5.1.8.2 WAC FM POLARIZATION RESULTS

As reported in Reference 5.1.8.2-1

Reference 5.1.8.2-1 - IOM 388-PAG-CCA96-15, "WAC FM Calibration Results: Polarization - Rev. 1", C. Avis, October 29, 1996, Change: Correction of wording on page 2

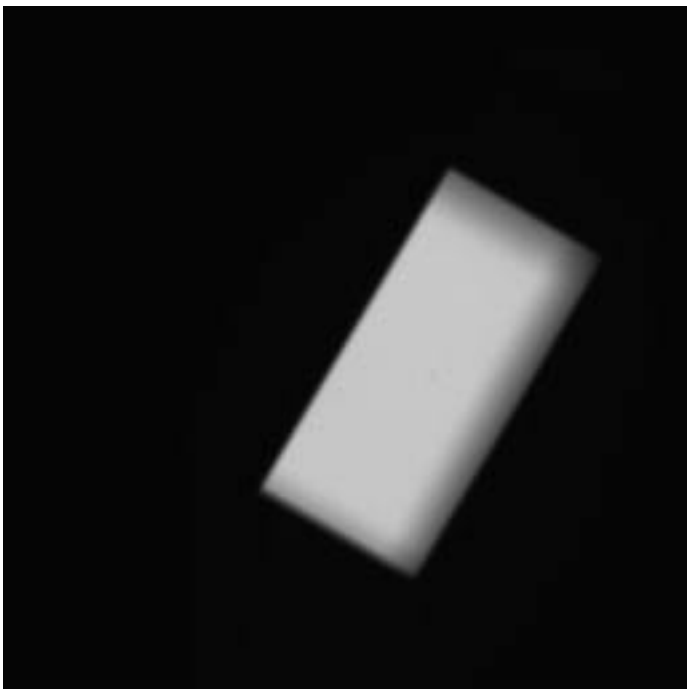
5.1.8.2.1 INTRODUCTION

The Wide -angle Flight Model thermal/vacuum testing included the acquisition of a set of images for determination of the polarization axis of the polarizing filters.

The image data was taken at a chamber temperature of 25° C. The reported optics temperature was 27° C and the detector was at -89° C. The test utilized a polarizing target whose polarization axis was perpendicular to an associated knife edge to ±0.25°. The target-knife edge combination was manually rotated between exposures. At each measurement angle, images were taken in full-resolution mode at Gain state 2 (‘100K’) in the six filter combinations listed below:

CL1/CL2	CL1/IRP0
CL1/IRP90	MT2/CL2

A typical Wide-angle image:



5.1.8.2.2 METHOD

As the polarized target rotated, the signal recorded by the camera varied because the polarized filter in the camera filter wheels remained fixed. The maximum response of the camera occurred when the two polarization axes aligned. Assuming the edge was precisely aligned perpendicular to the target polarization axis, the angle of the edge at maximum response determined the polarization axis of the camera's filter.

Therefore, the analysis job had three steps:

1. measure the angle of the edge within the image data,
2. measure the signal relative to that of an unpolarized camera filter,
3. fit these two measurements to a function in order to derive the exact maximum response angle.

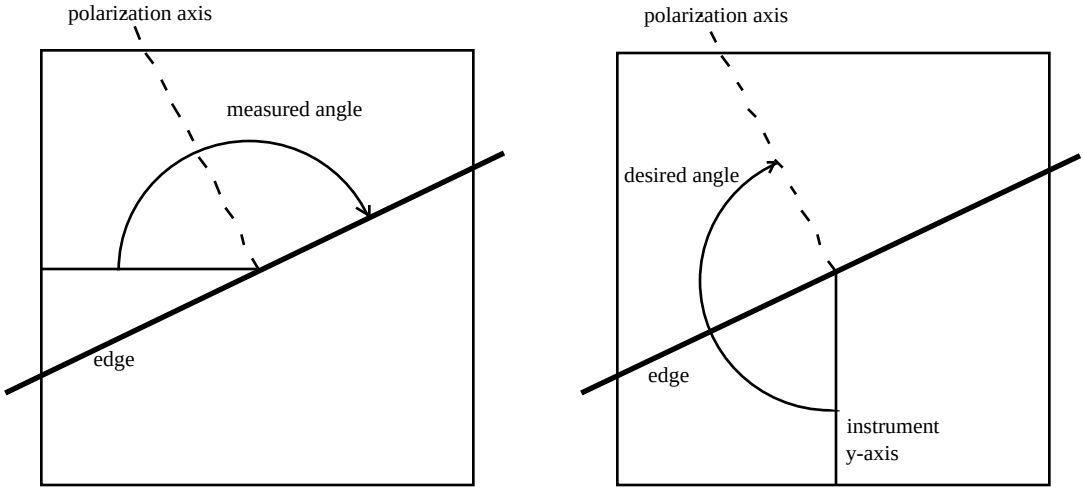
Measuring the angle

Because the various filter combinations were all taken at the same angle, the angle of the edge was measured in the unpolarized filter images. New software was written which first scanned the image for an edge. An edge-crossing point was defined as the point where the pixel values transitioned from below the image mean value to above. In addition, the values had to stay above the mean for a certain number of pixels. Because the illumination didn't extend to the image edges, the edge search area was restricted to the center region.

