# Proposal for 90 degree WFS pick-off geometry

**RGO NAOMI technical note 9  note-9.rtf**

**wht-naomi-97**

**A B Gentles**

**Version 1.3**
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## 1. Introduction

The existing Space envelope for the NAOMI system is based on an optical layout in which beams are picked off the DM relay output beam in the order: IR science, TTS, WFS and finally the OFC straight through beam. This is shown in Figure 1. The allocation given to the TTS was fairly small, based on the current pick-off design concept which placed both pick-offs near the same focal plane. The boundary was the continuation of the focal plane towards the edge of the ghril table.

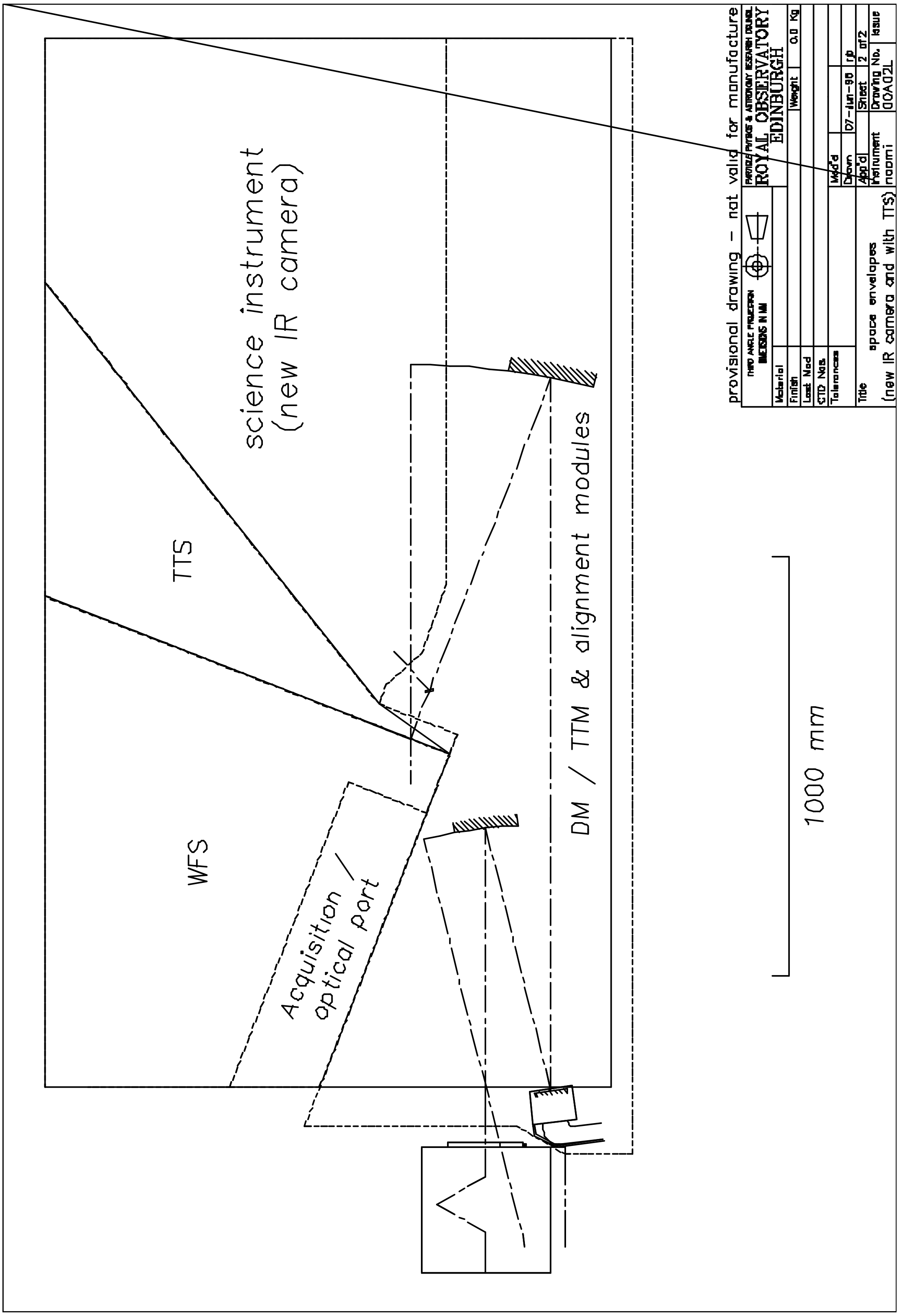


**Figure 1 The current space envelope.**

It was always recognised that the space available for the TTS was tight. Andy Weise drew up a provisional design which indicated that it would be possible to squeeze the support structure for the TTS pick-off disk into the 20mm between the focus and the field lens. There was no possibility of repeating the WFS pick-off design without compromising either the space for the FSM or the Dichroic, and probably both. This pick-off support was neither elegant nor particularly stiff leading to worries about vibrational stability. A request was made to increase the distance from the field lens to focus to allow a more rational design of support to be used. This still has the actual pick-off disk some 500 mm from the axis of the Y slide. Later, the WFS design had progressed to the point where we were dividing up the position repeatability goal specification of 0”01 between the various sources of error. When considering the performance of the slides in pitch and yaw and their interactions on the sensor output, it became obvious that the TTS would not be able to be built to meet the required accuracy.

