Feedback from NAOMI Wavefront Sensor PDR.

wht-naomi-69
Internal document number AOW/MAN/AJL/10.1/03/97/WFS PDR Feedback
Version date: 17/03/97

1. Executive Summary.

1. The presentations made by the RGO team were of a good standard. The material was clearly explained.
2. The full optical design was presented and was considered to be sound. RGO had worked hard in meeting nearly all the requirements and the Panel commended Sue Worswick on her work. The Review Panel have suggested some (probably) minor areas where it would be worth doing additional checks to ensure the integrity of the design.
3. The overall mechanical design was presented and appeared feasible. The Panel thought that it was encouraging that no serious flaws were uncovered in the review. The main body of this document contains a list of follow-up actions which should be dealt with as high priority items and it also lists some more general concerns which should be addressed by the CDR stage. In particular some aspects of the design in challenging areas which were presented only as concepts should be detailed as soon as possible as these could still prove to impact the overall performance in a major way.
4. The electronics area was covered only briefly, partly because the appropriate review team member had been unable to attend. However, the proposals were considered to be straightforward and therefore at an adequate level for this stage and no significant problems were uncovered. Written comments from the absent panel member will be circulated to relevant people as soon as possible.
5. The tabled Management Plan gave Gantt charts of top-level steps to WFS completion and more detailed expansion of steps to CDR. It too was discussed only briefly. The Panel noted the ~ one month delay in the time when the WFS would be ready for system integration, relative to the overall project plan. Ways to avoid this delay should be discussed with the Project Manager. Suggestions for where to set priorities on the work to CDR and the need for any prototyping were discussed. The XY pick-off stage was identified as a high risk area and one that should be detailed early and possibly built early.
6. The CCD Controller was noted as a critical path item. Steps to firm up on its requirements and a route to acquisition should be devised early on.
7. A top-level cost summary was tabled. Time constraints meant that little discussion took place about it. The Review Team members agreed to examine the information ‘off-line’ and to include feedback in a written report. It was agreed that the slight cost over-run indicated should be dealt with by looking at priorities project wide when a more uniform level of information is available.
8. The Requirements Traceability Matrix in the review document was highly commended and should be developed further, working with the Project Engineer and Manager.
9. Specific key areas requiring additional investigation include:
    - ?? expanded description of the relationships between the optical and mechanical error budgets and the connection to the proposed implementation
    - ?? a general alignment procedure for internal alignment, covering what measurements are required, how they are made, how the corresponding adjustments are

introduced, and how the calibration unit may best be used to enable adjustments to be done in situ.

10. A formal overall alignment document is urgently required from the project to assist in individual Work-package alignment planning.
11. Project wide, the handling arrangements on GHRIL now need to be dealt with as a matter of urgency. This will require some early and continued information exchanges with La Palma staff.
12. The (currently) generally conceptual interfaces between the WP areas need to be developed further as soon as possible. This should be done by putting in place a formal method for interface development and control.

2. Present

Richard Myers	Durham	RMM	Chair
Andy Longmore	ROE	AJL	Review Panel
Ron Humphreys	Durham	RAH	Review Panel
Isabel Escudero	IAC	IE	Review Panel
Andy Charalambous	UCL	AC	Review Panel
Martyn Wells	ROE	MW	Observer
Chris Hankinson	ING	CH	Observer
Clive Jackman	ING	CJ	Observer
Nick Dillon	RGO	ND	Observer(part)
Jim Oschmann	Gemini	JO	Observer(part)
Charles Jenkins	RGO	CRJ	Ext. Proj. Sci.
Mick Johnson	RGO	MRJ	Project Team
Sue Worswick	RGO	SPW	Project Team
Bruce Gentles	RGO	ABG	Project Team
Andy Weise	RGO	AW	Project Team
Paul Martin	RGO	PM	Project Team

Apologies: Andy Foster (RGO), Review Panel.

