MRO FTT/NAS & FLC

First Light Camera Test Procedure

MRO-PRO-CAM-1200-0167

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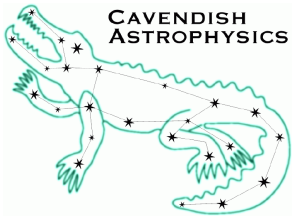

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Change Record

Revision	Date	Author(s)	Changes
0.1	2014-09-18	JSY	Initial version
0.2	2016-04-07	JSY	Incorporated EBS comments from 2014-09-19

Objective

To describe the acceptance test procedures for the MROI First Light Camera.

Scope

This document describes the procedures for acceptance testing of the First Light Camera. The technical requirements document for the FLC specifies a number of tests to be performed in Cambridge. The majority of the software for the FLC is common to the FTT/NAS, and the differences between the FLC and FTT/NAS opto-mechanics are not relevant to the tests, therefore some of these tests will only be performed as part of FATs for the FTT/NAS. This document describes the remaining tests that are specific to the FLC.

Reference Documents

RD1 Technical Requirements: First Light Camera (INT-403-TSP-0107) – rev 1.0, May 20th 2010

RD2 Technical Requirements: Fast Tip-Tilt/Narrow-field Acquisition System (INT-403-ENG-0003) – rev 2.2, May 20th 2010

RD3 Software Release Notes (MRO-MAN-CAM-1160-0163) – rev 1.5, February 23rd 2016

Acronyms and Abbreviations

EMCCD Electron Multiplying Charge Coupled Device
FAT Factory Acceptance Test
FTT Fast Tip-Tilt
FLC First Light Camera
GSI Generic System Interface
ICD Interface Control Document
ISS Interferometer Supervisory System
MROI Magdalena Ridge Observatory Interferometer
NAS Narrow-field Acquisition System
NMT New Mexico Tech
SAT Site Acceptance Test
SSH Secure SHell
TBC To be confirmed
TBD To be determined
UTM Unit Telescope Mount
VCMF Visitor Center and Maintenance Facility

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1 Introduction

The fast tip-tilt system contract between NMT and University of Cambridge specifies two main deliverables, the FTT/NAS and First Light Camera (FLC). Two distinct roles were originally anticipated for the FLC [RD1]:

- A standalone role, independent of the MRO ISS, which will primarily be used for commissioning and acceptance testing of the UTM. In this role the FLC will be used for manual target acquisition and to develop pointing models and perform open-loop tracking tests;
- A role where it operates under the control of the MRO ISS and performs the NAS functions (for example automatic target acquisition and tracking) that are anticipated for the FTT/NAS system. This role was intended for use when integrating the UT (including associated systems) with the ISS, prior to delivery of the first FTT/NAS system.

Since the requirements associated with the second role are a subset of the full FTT/NAS requirements [RD2], we decided to develop a common suite of software to satisfy both. This software suite can be used with either the FLC or the FTT/NAS opto-mechanical hardware. A distinct version of the control GUI software component satisfies the FLC-specific requirements associated with the first role above.

This document defines procedures for the acceptance tests which are relevant to its role in UTM commissioning. The remaining requirements will be tested as part of acceptance testing for the FTT/NAS. Table 1 shows that all of the FLC requirements to be tested either have an FLC-specific test (described in this document) or that equivalent requirements apply to the FTT/NAS.

2 FLC Factory Acceptance Tests

The tests described in this section will be carried out in Cambridge using Cambridge's own EMCCD camera and rack-mount computer. An identical camera and computer have been purchased by MRO for use at MROI. MRO could carry out a subset of the tests in the VCMF in order to verify that the system has been set up correctly.

The tests do not require any of the deliverable FLC opto-mechanics (lens and mount, fold mirror and mount, and camera mount). A temporary lens and camera mount may be used for the tests.

The requirements relating to remote operation of the control GUI may be satisfied in either of two ways. In both of these scenarios the system controller application runs on the rack-mount computer and the control GUI is displayed on a second computer:

1. The control GUI process runs on the second computer, and is configured to communicate with the system controller over the network using the dlmsg protocols.
2. The control GUI process runs on the rack-mount computer, and is displayed on the system controller using the X-windows protocol forwarded over a SSH connection.

The test descriptions have been written assuming the first method.

2.1 Prerequisites

The following items are required for the tests:

- The EMCCD camera, PCI card and signal cable.

Table 1: Summary of FLC requirements for which RD1 specified verification by means of a test. Each row of the table lists the reference number, a brief description of the requirement, then a summary field which describes the kind of verification associated with the given specification. These are followed by (if applicable) the FLC test ID, the reference numbers of the equivalent FTT/NAS requirements [RD2] and a comment. The summary field consists of 4 sub-fields denoted by the letters 'D' ("design"), 'A' ("analysis"), 'I' ("inspection"), 'T' ("test"), indicating the verification methods.

