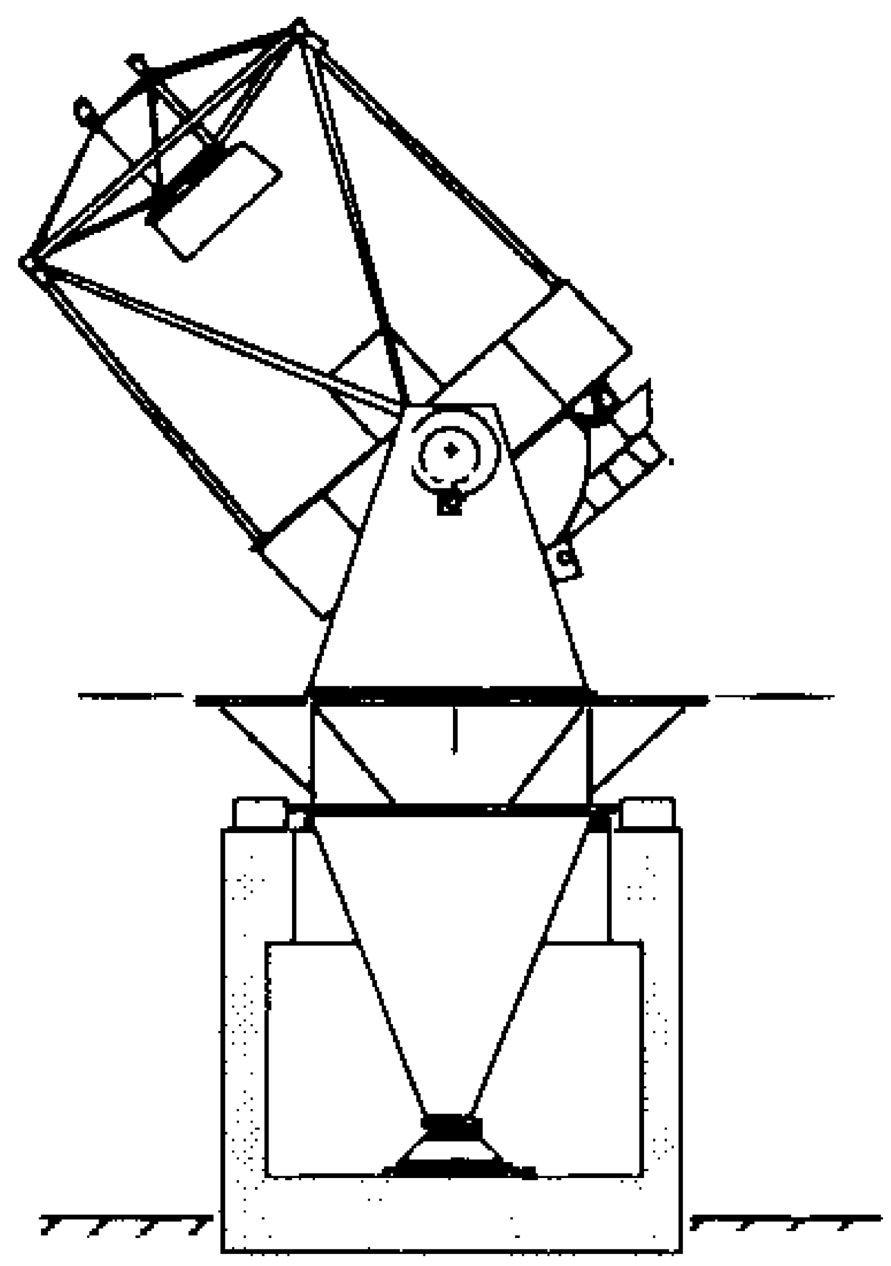
Wisconsin
Indiana
Yale
NOAO



3.5 Meter Telescope

Scientific & Technical Requirements for the WIYN 3.5 Meter Telescope

WODC 00-01-03

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/Matt Johns 5/2/91
Project Manager Date

/Gus Oemler 5/2/91
Scientific & Advisory Committee Date

/Blair Savage 5/2/91
WIYN Board Date

General Scientific & Technical Requirements

1. Purpose of project

New capabilities in astronomical instruments in combination with more sophisticated theories are leading to rapid advances in our understanding of the universe. As a result, the demand for large telescope time far exceeds the time available on existing instruments. NOAO is joining with the University of Wisconsin, Indiana University, and Yale University to build a 3.5-meter telescope on Kitt Peak to improve the facilities and to expand capabilities available to the U.S. astronomical community and give the three universities assured access to a large telescope . First light is planned for 1993.

The consortium has identified optical spectroscopy as the area in which the WIYN telescope can have the greatest impact. The development of fiber optics enabling simultaneous observations of a large number of objects has greatly improved the efficiency of spectroscopy. For a number of years NOAO has employed fibers to pipe light to instruments off the telescope.[1] About half of the WIYN telescope time will be devoted to multi-fiber spectroscopy. An automated fiber positioner with a capability of 100 blue-optimized and 100 red-optimized fibers is currently under construction at NOAO and is described by Barden and Rudeen.[2] A bench mounted, fiber-fed Multi-Object Spectrograph (MOS) capable of taking 100 spectra simultaneously is also being constructed[3]. These instruments will initially be used on the Kitt Peak 4-m telescope and eventually they will become part of WIYN.

