Technical Requirements

First Light Camera

INT-403-TSP-0107 rev 1.0

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Contents

Change Record

Revision	Date	Authors	Changes
0.1	2010-04-09	JSY	First draft
0.2	2010-04-09	JSY	Restructured, new requirement numbering
0.3	2010-04-23	JSY	Removed non-requirements, completed verification methods
0.4	2010-04-23	JSY	Added 1-04, 3-09 from FTT/NAS requirements
1.0	2010-05-20	JSY	Corrected cross-references to other documents

Objective

To state the technical requirements for the MROI First Light Camera.

Referenced Documents

The following documents are incorporated by reference:

INT-403-TSP-0003 rev 1.3 "Technical Requirements: Unit Telescopes for the MRO Interferometer"

INT-404-TSP-0003 rev 2.5 "Technical Requirements: Unit Telescope Enclosures and Relocation System for the MRO Interferometer"

MRO-ICD-AMO-6000-025 issue 3 "Unit Telescope Electrical ICD"

INT-403-ENG-0003 rev 2.2 "Technical Requirements: Fast Tip-Tilt/Narrow-field Acquisition System"

Acronyms used in this document

API Application Programming Interface

ASCII American Standard Code for Information Interchange

CCD Charge-Coupled Device

CSV Comma-Separated Values

FLC First Light Camera

FOV Field Of View

FTT Fast Tip-Tilt

FWHM Full Width at Half Maximum

GUI Graphical User Interface

ICD Interface Control Document

ISS Interferometer Supervisory System

MROI Magdalena Ridge Observatory Interferometer

NA Narrow-field Acquisition

NTP Network Time Protocol

UT Unit Telescope

UTM Unit Telescope Mount

1 Introduction

The First Light Camera (FLC) system will be used for commissioning and integration of the first AMOS-delivered Unit Telescope (UT) at the Magdalena Ridge Observatory Interferometer (MROI). The FLC will be a precursor for the more capable Fast Tip-Tilt/Narrow-field Acquisition System (FTT/NAS) described in INT-403-ENG-0003: owing to delays in procuring the FTT/NAS, the FLC is being procured to coincide with the arrival of the first UT. The FTT/NAS will be delivered later and will replace the FLC for regular MROI scientific operations.

The FLC will be operated in two distinct roles:

- 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 will be used when integrating the UT with the ISS, prior to delivery of the first FTT/NAS system.

In the standalone role, the FLC will be controlled from its own GUI, capable of being displayed either on an MRO-owned computer in the interferometer control room or from an MRO-owned laptop.

2 Functional and Performance Requirements

2.1 Requirements: Operating Modes

FLC-UR1-01: System modes The FLC shall implement the following system modes defined in INT-403-ENG-0003:

- Idle Mode

- Acquisition Mode
- Acquisition Check Mode (use of this mode is not anticipated for UTM commissioning)
- Dark Frame Mode
- Flatfield Mode

FLC-UR1-02: System mode functionality The system shall meet all of the functional requirements from INT-403-ENG-0003 Sec. 4 and Sec. 5.12 that are specific to the above system modes.

FLC-UR1-03: Mode switching time The FLC system shall be able to switch between any two of the operating modes listed above within 5 seconds (goal 1 second).

FLC-UR1-04: Operation without ISS and/or UTM It shall be possible to test the FLC software in all system modes independently of either or both of the ISS and UTM, with appropriate reductions in functionality being permitted.

2.2 UTM Vendor Requirements

The requirements in this sub-section have been defined in consultation with the UTM vendor.

FLC-UR2-01: FOV At least 60 arcsec $\times$ 60 arcsec

FLC-UR2-02: Pixel scale Between 0.15 and 0.25 arcsec per pixel

FLC-UR2-03: Operational wavelength band Any one of the V, B or R photometric bands. It shall be possible to remove the supplied filter, or replace it with an alternative filter (but note that only one filter need be supplied)

FLC-UR2-04: Pointing and tracking test functionality Able to support the development of a pointing model and undertaking tracking and pointing tests. We assume that for all tests mount offset commands (e.g. to acquire stars and center them on a pointing fiducial) will be manually generated, by the user interacting with the AMOS/OSL-provided UTCS

FLC-UR2-05: Image quality Shall deliver images with a FWHM no worse than 1 arcsec (ignoring any contribution from the seeing and UT optics)

