Document Number:	ODI-AD-05-0002	**Account Number:**	n/a
Document Title:	**ODI Scientific Commissioning Plan**		
Brief Description:	**We lay out the plan for commissioning ODI at the WIYN telescope and the required state of the instrument & facility for these activities.**		

Related Documents:	
Document Number/Title:	**ODI Science Requirements Document, ODI-AD-01-008 v2.2**
Document Number/Title:	**A Proposal for WIYN Scheduling in 2010A, ODI-AD-05-001**
Document Number/Title:	**Commissioning Report for the Mini-Mosaic Imager on the WIYN telescope (Saha et al.)**

Document Acceptance and Concurrence		
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Revision History

Version	Author	Date	Section Affected	Remarks
0.2	Daniel Harbeck	Sept 3rd 2008		Initial draft sent to SWG.
0.3	Daniel Harbeck	Oct 20th 2008	All	Implementing comments received in the first round of SWG discussion.

1. Members and affiliates of the ODI Science Working Group

1.1. SWG members

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2. Approach to scientific commissioning ODI

Although ODI is a just an imager, the utilization of OTA detectors allows very complex data acquisition modes. The “rubber focal plane”, the large number of amplifiers and detectors, the management of complex guide star configurations, and the sheer amount of data that ODI will most likely introduce unprecedented difficulties when ODI will be commissioned.

2.1. Prerequisites

Commissioning as defined in this document refers to the evaluation of the ODI/telescope system as a scientific instrument and its compliance with the ODI Science Requirement Document (ODI-AD-01-008). Commissioning activities will start only after the ODI installation team has finished installation at the telescope and demonstrated technical functionality. The handover from technical checkout to commissioning will be incremental with scientist involvement. An installation quality control needs to be passed. This acceptance criteria of this quality control check is still to be determined.

2.2. Phases of commissioning

Although the difficulties of ODI will have not be entirely linear independent, we suggest that commissioning proceeds in phases where efforts are concentrated to understand one mode of ODI, starting with the simplest mode. These phases, and their suggested order of implementation, are listed below. Major milestones of the commissioning process, functional dependencies, and what knowledge will be gained, will be detailed in dedicated sections in this document.

1. **Engineering verification**
   ODI will undergo engineering verification. This includes evaluation before shipment of the instrument to WIYN, and extensive evaluation off functionality at the telescope before commissioning starts. Examples are tests for flexure, light leaks, pointing, focusing, and overall image quality assessment.

2. **ODI as a static imager (SRD 2.1.1a)**
   Three or four guide stars in the corners of ODI’s field of view will optionally be utilized to guide the telescope and instrument rotator, but no attempt will be made to use on-chip image motion compensation.

3. **ODI as a coherently guided imager (SRD 2.1.1.b)**
   About four guide stars (e.g., in the corners of the field of view, but not a required restriction) are utilized to probe the correlated image motion caused by guiding errors and wind shake. This fast correlated image motion is corrected for using the OT capability of ODI. The slow portion of the guide star signal will optionally be used for telescope and instrument rotator tracking.

4. **ODI as a locally guided imager (SRD 2.1.1.c)**
   Local guide stars (i.e., at least four per detector) will be used to correct for local image motion. The guide signal of selected guide stars will optionally track the telescope and instrument rotator. Local guiding can be implemented in two incremental releases:
   - Local guiding over a selected area of the field of view, e.g. the central 2x2 OTA array.
   - Local guiding over the entire focal plate.

5. **ODI as shutterless photometry machine (SRD 2.1.2)**
   For up to 8 guide stars per detector (potential future upgrade up to 64) that are predefined (e.g., from an ODI preimage) shutterless photometry is collected.

6. **ODI with non-sidereal tacking (SRD 2.1.1.d)**
   Additionally to the coherent guide mode, a non-sidereal telescope tracking signal will be generated to allow observation of moving solar system objects.

Each of the five outlined basic modes will require support tools to prepare and execute observations. Also, the Tier I pipeline (according to ODI Instrument Pipeline Requirement Document) has to be operational to digest the incoming data, and tools will be required to investigate the data during commissioning.

2.3. Deliverables and Endpoint of Commissioning Phases

A commissioning phase is complete when the commissioned operational mode has been shown to meet specifications and can released for science. Incremental releases of observing modes are allowable. From a high level point of view, the deliverable of each commissioning phase is an operating mode that can be used for science. The details are elaborated below.