The telescope will also be used for a variety of instruments developed by the universities and NOAO. A large format CCD imager is the first of such instruments and others are planned. Excellent imaging performance is an important goal for the telescope.

While the main purpose of the WIYN project is to provide a state of the art facility for astronomical research, the telescope will serve as a test bed for new technology being developed as part of NOAO's 8-m Telescopes Project. The WIYN primary mirror supports and ventilation system are prototypes for the larger telescopes, and WIYN's experience with active optics and distributed control systems will also be applicable to the 8-m effort.

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[1] S. C. Barden, "Fiber Optics at Kitt Peak National Observatory", *Instrumentation for Ground-Based Optical Astronomy"*, ed. L. B. Robinson, 1988.

[2] S. C. Barden and A. Rudeen, "The Kitt Peak National Observatory Fiber Actuator Device", *Instrumentation in Astronomy VII*, ed. D. L. Crawford, vol. 1235, SPIE, 1990.

[3] D. Vaughnn, BAAS **22**, p. 887, 1990.

2. General Considerations

The scientific and technical requirements in this document represent engineering tasks of varying difficulty. These requirements, separated into two categories, are classified as specifications or goals according to the following definitions:

Specifications describe the design or performance capabilities of the observatory that have been approved by the board to meet the science goals of the project. These specifications have been reviewed by the project staff for technical difficulty and judged to be achievable with the approved budget and schedule. Changes to specifications require a review by the Scientific Advisory Committee (SAC) and approval by the board.

A goal is a performance capability that has been recommended by the SAC but which requires further study and development due to an uncertainty in its technical feasibility or the project's ability to achieve it with the allocated resources. The project staff will design to the goals and report to the SAC when changes are advisable. Proposed modifications will include an assessment of the technical impact and budgetary and schedule implications. Modifications to goals will be approved by the SAC. Goals will be converted to specifications by the SAC as development allows. Goals which cannot be achieved within the approved budget and schedule and which, in the judgement of the SAC, significantly affect the capabilities of the observatory will be referred to the board with the SAC's recommendation.

Requirements that are goals are labeled with a [G]. A [G] at the head of a subsection or category indicates that all requirements included in the subsection or category are goals. Requirements without a G-label are specifications.

2.1 Basic design

The telescope will benefit from experience gained from the Astronomical Research Corporation 3.5-m telescope, having a compact altitude-azimuth design with rolling element bearings and friction drives. For simplicity, cost and operational ease, it will have a single secondary and all instruments will share a common back-focus. The two Nasmyth foci will be the principal instrument positions. The telescope will have a wide field of view to take advantage of recent advances in fiber fed instrumentation and will be designed to take advantage of excellent imaging expected at the site.

[G]

Two additional foci are being planned for future expansion: a folded-cassegrain port on the top side of the optical support structure (OSS) and a modified-cassegrain focus immediately below the primary mirror. The beam will be directed to the folded-cassegrain focus by rotating the tertiary 90° about the primary optical axis from the Nasmyth positions. The tertiary will fold out of the way to allow the beam to reach the modified cassegrain focus. The initial design of the telescope will not include instrument rotators for these foci or the tertiary folding mechanism.

2.2 Operating modes

[G]

A number of observing modes are planned. NOAO will be supporting survey and synoptic spectroscopic observations with service observing of queued programs. The universities will split their time between on-site and remote observing (Appendix A). Both groups require the ability to rapidly switch programs to adjust to changing seeing, transparency and moonlight. They will require the telescope to quickly and reliably acquire objects and to track accurately. The telescope and control system must be versatile enough to handle these requirements without undue demands on the skill level and learning curve for the operators and observers.

2.3 Maintenance & reliability

[G]

The cost of operating the telescope over its lifetime will greatly exceed the initial capital cost. If recent history is a guide, operating budgets will be tight and capital improvements will compete with maintenance for the available funds. Two strong goals of the telescope and enclosure design are high reliability and low maintenance requirements to maximize the science return.

2.4 Thermal design

[G]

A number of strategies will be adopted to control thermally induced dome seeing. These include employing lightweight structures to minimize thermal mass, ventilating the telescope and enclosure to minimize the time it takes to come to thermal equilibrium, trapping and exhausting all sources of waste heat, and the use of special coatings to radiationally decouple sources exposed to the cold night sky.

2.5 Active optics

[G]

The telescope will employ an active optics system to keep the primary and secondary in alignment and in focus. Wavefront and focus sensors in the focal plane will provide input for making corrections in real-time. Active force actuators on the primary mirror axial supports will be provided as required to provide a level of correction for low spatial-frequency wavefront distortions to meet the image error budget for optical surfaces and supports.

2.6 Safety

Working at an observatory involves working around moving pieces of equipment often at night and from high platforms and ladders. All parts of the telescope and enclosure design will be subjected to and required to pass safety reviews.

3. Optical Design

The parent design of the telescope optics is Ritchey-Chrétien. The principal foci will be at the two Nasmyth locations. A third, folded Cassegrain, focus will be accessible for future use. Nominally all three foci will be parfocal. A fourth focus located in the center hole of the mirror cell will be used for polarimetry. Auxiliary optics will shorten the back focal distance for that focus.

