MOSAIC Operations Concept Document

NOAO Document M1U-AD-03-0002
Revision: 0

Authored by:
S. Howell, H. Schweiker, and D. Sawyer
Please send comments:
showell@noao.edu
## Revision History

<table>
<thead>
<tr>
<th>Version</th>
<th>Date Approved</th>
<th>Sections Affected</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1/11/2010</td>
<td>All</td>
<td>Original Version</td>
</tr>
</tbody>
</table>
Table of Contents

Revision History ........................................................................................................................................ 2
Table of Contents ..................................................................................................................................... 3
1 Introduction ........................................................................................................................................... 4
2 General Considerations ........................................................................................................................ 4
  2.1 Impact on Instrument Availability ................................................................................................. 4
  2.2 Impact on Science ............................................................................................................................. 4
  2.3 User Interface .................................................................................................................................. 5
  2.4 Observatory Physical Infrastructure Components ......................................................................... 5
    2.4.1 Lab Facilities .............................................................................................................................. 5
    2.4.2 Site Facilities .............................................................................................................................. 5
    2.4.3 Handling Equipment .................................................................................................................. 5
    2.4.4 NOAO Data Archive .................................................................................................................. 5
3 Science Operations .................................................................................................................................. 6
  3.1 User Interfaces and Observing Modes .............................................................................................. 6
  3.2 Data Management ............................................................................................................................ 7
  3.3 Data Processing ............................................................................................................................... 8
  3.4 Data Storage ..................................................................................................................................... 8
  3.5 System Performance Monitoring .................................................................................................... 8
4 Technical Operations .................................................................................................................................. 8
  4.1 Maintenance Requirements ............................................................................................................ 8
    4.1.1 Dewar Fills ............................................................................................................................... 8
    4.1.2 Spare Components ..................................................................................................................... 8
    4.1.3 MONSOON Controller Access ............................................................................................... 8
    4.1.4 Physical Limitations ................................................................................................................. 8
  4.2 Diagnostic Tools .................................................................................................................................. 9
    4.2.1 Software Tools ........................................................................................................................... 9
    4.2.2 Temperature Monitoring .......................................................................................................... 9
  4.3 System Interface Requirements ...................................................................................................... 9
    4.3.1 Telescope Control ...................................................................................................................... 9
    4.3.2 ADC Control ............................................................................................................................ 9
    4.3.3 Shutter Control ......................................................................................................................... 9
    4.3.4 Filter Control ............................................................................................................................ 9
    4.3.5 Corrector .................................................................................................................................... 9
    4.3.6 Guide Cameras .......................................................................................................................... 9
    4.3.7 Focal Plane Temperature Control ............................................................................................ 10
  4.4 Technical Interface Requirements .................................................................................................. 10
  4.5 Data Interface Requirements ......................................................................................................... 10
1 Introduction

This is the Mosaic Upgrade Operations Concept Document (OCD). It is a systems engineering level requirements document that will be used to flow down to the requirements for the instrument subsystems. This OCD is the Project’s response to the top-level Science Requirements Document (SRD) and the goals set forth in the project charge.

This document shall be used as guidance for the functional and performance requirements of the upgrade and provide guidance for the design and implementation of the operating processes.

The Mosaic-1 upgrade project involves the replacement of the CCDs and controllers to improve serviceability, reliability, efficiency and performance of the instrument. Mechanically there will be very little change in the Mosaic instrument as a result of the upgrade and thus changes to the operations support relating to instrument changes and servicing will be minimal. On the other hand, there will be many changes required to the software interfaces to support the new controllers and data acquisition paradigm, but none are known to be major work packages. This document details the requirements for achieving the top-level goal of the project to provide a user interface that includes all the functionality of the current Mosaic user interface, and maintains the same “look and feel”.

2 General Considerations

2.1 Impact on Instrument Availability

The plan is to take the Mosaic-1 imager out of service in mid-June 2010 so the upgrades can be done during the summer months. The instrument is expected to return to Kitt Peak for commissioning during the October 2010 timeframe. The instrument will then be released for shared-risk observing for the remainder of schedule 2010B.

