

To: Distribution

From: N. R. Izenberg

Subject: Linearity for CONTOUR imagers

References: (1) N. R. Izenberg, Master Calibration Record Parts 1-4
(2) M. R. Keller, B. Gotwols, Imagers Report SRO-02M-30

Summary

Linearity is determined for Comet Nucleus Tour (CONTOUR) imagers: CONOUR Remote Imager/Spectrometer (CRISP) and CONTOUR Forward Imager (CFI). Parameters were determined from calibration observations of a uniformly illuminated integrating sphere in the APL optical calibration facility (OCF) with varied exposure time. Linearity was determined to be acceptable for flight.

Introduction

CONTOUR's CFI and CRISP Imager are the two CCD-camera instruments on the CONTOUR spacecraft. Each imager has a 10-filter filter wheel in between the telescope optics and the CCD. Nine of the filters are "spectral" and one is a "clear" or wide-bandpass filter. Accurate knowledge of CCD linearity is required to determine the useful range dynamic range of the instruments for planning flight observations.

To support these analyses, a series of "flatfield" images were collected during the calibration of the instruments. Broad-spectrum, diffuse light was generated in the APL Optical Calibration Facility (OCF) using the facility's integrating sphere.

Test Conditions

The test setup for linearity determinations utilized the OCF "white" sphere fed Halogen and Xenon lamps. The integrating sphere has integrated attenuators to dim the light incoming to the sphere. Each imager took a series of dark and field-filled images at varied exposure times to determine the CCD response as a function of brightness. In order to determine if imager response is linear, we characterize DN accumulation rate (DN with respect to exposure time) with brightness level. All data were corrected for dark current and frame transfer smear to remove additive component of DNs. The additive component would affect results for shorter exposure times

The Dataset for CRISP was taken during the calibration test CIBMA_WLI. CFI linearity data is taken primarily from the CF0AC_WFR test. Calibration observations are documented in the Master Calibration Record (MCR, Ref. 1).

Results

Average raw DN values from field filling images from the integrating sphere, (smear corrected for the shortest exposures), were determined for different exposure times for each imager CCD. The shortest exposure times were used to normalize the change in signal (DN) with the change in exposure time, compared to the Raw DN in each image. The CCD was considered nonlinear as the (Delta DN/ Delta exposure time) value departed from near 1.0. CFI linearity tests (Figure 1, Table 1) included multiple filters at multiple exposure times. CFI was linear to ~3300 DN raw. CRISP linearity tests had on a single filter determined it to be linear to $2000 < DN < 2700$ raw.

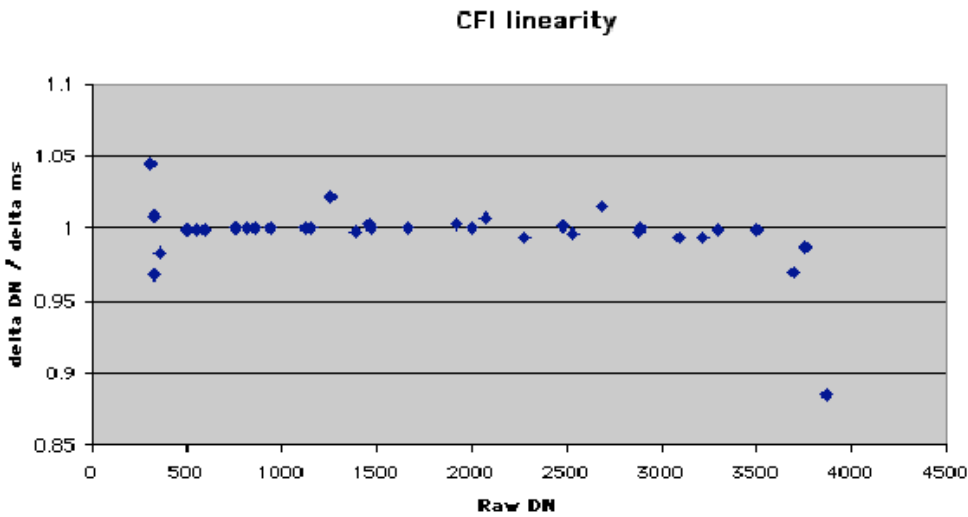


Figure 1. Plot of CFI Linearity

Table 1. CFI linearity data for Fig. 1 by filter and exposure time.