3.1 Principal optics

Primary Mirror:

Shape:	Concave hyperboloid
Diameter	3.5 meter
Focal ratio:	f/1.75
Central hole diameter:	0.96 meter
Radius of curvature:	12.250 meter
Conic constant:	-1.070833

Secondary Mirror:

Shape:	Convex hyperboloid
Diameter:	1.2 meter
Radius of curvature:	5.332 meters
Conic constant:	-3.731667

Tertiary Mirror:

Shape:	Plano, quasi-elliptical.
Major diameter:	1.10 meter
Minor diameter:	0.77 meter

3.2 Specification of foci

All foci except modified Cassegrain:

Focal ratio:	f/6.3
Plate scale:	9.36 arcsec./mm

Bare R-C without corrector:

Nominal field of view:	15 arcminutes.
Linear field:	96 mm.
Field radius of curvature:	2.11 meter.
Distance to exit pupil:	8.5 meter from focal surface.

Wide-field Nasmyth (MOS Port):

Corrector:	Doublet, all spherical surfaces, AR coat. [G]
Corrected field of view:	1°
Linear field:	385 mm.
Wavelength range[1]:	3300 A - 1.5 μm. [G]
Field radius of curvature:	5.51 meter. [G]
Broadband focus tolerance:	$\delta\lambda/\lambda = 0.5$ for 0.1 arcsec. enlargement

[1] Wavelength range over which images will meet the error budget. The range is set by the corrector design. The corrector will transmit down to the atmospheric cut-off with the image quality unspecified outside of the nominal range. [G]

Distance to exit pupil:	7.3 meter from focal surface.	[G]
General-Use Nasmyth (WIYN Port):		
Corrector:	4-element ADC, AR coated	[G]
Corrected field of view:	30 arcmin.	
Linear field:	192 mm	
Wavelength range[1]:	3500 A - 1.1 µm	[G]
Field curvature:	Plano.	
Broadband focus tolerance:	$\delta\lambda/\lambda$ = 0.5 for 0.1 arcsec. enlargement	
Folded Cassegrain:		[G]
Same as bare R-C.		
Modified Cassegrain:		[G]
Focal reducer:	Two mirror.	
Focal ratio:	f/13-f/13.5	
Nominal Field of view:	6 arcmin. diameter.	
Linear field of view:	82 mm. nominal.	
Focus behind primary vertex:	114 cm. nominal.	

4. Image size budget

[G]

The image size budget sets the imaging goals for the telescope and pre-allocates limits to the sources of image degradation to guide the design of the telescope and enclosure. As the design progresses, the allocations may be adjusted as necessary with the overall goal of keeping the total budget constant. Figures 1 and 2 show the image size budgets for the two cases of narrow-field and wide-field applications. These applications will normally be performed at separate foci on the telescope and have different imaging and control requirements. The image size is specified over the field angles and spectral ranges noted on the figures. The conditions under which the image budget applies are discussed below.

Image sizes are specified in arcseconds FWHM. Depending on the shape of the point spread function, these units may or may not be easily converted to a measure of enclosed energy. Assuming a gaussian profile, an image 1.00 arcsecond FWHM has a 1.18 arcsecond RMS diameter (63% enclosed energy) and concentrates 80% of its energy in 1.52 arcseconds. To insure acceptable energy concentration in the delivered optics, error budgets in FWHM will be converted to structure functions for the purpose of specifying optical surfaces.

The image budget for narrow-field imaging is set by the requirement that the telescope and enclosure not degrade 0.7 arcsecond seeing by more than 0.1 arcsecond. 0.7 arcsecond was chosen, somewhat ad hoc, to represent the median seeing of the site and is consistent with the limited site testing that has been performed on Kitt Peak and the measured seeing at other observatories in the area.

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[1]Wavelength range over which images will meet the error budget with the corrector inserted. Short wavelength limit is set by the 70% cut-off in the transmission of the ADC. Observations at wavelengths greater than the range are possible with unspecified image quality. [G]

The wide-field use of the telescope will be primarily for multi-object spectroscopy (MOS). MOS uses 200- and 300-micron optical fibers corresponding to 2 and 3 arcseconds on the sky respectively and doesn't require the sub-arcsecond images of the narrow field applications. The wide-field image budget is made larger to simplify the control requirements at the wide-field port. Should a requirement arise for improved wide-field imaging, guide/focus sensors and a wavefront analyzer could be provided at that port to achieve 0.38 arcsecond telescope performance.

The image budget applies to zenith distances up to 60°. The telescope will operate at lower elevations as specified in a section 5. The contribution to image size from seeing grows as $(\cos z)^{-3/5}$ where z is the zenith distance. The image budgets for the telescope and enclosure are allowed to increase according to the same law thus keeping the relative contributions the same.

The environmental conditions under which the image budget applies are: nighttime observing, wind speeds up to 10 m/sec. and outside air temperature gradients less than 0.5°C/hour. (10 m/sec. is approximately the 90 percentile wind speed on Kitt Peak).

The error budget for alignment includes the effects of despacing of the optical elements (focus) and collimation. The collimation term will be mostly effected by decentration and tilt of the secondary mirror with respect to the optical axis of the primary and, to a lesser extent, by decentration and tilt of the correctors.

The tracking error budget includes the effects of the telescope mechanical motions ("drives"), wind shake, and guide errors ("control system") including errors in matching field rotation.

The budgets for thermal degradation include the effects of thermal distortion of the optics and mirror seeing.