At this time a rough test and integration plan is as follows. During the latter half of June 2010 the Mosaic-1 Dewar will be decommissioned and brought to NOAO headquarters in Tucson. After completing the integration of new CCDs and controllers, the complete system including the software systems will be tested to the extent possible in the downtown lab. Assuming successful tests, the upgraded Mosaic-1 will be returned to the Mayall telescope and the tests will be re-run within the dome environment on the observing floor or in the clean room area. After those verification tests the instrument will be mounted on the telescope and connectivity tests will be performed during the daytime. This work can be done during the day switching to a CASS instrument at night. After all tests and systems check-out, a few T&E nights will be used for on-sky tests to check systems as well as verify system software performance. These last steps require coordination with the 4-m telescope schedule and will require the planning for the T&E to occur during April-May 2010.

2.2 Impact on Science

The instrument will have new detectors and controllers, and although the performance will be improved, astronomers must be aware of any changes in the resulting science images. For instance, the overall dimensions of the new CCD detectors are not identical to the original devices and thus IRAF scripts for determining astrometry will be different, and the QE will be improved and thus integration times will be different, etc.
2.3 User Interface

The user interface and user software must be changed as part of the upgrade project. Currently Mosaic-1 is run with an IRAF ARCON package as well as a few independent GUIs that control specific features of the instrument/telescope combination. Given the success of NEWFIRM’s user interface and control system (NOCS), we have explored this option to use for the new Mosaic-1 user interface. The advantages of choosing NOCS are 1) it has had two years of use and tuning at the Mayall telescope, 2) has complete and plentiful documentation, 3) a number of 4-m users are already experienced with its use, 4) the software will be going to Chile with NEWFIRM and so manuals already exist to teach the “new” system to the CTIO staff, and 5) it is likely that NOCS will be used by KOSMOS at the Mayall. Additionally, and the biggest seller to this project, is the fact that 90% of the functionality required to operate the new Mosaic-1 upgrade is already written and operational. It is estimated that approximately two months will be needed to provide a fully functional NOCS for the Mosaic-1 imager.

2.4 Observatory Physical Infrastructure Components

2.4.1 Lab Facilities

The mechanical work related to the instrument upgrade will be performed in the NSTC labs and clean rooms in Tucson. Performance verification and acceptance testing will also be conducted in one of the NOAO Tucson labs.

2.4.2 Site Facilities

The instrument must integrate into the existing infrastructure at the Mayall and use the same facilities for maintenance, support, and storage. The design of the upgrade will be done to improve the maintainability of the instrument (e.g. access to the controller electronics) while it is on the telescope.

Initially, the upgraded Mosaic will only be available on the Mayall, but the upgrade shall not preclude the instrument from being used at the 0.9-meter in the future. Operation at the 0.9-m telescope will require additional computer hardware to be purchased and configured.

2.4.3 Handling Equipment

The instrument cart used for servicing and transporting the Mosaic instrument will be reused. Any modifications to the exterior of the instrument (e.g. controller boxes) must not interfere with the cart or mounting points.

Rigging equipment used for instrument changes will be reused. Any modifications to the exterior of the instrument must not interfere with rigging mounting points.

2.4.4 NOAO Data Archive

TBD after Jan 2010 review
3 Science Operations

The MOSAIC-1 upgrade project will replace the current CCDs and controllers to produce a new, faster and more stable instrument. By necessity the current software running the ARCONs and the current user interface (via IRAF and other GUIs) requires replacement as well. A requirement of the upgrade project is to provide a user interface that has all the functionality of the current instrument. As a goal this project will exploit any opportunity to improve the user interface and add new features.

3.1 User Interfaces and Observing Modes

The main GUI that the user interacts with (MGUI) must provide many functions easily available to the user. Exposure control (start/pause/stop), filter control and shutter control are the most obvious functions but it also must provide all of the functionality of the current IRAF ARCON package parameter routines obspars, detpars, image file title, user comments, auto numbering and user control of the files needed for real-time post-processing prior to display. An example of required functionality is filter designation routines such as ‘wheel1’, ‘motor init’ (IRAF routines) and ‘savewheel1’ (Unix command).

The system must give an audible alert to the observer at the end of readout and when waiting for user input (e.g. waiting for acknowledgement during a mosdither sequence).

Additional required user control functions are:

Exposure Control - the ability must be retained to take sequences of exposures, repeat observations (like the ‘more’ command) and take ‘test’ exposures that are overwritten.