After finding the edge-defining pixels, the software then iteratively solved a least-squares equation for the best fit edge angleθ . At each iteration, the points with the worst residuals were removed. The resulting edge angles are in the following coordinate system:

- origin is at the image center
- zero is in the decreasing sample direction
- value increases clockwise

The left drawing below shows the angle being measured by finding the edge. The right one shows the desired angle (polarization axis relative to the instrument y-axis). This shows that finding the edge in the above coordinate system gives the appropriate value.



Measuring the signal

For each test image, the mean signal was measured. Each polarized filter's signal was compared to that of the unpolarized filter's signal at the same angle:

$$S_p = M_p / M_u$$

where S_p = the corrected mean signal for polarized filter *p*,
M_p = the mean signal for polarized filter *p*,
M_u = the mean signal for unpolarized filter.

The unpolarized filter combination used for the ratio was the CL1/MT2.

Deriving the angle of maximum response
For the set of polarized images, a collection of S_p and θ values were fit to the following function:

$$S_p = a + b \cdot cos^2(\theta - \theta_0)$$

where a = an offset factor,
b = a scale factor,
θ = the measured angle,
θ_0 = the angle of maximum response.

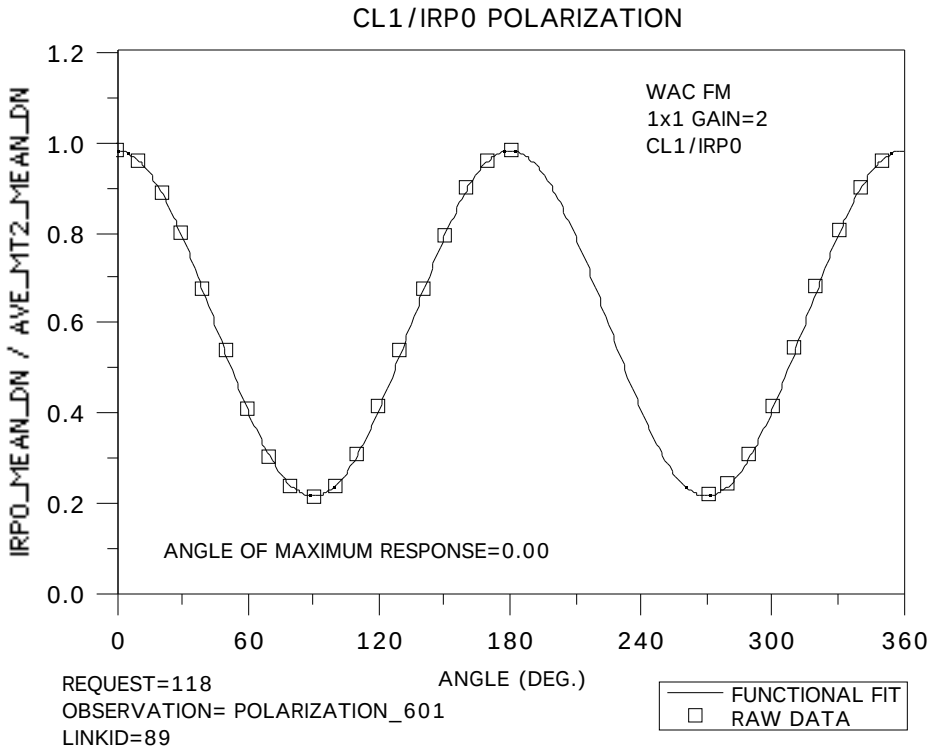
The best values of *a*, *b*, and θ_0 were derived from an iterative Metropolis algorithm.