5. Telescope

[G]

Axis motion:	
Azimuth:	+/- 270°
Zenith angle, observing:	0.4° < z < 75°
Zenith angle, hard stops:	-2° and 90°
Zenith blind spot:	0.8° diameter max.
Slewing:	
Maximum slew rate:	5°/sec.
Slew ramp:	$1°/sec^2$
Settling time:	10 sec. max.
Time for track to track:	100 sec. max., < 360° azimuth rotation. 20 sec. max, < 10° offset & < 10° azimuth.

Pointing accuracy:

Offsets ≤ 1 degree:	≤ 0.2 arcsec. rms
Offsets > 1 degree:	≤ 1 arcsec. rms
Offsets > 10 degrees:	≤ 2 arcsec. rms

Track rates:

Maximum track rate:	0.5°/sec.
Track ramp:	$0.1°/sec^2$ max.

Tracking accuracy:

Open loop:	≤ 0.10 arcsec. rms for 2 minutes.
Open loop:	< 0.5 arcsec. rms for 15 minutes.
Closed Loop (Guided):	≤ 0.10 arcsec. rms for 1 hour.

6. Telescope Equipment

Common equipment supplied as part of the telescope and shared by more than a single scientific instrument:

6.1 Baffles

Baffles will be provided at the secondary and tertiary mirrors and on the altitude axis near the edge of the primary mirror to eliminate lines-of-sight from the focal plane to the night sky or inside of the dome.

Obscuration:	≤16.7%	[G]

6.2 Instrument rotators

Availability:	Provided on both Nasmyth foci.	
Weight capacity:	See section 7.	
Rotation range:	360°.	
Rotation rate:	-5°/sec. to +5°/sec.	[G]
Ramp rate:	$-1°/sec^2$ to $+1°/sec^2$	[G]
Accuracy:	≤ 5 arcsec.[1]	[G]

6.3 Instrument adapter

[G]

Availability:	General-use Nasmyth focus (WIYN Port)
Features:	Autoguide & derotate, autofocus, image analyzer, spectral calibration, ADC.
Weight capacity:	See section 7.

[1] Equivalent to a 0.044 arcsecond displacement due to rotation at the edge of the 0.5° field.

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.
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 Hz. to 1 Hz.
Set-up time:	10 seconds.
Autofocus:	
Sensitivity:	5% degradation of delivered image at m_V = 16 averaged over 30 seconds.
Update rate:	30 seconds.
Set-up time:	10 seconds.
Program interruption:	None allowed.
Image analyzer:	
Faint limit:	m_V = 11.
Integration time:	30 seconds.
Set-up time:	15 seconds.
Program interruption:	$\leq$2 minutes including active collimation.
Update requirement:	$\geq$30 minutes.
Internal Calibration sources:	
Beam shape:	TBD.
Wavelength calibration:	TBD.
Continuum source:	TBD.
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 micron.
Estimated throughput:	
3341A:	49%
3500A:	73%
4000A:	89%
1.1 micron:	89%
Set-up time:	10 seconds.
Time to insert:	1 minute, manual operation.

Useable with field acquisition, guiders, autofocus, image analyzer, and calibration sources.

6.4 Tertiary rotator

[G]

Description:

Rotates tertiary mirror about the primary optical axis to direct the telescope beam to one of two Nasmyth ports or the folded Cassegrain port. Tertiary mirror may also be moved out of the beam to allow on-axis Cassegrain operation behind the primary mirror.

Time to beam switch:	< 1 minute, Remotely actuated.
Repeatability:	< 4 arcseconds.
Accuracy:	<30 arcseconds. [1]

6.5 Primary mirror cover

Description:

Seal primary mirror against dust when closed.
Protect against blunt impacts of ≤ 20 kg-m/s.
Present minimal cross section for wind shake.

6.6 Flat field

[G]

Description:

A screen and illuminating lamps covering the full aperture of the telescope for calibrating the instrumental response over the full field of view. The screen will be mounted on the inside sloping panels of the dome oriented so that it may be viewed normal to the optical axis of the telescope. Three sets of lamps will be mounted on the telescope to illuminate the spot: a high intensity set for quick exposures, a continuum source with color balance filters, and a third source TBD.

7. Instrument mounting & weights

[G]

Wide-field Nasmyth (MOS Port):

Mounting surface (S):	Instrument rotator.
Back focus distance from S:	508 +/- 0.6 mm nominal.
Instrument weight:	1000 kg max.
Cantilever moment from S:	3000 N-m max.
Instrument envelope:	2.5 m L. x 2.0 m D.
Imbalance about axis:	30 N-m max.

General-Use Nasmyth (WIYN Port):

Mounting surface (S):	Instrument adaptor.
Back focus distance from S:	127 +/- 0.6 mm.
Instrument weight:	600 kg max.
Cantilever moment from S:	2500 N-m max.
Instrument envelope:	2.0 m L. x 2.0 m D.
Imbalance about axis:	30 N-m max.

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[1] So as to produce less than 0.1 arcsecond image displacement due to differential field distortion at a field radius of 0.5° caused by the apparent decollimation of the corrector.

Folded Cassegrain:

Mounting surface (S):	Flange on center section of OSS.
Back focus distance from S:	TBD.
Instrument weight:	TBD.
Cantilever moment from S:	TBD.
Instrument envelope:	TBD

Modified Cassegrain:

Mounting surface (S):	TBD
Back focus distance from S:	TBD
Instrument weight:	TBD.
Cantilever moment from S:	TBD.
Instrument envelope:	TBD

8. Instrument support

Requirements for power, gasses, vacuum, waste heat extraction and cabling at the various scientific instrument locations.