3. Introduction

The Executive Summary above relays the essence of the Review Panel's conclusions and recommendations. The rest of this document is presented in three further sections with very different styles. Section 4 is a prioritised listing of all the recommendations and suggestions made by the Panel and brought up during discussions, sorted by work type (Project Level, WFS System level, WFS Camera/Controller, Optics, Mechanics, Electronics). Management issues are covered in the Project and WFS System Level headings. Section 5 lists additional comments or questions arising from the PDR document which were not addressed at the review either in open or closed sessions but which individual Panel members thought should still be considered/resolved. Section 6 is a highly abbreviated note-form summary of discussions at the meeting covering only the areas which resulted in proposed actions or modifications. These notes can be used as additional help in setting the context of some of the actions and suggestions listed in the first section. All the feedback which requires noting or action is contained in sections 4 and 5.

Annexe A is a compliance matrix drawn up against the Scientific and Operational Requirements document as an additional check of the extent to which the design presented at PDR met top level requirements.

4. Prioritised Actions and Recommendations

4.1 Project Level.

1. Prepare a formal global alignment requirement document and where necessary (e.g. because of cross-work package designs) relate to relevant implementation details.(MW, SPW, RAH, RMM)
2. Develop the Requirements Traceability Matrix table (possibly put onto Access database). (RAH,AJL,ABG)
3. Introduce a formal interface document and change control method.(AJL, RAH)
4. RAH to determine if ADC error budget can be increased.
5. RAH/RMM to confirm formally that the 400nm - 500nm wavelength range need not be considered in any calculations involving optimisation of WFS design except as a discriminator between two otherwise equal options.
6. The GHRIL room annexe needs to be confirmed as the location for off-bench NAOMI electronics. (RAH/CH/Maureen Ellis/Paul Martin).
7. CH to advise project on any testing and certification of mechanics or electronics required for La Palma.
8. Potential safety hazards should be identified along with the steps proposed to alleviate them.
9. Remaining areas of high technical risk should be clearly identified in a summary sheet and the approach to dealing with them agreed with the Project Engineer.

4.2 WFS System Level

1. Investigate means to recover slip so that WFS is ready for system integration one month earlier than shown in the WFS Gantt chart. (Management).
2. A description of how the optical tolerancing feeds into the mechanical specification should be clarified further and expanded to give a more complete systematic breakdown. Units should be added to individual items to aid the reader and it should be made easier to compare performance to specifications. (RGO)
3. Use the internal optical alignment procedure(s) to feed into mechanical design as appropriate. Account should be taken of the effects of the limitations on flatness of the optical table.
4. The accessibility to the WFS system required both optically and mechanically to carry out alignment procedures should be described and confirmed as being available. This applies both to off-GHRIL and to on-GHRIL alignments.
5. Indicate areas where further savings may be made, with description of corresponding loss of functionality. (This will then be used in a Project-wide evaluation of how to keep within the total budget). (MRJ)
6. Add ‘Description of all appropriate test results and their conditions’ to list of required documents. (MRJ).

4.3 WFS Camera and Controller

1. RGO to develop with AJL, RMM and RAH a plan to obtain a camera/controller combination which meets all three relevant science clauses. The route proposed is allowed to go over budget if necessary, within reason.
2. Confirm gains given by and thereby the need for 4 x 4 pixel/subap performance in relation to latest estimates of optical performance. Can JOSE data also help in setting priorities here? (needs AO modelling input as well as camera/controller parameters).