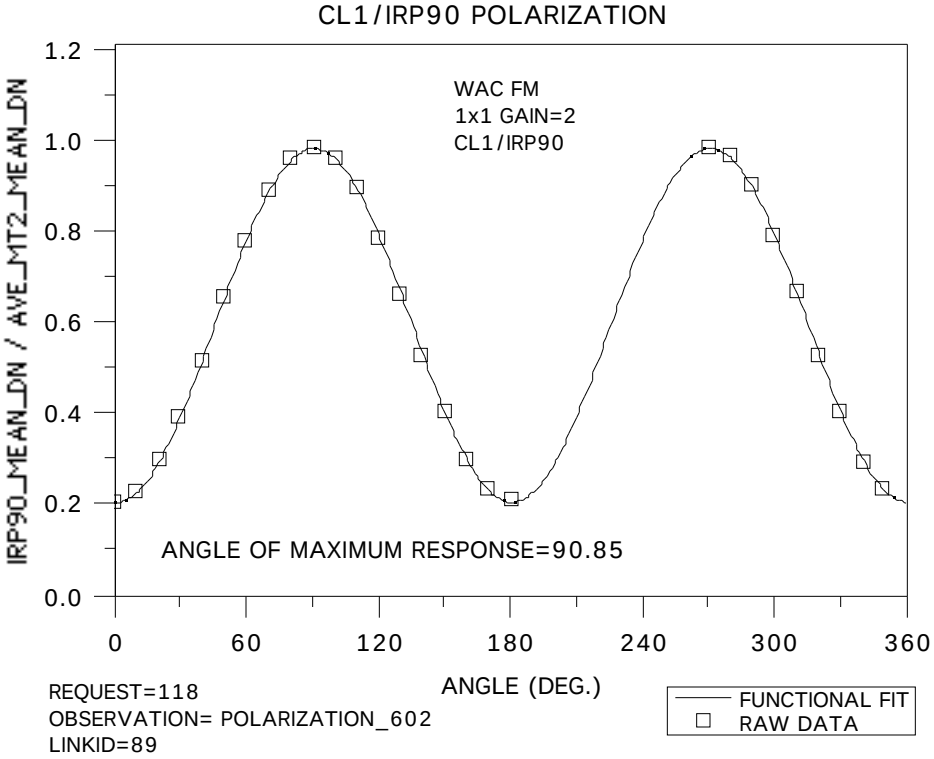
5.1.8.2.3 RESULTS

The following table lists the best fit angle of maximum response for each of the polarizing filter combinations.

FILTER COMBINATION	ANGLE OF MAXIMUM RESPONSE	PERCENT ERROR
CL1 / IRP0	0.00	0.222
CL1 / IRP90	90.85	0.179

The following plots show the measured data points and the best fit function for each of the polarizing filter combinations.


CL1/IRP0 POLARIZATION
WAC FM
1x1 GAIN=2
CL1/IRP0
IRP0_MEAN_DN / AVE_MT2_MEAN_DN
ANGLE OF MAXIMUM RESPONSE=0.00
ANGLE (DEG.)
REQUEST=118
OBSERVATION= POLARIZATION_601
LINKID=89
FUNCTIONAL FIT
RAW DATA


CL1/IRP90 POLARIZATION
WAC FM
1x1 GAIN=2
CL1/IRP90
IRP90_MEAN_DN / AVE_MT2_MEAN_DN
ANGLE OF MAXIMUM RESPONSE=90.85
ANGLE (DEG.)
REQUEST=118
OBSERVATION= POLARIZATION_602
LINKID=89
FUNCTIONAL FIT
RAW DATA