User options for post processing (overscan subtraction and flat fielding) prior to display - These are currently done in the DCA and must be retained. That is, the ability to change the pointer to the OTFF (on the fly flat) calibration files and the ability to enable or disable OTF (on the fly) processing. As a goal, we wish to implement the quick reduction pipeline (QRP) features currently available in NEWFIRM of WCS solution and photometric zero point estimation.

User control of CCD readout rate (and thus acceptable noise level)

User option for gain selection (if desirable or needed)

User settable binning, 1x1 or 2x2 required (region of interest not required)

User settable center of FOV to not fall on a gap – this is listed here but is really a TCS “z” requirement already available.

Ability to close shutter and force proper CCD readout and file storage

Auto Display - on/off control with default image display being all 8 CCDs at lower resolution (sampled every other pixel as done now). As a goal, provide a user selectable mode for full resolution display of any one of the CCDs.

Single CCD readout mode – this is a goal to allow the user to specify which CCD and to provide “video mode” readout of one-half of one CCD to use for telescope pointing/star placement and/or crude focus.
Dither control – must at least provide the current functionality of MOSdither and MOSgrid. These functions already exist in NOCS for NEWFIRM. Dither control goals include (and may be implemented via scripting)

- automatic dither with guider reacquisition and filter control is desired.
- “standard” dither patterns should be available, with the ability to edit these and/or create custom dithers.

Mosaic virtual instrument display – The content of this display-only GUI should be maintained in terms of its look and function. It can be used as is or redone as a NOCS product and be a part of the MGUI.

Filter and Shutter movement and control – The look and feel of the current filter/shutter control GUI must remain as is, but this GUI should be reformulated to be part of the general user interface (MGUI). Note the shutter has three modes: open, closed_dark, closed_guide. These should be automated as at present for exposure control as well as made available to the user for independent control. Telescope focus and guide camera focuses are also required to be controllable via this GUI – available to both the user and the OA as is currently available.

ADC control – The functionality of the current manual ADC control GUI is required to be maintained. It provides the needed manual motions some users require when setting the ADC mode for specific filters, perhaps those not known or handled properly by the automatic software. This functionality can be placed into a NOCS GUI. The MOSAIC-1 exposure control software must provide the same level of automatic control as currently exists, that is using the known telescope position and filter choice to automatically set the ADC control. Exposure control must be interfaced such that exposures do not start until the ADCs are not moving and fixed in their proper position.

Autolog – keep at least the functionality of the current system.

Calibration sequences – An easily selectable automatic routine must be available for the user to obtain typical CCD calibration images – bias, dark (if desired) and flat fields (dome screen or sky). The routine must allow the user to control the filters, exposure times and number of such frames desired. As a goal, we will work toward getting the Mayall flat field lamps brought under computer control to be integrated into these routines as needed.

Focus Sequences – The current focus routine functionality must be retained with a more automated focus routine (such as NEWFIRM has) being desired. This routine should be easily selectable by the user.

Image Headers – Mosaic-1 images must be stored as standard fits files with complete and proper headers. The details of the headers will be specified in a future document but must be at least as complete as the current Mosaic-1 file headers.

Autofocus Monitor – The capability for using the Autofocus monitor tool must be retained.

System level post-processing Script - The capability to trigger a general-purpose script following readout must be retained. This script should be protected from user tampering and is used to trigger data transport to the archive, etc.

3.2 Data Management

Through the NOCS, the data will get ingested into the NOAO data archive so that the observers have access to their data over the Internet immediately following their observing sessions. As a goal the Mosaic DHS shall include FITS tile compression to reduce data volume.
3.3 Data Processing
The requirements for data processing are TBD.

3.4 Data Storage
A requirement of the project will be to retain the current data storage capability as well as to retain the current data recording capabilities (DVD/CD writer, Dat drive). The shortened readout time (from 2.5min to < 60sec) will allow more images to be taken each night and the file size of each image will approximately double (due to 18-bit), meaning the data volume is expected to increase (possibly 3 - 4 times the current amount). A goal of this project is to increase the data storage capacity to 1 Terabyte to allow for this increased data volume.

3.5 System Performance Monitoring
The Mosaic instrument performance will continue to be monitored as it is currently with frequent checks of readnoise, gain, shutter correction, astrometry, etc. There will continue to be regular T&E and checkout nights at the beginning of each Mosaic observing block.

