MOSFIRE Pre-Ship Review Report

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Executive Summary

The MOSFIRE Pre-Ship Review (PSR) was held at Caltech on 11 April, 2011. The PSR committee reviewed a written acceptance test plan report, a design note on commissioning, and a requirements compliance matrix in advance of the meeting. The MOSFIRE PIs Ian McLean, Chuck Steidel as well as other personnel gave presentations on this material during the meeting and addressed the review committee's questions.

The review materials were generally extensive and candid. The panel, overall, was impressed with the skill and dedication of the MOSFIRE team, the high level of the design and its implementation, and the thoroughness of the review of requirements presented. The team and WMKO staff have obviously been working hard to complete MOSFIRE, and it appears that they did not have sufficient time to completely finish all documents expected at a PSR (i.e., detailed commissioning plan, actual spares list, and some interfacing details). We provide extensive comments below, but these should not obscure the fact that we believe MOSFIRE is ready to become a unique and scientifically productive instrument at Keck. Subject to a few important details, the team should be allowed to proceed with their plans to send MOSFIRE to the telescope.

The PSR charter charged the review committee to:

1. Evaluate the completeness of the full scale development phase and the readiness of the instrument for installation at the Observatory
2. Evaluate the completeness of the Observatory interfaces required by the instrument
3. Evaluate the plans for installation and commissioning of the instrument at the Observatory

The MOSFIRE hardware development is generally complete, and MOSFIRE meets all critical requirements set for it during the design phase. Thus MOSFIRE generally satisfies the PSR charter criterion number one. The biggest issue is that the MOSFIRE software work is not yet complete. A detailed completion plan was not presented, so we cannot evaluate whether this work is likely to be finished before the end of commissioning.

The Keck Observatory interfaces were judged to be essentially complete. Our primary recommendation in this area is that the MOSFIRE team prepare a final checklist of the interface requirements expected to be provided by the Observatory and that the WMKO (perhaps the MOSFIRE Support Astronomer) be responsible for ensuring that all items on the checklist are in place, or will be in place, when needed for installation.

MOSFIRE commissioning tasks are reasonably comprehensive, but the commissioning plan has insufficient detail to be executed as-is or evaluated for feasibility given the labor and time resources

available. No commissioning schedule was presented, and it was not clear how well the durations of the tasks fit within the 10 nights of allocated commissioning time. The labor assignments for performing the on-sky commissioning and analyzing the data were not shown. Explicit products of tasks were not always obvious, dependencies between tasks were not shown explicitly, and the specific prerequisites of tasks were also not listed.

We have four primary recommendations:

1. MOSFIRE should be shipped to Hawaii once the team has successfully completed the pre-ship hardware repair tasks they have documented (Acceptance Test Report v. 1.10 p. 13). The documented post-shipment tasks should be completed as well.
2. The MOSFIRE team and WMKO management should agree on a software completion plan before MOSFIRE is mounted on the telescope. This plan should be developed by the MOSFIRE team and presented to WMKO management. It should include a task list, labor assignments, and a schedule.
3. MOSFIRE should start on-sky commissioning only after an improved commissioning plan is presented to and accepted by WMKO management. The commissioning tasks should be developed in more detail to evaluate better their required labor, analysis, prerequisites, and dependencies. Additional plans to measure pupil flexure, measure and mitigate detector persistence in different observing regimes, and assess the impact of light leaks between slit mask bars on faint-object observing should be considered. A commissioning schedule and labor plan should be developed to optimally plan commissioning within the resources available to MOSFIRE (primarily labor and time). It may be helpful if a single person available at close to full time was assigned to oversee all commissioning planning, acquisition, and analysis tasks.
4. WMKO, the SSC, and the MOSFIRE team should consider that there will likely be considerable demand for using MOSFIRE as a wide field, high sensitivity camera. MOSFIRE will provide Keck with powerful imaging capabilities, and observers will likely want to install additional filters to fully exploit this opportunity. WMKO and the MOSFIRE team should also plan for post-commissioning servicing of the instrument on the summit.