5.1.8.2.4 IMAGES USED IN POLARIZATION ANALYSIS

image	day	eventtime	filt1	filt2	expos
134036	207	18:57:55.0	CL1	IRP0	5
134037	207	18:59:49.0	CL1	IRP90	5
134038	207	19:1:53.0	MT2	CL2	320
134039	207	19:9:39.0	CL1	CL2	5
134040	207	19:12:27.0	CL1	IRP0	5
134041	207	19:14:14.0	CL1	IRP90	5
134042	207	19:16:29.0	MT2	CL2	320
134043	207	19:24:47.0	CL1	CL2	5
134044	207	19:26:42.0	CL1	IRP0	5
134045	207	19:28:26.0	CL1	IRP90	5
134046	207	19:30:25.0	MT2	CL2	320
134048	207	19:39:25.0	CL1	CL2	5
134050	207	19:43:5.0	CL1	IRP0	5
134051	207	19:47:12.0	CL1	IRP90	5
134052	207	19:49:24.0	MT2	CL2	320
134053	207	19:54:27.0	CL1	CL2	5
134054	207	19:56:28.0	CL1	IRP0	5
134055	207	19:58:14.0	CL1	IRP90	5
134056	207	20:0:16.0	MT2	CL2	320
134057	207	20:18:23.0	CL1	CL2	5
134058	207	20:20:18.0	CL1	IRP0	5
134059	207	20:22:40.0	CL1	IRP90	5
134060	207	20:24:39.0	MT2	CL2	320
134062	207	20:30:30.0	CL1	CL2	5
134063	207	20:32:20.0	CL1	IRP0	5
134064	207	20:34:16.0	CL1	IRP90	5
134066	207	20:56:49.0	MT2	CL2	320
134069	207	21:7:37.0	CL1	CL2	5
134070	207	21:9:33.0	CL1	IRP0	5
134071	207	21:11:17.0	CL1	IRP90	5
134073	207	21:14:50.0	MT2	CL2	320
134075	207	21:32:23.0	CL1	CL2	5
134076	207	21:34:25.0	CL1	IRP0	5
134077	207	21:36:7.0	CL1	IRP90	5
134078	207	21:38:9.0	MT2	CL2	320
134079	207	21:43:1.0	CL1	CL2	5
134080	207	21:45:47.0	CL1	IRP0	5
134081	207	21:47:36.0	CL1	IRP90	5
134082	207	21:51:15.0	MT2	CL2	320
134083	207	21:55:31.0	CL1	CL2	5
134084	207	21:57:32.0	CL1	IRP0	5
134085	207	21:59:9.0	CL1	IRP90	5
134086	207	22:1:3.0	MT2	CL2	320
134087	207	22:17:44.0	CL1	CL2	5
134088	207	22:19:36.0	CL1	IRP0	5
134089	207	22:21:47.0	CL1	IRP90	5
134091	207	22:25:37.0	MT2	CL2	320
134092	207	22:29:53.0	CL1	CL2	5
134093	207	22:31:44.0	CL1	IRP0	5
134094	207	22:33:27.0	CL1	IRP90	5
134095	207	22:35:19.0	MT2	CL2	320
134097	207	22:42:3.0	CL1	CL2	5
134099	207	22:45:31.0	CL1	IRP0	5
134101	207	22:48:51.0	CL1	IRP90	5
134102	207	22:50:51.0	MT2	CL2	320
134103	207	22:54:31.0	CL1	CL2	5
134104	207	22:56:18.0	CL1	IRP0	5
134106	207	22:59:33.0	CL1	IRP90	5
134107	207	23:1:27.0	MT2	CL2	320
134108	207	23:10:34.0	CL1	CL2	5
134109	207	23:12:21.0	CL1	IRP0	5
134110	207	23:14:1.0	CL1	IRP90	5
134111	207	23:16:2.0	MT2	CL2	320
134112	208	0:23:55.0	CL1	CL2	5
134113	208	0:27:50.0	CL1	IRP0	5
134115	208	0:33:35.0	CL1	IRP90	5
134116	208	0:36:5.0	MT2	CL2	320
134117	208	0:42:27.0	CL1	CL2	5
134118	208	0:45:57.0	CL1	IRP0	5
134119	208	0:48:13.0	CL1	IRP90	5
134120	208	0:50:44.0	MT2	CL2	320
134121	208	0:54:39.0	CL1	CL2	5
134122	208	0:56:56.0	CL1	IRP0	5
134125	208	1:2:58.0	CL1	IRP90	5
134126	208	1:5:14.0	MT2	CL2	320
134127	208	1:19:54.0	CL1	CL2	5
134129	208	1:27:45.0	CL1	IRP0	5
134130	208	1:42:4.0	CL1	IRP90	5
134131	208	1:44:57.0	MT2	CL2	320
134132	208	1:55:57.0	CL1	CL2	5
134133	208	2:6:3.0	CL1	IRP0	5
134134	208	2:9:11.0	CL1	IRP90	5
134135	208	2:11:17.0	MT2	CL2	320
134136	208	2:19:35.0	CL1	CL2	5
134138	208	2:30:4.0	CL1	IRP0	5
134139	208	2:33:53.0	CL1	IRP90	5
134140	208	2:36:31.0	MT2	CL2	320
134141	208	2:43:32.0	CL1	CL2	5
134142	208	2:46:31.0	CL1	IRP0	5
134143	208	2:48:18.0	CL1	IRP90	5
134145	208	2:52:17.0	MT2	CL2	320
134146	208	2:56:12.0	CL1	CL2	5
134147	208	2:58:7.0	CL1	IRP0	5
134148	208	2:59:44.0	CL1	IRP90	5
134149	208	3:1:44.0	MT2	CL2	320
134150	208	3:5:16.0	CL1	CL2	5
134151	208	3:7:51.0	CL1	IRP0	5
134154	208	3:14:33.0	CL1	IRP90	5
134157	208	3:38:23.0	MT2	CL2	320
134158	208	3:42:2.0	CL1	CL2	5
134159	208	3:45:14.0	CL1	IRP0	5
134161	208	3:48:46.0	CL1	IRP90	5
134162	208	3:50:51.0	MT2	CL2	320
134164	208	4:29:43.0	CL1	CL2	5
134165	208	4:33:9.0	CL1	IRP0	5
134166	208	4:35:4.0	CL1	IRP90	5
134167	208	4:37:22.0	MT2	CL2	320
134168	208	4:40:43.0	CL1	CL2	5
134169	208	4:45:37.0	CL1	IRP0	5
134170	208	4:47:40.0	CL1	IRP90	5
134171	208	4:49:50.0	MT2	CL2	320