ODI Requirements Document

ODI-DewarFocalPlaneTestRequirements.doc

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Document Title:	ODI Dewar and Focal Plane Assembly & Test Requirements		
Brief Description:	Before integration into the ODI system the Dewar, housing the focal plane and CCD controller, will require thorough functional verification and optimization. Basic tests and their operational needs are summarized here.		

Related Documents:	
Document Number/Title:	ODI Science Requirements Document ODI-AD-01-008 v2.2
Document Number/Title:	ODI Schedule
Document Number/Title:	

Document Acceptance and Concurrence		
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Revision History

Version	Author	Date	Section Affected	Remarks
1.0	Daniel Harbeck	Aug 27th 2008		First ODI-internal release with definitions.
1.1	Daniel Harbeck	Aug 28th 2008	1.2,1.4, plus minor changes	Input from G. Muller, added ISP/ODI integration.

In this document we explore the requirements for a proper lab evaluation and testing of the ODI Dewar and focal plane. In the first part we list test and optimizations we aim to do. In a second part we detail the required test setups. In an appendix we summarize the test equipment and lab space requirements, including supporting infrastructure.

1. Dewar Assembly Stages

1.1. Thermal Test Configuration

Schedule: April 2009-August 2009

The Thermal Test Configuration will consist of:

- Dewar shell
- All connector feedthroughs
  - But no Stargrasp flex circuit feedthroughs yet. Metal plates instead.
- A metal plate in the front, i.e., the entrance lens will not yet be mounted.
- Second SiC base plate with temperature sensor network mounted.
  - Additionally, a heat resistor network is mounted on the SiC base plate.
  - Power feed-through for heat resistors can go through a now unused Stargrasp interface plate.
- A control system to ingest power to the focal plane is to be included.
- All connections and systems are connected that are required to run the Dewar without the CCDs:
  - Cooling heads & helium manifold
  - Vacuum valve & pumps.
  - Thermal distribution plate
  - Thermal control system
  - Temperature sensors and multiplexer
  - Vacuum sensor
- Data logging software and query tools

In this configuration extensive thermal testing will be done. The Dewar needs only be cleaned to a level where reasonable vacuum hold times are possible.

1.2. Intermediate Configuration

Schedule: September 2009

Before installing the focal plane, the final dewar setup will be tested. Incremental changes to the Thermal Test Configuration are:

- Install Dewar window **(coordinate with on-telescope optics test)**
- Install Stargrasp/CCD flex circuit feedthrough assemblies[1]
- Remove resistor network from SiC plate.

This assembly will only be vacuum-tested. And will also be used to check the mounting scheme for the populated focal plate.

[1] Focal plate installation protocol: Remove flex feedthrough plate -> Mount populated focal plate -> Mount flex feedthrough plates -> Establish electrical connections.

1.3. Final Lab Configuration

Schedule: October 2009 – January 2010

The final lab configuration will consist of the Dewar and Dewar window module. During lab testing it will not be integrated with the instrument support package. However, the Dewar window assembly (but without the Dewar shell) will have been fit checked with the Instrument Support Package on the telescope during a planned verification run in Summer 2009.

- Exchange spare SiC base plate with the OTA focal plane and wire it up **(depending on delivery of populated focal plate)**
- Attach Stargrasp controller and its housing/cooling system.
- Mount the cable wrap assembly

This final configuration will be used for very extensive functional verification w/ Stargrasp controller until acceptance testing and subsequent shipping to the mountain.

1.4. Final Instrument Integration at telescope

Schedule: February 2010 – April 2010

The Instrument Support Package and the Dewar assembly will be integrated at the telescope during the overall ODI installation at WIYN, scheduled to start in February 2010.

Incremental configuration changes to the lab test:

- Full integration with the ISP.
    - Connections from the Cable wrap to the ISP control system
- Connection through the cable warp to the control/supply infrastructure at WIYN:
    - Coolant lines
    - Fiber lines
    - Other wiring

This final ODI configuration will undergo extensive verification and testing on the engineering level before commissioning starts in April 2010.

2. Dewar Operations Test (Configuration 1.1)

2.1. Sensor verification & calibration, temperature, pressure

Connect all temperature and pressure sensor of the Dewar and continuously monitor temperature and pressure while the Dewar is in the lab.

2.2. Vacuum pump operations

The vacuum in the Dewar will most likely need long-term pumping at the beginning when outgassing will be going on. The lab-testing is a good opportunity to train personnel in the operation of the vacuum gauge and pumping.