We believe that MOSFIRE will meet its PSR success criteria as listed in the charter after all of these recommendations are completed. The PSR committee was impressed with the generally excellent work done by the MOSFIRE team and WMKO staff. We are confident that MOSFIRE will be a significant scientific success for Keck once its few remaining tasks are completed and after it is successfully commissioned.

Detailed Report

We now provide more detailed findings, discussions, and recommendations in each of the three areas listed in the charter.

Charge #1: *Evaluate the completeness of the full scale development phase and the readiness of the instrument for installation at the Observatory.*

Success Criterion: *The instrument meets the requirements set for it during the design phase*

Finding: The instrument mostly meets the requirements set for it during the design phase, and meets all critical requirements.

Discussion

The MOSFIRE team has produced an extensive compliance matrix. Items in the matrix are categorized according to the degree of compliance and the project team's plans to address any non-compliance. The review committee agrees, in all cases, with the team's assessment of compliance, so the discussion that follows mainly addresses the self-identified non-compliant items. There are a few instances, also discussed, where the requirements themselves could have been expanded.

The non-compliant items fall into three categories:

- Items where full compliance is not currently achieved or not currently demonstrated, but where there is a plan to address non-compliance or to demonstrate compliance, either prior to or during commissioning at the telescope;
- Items where full compliance is not currently achieved, and the team does not intend to reach full compliance; and
- Items where full compliance has been achieved in the past, but not at present. These are, in essence, repairs. These are not listed as such in the compliance matrix, but were described in the review presentations.

Of the items where further work (as opposed to testing) is planned, only a couple are noteworthy – the heat dissipation seems primarily to require a decision by WMKO whether it is a concern or not; if it is, there is a clear path to addressing it. A second area is software documentation (in reality, documentation in other areas is still being completed as well, and may be a concern if it falls behind schedule). The committee's concern was that the remaining software effort is substantial (which the team is well aware of) and therefore that some formal planning/scheduling is needed to ensure that all tasks are completed in an acceptable way.

Many of the "unmet" requirements that will not be brought into compliance are things that are nearly met (e.g., filter wheel time to reconfigure) or which have little impact (e.g., access to the getter or handles on all internal sub-assemblies). The instrument is somewhat over-weight, but discussions at the review indicated that WMKO did not see this as a problem and have a plan to address the situation. The one item that may not fall into these categories is the slit mask light blocking, where light leaks between the bars are higher than specified. The MOSFIRE team believes that the performance is acceptable, but it should be a priority to demonstrate this using commissioning observations.

Items in the "repair" category include a dewar vacuum leak (straightforward) and the instrument rotator/cable wrap-up (diagnosis required). The rotator raises concerns about longer-term reliability that need to be addressed, but the design is clearly capable of meeting requirements. These activities are included in the project team's final pre-ship activities.

There are a few gray areas, where the requirements do not completely address aspects of instrument performance that can impact scientific productivity or instrument safety.

- There is no set of requirements associated with prolonged power failures (many hours or a few days), which are possible on Mauna Kea. The primary concern is condensation on the dewar window or the detector; the solution is to develop an operational response for these situations together with WMKO staff.

- The pupil alignment and flexure need to be measured at the telescope and the impact on science observations (background and zero point variations) should be characterized and used in defining appropriate observing strategies. The requirements do not cover all aspects of the pupil, but those requirements that do exist are met and lead one to believe that there will not be significant difficulties.
- Detector persistence does not have a particularly useful requirement, for the reasons that it is hard to write a useful requirement, and harder still to get the vendor to address it. It is clear that detector persistence will impact observing (and equally clear that no detector the team could have purchased would have been free of the problem); it should be a priority during commissioning to document performance during plausible observing scenarios, and to devise approaches to observing that minimize impact to the extent possible.
- There is no requirement to easily install or replace filters in the dewar. Any such requirement would have been extremely difficult to meet, but as a consequence such filter exchanges are a major operation, and frequent exchanges will be a burden on observatory operations and will pose some risk to the instrument. WMKO management needs to work with both the project team (and probably the Keck SSC) to develop a policy on filter exchanges.
- Compatibility of the FITS header with the VAO was not described. If they are not in fact compatible already, this would be worth doing.