8.1 Nasmyth instruments

[G]

Services provided for instrument support at each Nasmyth focus. Unless noted, termination will be on a panel fixed to the fork tine.

Power:

Uninterruptible clean power:	120 VAC, 15 amp.
Dirty power:	120 VAC, 15 amp.

Signal lines (from computer room):

Control:	Serial TBD, three cables.
Data:	Optical fiber, number TBD. Coaxial cable, number TBD.
Video acq./guide/wavefront:	Serial TBD, four cables.
Camera gain:	Four twisted pairs.

Fiberoptic feed to spectrograph room:

Cableway for four 100 optical fiber cables in four 2" diameter armored flex-conduits. Fibers will be terminated on the instrument.

Gasses & coolant:

Dry filtered N_2:	10 cfh at 5 psi.
Coolant (piping only):	2 lines, 0.38" ID terminate in mech. rm.

Waste heat scavenge:

Connection to mount exhaust plenum through fitting on tine.

8.2 Spectrograph Laboratory

[G]

Description:

Two stations will be provided for stationary spectrographs. The first will be occupied by the MOS. The other will be available for future instruments. The following specifications apply per station.

Power:

Uninterruptible clean power:	120 VAC, 15 amp.
Dirty power:	120 VAC, 30 amp.

Signal lines (from computer room):

Control:	Serial TBD, three cables.
Data:	Optical fiber, number TBD.
	Coaxial cable, number TBD.
Video acquisition:	Serial TBD, two cables.
Camera gain:	Two twisted pair.

Gases and vacuum:

Dry filtered N_2:	10 cfh at 5 psi.
Compressed dry filtered air:	10 cfh at 100 psi.
Vacuum:	TBD.

Waste heat scavenge:

Connection to mount exhaust plenum through ported duct.

Remote alarm sensors:

O_2 depletion.

Interconnected smoke detector.

9. Facility Instruments

Facility instruments will be supported by the WIYN Observatory for use by all observers. The instruments described in this section will be available at the start of telescope operations.

9.1 HYDRA

[G]

Description:

Robot for positioning fiber optics in the focal plane of the MOS port. See Appendix A[1]. HYDRA will mount directly to the instrument rotator and place its focal plane at the appropriate position as specified in section 7. The fibers will pipe light to a spectrograph off the telescope. Means will be provided for acquiring the field and for sensing guide errors, field rotation and focus errors. An alignment camera with the ability to simultaneously view the superimposed images of the fiber and program object will provide a check of fiber positioning.

Positioner:

Useable field diameter:	385 mm.
Field curvature compensation:	TBD.
Area lost to steps:	≤TBD.
Mechanical positioning accuracy:	≤ 20 µm.
Min. fiber-fiber spacing:	3.5 mm.
Mean setup time per fiber:	≤ 9 sec.
Max. number of fibers:	200.
Min. number of science fibers:	180.
Size:	1.5 m x 1.5 m x 0.9 m D.
Weight:	227 kg.
Power:	TBD.
Temperature range:	TBD.
Humidity:	TBD.

Fiber placement camera:

Type:	Intensified CCD (Amperex 1610).
Input photocathode:	S25 with extended blue response.
Brightness operating range:	m_V = 8-21.
Active imaging diameter:	18 mm.
Controls:	Power & gain.
Output:	RS170 standard video format.

Field alignment/guide camera:

Type:	Intensified Lens coupled CCD.
Designation:	NOAO type ILS.
Input photocathode:	S25.
Brightness operating range:	m_V = 11-17.
Active imaging diameter:	16 mm.
Controls:	Power & gain.
Output:	RS170 standard video format.

[1]S. C. Barden and A. Rudeen, "The Kitt Peak National Observatory fiber actuator device", *SPIE 1236*, 1990.

Fiber cable #1 ("blue"):

Fiber type:	Polymicro FVP.
Active & spare fibers:	100.
Min. number of active fibers:	90.
Fiber diameter:	300 microns.
Length:	≤25 m.
Transmission:	See figure TBD.

Fiber cable #2 ("red"):

Fiber type:	Polymicro FBP.
Active & spare fibers:	100.
Min. number of active fibers:	90.
Fiber diameter:	200 microns.
Length:	≤25 m.
Transmission:	See figure TBD.

9.2 MOS Spectrograph

[G]

Description:

Bench mounted multi-object spectrograph for use with the HYDRA. MOS will include a selection of gratings and cameras to cover various spectral resolutions and wavelength ranges. Commonly used functions that will be automated include collimator focus, grating tilt and camera focus. The spectrograph entrance aperture will be large enough to accommodate the output of all the active fibers in a fiber cable with adequate separation of adjacent spectra on the detector. Remote post slit viewing will be provided to verify fiber positioning.

Basic configuration:

Optical layout:	See figure TBD.
Mounting:	Vibration isolated table.
Entrance aperture:	75 mm.
Collimator:	On-axis paraboloidal mirror.
Beam diameter (zero field):	152 mm. at collimator.
Dispersion:	Replicated planar reflection gratings.
Cross dispersion:	TBD.
Cameras:	Selection of two: blue- and red-optimal.