4.4 Optics

1. Once RAH has confirmed or revised the ADC error budget and wavelength range priorities, SPW should propose appropriate ADC design. Expectation from the review was that a simple (e.g. LLF6/BK7) implementation would be satisfactory.
2. Note that zero deviation use of ADC was greatly preferred because of alignment simplification.
3. SPW to devise/describe an internal optical alignment procedure which includes how alignment measurements will be made. The calibration unit design should of course keep in mind the alignment requirements and the calibration unit concept should be used to work up alignment procedures.
4. RGO to confirm that ghosting levels improve significantly if CCD is tilted and to calculate the optimum tilt if tilting is worthwhile.
5. The anticipated quality of the lenslets and the implication of this on the performance was not addressed. This should be done by the time of the system review. (Would RGO confirm that they do not plan to use orthogonal pairs of cylindrical lenslets).
6. SPW to ray trace the DM pupil mapping onto the lenslet array pupil and (with MW) evaluate result.
7. SPW to confirm size of calibration unit pinhole needed to produce spherical wave to required calibration accuracy.
8. MW/SPW to determine whether field-dependent colour term introduced by convergence of beam at the dichroic is significant and to propose solution if it is.
9. RGO to give special consideration to ensuring pick-off mirror can be kept clean as it is near a focus.
10. RAH to advise on whether it is necessary for pick-off design requirement to include easy removal for cleaning.
11. RGO to provide information on maintenance and durability of optical coatings proposed.
12. SPW to calculate additional ghost effects which could be introduced by central rays if conjugation to a turbulent layer is used.

4.5 Mechanics

1. An opportunity to evaluate the detailed schemes (e.g. final motor choices, final encoder choices, alignment implementation) for the WFS should be arranged once some of the concepts described have been made firm. This check should be before detailed workshop drawings are started. (AJL/MRJ).
2. The mechanisms for the pick-offs are the most challenging, and so their design (and later manufacture) should be as early as possible. This approach should eliminate the need for prototyping. (Recommendation).
3. The designs of mechanisms required to facilitate optical alignment should be done early on (e.g. pick-off fold mirrors) so that the whole design can be validated further.

4. Once designs of adjustment mechanisms are available in sufficient detail that their expected performance can be compared with requirements, the error budget breakdown should be re-visited and related more clearly to optical tolerances and the top level error budget (see also to WFS Level action bullet 5).
5. AW/SPW/MW to re-evaluate the 20mm stand-off of the XY pick-off and its ~7mm diameter with a view to reducing both. Additional strip obscuration and/or edge obscuration of the optical science field is generally preferable to unnecessary obscuration should trade-offs be required.
6. The encoder for the lenslet unit should be mounted directly onto the shaft axis, and not onto the worm. (Recommendation).
7. AW's idea of supporting the dichroic unit on the base of the WFS and not the GHRIL table should be followed. (Recommendation - requires ratification that this does not introduce more than compensatory complications in OMC work).
8. Check on vibration sources to WFS, so that an initial check on natural frequencies of components in the WFS can be made. (a) CH to measure GHRIL vibration spectrum with WHIRCAM present and with DM being used during ELECTRA run; (b) MW to supply relevant information about FSM if known by the manufacturer.
9. High-risk vibration areas within the design should be identified and analysed in comparison with information on the likely driving power levels and spectrum. (AW).
10. Care should be taken to prevent/reduce dust access to the mechanisms (especially the precision slide(s)). (Recommendation).
11. Pads which still allow accurate registration after clamping should be used on base-plate, to allow low friction between the WFS base and the table, and to prevent scuffing. Should be simple. e.g. PTFE. (Recommendation).
12. WFS base to locate on the GHRIL table via dowels. Adjustable holes on the base-plate can allow alignment that is not lost between instrument changes. Dowels should not over-constrain. (Recommendation).
13. An evaluation of thermal effects on the design performance is required (AW).
14. The bracket which holds the second fold mirror should not be an open C shape, but closed off to reduce chances of vibration problems. (Recommendation).
15. Provide compliance in the bearing blocks of the outriggers. Belleville springs? (Recommendation).
16. Consider using pneumatics. Good for clamp releases, with spring actuation. Good solution for the shutter. (Recommendation).

4.6 Electronics and Control

1. PM/AW to ensure system does not damage itself if motors are still driving when mechanical stop engages.
2. An estimate is required of (a) the likely 'quiescent' system power dissipation, during a normal observation and (b) the potential peak power dissipation during an alignment and/or calibration procedure.
3. Especially with stepper motors, have an encoder check reading after positioning and power down. (Recommendation).
4. Control/monitoring of coolers needs to be included in the description of components/requirements (PM).
5. General list of proposed standard and any special precautions needed for system safety, protection against incorrect connections etc. should be added. Should be used as a check list later. (PM).