An observing mode will be declared operational by the WIYN director upon recommendation by the head of ODI commissioning and the WIYN SAC.

At the end of each of the commissioning phases there will be a number of deliverables. Note that intermittent deliverables should be acceptable if modes are partially released for science. The deliverables include:

1. Modified hardware and documentation thereof (hopefully not!).
2. Updated and additional software tools (unavoidable), and documentation thereof.
3. Characterization of each mode, and workflow definitions for data acquisition.
4. Standard data calibration plan.
5. Cookbooks for scientific users on how to prepare, take, and reduce data. Documentation of data formats.
6. Training of WIYN/KPNO support personnel to support and maintain the released mode.
7. Documentation for user support and maintenance for WIYN support personnel, hand-over to operations.
8. Summarizing commissioning report with references to related documentation and overall performance assessment.
9. Spectacular images demonstrating the observing mode, aimed at use for public announcement, press releases, or outreach activities.
10. A paper in a refereed journal describing and characterizing the available mode.

Each new operational mode of ODI will increase the level of complexity, and it is recommended that commissioning of the more advanced modes will not start with full dedication[1] before the less complex modes are understood to a sufficient level.

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[1] There should, of course, be enough freedom to satisfy early curiosity if the advanced modes work at all.

A brief remark on wording: We will often use words like *test, verify, establish* etc. In practice these words should be understood as iterate *taking data, analyzing it, finding out that things not to work, tune/repair, and start over* until functionality of a component is reached.

2.4. Instrument Acceptance

ODI will be accepted and declared as a facility instrument by the WIYN Board upon recommendation by the WIYN Director. Partial acceptance of released modes shall be allowable. Acceptance of ODI as a facility instrument marks the end of the ODI instrument project, and responsibility for future improvement, upgrades, and operations will be integrated into WIYN's operational plan.

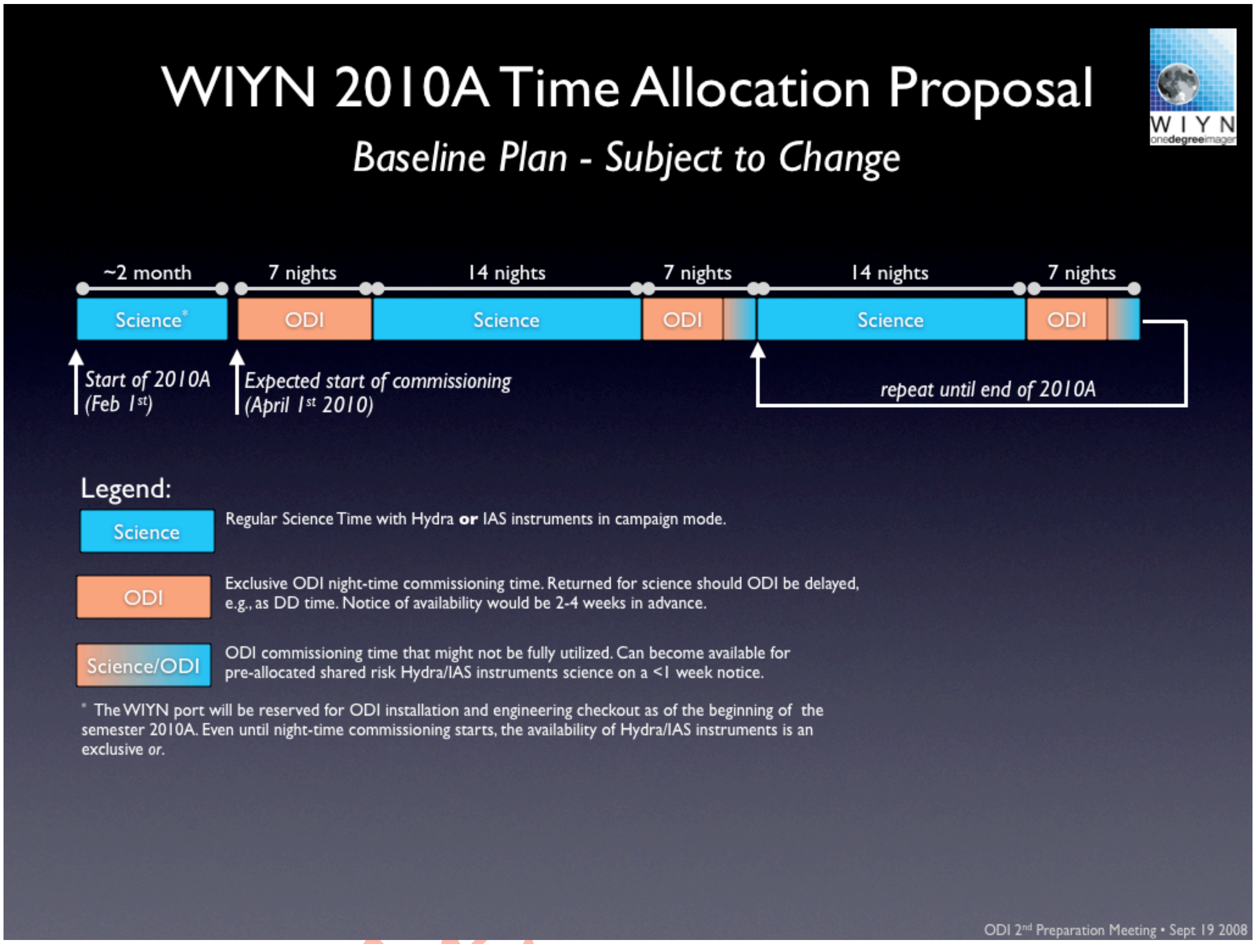
2.5. Data Reduction Pipeline and Analysis Software