Fiber holder:

Maximum number of fibers:	100 + 2 internal calibration.
In-line aperture/filter slots:	4.
Interference filter size:	9.5 mm x 76 mm.
Glass filter size:	TBD.
Filters:	See tables below.
Beam obscuration:	12.7 mm x 127 mm.

Fiber output viewer:

Type:	Intensified lens-coupled CCD.
Brightness operating range:	m_V = 9-16.
Field of view:	80 mm.

Collimator:
- Focal length: 1020 mm.
- Aperture: 240 mm.

MOS Glass Filters	
F1:	RG-610
F2:	RG-695
F3:	GG-375
F4:	GG-420
F5:	GG-495
F6:	BG-38
F7:	BG-39

MOS Interference Filters			
		λc	$\delta\lambda$
IF1:	Mg I	5174A	17A
IF2:	Li I	6712A	28A
IF3:	H-alpha	6562A	28A

WIYN/MOS Low Dispersion Gratings

				Red Camera		Blue Camera	
Grating	Ruling lines/mm	θ_B degrees	Order	λ_c A	$\delta\lambda/\delta x$ A/mm	λ_c A	$\delta\lambda/\delta x$ A/mm
G1: TBD.							

θ_B : Blaze angle; λ_c: Wavelength; $\delta\lambda/\delta x$: Dispersion.

Low resolution gratings:
- Type: Plane reflection.
- Size: 204 mm x 254 mm nominal.
- Selection: See table above.

Echelle:
- Type: Plane reflection.
- Size: 203 mm x 381 mm.
- Ruling: 316 l/mm.
- Blaze: 63.5°.

Cross dispersion:
- Type: TBD.
- Ruling: TBD.
- Order separation (echelle): TBD.

Camera 1 ("Red"):	
Type:	Refractive.
Focal length:	267 mm.
Aperture:	210 mm.
Central obscuration:	None.
Wavelength range:	3800A - 1.5 micron.
Useable field:	60 mm nominal.
Camera 2 ("Blue"):	
Type:	Catadioptric.
Focal length:	381 mm.
Aperture:	215 mm.
Obscuration:	$\leq$30%.
Wavelength range:	3000A - $\geq$1 μm.
Useable field:	50 mm nominal.
Detector:	
Type:	Backside illuminated, thinned CCD.
Min. format:	$\geq$1024 x 1024.
Nominal pixel size:	15-27 μm.
Noise:	<10 e.
Min. active area:	25 mm square.
Performance:	See Table TBD.
Spectrograph controller:	
Chassis:	Rack: Standard 19", dual bays.
Size:	21" W x 15" H x 24" D.
Peak power:	100 W.
Quiescent Power:	10 W.
Temperature range:	0-55 °C.
Humidity:	Non-condensing.
Camera controller:	
Features:	Support for mosaics. Programmable clocks. F/O data & command links. Shutter control.
Readout rate:	> 75 kpix/sec. (per chip if mosaic). < 2.5 sec for two star-sized subarrays.
Physical:	
Chassis:	TBD.
Estimated size:	6" x 8" x 8".
Estimated weight:	18 lbs.
Estimated power:	110 VAC, 25W.
Temperature range:	0-55 °C.
Humidity:	Non-condensing.

Spectrograph:

Size:	5' W x 8' L x 5' H.
Weight with table:	3000 lbs. est.
Pressurized air:	10 cfh @ 100 PSI.
Temperature range:	0-55°C.
Temperature refocus tolerance:	+/-2°F.

9.3 CCD Imager

[G]

Description:

Wide-field CCD imager for use on the WIYN Port. The imager will mount on the Instrument Adapter with its focal plane appropriately spaced as specified in Section 7. The probes in the Instrument Adapter will be used for field acquisition and guiding. A shutter, automated filter wheel and a selection of broadband filters will be provided with the instrument.

Detector:

Type:	Thinned, backside illuminated CCD.
CCD format:	≥ 2048 x 2048 pixels, mosaic or single CCD.
Pixel size:	15-22 μm.
Noise:	≤ 8e rms.
CTE:	≥ 0.99999
Efficiency:	
350-500 nm:	> 0.30
500-850 nm:	> 0.50
850-950 nm:	> 0.20
Dark current:	TBD.

Filter Carousel:

Configuration:	Automated turret with manually changeable carousels.
Carousel capacity:	8 filters each.
Filter size:	4-inch diameter.

Filter slide:

Configuration:	In-line with carousel, manual change.
Capacity:	1.
Filter size:	4-inch diameter.

Filter selection:	Harris UBVRI, H-alpha (20Å), ...

Controller:

Same as for MOS.

10. Enclosure

Description:
See Appendix TBD.

Dome rotation:

Azimuth range:	Unlimited.	
Slew rate:	-4°/sec. to +4°/sec.	[G]
Track rate:	-0.5°/sec. to +0.5°/sec.	[G]
Slew Ramp:	0.75°/sec^2	[G]
Tracking accuracy:	0.5°	[G]

Shutters:

Unobstructed width open:	4.3 m	
Unvignetted horizon limit:	15° altitude maximum.	
Unvignetted zenith limit:	92° altitude minimum.	
Time-to-open/close:	45 sec. max.	[G]

11. Servicing & Maintenance

[G]

Typical time for routine periodic operations:

Remove or install primary mirror:	7 hours
Remove or install secondary mirror:	2 hours
Remove or install tertiary mirror:	3 hours
Remove or install W-F secondary baffle:	20 minutes
Mount & cable instrument at WIYN port:	2 hours

Time to perform servicing and maintenance operations:

Service/replace dome truck or drive:	4 hours
Replace shutter drive:	7 hours
Replace telescope encoder & electronics:	1 hour
Replace telescope drive & amplifier:	2 hours

12. Site & Environmental

The telescope will be located on the former site of the Kitt Peak #1-36" telescope (Long. -111° 36'.0, Lat. +31° 57'.8). The elevation is approximately 6838'.