2.3. Structural Integrity Test under Vacuum

Before installing the focal plate, the Dewar should be pumped down (with the final dewar window/lens) and tested for structural integrity. Moving the dewar on the assembly cart could serve as a vibration test.

2.4. Vacuum lead tests

A Helium leak test will identify leaks in the Dewar assembly.

2.5. Vacuum hold time tests

Potential leaks in the Dewar can be best identified though constant pressure monitoring, and the hold time of the Dewar will naturally be measured. A minimum acceptable vacuum hold time (time between pumping) is of order of one week, with several months a goal.

2.6. Cooling head test

The cooling head mounts are to be tested under vacuum load. During the entire Dewar lab test it should be looked out for potential degradation of the mounts.

Accelerations of the (dummy) focal plane caused by the cooling heads should be measured to verify that damping worked, and that the displacement (double-integral of acceleration data) does not exceed specifications (from error budget).

Alternatively, the effect of vibration on image quality could be tested by projecting a pinhole on the focal plane, once with cooling heads on, once with cooling heads off. Image degradation would be attributed to the vibration of the cooling heads.

2.7. Dry air/N_2 Purging Verification

Already in the lab there will be the requirement to purge the Dewar entrance window with dry air or N_2. This will prevent fogging in order to:

1. Protect the coatings on the lenses
2. Enable projecting images on the focal plane

Note that there are complications with purging the Dewar window in the lab:

1. If N_2 is used, there are safety issues that have to be dealt with by ventilation and O_2 monitoring.
2. The gas flow not be contained by the HEMI unit, as the Dewar will be tested in a stand-alone mode.

2.8. Temperature control system test w/ dummy focal plane

The temperature control of the focal plate is key for the success of ODI. Before the final focal plate is mounted into the Dewar, a test of the temperature control system should be done with a dummy plate. This plate should be equipped with temperature sensors and heater elements to simulate the heat load of the OTA detectors. Following characteristics and failure responses are to be tested:

- Time scales to cool the focal plate from ambient to operational temperature; time to warm up the focal plate from operating temperature when cooling is switched off; with and without active heating.
- Temperature homogeneity across the focal plate with a 2W/detector simulated load.
- Temperature stability with OTA load on/off (that is a 2W*64=128W difference for the control system to deal with).
- Control loop behavior under varying failure modes:
    - Failure of cooling system – heating runaway?
    - Failure of heating system.
    - Short power outages.
    - Left alone over the weekend.

- Cooling capability at different ambient temperatures. Ambient temperatures from -5ºC to +30ºC should be tested if possible.

In the process of this testing it might become necessary to adjust the thermal coupling between the focal plane and the cooling head. About three cooling cycles are expected to be necessary.

2.9. Temperature control system test w/ real focal plane

Once the real focal plate with detectors is mounted some temperature control system tests should be repeated.

- Time scales to cool the focal plane from ambient to operating temperature. Time scale to change the temperature from -110ºC to -90ºC and vice versa. Possible once measure time for a complete warm-up.
- Temperature homogeneity of the temperature as sensed by the temperature probes, with and without constant (amplifier on, but idling detectors) load.
- Control loop behavior and temperature stability under different operating scenarios; Sequence of 100 consecutive biases, simulated guided observations etc.
- Temperature stability tests under different ambient and operating temperatures if there is an indication that the detector's power consumption differ significantly from the simulating heaters of the dummy plate.

3. Stargrasp & CCD Controller System Operations Test (Configuration 1.3)

3.1. Sensor verification & calibration

The temperature sensors in the Stargrasp housing are to be calibrated and checked for consistency.

3.2. Cooling lines leak tests.

The cooling system of the Stargrasp housing is to be checked for leaks. Also, measure the waste heat that is emitted by the controller housing into the environment (<10W requirement for WIYN site).

3.3. Functional test of Stargrasp system

The Stargasp controllers will be tested for basic operations, i.e., if they are correctly connected to the network and if addressing schemes are correct.

Potentially for all, but certainly for a subset of controllers the output voltages should be manually verified before the focal plate is connected.

3.4. Thermal control system test under different loads and operation scenarios

The thermal control system of the Stargrasp controller should be tested under varying ambient temperatures, and under varying loads. Note that this is a different test from verifying the thermal control system of the focal plate! This test is to be passed before any CCD is connected!

3.5. Verification of CCD control line signals during power outages

The response of the CCD controllers to power outages will be tested. Given the value of the focal plate we have to ensure that no damage can be done to the detectors by accidental power outages as they often occur in the Tucson and on the Kitt Peak summit, especially during the summer. ! This test is to be passed before any CCD is connected!