We then considered other general approaches to solving the TTS/WFS space envelope problem. The most promising option has been pursued and has been found to be feasible and also rational. It is based on the fact that the LGS focus is always more than 30 mm downstream of the NGS focus. It is described as follows

## 2. <u>The proposed Wavefront sensor system.</u>

1. Built a dedicated NGS WFS now, with its pick-off at the NGS focus.
2. Leave space downstream for a dedicated LGS WFS.
3. Abandon the upstream TTS.
4. The NGSWFS will become the TTS when the laser system is added.
   The acquisition configuration of the NGS WFS will have a full aperture lens in the lenslet selector wheel which allows it to relay the corrected focus straight onto the CCD. This can be used with no modifications to implement a TTS by binning and/or windowing the CCD to have a single subaperture centred on the WFS optical axis.
5. The space envelope for the NGSWFS will straddle a the beam at 90 degrees to the DM relay output beam. The pick-off thus has the length of the beam from 30 mm upstream to 30 mm downstream to use for the pick-off support structure. Room must be left for the LGSWFS pick-off.
6. The LGS WFS will place a field stop at the LGS focus. This need not be coincidental with the pick-off fold mirror or support disk.
7. The complete LGS WFS assembly will be on a focus slide which moves the field stop, pick-off and the rest of the sensor together down the input beam.
8. The LGSWFS fold assembly can be downstream of the field stop and thus well away from the NGSWFS pick-off slides. This is possible because the amount of pick-off field travel is so much less that less of the focal length is used up in the XY pick-off motion.

## 3. <u>Packaging issues with the Downstream LGSWFS</u>

Attempting to package both a multi-function WFS/TTS and also a LGSWFS is not trivial. This has resulted in several changes to the previous WFS concept, but an elegant feasible solution has been arrived at. Figures 2-5 show various plan views of the concept.