Commissioning ODI will require the ability to analyze ODI images to high precision. The PanSTARRS IPP data pipeline provides most of the required functionality. The baseline approach for ODI commissioning is to utilize IPP plus some extra analysis tools. While the viability of that pipeline has to be verified in Tucson, upon meeting with the IPP project lead (Eugene Magnier) we concluded that it should be very useful. Nevertheless, other pipeline choices, such as the DEC pipeline, should be evaluated at a similar level, since it would have the advantage of having NOAO-internal support.

References to IPP:
http://pan-starrs.ifa.hawaii.edu/project/IPP/software/

2.6. On-sky time/data analysis time distribution

ODI will produce complex, and abundant amounts of data. Especially at the beginning of commissioning, data analysis parallel to data taking might not be a feasible approach. The baseline plan is therefore that on-sky campaigns are dedicated to obtain predefined data sets on sky (in one-week campaigns), and dedicate two weeks to data analysis and planning of the next on-sky campaign. This concept was first presented in the WIYN 2010A scheduling proposal.



WIYN 2010A Time Allocation Proposal

Baseline Plan - Subject to Change

~2 month — 7 nights — 14 nights — 7 nights — 14 nights — 7 nights

Science* — ODI — Science — ODI — Science — ODI

Start of 2010A (Feb 1st)

Expected start of commissioning (April 1st 2010)

repeat until end of 2010A

Legend:

Science	Regular Science Time with Hydra **or** IAS instruments in campaign mode.
ODI	Exclusive ODI night-time commissioning time. Returned for science should ODI be delayed, e.g., as DD time. Notice of availability would be 2-4 weeks in advance.
Science/ODI	ODI commissioning time that might not be fully utilized. Can become available for pre-allocated shared risk Hydra/IAS instruments science on a <1 week notice.

* The WIYN port will be reserved for ODI installation and engineering checkout as of the beginning of the semester 2010A. Even until night-time commissioning starts, the availability of Hydra/IAS instruments is an exclusive or.

ODI 2nd Preparation Meeting • Sept 19 2008

Figure 1: Baseline scenario for ODI commissioning tie allocation in the initial commissioning semester (2010A according to the current schedule).

Different types of teams will be required during commissioning: On-site data acquisition teams, technical support teams, and headquarter (WIYTN partners) data analysis teams.

2.7. Personnel & Coordination

Experience with QUOTA on-sky campaigns has shown that a clear definition of task, goals, responsibilities and interfaces would be highly beneficial. Some key functions are listed now:

2.7.1. Commissioning supervision

The WIYN director will assign one person to lead and coordinate ODI commissioning, and this person will define goals and task lists for each on-sky campaign. This person will also form commissioning teams for the on-sky campaigns.