FLC-UR	Description	D	A	I	T	FLC-AT	FTT-UR	Comments
1-01	Provision of system modes: idle, acquisition, acquisition check, dark frame, flatfield	x			x		2, 6, 8, 9	
1-02	System mode functionality as FTT/NAS	x			x		3, 7, 10, 11, 13, 14, 51, 52	
1-03	Mode switching time <5 s	x			x		1	Goal <1 s
1-04	Testing without ISS and/or UTM	x			x		30	
2-08	Exposure times 5–1000 ms; sampling rates 1–10 Hz	x	x		x	01		Inspection of camera specifications at CoDR; test at delivery
2-09	Remote operation from control room	x			x	02	26	
2-10	Remote display (full-frame)	x			x	02		
2-11	Remote display (zoom of full frame)	x			x	02		
2-12	Compute centroid of selectable star w.r.t. user-specified fiducial. Display cross-hairs	x			x	03		
2-13	Display of computed centroid position on GUI	x			x	03		
2-14	Logging of centroids and timestamps to CSV file	x			x	04		
3-03	GUI display-only mode for use with ISS	x			x		27, 29	ISS not required for test
3-04	Provision and documentation of API	x		x			23	
3-05	Control of system functions using API	x			x		24	Unit tests of individual commands — ISS not required
3-06	Data transmission to ISS	x			x		37, 44	MRO will provide a simple data collector
3-07	Time-stamps on data transmitted to ISS accurate to 1 ms	x			x		38	
3-08	Full-data-rate low-latency ($\leq$0.2 s) transmission to ISS	x			x		45	MRO will provide a simple data collector
3-09	Operation from laptop	x			x		28	

Exposure /ms	Period /ms
5	100
10	100
20	100
5	1000
10	1000
20	1000
100	1000
1000	1100

Table 2: Exposure times and frame periods for test FLC-AT-01.

- An oscilloscope and cable to monitor the output of the "Fire" connector on the camera body.
- The rack-mount computer running Xenomai real-time Linux.
- The system controller and FLC control GUI applications must have been built and installed on the rack-mount computer as described in RD3.
- The FLC control GUI application must have been built and installed on a second computer connected to the same local network. The configuration file must contain the correct IP address of the rack-mount computer.
- Software for recording digital video of the computer display (e.g. kazam) must have been installed on the rack-mount computer and the second computer.
- The Python Analysis GUI must have been installed on the rack-mount computer, or on a computer that can access files recorded by the FLC control GUI over the network.
- A means of focusing an artificial star image onto the CCD must be provided. Test FLC-AT-03 requires a second artificial star image at a different location on the CCD. The tests take advantage of the fact that the images will drift by a small but measurable amount over time.
- Access to a server computer configured to export a writable filesystem over the network using NFS.

The instructions assume that all software components are stopped after completing each test and restarted as necessary for subsequent tests.

2.2 Test descriptions

Test ID FLC-AT-01

Requirement(s) FLC-UR-2-08: Exposure times from 5–1000 ms and sampling rates between 10 Hz and 1 Hz.

Test description

1. Start system controller
2. Start FLC control GUI (starts a new recording session)
3. Start recording video of the computer display

4. Set acquire decimation to 1 so that every image in the sequence is displayed
5. Focus a single artificial star image onto the CCD and adjust its brightness (or insert neutral density filters) so that the CCD just does not saturate in an exposure time of 1000 ms
6. Connect an oscilloscope to monitor the output of the "Fire" connector on the camera body (the camera is supplied with a suitable cable)
7. For each exposure time/frame period combination to be tested (see Table 2):
   (a) Set exposure time
   (b) Set frame period
   (c) Start acquire run
   (d) Observe update rate of live image display
   (e) Measure exposure time and frame rate from camera "Fire" signal using oscilloscope
   (f) Record next 30 s of data to FITS, adding an informative comment
   (g) Stop run
8. Stop video recording
9. Verify frame periods by examining intervals between frame timestamps in recorded data (this can be done with FV)
10. Verify exposure times by examining signal levels in recorded data

Test outputs

1. FITS data recording for each exposure/frame period combination
2. Video of the computer display showing the FLC control GUI displaying images

Pass/Fail criteria

1. The frame timestamps in the recorded data must have intervals equal to the specified frame periods
2. The signal levels in the recorded data must increase in proportion to the specified exposure times

Test ID FLC-AT-02

Requirement(s) FLC-UR-2-09, 2-10, 2-11: Able to be operated from the control room by means of a MRO-owned computer terminal. Able to display full frame images at the exposure sampling rate (i.e. up to 10 Hz). Shall provide an enlarged display of a user-selected region of the full frame images.