Filter	exposure/ms	Mean of image/DN	DN Normalized	Delta DN/delta exp. t	
7	81.92	629.4661	391.7361		
	184.32	1118.9355	881.2055	1	
	368.64	2000.2596	1762.5296	1.000316874	
	552.96	2879.838	2642.108	0.998335476	
	737.28	3750.0154	3512.2854	0.987665192	
4	81.92	493.01534	255.28534		
	184.32	811.83285	574.10285	1	
	368.64	1384.5637	1146.8337	0.998012329	
	737.28	2528.6301	2290.9001	0.996796638	
	958.464	3213.2976	2975.5676	0.994222979	
3	6002.048	3960.3744	3722.6444		
	3002.048	3958.205	3720.475	0.609069572	
	1002.048	1918.835	1681.105	1.0034372	
	737.28	1474.0452	1236.3152	1.0005278	
	368.64	856.55404	618.82404	1	
	184.32	547.97133	310.24133	0.999695868	
	81.92	376.58863	138.85863		
	81.92	247.03895	9.30895		
	184.32	254.17792	16.44792		
	737.28	304.07427	66.34427	1.045245728	
	1002.048	326.21066	88.48066	0.968466589	
3002.048	498.71329	260.98329	0.999100244		
6002.048	757.70026	519.97026	1		
2	81.92	249.34161	11.61161		
	737.28	326.09435	88.36435	1.008331144	
	1002.048	356.32444	118.59444	0.983021845	
	3002.048	588.35524	350.62524	0.99886056	
	6002.048	936.79847	699.06847	1	
1	81.92	1051.6733	813.9433		
	92.16	1153.2927	915.5627	1	
	102.4	1257.1801	1019.4501	1.022318573	
	122.88	1459.6634	1221.9334	1.003071882	
	143.36	1662.9104	1425.1804	1.000040347	
	184.32	2071.8006	1834.0706	1.006832045	
	204.8	2273.6638	2035.9338	0.994116946	
	225.28	2477.1566	2239.4266	1.002142247	
	245.76	2683.5478	2445.8178	1.015510818	
	266.24	2886.8445	2649.1145	1.000284887	
	286.72	3088.8863	2851.1563	0.994110377	
	307.2	3291.9441	3054.2141	0.999109422	
	327.68	3494.9628	3257.2328	0.998917037	
	348.16	3691.9291	3454.1991	0.969137291	
	368.64	3871.8437	3634.1137	0.885237464	
	Dark	81.92	240.59683	2.86683	
		163.84	240.34791	2.61791	
327.68		240.8948	3.1648		
327.68		240.91159	3.18159		
655.36		242.0615	4.3315		
958.464		243.1755	5.4455		

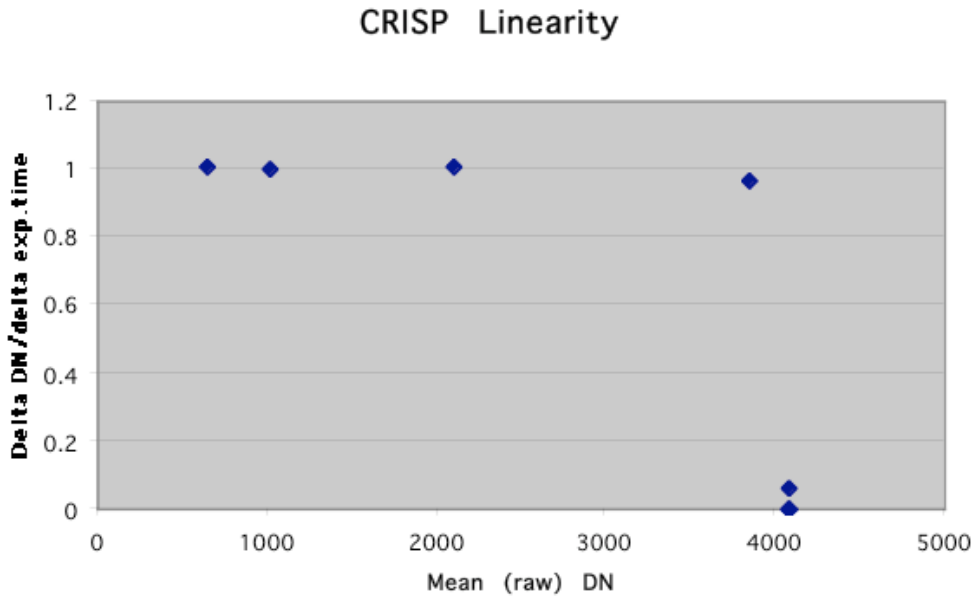


Figure 2. Plot of CRISP Linearity

Table 2. CRISP Linearity data by exposure time.

CIBMA_WLI exposure/ms	mean of image/DN	DN Normalized	Delta DN/delta exp.t
0.128	285.24	0.28244101	
10.112	648.787	0.642420612	1.006712485
20.096	1009.91	1	1.00000009
50.046	2099.99	2.079383311	1.006261847
100.096	3849.07	3.811300017	0.966173349
200.046	4079.95	4.039914448	0.063863538
300.096	4079.95	4.039914448	0
500	4079.95	4.039914448	0
700	4079.95	4.039914448	0
900	4079.95	4.039914448	0

Conclusions

CRISP linearity was somewhat low, but linearity for CRISP and CFI was acceptable. In-flight calibrations were planned to update and supplement the results of the on-ground calibrations.

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