The configurable slit unit (CSU) currently meets its requirements. The MOSFIRE team carried out the component deep cryogenic cycling and cleaning recommended by the CSU Clutch and Brake Magnet Failure and Solution Review. The CSU has functioned nominally since then, and the MOSFIRE team has contingency plans for mitigating CSU bar failures.

We also note that lists of required and actual spares were not presented at the PSR, so we were not able to comment on the adequacy of the supplied spares.

It is important to emphasize that all requirements that can be thought of as critical to the scientific performance of the instrument have been met, or have been verified in the lab to the point where there is a high degree of confidence that they will be met on the telescope. The recommendations therefore are largely aimed at identifying ways to optimize the scientific performance of what promises to be a superb instrument.

Except for pending tasks identified by the MOSFIRE team, the instrument is therefore ready to be shipped and installed at the telescope.

Recommendations:

The project team should proceed with the "repair" tasks they have identified as required prior to shipment of the instrument.

A schedule of tasks for the remaining software effort should be prepared and delivered to WMKO management prior to shipment of the instrument. We also recommend that the MOSFIRE FITS files be compliant with VAO specifications.

WMKO management should assess the instrument heat dissipation and issue direction to the project

team prior to shipment of the instrument.

Prior to hand-over, the instrument team and WMKO staff should jointly develop and document a procedure to deal with prolonged power failure.

Prior to any call for proposals, WMKO management should define a policy on filter exchanges, which should be developed after appropriate consultation.

WMKO needs to formally decide to accept requirements that are not fully met, such as the filter wheel rotation time. WMKO should also assess the supplied spares for adequacy if this has not yet been done. Except for those noted above, the panel does not believe that any of these requirements are critical to the scientific performance or safety of the instrument, if they are partially met, and recommends that WMKO accept them all.

Charge #2*. Evaluate the completeness of the Observatory interfaces required by the instrument.*

Success Criterion: *The observatory interfaces complete and ready for the instrument.*

Findings:

During the PSR, the committee received limited documentation describing the Observatory interfaces either required by MOSFIRE or those provided by the Observatory. Consequently, our report in this area will be brief.

Discussion:

There are several specific interfaces or interface requirements that merit discussion. We then describe our overall assessment of the interfaces.

- The instrument over-weight and excess heat dissipation are both interface-related, but as they are also requirements on the instrument, they were discussed in the preceding section. In both cases, a plan was outlined to address the issue.
- Provision of a portable clean room that allows servicing the instrument is a requirement on the observatory, which has not been met. The problem appears to be financial. The panel is concerned that deferring this purchase poses risk to the scientific operation of the instrument – right now, there is no way to perform an internal inspection if there is a suspicion of damage during shipment, or if any mechanism fails during commissioning or early science use. This is, in essence, a trade between deferring the expenditure on the clean room and a delay of several weeks if it is needed suddenly.

We categorize the interfaces into six primary areas. Based on the material presented, we denote our level of confidence that an interface is in place with a (✓) for high confidence, a (✘) for low confidence, and a (**?**) if we don't have the information to make an assessment.

1. Cables and hoses
    a. Computer cabling (Ethernet fibers, power) (✓)
    b. Coolant lines (helium for CCRs, thermal control of heat dumped in the dome) (✓)

    c. Instrument power (120 and 208 3-phase), including UPS support and generator power during a mains failure (**?**)
    d. Air / nitrogen lines (**?**)
2. Mechanical
    a. Elevators and cranes to install (✓)
    b. Equipment to re-balance telescope and other instruments (**?**)
    c. Mount points for rotator (✓)
    d. Alignment tools (✓)
    e. Pneumatic control panel (**?**)
3. Software
    a. TCS links for nods and dithers (**?**)
    b. Rotator control (and electronic drives) (✓)
    c. Archive interface (*is there a general Keck archive facility???)*
4. Optical
    a. Deliver an unvignetted field of view (✓)
    b. Deliver the expected optical prescription (**?**)
5. Personnel
    a. Technical, to support installation and commissioning (✓)
    b. Technical, to provide follow-on maintenance and support after commissioning (**?**)
    c. Scientific, to provide user support for proposal preparation and observations (✓)
6. Other
    a. Equipment to transport to the summit and unload the instrument (**?** – vendor to provide)
    b. Room for warm testing prior to cool-down an installation (**?**)
    c. Vacuum pumps, fittings, hoses (**?**)
    d. Clean room for disassembly for repairs or filter swaps (✘)
    e. Space reserved for computers, compressors, spares, test equipment , environmentally controlled space for additional filters (in the future), and storage for transport boxes (✓ - at least for some)