5. Additional Written Input

This section adds responses to the PDR document from members of the Project Team which were not mentioned in the review because of time constraints but should still be considered.

5.1 WFS System Level

5.2 WFS Camera and Controller

5.3 Optics

1. PDR document sect. 4.3.2. There is inconsistency between the requirement described in NAOMI-2 sect. 4.3.2 and the table in NAOMI-3 sect. 2.3.1. The latter is incorrect when compared with the WFS WPD requirements.
2. Do the prism wedges need testing for skewness as well as angle? What is skewness tolerance? (SPW).

5.4 Mechanics

1. PDR document p18. Note that *differential* rotation about the optical axis could affect performance (e.g. alignments relative to DM) so these can't be ignored.
2. What space envelope is available for mounting XY-movement camera stage? (sect. 5.4.4.2).

5.5 Electronics and Software

5.5.1 Electronics Report from absent Reviewer

Still to be provided - reviewer currently unavailable.

5.5.2 Additional Comments

1. p54 sect 6.3. The selection of cards and interface described could be improved.
2. NAOMI-03 sect. 1.5.3. Note that the decision to integrate the WFS and OMC EPICS applications into a single IOC crate is not confirmed. The final adopted solution should be the most pragmatic one taking into account the space available and the need for stand-alone testing.
3. NAOMI-03 p11 sect. 3.1 req.3. A speed range should be given not just a speed upper or lower limit. It is not clear from the document whether the system can move slower than the limit given.

6. Abbreviated Meeting Notes

6.1 WFS Camera/Controller

ABG: suggestion that we can use SDSU with 12 bits to get 750 kpxl/sec
RMM: scientific premium on following EEV noise curve over full B/W spec even if solution is not neat. This is sufficiently important that even if it goes over budget the gains should be traded off with a view to making savings in other areas.
ND: notes that tilt elements of off-axis (telescope) COMA should be rejected when trying to work in quad-cell mode off-axis. Also noted final Leach architecture not implemented yet.
General: need to confirm gains given by 4 x 4 pxl/subap performance given improved knowledge of overall optical performance.

6.2 Optics

6.2.1 ADC summary

- limited range of materials if want to avoid large angles
- whole prism assembly tilted to restore zero-deviation, zero-dispersion
- there remains a chromatic pupil shift: at zero disp 2.3%/subap at 500nm and -2.2% at 1000nm; at 60 degrees ZD it is 7.3% and -6.8% respectively. Worst case: 2.8% shift in 1 hour.
- RAH/SPW: propose that spec could be slightly relieved and a simple implementation adopted, possibly based on LLF6/BK7.
- JO: points out that Gemini are using non-zero deviation option but doesn't necessary recommend this for NAOMI
    - *JO/IE/SPW agree that alignment benefits of zero deviation solutions are decisive.*
- Compound solution has reduced throughput especially at short wavelengths
- AC asked about alignment tolerances; SPW: confirms alignment and stability are both at 0.1 degree level

6.2.2 WFS performance on telescope

- SPW presented full ray-trace of tel, derot, OAPS,dichroic,field lens feeding WFS.
- Look at displacement of spots from images at end of 2.9" field
- Also look at pupil effects - non telecentricity. Predicted numbers can be compensated by ??.
- CRJ notes that offsets are well within atmospheric off-axis decorrelations even if they were NOT compensated electronically. Action: confirm regime where this occurs.

6.2.3 Ghosting

Complete ghosting analysis was presented in tabled doc.
Plain parallel surfaces in collimated beam is worst case (if all squared on): yields 3 % over worst part of coatings. Some of ghosts can be removed by tilting filters (by 2 - 3 degrees to completely clear the field), reducing worst case effects to ~ 1%.
Ghosts from relay optics: Bright spot would be on pedestal a factor 3000-80000 down
JO: suggests looking at tilting the CCD itself (as a major contribution is reflections from the CCD itself).