The following specify the conditions under which the telescope will be operating and those under which the telescope and enclosure must be capable of surviving without damage.

12.1 Operating conditions

Operating conditions will apply when the enclosure shutters and windows are open and the dome is rotating to track the telescope:

Peak wind gusts:	60 mph
Temperature:	0°F to 100°F
Humidity:	98% non-condensing

12.2 Survival requirements

Earthquake:	UBC Zone 2

Worst case weather conditions at the site at which time the dome will be parked with the shutters and windows closed:

Peak wind speed:	150 mph
Snow load:	24 inches

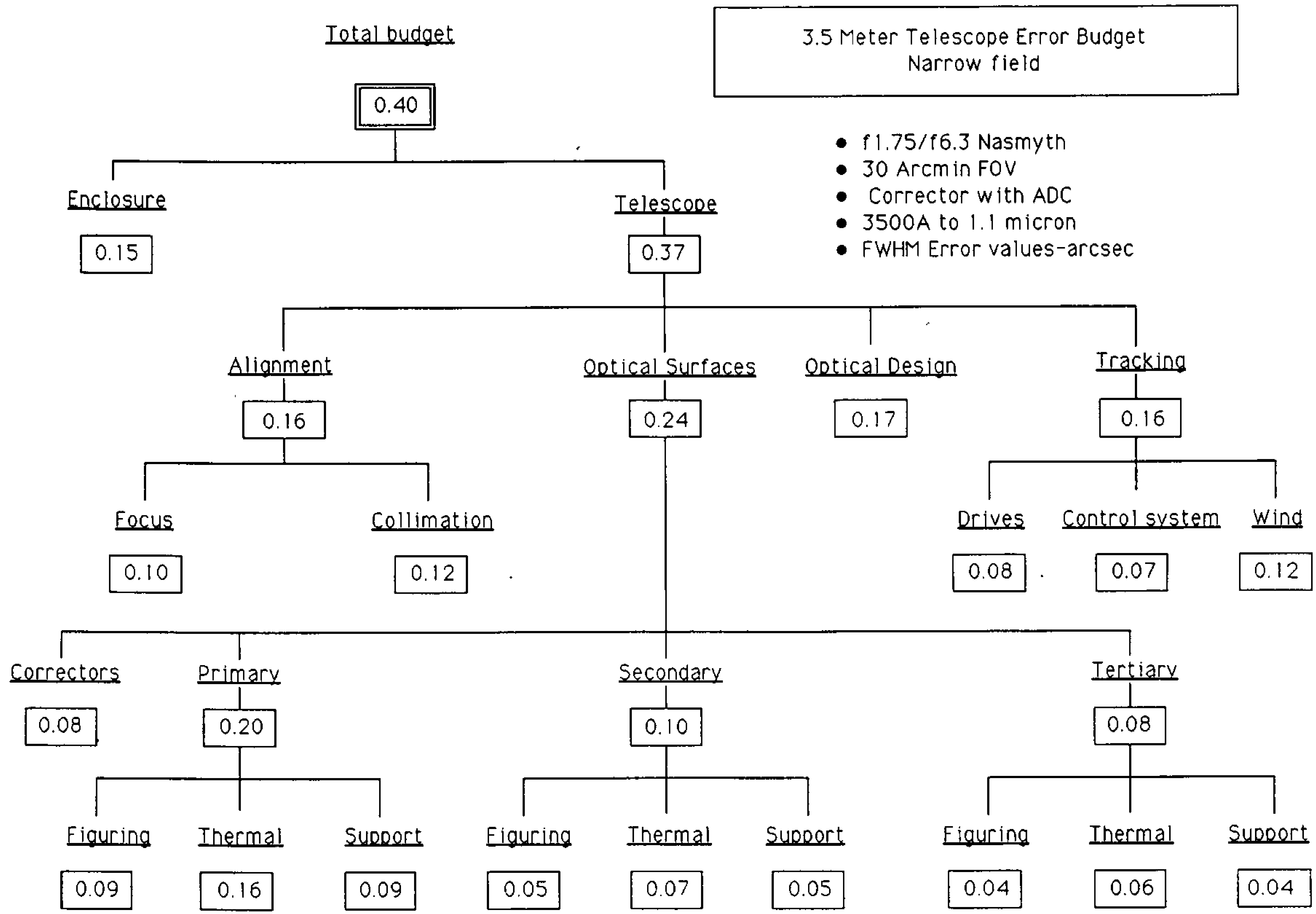
3.5 Meter Telescope Error Budget
Narrow field
f1.75/f6.3 Nasmyth
30 Arcmin FOV
Corrector with ADC
3500A to 1.1 micron
FWHM Error values-arcsec
Total budget
0.40
Enclosure
0.15
Telescope
0.37
Alignment
0.16
Optical Surfaces
0.24
Optical Design
0.17
Tracking
0.16
Focus
0.10
Collimation
0.12
Drives
0.08
Control system
0.07
Wind
0.12
Correctors
0.08
Primary
0.20
Secondary
0.10
Tertiary
0.08
Figuring
0.09
Thermal
0.16
Support
0.09
Figuring
0.05
Thermal
0.07
Support
0.05
Figuring
0.04
Thermal
0.06
Support
0.04