2.7.2. Campaign lead

Each ODI campaign during the commissioning period will last about three to seven days. While at the telescope, this person is in charge of the proper execution of the commissioning run and will be local interface to support personnel, such as technical assistance by KPNO staff.

2.7.3. Science support

During each on-sky campaign, there should be probably two scientists at the telescope (one of whom will serve as the campaign lead). The number of scientists in the telescope control room should be limited, as otherwise chaos might break out in the control room.

2.7.4. Data analysis assistance

The commissioning runs will be designed that data will be taken and analyzed in-depths in the following two weeks in Tucson. This can be done by either scientists or data reduction analysts. Some data reduction analysis help will also be required on the mountain for near-realtime data evaluation.

2.7.5. Technical assistance

Once ODI will enter the commissioning phase, it should be free of obvious technical flaws, as they should have been eliminated during the engineering checkout. However, as the instruments will be used under real conditions, more sophisticated issues in hardware and software will surface. Technical assistance to repair hardware and software issues will be required. Skill sets include: mechanical and electrical engineering, plus software engineering.

2.7.6. WIYN Personnel

ODI will be operated and supported by WIYN and Kitt Peak personnel, with details to be determined. The WIYN director and head of ODI commissioning will plan for integration of future ODI operational and maintenance personnel into the commissioning effort as seen necessary. Assignment of WIYN/KPNO personnel will be integrated into WIYN's operation plan into which ODI's commissioning will start (FY 2010 expected).

2.8. Equipment

2.8.1. Computer workstations

Two computer clusters will exists as part of the ODI instrument project: The development system in Tucson, ad the deployment cluster to be locate at Kitt Peak. This computing power can be utilized during commissioning, but user workstations will be required. We anticipate the need for two of such workstations: One in Tucson, one at the WIYN facility.

Baseline Specification of workstation

- Dual/Quad Core pc with Linux, 4GB ram
- Dual Gigabit Ethernet link
- 2x30" Displays
- ~ 2x $4500 each = **$9000**

2.8.2. Data storage

Besides the on-site data storage capabilities we plan to buy about 10 portable hard drives. These could be either normal SATA drives with external interfaces, or truly external stand-alone drives in an external enclosure.

- External hard drives, 10x$300 = **$3000**
- Internal hard drives, 10x300 = **$3000**

2.8.3. Coffee machine & coffee

ODI commissioning will require very high and sustained levels of caffeine. It might be worthwhile to invest into a good coffee machine (automated, fresh ground beans) and good coffee beans.

3. Engineering Verification

ODI will undergo extensive engineering level evaluation at the telescope before the official start of science commissioning. Engineering evaluation will also involve support by astronomers to ensure that engineering testing is connected to operational needs.

The engineering test plan will be defined in a separate document. This test phase will for overlap and interaction between engineering and science teams.

4. Characterization of Static Imaging

Static Imaging will be the first functionality with which ODI will be tested on the telescope. We expect that during this first integration phase a substantial amount of time will be dedicated to debug the interplay between the facility and the instrument. For the first time, the Tier 1 pipeline will see real night-sky images, and adjustments, debugging, and additions of the data flow are expected to be required. As the observations tools will be used the first time on the telescope, and at 4 am, in the morning, we also expect that a wish list of changes to the user interfaces and workflows will result from these first runs.

4.1. Performance tests

4.1.1. Basic Parameters without sky access:

- Quick look functionality
- Readout time
- Thermal stress test with 1 hour long repeated bias exposures, monitor temperature and overscan level
- Linearity stress test with 1 hour repeated LED illuminations (2 light levels, one bias)
- Dark current test
- Readout noise, Gain, Full Well when telescope is powered off
- Readout noise, Gain, Full Well when different telescope/facility power consumers are incrementally switched on.
- Dome flat fields in different filters, assess QE variations, vignetting, and define default flat field setting.
- Dome flat stability under different instrument rotation angles and different ADC configurations.
- Bad pixel mask (update, should be same as in lab), integrate into data acquisition system
- Shutter effect on dome flats
- Cosmic ray rate

4.1.2. Basic Characterization on sky

The first on-sky test will collect data that are suitable to test if the instrument if operational at a very basic level. Fields will be chosen to cause little or no instrument rotation (objects with declination close to WIYN latitude so that the rotator can almost idle except when close to zenith). All tests also have to be done under unfavorable condition to verify error recovery and robustness of observing modes. Examples include telescope guiding with cirrus clouds and relative wide-field photometry under non-photometric observing conditions.