FLC-UR2-06: Focus and focus stability Able to be focused to meet the image quality requirement and to maintain that focus for temperature changes of at least 5 degrees Celsius (excludes focus changes associated with the UT and Nasmyth table)

FLC-UR2-07: Sensitivity Able to operate with stars as faint as $V = 10$ (This assumes an A spectral type)

FLC-UR2-08: Exposure time and sampling Able to support exposure times from 5–1000 ms and sampling rates (i.e. inverse of time between consecutive images) of between 10 and 1 Hz

FLC-UR2-09: Remote operation Able to be operated from the control room by means of a MRO-owned computer terminal

FLC-UR2-10: Remote display (full-frame) Able to display full frame images (corresponding to the FOV in FLC-UR2-01) on the screen of the MRO-owned Linux computer at the exposure sampling rate (i.e. up to 10 Hz)

FLC-UR2-11: Remote display (zoom of full frame) Shall provide an enlarged display of a user-selected region of the full frame images on the MRO-owned computer at the exposure sampling rate (i.e. up to 10 Hz)

FLC-UR2-12: Centroid computation Able to compute centroid of selectable star in full frame, with respect to a user-specified fiducial point on the CCD. The GUI shall display cross-hairs at the fiducial point

FLC-UR2-13: Display of computed centroid position 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 and 5000 ms). Display of recent history of 10 previous average and rms values on GUI.

FLC-UR2-14: Logging Able to log time-series of raw (unaveraged) centroids to ASCII CSV-format log-file on user command. Logged centroids shall have accompanying UTC time-stamps 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.

FLC-UR2-15: Mechanical stability Designed such that a temperature change of 5 degrees Celsius will not induce image motion in the plane of the image of more than 1 second of arc

FLC-UR2-16: Environmental envelope Designed to operate in the "reduced performance" conditions that were specified for the UT mount (INT-403-TSP-0003), but only for ambient temperatures above -15 degrees Celsius

FLC-UR2-17: Space envelope Designed to fit onto Nasmyth table

FLC-UR2-18: Cooling Designed to operate without an external supply of chilled fluid

2.3 ISS Interface & Software Requirements

FLC-UR3-01: ISS interface The vendor shall implement an interface to the MRO ISS that allows the FLC to be integrated into the overall MROI control system. This interface should include a set of high-level commands for controlling the system and configuring the transmission of acquisition offsets, detector frames and diagnostic data to the supervisory system. MRO will supply interface software, available in both Java and C versions for incorporation into the FLC system, that runs under Linux and that implements a TCP/IP-based Ethernet messaging protocol for receiving commands and transmitting data. Included in this MRO-provided software will be methods for transmitting faults and alerts, saving log messages to a local file, and saving and retrieving configuration data (such as dark and flatfield frames).

FLC-UR3-02: Use of ISS interface framework The FLC shall use the same framework (C or Java) as the FTT/NA system to interface with the ISS.

FLC-UR3-03: GUI display-only mode It shall be possible to use the standalone-role GUI in a display-only mode when under ISS control, including when data transmission to the ISS is active.

FLC-UR3-04: ISS command API The vendor shall provide and document an Applications Programming Interface (API) which permits the MRO to command the FLC system with the ISS.

FLC-UR3-05: Command API functionality The API shall provide control of all system functions through a simple, robust, and well documented TCP/IP protocol over Ethernet, using an appropriate subset of the commands defined for the FTT/NAS system.

FLC-UR3-06: Data transmission to ISS In acquisition mode and acquisition check mode, the FLC system shall transmit detector frames and telemetry data (an appropriate subset of the data items defined for the FTT/NA system) to the MRO ISS data collector using well-defined protocols over Ethernet.

FLC-UR3-07: Time-stamps on transmitted data All transmitted detector frames and telemetry data shall have accompanying UTC time-stamps which are accurate to 1 ms.

FLC-UR3-08: Latency and reliability for data transmission Full-data-rate detector frames and telemetry data shall be transmitted with a maximum latency of 0.2 sec using a protocol that guarantees no data loss, such as TCP/IP.

FLC-UR3-09: Operation from laptop It shall be possible to display and operate the standalone-role GUI from a customer-supplied laptop computer situated inside the UT enclosure.

