR5	CL2	0.167
IR5	IRP90	0.173
IR3	CL2	0.173
IR5	IRP0	0.174
IR3	IRP90	0.175
IR3	IRP0	0.179
CL1	BL1	0.190
CL1	RED	0.247
MT2	CL2	0.250
CB2	CL2	0.270
CL1	HAL	0.336
CL1	GRN	0.393

5.2.1.2.5 List of frames used in MTF analysis

[illegible]