6.2.4 General Discussion of Optics

IE asked Sue to confirm that alignment, including choice of wavelength as 630nm, had been main driver for choice of zero deviation design. Also that IF this had not been the case then would it have been possible to reduce the chromatic pupil shift. Sue: basically yes; noted that spec. has probably relaxed and that one should factor in the likely source spectrum and CCD response. 400nm may well be sacrificed but nobody could think of any reason why blue guide stars should be particularly scientifically important (i.e. over and above their numerical representation)
IE asked about ray trace of DM/lenslet pupil registration. ACTION
IE asked about GHOSTS in relay; could be important in calibration for conjugation and when using conjugation. That is to say: the spots which return to the CCD go into the centre (which are normally unused EXCEPT FOR CONJUGATION) ACTIONS? Also, if there was no central obstruction on calibration source to reduce central ghosts, how would this affect calibration? CRJ: probably not much as those central actuators wouldn’t be used anyway.

IE asked about pinhole size for calibration source - SPW had taken the calibration source ray-trace out to 50 microns BUT actually had thought of a ~ 20 micron pinhole. IE suggested checking if this was small enough - would it give good enough spherical wave?.
IE asked about dirt and the location of the pick-off mirror close to a focus. SPW: It is 3mm upstream and has a 500micron zero-field beam. LP dust is around 50microns. Sue's thinking about a scaled-down version of a CO_2 snow clean.
CRJ: is mirror easily replaceable in situ? MW: or can whole disk be replaced? SPW: alignment tolerance is very tight, but it may be possible.
IE asked about filter flatness specification: it is lambda by 4 on reflection over all surface
IE asked about the dichroic - divergence of the principal rays over the field. That is: could we get a field dependent colour dependence over the dichroic. (Approx. half a degree divergence occurs at extreme science field.) ACTION: MW to check.

6.3 Mechanical Design

AW summarised top-level design
AC: what encoders are you proposing to use on the precision slide?
AW: Probably Haydn-Hayne glass strips but possibly single long linear strip.
AC: how are filter positions set? Lenslet wheel positions? AW: filters - step counts from Datum; trying to avoid the use of detents; lenslets - encoding will probably be on the worm. Every rotating component has a datum.
ACTION: AW,MW,SPW,CD: look at mounting the WFS calibration unit on the field lens unit (separated from OMC).
Filter change options: a bit tricky but possible. Discussion identified that changing filters in situ was *not* a requirement.
Question: how will CCD be mounted if the DRAL camera is adopted?
AW: need new fixing holes as current front of housing does not have any.
ACTION CH: look at SB/RMM proposal for changes to GHRIL.
Add Al side covers: requirement: make removable
ACTION: more work on vibration; identify high risk areas in design
ACTION: MW - find out about TTC FSM vibration rejection
ACTION: CH - get power spectrum of GHRIL vibrations due to closed cycle cooler.
AW: adjustment of pick-offs not fully detailed yet.
Placement solution: dowel into the bench; cams on the WFS unit; adjust and fix cams; then just use dowel holes for replacing.
AJL: could sliding base-plate over bench during alignment damage the bench itself.
AC: Yes, - clean surfaces before installation and use PTFE pads. ACTION: look at PTFE pads.
JO/IS: Because WFS calibrator is in OMC space, for alignment purposes would field lens and dichroic be better installed on WFS base-plate?
Discussion: worth looking at - could have several advantages. If 10mm is cut off the mountings in OMC design, they could be installed on individual or WFS base-plate as required.
Also, would need early plan for cabling installation/removal if they are always separate.