3 Requirements Verification

Verification that the requirements in this document have been met will be made by a combination of reviewing design documents and drawings, inspection of certificates or test results, and a series of Acceptance Tests, as described below.

Acceptance testing shall be performed in accordance with the Acceptance Test Plan developed by the supplier and approved by the customer. All tests and their results shall be documented by the supplier. These tests shall demonstrate that the FLC system performs in accordance with the specifications in this document. The supplier is expected to have or obtain all and any other special test equipment necessary to demonstrate compliance with the system requirements and interfaces.

What follows are a number of tables of references from each "shall" requirement in this specification document. These tables will serve as a checklist for product acceptance. Each entry lists first the reference number, then a summary field which describes the kind of verification associated with the given specification. This is followed by a brief description of the requirement being referred to (the requirement in the main text is to take precedence over the summary description in all cases) and a comment clarifying, e.g. the type of verification the MROI Project Office is expecting.

This summary field consists of 4 sub-fields denoted by the letters 'D', 'A', 'I', 'T', denoting the main methods by which the customer will verify whether the requirement has been satisfactorily met by the supplier. These methods are as follows:

D: "design" Inspection of drawings and other documents (including ICDs) showing proposed designs, methods, or procedures. In many cases these documents are part of design review documentation.

A: "analysis" Inspection of documents which verify by computational methods (e.g. analytical calculations) that a proposed design, method, or procedure, meets the given requirements.

I: "inspection" Visually inspecting, measuring, activating or other actions on as-built components to determine proper form, fit or function of the supplier's solution to the given requirement. Inspections do not in general rely on any specialized test equipment.

T: "tests" Tests performed upon delivery of each system at NMT or at the Magdalena Ridge (as appropriate).

FLC-UR	Description	D	A	I	T	Comments
1-01	Provision of system modes: idle, acquisition, acquisition check, dark frame, flatfield	x			x	
1-02	System mode functionality as FTT/NAS	x			x	
1-03	Mode switching time $< 5\,\mathrm{s}$	x			x	Goal $< 1\,\mathrm{s}$
1-04	Testing without ISS and/or UTM	x			x	
2-01	FOV $\geq 60'' \times 60''$	x				
2-02	Pixel scale 0.15–0.25″/pix	x				
2-03	Operational wavelength band: any one of V, B, R	x				
2-04	Support for pointing and tracking tests using manual target acquisition	x				
2-05	Image FWHM $\leq 1''$	x	x			Zemax analysis of conceptual optical design
2-06	Can focus to meet image FWHM requirement; maintain focus for $\Delta T \geq 5^\circ$ C	x	x			Zemax analysis of conceptual optical design
2-07	Limiting magnitude $V \geq 10$	x	x			
2-08	Exposure times 5–1000 ms; sampling rates 1–10 Hz	x	x		x	Inspection of camera specifications at CoDR; test at delivery
2-09	Remote operation from control room	x			x	
2-10	Remote display (full-frame)	x			x	
2-11	Remote display (zoom of full frame)	x			x	
2-12	Compute centroid of selectable star w.r.t. user-specified fiducial. Display cross-hairs	x			x	
2-13	Display of computed centroid position on GUI	x			x	
2-14	Logging of centroids and timestamps to CSV file	x			x	
2-15	Image motion $\leq 1''$ for $\Delta T = 5^\circ$ C	x	x			Conceptual optomechanical design with Zemax analysis
2-16	Operate in UTM "reduced performance" envelope for $T \geq -15^\circ$ C	x				
2-17	Designed to fit onto Nasmyth table	x				
2-18	Operate without external chilled fluid supply	x				

FLC-UR	Description	D	A	I	T	Comments
3-01	Provision of ISS interface	x				
3-02	Use same ISS interface framework as FTT/NAS	x				
3-03	GUI display-only mode for use with ISS	x			x	ISS not required for test
3-04	Provision and documentation of API	x		x		
3-05	Control of system functions using API	x			x	Unit tests of individual commands — ISS not required
3-06	Data transmission to ISS	x			x	MRO will provide a simple data collector
3-07	Time-stamps on data transmitted to ISS accurate to 1 ms	x			x	
3-08	Full-data-rate low-latency ($\leq$0.2 s) transmission to ISS	x			x	MRO will provide a simple data collector
3-09	Operation from laptop	x			x	