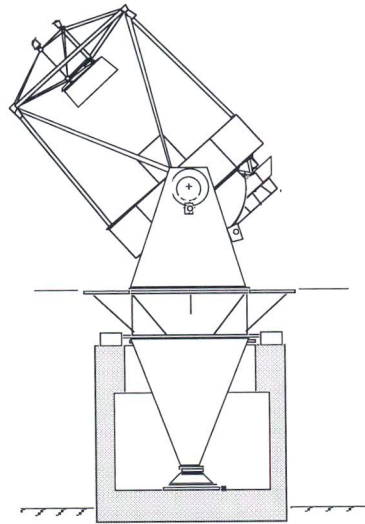WISCONSIN

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**WIYN Operations Readiness Review:
Review of Instrument Adaptor Subsystem Design
Requirements**

WODC 02-40-01

Operations Readiness Review

Instrument Adapter

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1. Introduction

This document describes the operational readiness of the Instrument Adapter Subsystem (IAS) for the WIYN telescope.

The IAS was designed to be a general instrument interface performing the functions of acquisition, autoguiding and derotation, autofocus, image analysis, spectral calibration, and atmospheric dispersion compensation. The IAS is constructed in modular form to allow phased deployment of the various modules, and to enhance the maintainability of the system.

As of this report all IAS modules have been installed with the exception of the spectral calibration module and the atmospheric dispersion compensator. These remaining modules are in preparation and are expected to be completed in the next two months.

The hardware installation does not always imply full operation, however. Software development which was initially specified as part of the control system deliverable has become the pacing item for completion of the IAS.

2. Requirements & test results

The sections of this document parallel the requirement as set forth in the Scientific & Technical Requirements document (WODC 00-01-05) section 6.3. Quotes from that document are shown in italics

- *Availability:*
  General-use Nasmyth focus (WIYN Port).
  Autoguide & derotate, autofocus, image analyser, spectral calibration, ADC.

These goals have either been met or are in development.

Standard bolt patterns were included on the instrument mounting flange to make mounting many different instruments possible. However, heavy instruments must interface to the mounting bolts at the corners of the IAS structure.

- *Weight capacity:*
Instrument weight :	*600 kg maximum.*
Cantilever load:	*2500 N-m maximum.*

This has not been tested, however the IAS was designed to meet these specifications provided the instrument is mounted to bolt pattern provided at the corners of the structure. A finite element model of the IAS when subjected to the maximum specified instrument loads predicted that the instrument mounting flange would sag 7 μm and tilt 0.35 arcseconds (equivalent to an image motion of 0.06 arcseconds measured at the image plane).

- *Field acquisition:*
Sensor type	*TBD*
Field of View:	*1.5 arcminute.*
Limiting magnitude:	$m_v = 21$ *in 10 seconds with a dark sky.*
Set-up time:	*5 seconds.*

Field acquisition is generally done with one of the two guide probes. These are intensified CCD cameras, one with a 1.5 arcminute FOV, the other with a 1.0 arcminute FOV. They are capable of acquiring images somewhat fainter than $m_v = 16$.

An thermo-electrically cooled integrating CCD camera has been provided to serve the dual functions of acquisition and wavefront sensing. The CCD is a Princeton Instruments model #TE/CCD-576T. The camera uses a Thomson CSF model TH7883CDA array with a 576 x 384 pixel format. Pixel dimensions 23 x 23 μm which provides a 2.09 x 1.38 arcminute field of view. The camera is mounted on an X-focus stage and can be trammed across the 0.5° field available at the WIYN port, and scanned 25 mm above and below focus to obtain out-of-focus images for wavefront analysis. At this time we have verified the camera is functional, however we have not yet completed a wavefront reduction with images from this camera nor have we used the camera for field acquisition. Limiting magnitude and set-up time are unknown. This portion of the IAS is under development.

- *Guider:*

Number:	*Two probes.*
Sensor type:	*TBD*
Field of view:	*1.5 arcminute.*
Sensitivity:	*Centroid to 10% of seeing disk at $m_v = 16$ @ 1 Hz*
Update Rate:	*0.1 to 1 Hz.*
Set-up time:	*10 seconds.*

These requirements have been met with exception of set up time.

The IAS supports two intensified CCD cameras mounted on X-Y-Focus stages. These are Phillips type FTM800 image sensors modules bonded to a Gen II intensifier tube. Both provide a 1/2" diagonal image area and standard video output. One camera, called the guide probe, has a 1.5 arcminute FOV. The other, called the focus probe, is fitted with special focus sensing optics however it can also be used for guiding. It has a 1.0 arcminute FOV at higher magnification. The sensitivity has not been rigorously tested, however they are capable of guiding on images of $m_v = 16$ stars. This performance is achieved using real time video rates, so it may be possible to guide on fainter images by incorporating an integrating (leaky) memory.