6.3.1 General Discussion

MW/AJL: why is PO 20mm off disk and so big (7mm) and therefore vignetting Optical field.
ACTION team: look at reducing this
AC: can the C shape in the pick-off support (tuning fork) be closed up ACTION: AW investigate this (cost/benefit). ACTION: ABG look at lifetime of linear motors/ EMC susceptibility.
AC: drives on rails; baseline choice classical but investigating linear motors

AC suggests clamping directly on to the rail - but probably meeting spec anyway ACTION
Question: if items weren't clamped, would they move? ABG: will be acceleration as telescope goes into slew rate. AW: investigate; ACTION: ABG: confirm maximum angular acceleration of WHT.
AC questions use of tape encoding attached to rail: this could get distorted. Need to
AC: for outrigger rails: build in a bit of compliance to mechanical connections. Help to avoid crabbing.
CH: dust in mechanisms?
AW: generally enclosed bearings with sweep mechanism. Action: confirm best policy is adopted for this.
Question: can system be stored at positive pressure off telescope?
CH: no existing facility but plenty of air lines: therefore probably yes.
Vibration discussion: need some more information on bench frequencies. Agreed that could not do FEA on entire system with these budget levels, but should look at highest risk areas and ensure they are above or below main driving frequencies. After this, most problems would have to be solved after on-site experience.
Alignment.
AJL: are tolerances met? AC: concept is good. Need detailed designing to confirm further.
Answer: first and second folds need very precise adjustment. Don't have details yet.
AC: important to have kinematic support of pick-off disk.
Mounting.
JO/AC proposed doweled location on bench and then references to other bench holes.
Concern expressed that every time WFS is removed from the bench, it may need re-alignment in return regardless of nominal tolerances.

6.4 Electronics

Presented by PM
Instrument Controller and Electronics: proposed copy of WYFFOS/ISISP EPICS system
AC: will use of fractional stepping produce a small motion ACTION PM/team: investigate using encoder reads after power removal to ensure correct settling.
AJL: are there mechanical stops as well as limit sensors and if yes, will there be anything to prevent damage if motors drive components into mechanical stops, e.g., clutches AW: yes there will be mechanical stops; AC: clutches do work OK in this sort of situation. AW: no clutches are planned; can put current limiters into drive cards. ACTION AW/PM: look at safety when mechanical stop engages.

6.5 Project Plan

MRJ showed WFS Gantt chart to completion and expanded details to CDR. Noted one month slip in readiness for system wide integration relative to overall Project Plan.
Critical path: choice of CCD controller: mid-April decision crucial
AJL: to what extent might interface instability pre: system design review interfere with WFS work which is done in this period. ACTION AJL/MRJ: investigate this.
Discussion: Pre-CDR work should be planned to resolve key risk areas as soon as possible, e.g. design and possibly build XY pick-off early on to give time to modify. No longer thought to be a need to do a prototype lenslet selection mechanism.

6.6 Technical Discussion

JO: use integral CAL unit concept to work up alignment procedures. Should give better estimate of risk and may permit progress on some of the detailing.

SUGGEST: early build of relay lens area.

Annex A

NAOMI WFS PDR Feedback

Fulfilment matrix for Top Level Scientific and Operational Requirements and Goals

Key

?	=	Met at PDR
X	=	Not met at PDR
O	=	Not fully demonstrated at PDR (this does not imply failure)
O/?	=	Partially met at PDR
S	=	System design review issue
?	=	Project action or investigation required
()	=	Requirement of limited relevance
Blank	=	Not relevant in this context

Requirement	**Optics Design**	**Mechanical Design**	**Electronic Design**	**Software Design**	**Overall System**	**WFS Camera and Controller**
Science Clauses	? (ADC?)	O	?	?	O	
Throughput	? RAH					
Heat output			O			
Camera Sensitivity						O
Optical Science port	?	X				
Dithering	?	O	O/?	O/?		
Laser	?	?				
Non-sidereal	?	O	O/?	O/?		
Safety		O	O		O	
Observational Efficiency	?	?	?	?	O/?	
Alignment Efficiency	O	O		?	O	
Network/ DRAMA			(?)	?		
Acquisition	?	?				
Off-telescope Calibration	O	O	?	?		
Installation Efficiency	O	O	(?)	(?)	O	
Document-ation	S	S	S	S	S	
Reliability	?	?	?			O
Environment	?	O	O		(O)	O