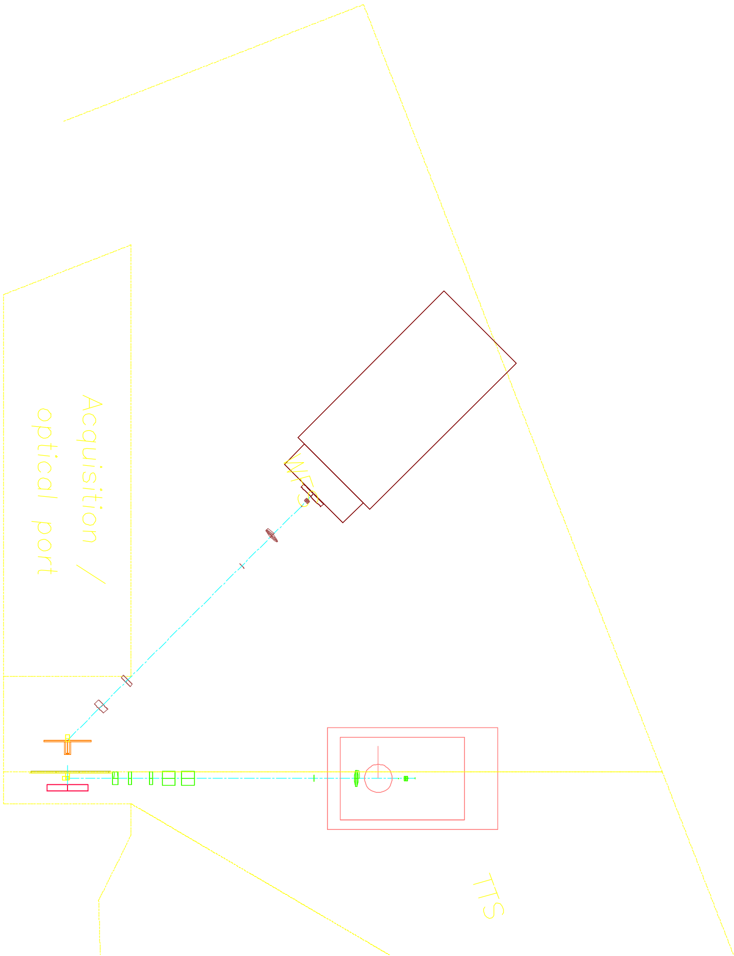


**Figure 2 The overall layout of the two sensors with the existing space envelope.**

The overall optical layout can be seen in Figure 2, This shows the WFS beam running at 90 degrees to the DM relay output beam. Note how neatly the WFS components are packaged and that there is plenty of free space around the CCD camera. This drawing shows the components overlaid onto part of Figure 1, hence the labels for TTS and WFS.

Figure 3 Shows the Pick-off area. Following the input beam from bottom to top we can see the outline of the field lens followed by the NGSWFS pick-off mirrors then the NGSWFS pick-off support disk. Next comes the LGS field stop mounted upstream of the pick-off disk. This is shown in its most upstream position. Downstream of the LGS Pick-off disk, we see the fold mirror and the beam going into the LGSWFS.

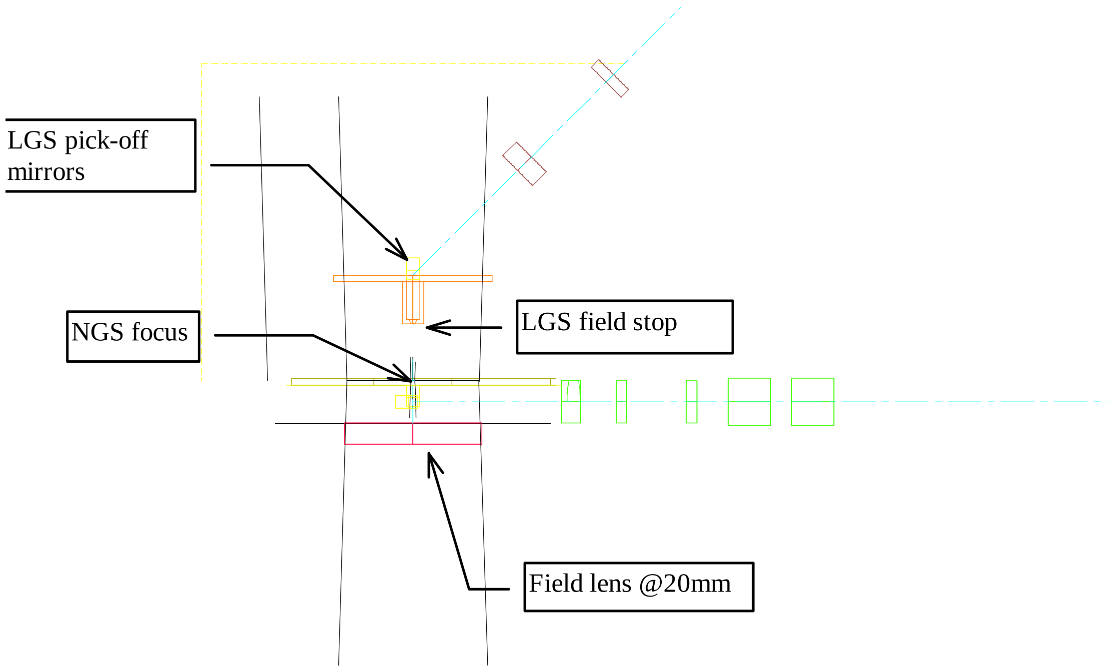


**Figure 3 Detail of the pick-off area**

Note that all the working components are reasonably well spaced from each other, which will allow some leeway for adjustment of final designs. The Collimator lens in the NGSWFS can be seen in green to the right of the NGSWFS pick-off. This will slide to the left to follow the focus when the pick-off moves down in Y. The two items will never collide unless both are moved towards each other at once which is not done in practice. This conflict will be resolved by some combination of reducing the collimator lens diameter, increasing the collimator focal length or moving the disk downstream.