3.6. Functional Test of Focus CCD control system

The focus CCD system is to be tested.
For this purpose a pinhole (star) array would need to be projected onto the focus sensor detector.

3.7. Test of Bonn Shutter Integration

Proper function of the Bonn shutter is to be tested. If it is driven

4. Focal Plane Optimization & Operation Test (Configuration 1.3)

4.1. OTA CCD optimization

Although ITL will deliver characterized OTA detectors it can be expected that actual operating voltages and sequence patterns/timings require adjustments. ITL's parameters will be good starting point in this process. Note that there will be different merit functions in the optimization test for science image readout and guide star readout/charge shift resulting in different OTA operational parameters in each mode. Trade-offs need to be made between speed, CTE, charge injection, traps, etc.

4.1.1. Linearity test

Linearity is a key requirement for ODI and can be tested by exposing the focal plate to a determined amount of light. Homogeneity of the focal plate's illumination is of secondary importance. An LED driven by accurately timed pulses (e.g., through Stargrasp) could serve as a light source.

4.1.2. Gain, noise & full well test

A photon transfer curve is the appropriate method to measure a gain, noise, and full well. An LED could serve as an input light source, although a more homogenous illumination would be preferred for this test.

4.1.3. Crosstalk test

Crosstalk is best examined by projecting a bright point source onto one cell and to measure the occurrence of a crosstalk ghost in other cells.

4.1.4. Imaging test

Seeing is believing, and the ability to project an onto the focal plane, or at least of subsets, is priceless. This arrangement will then also allow elegant testing of crosstalk, and later on guide star operations, although on limited field of views only.

4.1.5. CTE test

Charge transfer efficiency is best measured with Fe-55 X-ray illumination. However, no Fe-55 source will be available for testing the ODI focal plane, and the overscan edges of a flat field has to serve as a good measure of the CTE.

4.1.6. Dark Current test

Dark current test from 0s exposure time to 1 hour should be conducted, and can be run automatically at nighttime. Dark current tests should also be done for one hour when some cells are constantly read out, and others are shifted, as it would be the case in a long narrow-band exposure. Potential amplifier glow should be minimized in this process.

4.1.7. Pocket-pumping tests

Charge traps are of particular concern for ODI, and a dark / flat-field should be subjected to a series of OTA charge shifts as they are expected during normal OTA operations. Clocking/voltages should be optimized to minimize the occurrence of traps. Note that the trap occurrence might differ at various flat field illuminations (including no illumination for a dark).

4.2. Focus CCD system optimization

The focus sensor CCD system has to be tested and verified. If indeed the tilted focus sensor wil be used, a pinhole array should be projected onto the titled focus sensor to verify the operation of its control software. Also, the detector itself will need some optimization as well.

4.3. Test OTA array at varying focal plane temperatures -90ºC, -100ºC, -110ºC

The focal plane characteristics should be identified at some different temperatures to make the best tradeoff between potential cooling limitations and detector performance.

4.4. Test at inhomogeneous loads

Typical observing scenarios should be scripted and played back. Such scenarios include: Sequence of 20 bias images, sequence of flat fields, dither patterns executions, some idle time etc. The stability of focal plane temperature, overscan levels etc is to be monitored. A gain determination at various stages of this test should be inserted to ensure its stability.

4.5. Guide star acquisition test

A star field will be projected on the focal plane, or subsets of it, and the automatic guide star acquisition will be tested and optimized.

4.6. Guide loop test

A star field with controlled (at least coherent) motion will be projected onto the foal plate, or subsets thereof. Some basic testing of the guide loop and its stability, latency, etc can be verified and optimized. This will be a crucial robustness test of the ODI system before going to the mountain.

4.7. Verification of data Format and Header Information

The data format produced by various observing modes needs to be verified against the applicable standards. Test data ingestion into the NOAO data archive should be facilitated.

5. Summary of Assembly Requirements

Personnel & Equipment here.

5.1. Dewar Assembly 1.1

TBD

5.2. Dewar Assembly 1.2

TBD

5.3. Dewar Assembly 1.3

TBD

6. Summary of Operational Infrastructure in the Dewar Lab

As of configuration 1.1:

- Helium Compressor for focal plane cooling & heat sink.
- Computer infrastructure for thermal control and monitoring.

Additionally as of configuration 1.3:

- Stargrasp housing cooling equipment
    - Pending on actual cooling configuration, if closed-box system: Glycol cooler, pump, and heat sink
- Stargrasp control computer cluster and fiber link to it
- Optical test bench for Detector Evaluation.
- Dry air purge for Dewar window.
  Alternatively a policy that we do not cool the focal plane when there is humidity out there.