- Twilight sky flats, comparison to dome flats
- Field orientation on sky
- Establish focus optimization points w.r.t. the focus sensor, in each filter.
- Select OTA guide stars for telescope guiding, test telescope guiding, rotator guiding; Establish stellar magnitude ranges for guide stars in different filters.
- Basic Linearity test: exposures of increased durations of a selected standard star field.
- Test for crosstalk and establish crosstalk correction matrix.
- Basic photometric transformation and zeropoint of SDSS filters
    - Global
    - Per detector
    - Per cell

- Characterization of saturation behavior: PSF effect, bleeding.
- Astrometric solution, determine WCS, integrate into data acquisition system, distortion.
- Test for stuck bits in the A/D converter from Ha image.
- Create fringing maps in red filters, test removing fringing from sparse fields with super-sky fringe maps/flat field.
- Narrow band filters (details TBD)
- Verify image quick look approach, image cataloging etc.

4.1.3. Advanced Characterization on sky

- Assess PSF variations over the field of view
- Assess bending of the instrument under varying rotator angles at one field
- In-depths photometric performance test: FAT ZERO test, photometry in varying locations on focal plane
- Night-sky flat, comparison to dome, twilight flat
- Pupil ghost characterization and removal strategies.
- Photometric flat field creation in each filter. Validation of photometric flat field recipe.
- Spatial depended color-term correction map creation and validation of recipe[2].
- In-depth astrometric tests: high-frequency components of astrometric solution
- Stray-light test: pointing near very bright stars
- Detector robustness tests: pointing at very bright stars, check for residual charge and ghosts.
- Impact of instrument rotation on fringe map (bending might alter fringing?)
- Test nightly stability of fringe maps: Apply fringe map from one field on a different field.
- Test weekly stability of fringe maps: Does a one-week old fringe map provide first order correction?
- Dither images, and test stackability.
- Test automatic dither sequences and automatic telescope guide star assignment.

4.1.4. Test of binned imaging (2x2 only)

- Compare truly binned flat fields (i.e., binned in the detector) to electronically binned flat fields (i.e., binned in the computer), attempt to establish transformation
- Establish readout noise, gain, full well, saturation behavior, bad pixel map for binned pictures.
- Test linearity on standard star field
- TBD

4.1.5. Summary of observations to be taken

TBD

4.2. Implemented Instrument Functionality & Observing Tools

Take images w/ image types: Bias, Dark, Flat, Sky Flat, Object
Readout guide stars from at least four OTA detectors during an object exposure (also during dark goal)
Acquire at least four guide stars in the corner OTAs

- from a 1 second preimage
- from a pre-selected cell during an exposure

Guide the telescope with the guide stars:

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[2] A spatial-dependent color-term correction could be required to compensate for chip-to-chip QE variations, and for radial gradients in the filter transmission characteristics.

- relative to the initial positions of the guide stars
- relative to a pre-defined (from previous exposure) position
- relative to the center of a guide star box

Acquire images with the focus sensor

- during an object exposure
- stand-alone to focus or to take dome flat fields
- focus the telescope
- support sequence open shutter – reset telescope w. guide stars – close shutter – wipe ccd – start exposure

TBD

4.3. Tier I pipeline requirements

Overscan subtract images
Create master calibration files: Bias, Zero, Dome Flats, Sky Flats, Fringe maps
Apply master calibration files to object images
Update world coordinate system

4.4. Specific data analysis tools requirements (can be off-site)

- run aperture photometry on selected detectors and create catalog w. ra/dec coordinates
- stack images that do not have an offset.
- PSF characterization and matching.

4.5. Observatory access & personnel requirements

5. Characterization of coherently guided imaging

Once testing the coherently guided imaging mode starts we can build on the foundation of what we learned when static imaging was commissioned. We will know how photometry on static images works and how to handle the data. This next commissioning phase can concentrate on the incremental complication and benefits that OT guiding brings. Limiting ourselves to coherent guiding should keep the incremental difficulties under control.

5.1. Performance tests

5.1.1. Basic parameters without sky access

Obtain dome flat field in static mode and with a pre-defined OTA motion pattern; establish if shift history convolved images reproduce shifted flat fields. The same for binned flat fields.