Figure 1

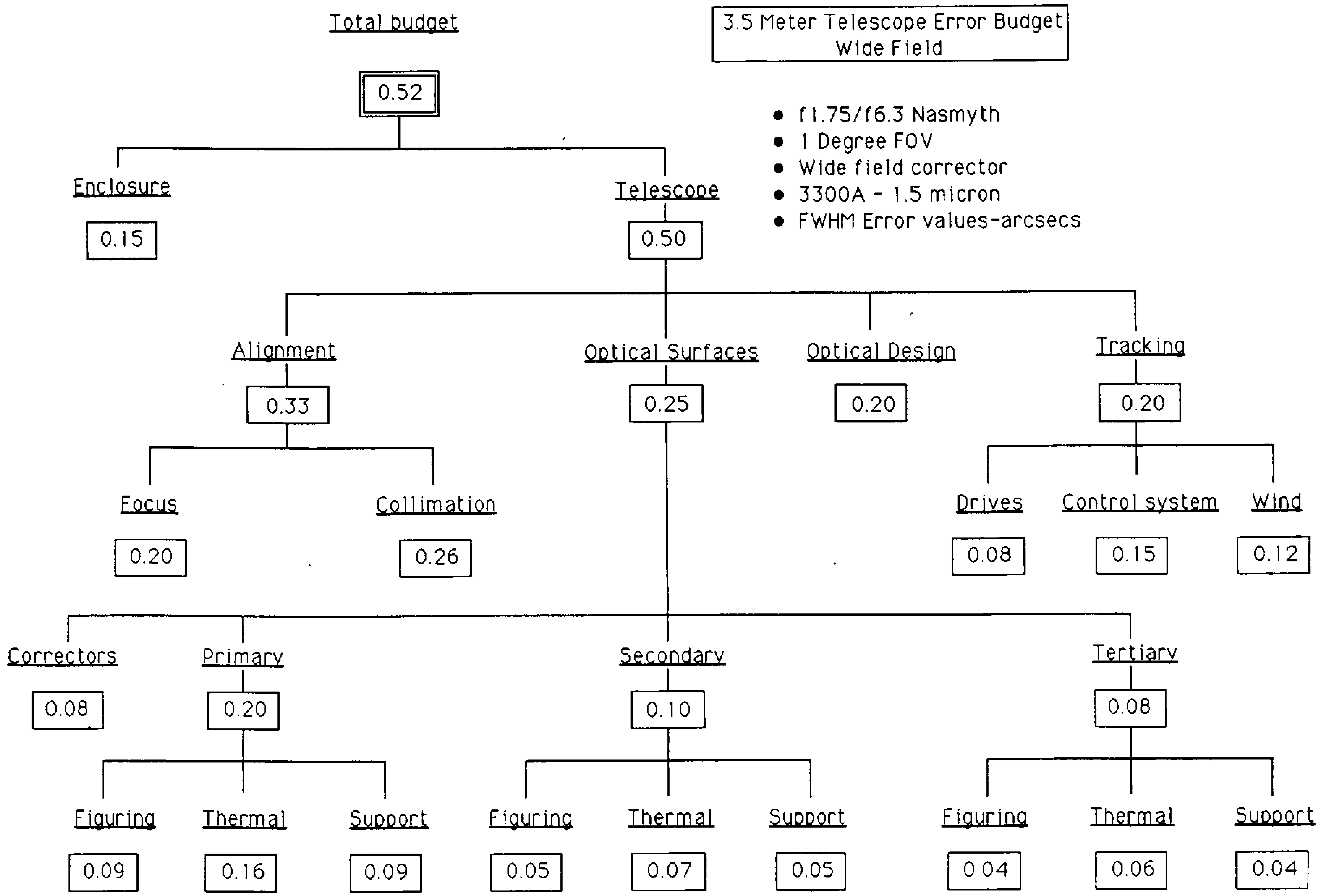
3.5 Meter Telescope Error Budget
Wide Field
f1.75/f6.3 Nasmyth
1 Degree FOV
Wide field corrector
3300A - 1.5 micron
FWHM Error values-arcsecs
Total budget
0.52
Enclosure
0.15
Telescope
0.50
Alignment
0.33
Optical Surfaces
0.25
Optical Design
0.20
Tracking
0.20
Focus
0.20
Collimation
0.26
Drives
0.08
Control system
0.15
Wind
0.12
Correctors
0.08
Primary
0.20
Secondary
0.10
Tertiary
0.08
Figuring
0.09
Thermal
0.16
Support
0.09
Figuring
0.05
Thermal
0.07
Support
0.05
Figuring
0.04
Thermal
0.06
Support
0.04

Figure 2.

JANE -

THIS IS THE ORIGINAL SIGNATURE COPY & NEEDS TO BE KEPT UNTIL WE HAVE ~~THE~~ THE NEXT COMPLETELY SIGNED REVISION.

MATT.

Matt -

Can this be tossed since we have WODC 00-01-04 or do we need to keep it? → YES!

Jane