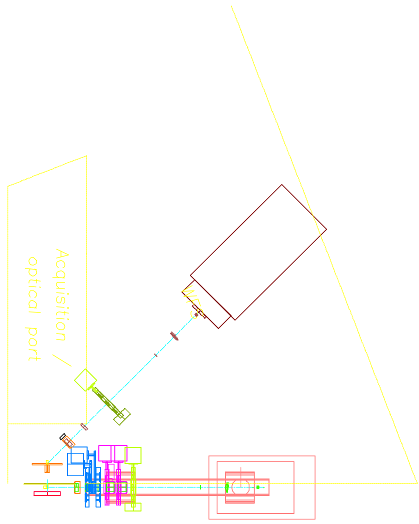


**Figure 4 Detail of components in both sensors**

More detail of the lens cells and motor outlines are shown in Figure 4. There is another slight conflict between the motors of the NGSWFS filter wheels and the LGSWFS collimator lens, shown in Figure 5. There is no conflict is practice as the motors are at a different height from the collimator lens. The motors could be packaged to be elsewhere in a future revision. The LGSWFS beam could easily be at a different angle thus separating the LGSWFS collimator from the NGSWFS filter wheel motor, at the expense of using up more of the OFC space. Figure 4 shows the lenslet selector motor in green fouling the space envelope for the OFC, this could be packaged to be above the wheel, thus avoiding this conflict. When the LGSWFS assembly moves to follow the spot focus, the whole assembly will move up to 80 mm downstream, thus taking up some of the OFC area. Permission to use a small area of the OFC space envelope has already been approved by the project.

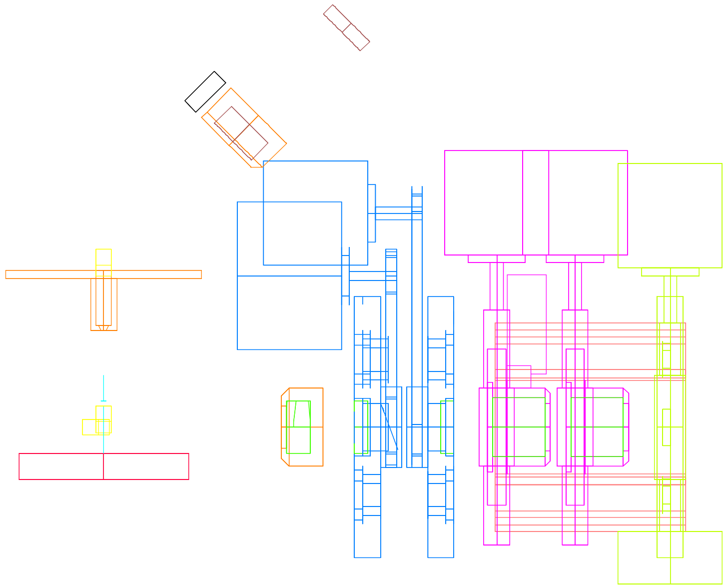

**Figure 5 Close up of the Pick-off area showing component outlines**

## 4. Conclusion

A division of the NGS and LGS WFS functions into separate sensors has been shown to be feasible. It provides the only solution found to date which achieves all of the required functionality whilst also allowing an safe, elegant and sensible design. The WFS design can also be converted to a TTS with no additional cost, so that the upgrade to a laser beacon need only fund the laser wavefront sensor as a completely separate unit.

## 5. Proposal

It is proposed that the NAOMI project adopt this architecture, with upstream NGS WFS and downstream LGS WFS.

Bruce Gentles 6/12/96

## Appendix 1

Visualisation of the WFS concept.

This image is also available at URL

http://www.ast.cam.ac.uk/~ngs/docs/90-degpo.html