5.1.2. Basic parameters with sky access

- Verify that telescope and on-chip guiding do not interfere.
- Establish benefit of coherent guiding in different filter and guide speeds (1Hz to 30 Hz): Sequences of unguided/guided exposures, or every other device guided/unguided.
- Test for charge traps in sky background or stars in guided mode, and their impact on photometry.
- Characterize PSF variations over the field of view, compare variations when OT guided and static
    - In two phases: first rough assessment, then in more detail (potentially a very time consuming task).
- Test flat field convolution
- Linearity test and photometric transformation test for coherently guided exposures; at different seeing!
- Test flat field convolution and photometric transformation in binned images
- Do a fat zero test with OT-guided exposures.

5.1.3. Advanced characterization on sky

- Test WCS adjustments after coherent guiding
- Test dithering/combining images with coherent guiding
- Test automatic coherently guided dither sequences.

5.1.4. Summary of observations to be taken

5.2. Implemented Instrument Functionality & Observing Tools

TBD

5.3. Tier I pipeline requirements

TBD

5.4. Specific data analysis tools requirements (can be off-site)

TBD

5.5. Observatory access & personnel requirements

TBD

6. Characterization of locally guided imaging

By now we have established that we can do coherent image motion compensation, and properly reduce data that experienced OT shifting. Local guiding adds new complexity compared to coherent guiding:

- About 4+ guide stars are required per detector, or 64*4=256 guide stars on the entire focal plane. These guide stars have to be automatically identified.
- Not all detectors might have sufficient guide stars for local guiding; they might be operated in coherent or static imaging mode.
- Image motion correction will no differ from OTA cell to OTA cell. Flat field convolution will require more sophistication.
- Local guiding will require a higher guide frequency (about 20+Hz vs. 10Hz).
- Depending on a cell's distance to the nearest guide star, there will be PSF variations that differ from image to image.
- Each cell will have a different Astrometric reference frame, and bringing all cells on the same reference frame will require high-order resampling of the data.

In other words, while coherent guiding is basically conventional imaging with better telescope guiding, we are leaving known territory with local guiding and are embracing all the issues that adaptive optics system have with PSF stability.

6.1. Performance tests

6.1.1. Advanced characterization with sky access

- Automatically configure guide stars from preimage & on the fly at various locations on sky.
- Quantify seeing improvement in comparison to coherent guiding.
- Quantify PSF variation
- Study impact on photometry
- Study impact on astrometry

6.1.2. Summary of observations to be taken

TBD

6.2. Implemented Instrument Functionality & Observing Tools

Convolving flat fields and fringe maps with the guide history is part of instrument pipeline.
TBD

6.3. Tier I pipeline requirements

TBD

6.4. Specific data analysis tools requirements (can be off-site)

TBD

6.5. Observatory access & personnel requirements

TBD

7. Characterization of shutterless photometry

By establishing the locally guided imaging mode we have established that we can handle a large amount of guide star streams. Handling the guide stars and doing centroids of them obviously worked well for us because we finished commissioning of the OT-guided modes – we wouldn't be here yet otherwise. In order to do targeted shutterless photometry with the guide stars we need to establish two more functionalities:

- Defining a guide star configurations to observe those stars that the observer is interested in
- Establish that the photometry code for the guide stars is working, so we can store just a table of photometry data instead of the entire guide star video stream.

These two activities can in part be done in parallel to commissioning the locally guided observing mode, although the observations would not be optimized for targeted fast photometry. Also, there is no requirement to do OT guiding during fast photometry runs, and integration times can be of order of up to 40 seconds.
An additional difference to fast guiding is that for targeted photometry one might be tempted to observe faint stars, while the photometry code for OT-guiding will be optimized for high S/N guide stars. Thus there might be a different photometry core working in the shutterless photometry mode.

7.1. Performance tests

7.1.1. Basic parameters with sky access

- Demonstrate target selection workflow
- Verify real-time photometry with after-the fact photometry based on guide star videos.

7.1.2. Summary of observations to be taken

TBD

7.2. Implemented Instrument Functionality & Observing Tools

TBD

7.3. Tier I pipeline requirements

TBD

7.4. Specific data analysis tools requirements (can be off-site)

TBD

7.5. Observatory access & personnel requirements

TBD

8. Characterizing non-sidereal tracking mode

TBD