Set up time is presently prolonged by two factors: first, the number of key stroke and/or mouse clicks required to start the guide process. This operational overhead will be reduced as the software is developed and streamlined. Second, due to a problem with the drive electronics the X-Y camera stages are presently limited to slow speeds (250 steps per second). At this rate it takes 80 seconds for a probe traveling from its home position at the edge of the field to reach the field center for acquisition.

We are presently studying this problem and hope to provide faster operation soon.

- *Autofocus:*

Sensitivity:	*5% degradation of delivered image at mv = 16 averaged over 30 seconds.*
Update rate:	*30 seconds.*
Set-up time:	*10 seconds.*
Program interruption:	*None allowed.*

This part of the IAS is under development.

Optics for sensing changes in the telescope focus are resident in the so-called focus probe camera. These are mounted on a filter/pupil wheel so that they can be removed from the beam to the camera. Since these focus sensing techniques are somewhat developmental, two sets of optics were included as a safeguard and as a means of comparison of technique.

The first set of optics introduce a wedge prim at a pupil image. This splits the light beam into two pencils which form two images at the camera focus. A change in focus can be detected as a change in separation of the image centroids, while the common motion of the two centroids can be used to correct the guiding. The sensing technique is a simple version of a Shack-Hartmann wavefront sensor.

The second set of optics introduces either a weak positive or a weak negative lens at the pupil. Changes in focus are determined either by a change in the average surface brightness of the out-of -focus image, or a change in the image diameter, or both. Comparing the inside-of-focus to the outside-of-focus images can give an absolute rather than relative indication of telescope focus. This technique is related to the curvature sensing wavefront analyser developed by Francios and Claude Roddier and used as the main wavefront analyser at WIYN.

The pacing item for developing either or both of these focus sensing techniques is the software.

- *Image Analyser:*
Faint limit:	*$m_v = 9$*
Integration time:	*30 seconds.*
Set-up time:	*15 seconds.*
Program interruption:	*≤ 2 minutes, including active collimation.*
Update requirement	*≥ 30 minutes.*

Image analysis, more widely known as wavefront reduction, is presently done with the science CCD camera. Though the hardware is resident in the IAS, software for transferring the images into a useable format is still in development.

From the S&T specifications it is clear that the original concept for WIYN involved a real-time wavefront sensor used to correct the optics based on data obtained by interrupting the science program for about 2 minutes every half hour or so. During project development this concept was abandoned and replaced with a more practical one based on experience from the Multiple Mirror Telescope. We now make continuous corrections to the collimation and primary figure based on look-up tables that are up-dated two or three times a year. The result is a sizable reduction in program interruptions from one every half hour to one or two per night. This has proved to be a successful way to maintain high quality wavefront and optical collimation.

- *Internal Calibration sources:*
Beam shape:	*TBD*
Wavelength calibration:	*TBD*
Continuum source:	*TBD*

This part of the IAS is under development.

As of this report the Comparison Illumination Assembly (CIA) is being assembled. The lamps presently included are:

> Quartz continuum
> Mercury
> Sodium
> Copper-Argon
> Thorium-Argon (2 lamps)

The lamps illuminate an integrating sphere whose output beam is lambertian - that is, the luminance is constant and not dependent on the angle of incidence. The assembly is equipped with a filter wheel over the output of the integrating sphere. Filters for the four positions have yet to be determined. The output beam is relayed via two quartz lenses to illuminate a 4 arcminute diameter area centered on the focal plane.

Atmospheric dispersion compensator (ADC):

Type:	*4-element, 2 rotating groups, AR coatings.*
Optical design:	*Coma correction over 30 arcminute field.*
	Parfocal with R-C focus.
Design wavelengths:	*3500A - 1.1 µm.*
Estimated throughput:	
3341 A:	*49%*
3500 A:	*73%*
4000 A:	*89%*
1.1 µm:	*89%*
Setup time:	*10 seconds.*
Time to insert:	*1 minute, manual operation.*

Usable with field acquisition, guiders, autofocus, image analyser, and calibration sources.

The ADC is still under development.

As of this report the mechanics (lens holders and rotators) are finished. Considerable delay was incurred in figuring the lenses. The combination of thin wedges and high CTE glasses proved particularly troublesome for obtaining flat surfaces. We hope to take delivery of the lenses this month (February, 1996) and complete the ADC installation within two months.

The optical design acts as a field corrector and flattener to give coma correction over a flat 0.5° field. In addition, the lenses can be rotated to compensate for atmospheric dispersion over the specified band-pass. These lenses will be coated with an anti-reflective coat of Mg-Fl. The lens will be bonded into two doublets with high UV transparency cement.

The mechanical mounting allow the lenses to be removed or inserted into the telescope beam under remote (not manual) control and rotated singly, together or counter-rotated in 0.1° increments. Software specification have been written for determining the position of the lens-prisms as a function of zenith distance, ambient temperature, barometric pressure and humidity. Unless specifically entered, the last few terms default to values for a standard atmosphere.

The ADC can be inserted into the telescope beam above the acquisition, wavefront sensing and focus sensing cameras and is usable with them. Light from the calibration sources however, does not pass through the ADC.