4 Technical Operations

4.1 Maintenance Requirements

4.1.1 Dewar Fills
Dewar fills will remain unchanged. Connectivity to the Dewar must remain accessible for attaching the LN2 fill line.

The Dewar hold time must be 13 hours or longer with a goal of 16 hours.

4.1.2 Spare Components
The replacement software and computers shall be designed with redundancy to allow backup operation in the event of a computer system failure.

A spare Torrent controller must be included to allow rapid swaps in the event of a controller failure. If MONSOON Orange is used, spare boards must be provided for failure support.

4.1.3 MONSOON Controller Access
The controllers must be designed to allow access for repairs while the instrument is mounted on the telescope without having to disassemble the instrument. A goal of the project will be to mount the controllers to allow easy access to test points and rapid removal/installation of controllers (Torrent) or boards (Orange). No parts may extend from the Prime Focus cage that would inhibit a major flip.

4.1.4 Physical Limitations
Any modifications or additions to Mosaic must fit within the envelope of the Mosaic frame to allow for ease of installation at the 4-meter. They must also be secured within the prime focus cage (e.g. power supplies must be affixed to the PF cage or Mosaic).
4.2 Diagnostic Tools

4.2.1 Software Tools
An easy to read and understandable image acquisition (CCD, controller and pan) error logging window or file is required.
Remote restart-power on/off, login, eyes drop and control are required.
Password protected GUI “button” to bring up an engineering GUI. This will be populated with controller and instrument test features such as single CCD readout, MONSOON/Torrent controller diagnostics, etc. The features here will be determined at a later date in collaboration with the engineering and EM teams.

4.2.2 Temperature Monitoring
The ability to monitor CCD and Dewar temperatures both when the instrument is in use on the telescope and when the instrument is not installed on the telescope (e.g. the instrument is on the observing floor or in the computer room) must be retained. The monitoring must also send out email warnings when temperatures are out of range.

4.3 System Interface Requirements

4.3.1 Telescope Control
The system must interface to the current telescope control system (TCS) to control telescope focus, guider focus, pointing offsets, ADC position and gather metadata for header information.
The 0.9-m telescope does not support a telescope interface for focus adjustments and pointing offsets and so a disable feature must be available for these functions.

4.3.2 ADC Control
The existing ADC control interface and operation must be retained.

4.3.3 Shutter Control
The shutter is controlled by a signal generated by the Arcon controller. Since these controllers are being replaced, the MONSOON controllers must generate a signal that is compatible with the existing shutter control hardware.

4.3.4 Filter Control
The existing filter control interface and operation must be retained.

4.3.5 Corrector
The existing corrector will be used and remain unchanged.

4.3.6 Guide Cameras
The existing guide camera control interface and operation must be retained.
4.3.7 Focal Plane Temperature Control
Currently the Arcon controllers provide the temperature control for the focal plane. Since these controllers are being replaced, it will be necessary to achieve temperature control by some other means. The Torrent controllers will provide the functionality for temperature control, but since the Torrent availability and temperature control performance are uncertain at this time, alternate solutions should be considered as well.

The MONSOON Orange systems (the fallback option for Torrent controllers) do not provide temperature control and will require an alternate solution for temperature control.

4.4 Technical Interface Requirements
Basic services for the instrument are already available in the prime focus cage (e.g. 115V AC, Ethernet, optical fibers, etc) and will be utilized to the extent possible. Any additional signals or interface requirements resulting from the upgrade will be defined in a supplemental ICD and installed as part of the upgrade project.

MONSOON interface requirements:
- 115 VAC power
- Remote reset for MONSOON controller(s)
- (2) Fiber cables for Systran interface

4.5 Data Interface Requirements
We note here that the faster readout time of the new MOSAIC-1 (30-60 sec) and the 18-bit nature of the data will mean many more larger images will be required to be stored at the telescope, copied by the user and sent to the archive.

The FITS files produced for the Mosaic-1 upgrade instrument must meet all the requirements of the NOAO Science Archive and be fully compatible with the archive as well as the Mosaic-1 post-observation science pipeline. Thus, in addition to the requirements listed herein there may be additional requirements and goals, identified during the Project Design Reviews or after discussions with NOAO Data Products Group, related to FITS headers, image archive and Mosaic-1 science pipeline processing.