Slides 110 and 111 of the PSR presentation summarize many of the MOSFIRE requirements in graphical form. Reference 5 of the MOSFIRE Acceptance Test Report discusses these in detail from the MOSFIRE viewpoint (reference 5, version 1.4 wasn't found, but we assume that version 1.3 is equivalent). Mike Pollard's presentation provides an overview of Keck's readiness and installation plan but not the interface details.

We assume that the requirements in reference 5 have been satisfied by Keck. Nevertheless, we suggest that this document be reviewed with the MOSFIRE team prior to shipping.

Recommendations:

Our primary recommendation regarding Observatory interfaces is that the MOSFIRE team prepares a final checklist of the interface requirements expected to be provided by the Observatory (this could be reference 5, perhaps reviewed one last time) and that the Keck MOSFIRE Instrument Scientist be responsible for ensuring that all items on the checklist are in place, or will be in place, on the schedule for installation.

Charge #3*. Evaluate the plans for installation and commissioning of the instrument at the Observatory.*

Success Criterion: *The plans for installation and commissioning are of sufficient completeness to establish* confidence that the result will be a satisfactory facility class instrument at the Observatory.

Findings:

We found the commissioning plan to have insufficient detail to be executed or evaluated for feasibility given the labor and time resources available. We did not evaluate MOSFIRE installation plans beyond what was described in the "observatory interfaces" part of this report.

Discussion:

The MOSFIRE team presented the committee with the 25 page document "MOSFIRE General Design Note 14.04, MOSFIRE On-Sky Commissioning Plans" revised April 2011. Chuck Steidel also presented a helpful summary of commissioning tasks, covering fundamental tasks, break in, calibration, and science verification tasks (p. 193 – 205 of the presentation slides). This presentation gave the tasks in essentially chronological order, which the committee found helpful. The tasks were described as High, Medium, or Low priority in the 25 page document. On-sky time estimates and required sky conditions were also given for each task.

No commissioning schedule was presented, and it was not clear how well the durations of the tasks fit within the 10 nights of allocated commissioning time, plus available day time. The labor assignments for performing the on-sky commissioning and analyzing the data were not shown. Each task was described at a level of only modest detail in the commissioning document. Explicit products of tasks were not always obvious, dependencies between tasks were not shown explicitly, and the specific prerequisites of tasks were also not listed. The tasks were described in sufficient detail to be understandable, but in many cases extra work will be required to prepare for the specific observations needed (e.g., select appropriate standards).

Recommendations:

The commissioning tasks should be expanded to include measurement of:

- Pupil flexure
- Detector persistence under plausible observing scenarios and development of observing procedures to minimize its impact (to the extent possible)
- Impact of light leaks between slit mask bars on faint-object observing; this is probably best done at K (not Ks) and need not be repeated in other filters. It may also be worth measuring performance with a bright star in the field.

The commissioning tasks should be developed in somewhat more detail to evaluate better their required labor, analysis, prerequisites, and dependencies. A commissioning schedule and labor plan should be developed to optimally plan commissioning within the resources available to MOSFIRE (primarily labor and time). It may be helpful if a single person available at close to full time was assigned to oversee all commissioning planning, acquisition, and analysis tasks.

WMKO staff should evaluate and accept the complete commissioning plan as described above before

providing any night time on-sky commissioning time to MOSFIRE. We recommend that the Keck SSC be kept abreast of commissioning plans and progress as nights are awarded and used.

WMKO should plan for post-commissioning hardware servicing of MOSFIRE. This includes discussing post-commissioning support with the MOSFIRE team and also planning to construct a clean room on the summit where MOSFIRE can be disassembled. MOSFIRE will need to be opened for any filter exchanges and for any mechanism repairs (e.g., the CSU, but hopefully not). As noted above under interfaces, there is some risk if there is no clean room when MOSFIRE arrives (e.g., to deal with shipping damage).