Test description

1. Start system controller on rack-mount computer
2. Start FLC control GUI on second computer (starts a new recording ses-

sion)

3. Start recording video of the computer display
4. Set frame period to 0.1 s
5. Set acquire decimation to 1 so that every image in the sequence is displayed
6. Focus a single artificial star image onto the CCD
7. Start acquire run
8. Set image display to "Fit in window" to show the full frame
9. Observe image display update rate
10. Click "Zoom In" button several times and pan the image as necessary
11. Observe image display update rate
12. Stop run
13. Stop video recording

Test outputs

1. Video of the computer display showing the FLC control GUI displaying images remotely

Pass/Fail criteria

1. The system controller must accept commands from the control GUI running on the second computer
2. Full frame images must be updated on the remote control GUI at 10 Hz
3. Zoomed images must be updated on the remote control GUI at 10 Hz

Test ID FLC-AT-03

Requirement(s) FLC-UR-2-12, 2-13: Able to compute centroid of selectable star in full frame, with respect to a user-specified fiducial point. The GUI shall display crosshairs at the fiducial point. Shall provide live numerical display of average and rms of centroids on GUI, updated at intervals equal to the averaging time (user-specified between 100 ms and 5000 ms). Display of recent history of 10 previous average and rms values on GUI.

Test description

1. Start system controller
2. Start control GUI
3. Start recording video of the computer display
4. Set acquire decimation to 1 (this determines the minimum number of frames averaged)
5. Set frame period to 0.1 s
6. Record a dark frame and set the system to use it when calculating centroids

7. Focus two separated artificial images onto the CCD
8. For each number of frames to be averaged (1, 2, 10, 50):
   (a) Start acquire run
   (b) Set tip-tilt zero point to an arbitrary location by dragging a box around the intended position on the displayed image; note the new zero point coordinates displayed on the GUI
   (c) Set acquire scope to a rectangular region containing only one of the two star images, chosen alternately
   (d) Stop and restart acquire run
   (e) Record next 30 s of data to FITS, adding an informative comment
   (f) Stop run
   (g) Select the displayed average and rms centroid coordinates for the latest run using the mouse; paste these into a text file
9. Stop video recording
10. Use the analysis GUI to verify the consistency of the displayed and recorded centroid coordinates

Test outputs

1. Video of the computer display showing the FLC control GUI displaying cross-hairs and recent average and rms centroid coordinates
2. FITS data recording for each number of frames averaged
3. Text file of displayed average and rms centroids for each number of frames averaged

Pass/Fail criteria

1. The displayed average centroid coordinates must match the position of the selected star image relative to the specified fiducial position, to 0.2 pixel
2. The average centroid coordinates copied from the display must correspond to averages of the raw centroids in the corresponding FITS recording, within rounding error
3. The rms centroid coordinates copied from the display must correspond to rms values of the raw centroids in the corresponding FITS recording, within rounding error

Test ID FLC-AT-04

Requirement(s) FLC-UR-2-14: Able to log time-series of raw (unaveraged) centroids to ASCII CSV-format log file on user command. Logged centroids shall have accompanying UTC timestamps which are accurate to 1 ms. Logging should stop after a user-specified duration or when interrupted by the user. Log-file shall be accessible via a network shared drive.

Test description

1. Start system controller

	2. Mount a shared filesystem using NFS 3. cd to the shared filesystem and start the control GUI 4. Record a dark frame and set the system to use it 5. Set frame period to 0.1 s 6. Focus one artificial image onto the CCD 7. Start acquire run 8. Start recording centroid data to CSV for 30 s 9. Record next 30 s of data to FITS 10. Wait for recordings to complete 11. Record centroid data to CSV for 30 s 12. Interrupt recording while in progress and note the displayed recording progress 13. Use the analysis GUI to verify the accuracy of the centroids recorded to CSV
Test outputs	1. CSV log files (one full length, one interrupted) 2. FITS data recording contemporaneous with full-length CSV recording
Pass/Fail criteria	1. The CSV log files must be saved to the shared drive 2. The CSV log files must be formatted correctly and suitable for import into Microsoft Excel 3. The duration of the CSV log files must be as expected 4. The logged raw centroid coordinates must match those recorded to FITS, to 3 decimal places 5. The logged raw centroid coordinates must match the results of an independent calculation from the recorded images, to 0.2 pixel

How to test the CSV timestamp accuracy? OK to verify the timestamps match the computer clock, with NTP taking care of the rest?