MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Laser Interferometer Gravitational Wave Observatory (LIGO) Project

To/Mail Code:	ASC PDR board
From/Mail Code:	ASC group
Refer to:	LIGO-T970063-00-D
Date:	14 February 1997

Subject: **Response to Alignment Sensing and Control DRR2 Action Items**

This memo is intended as the response to the action items (AI) generated in the ASC DRR2. Specifically, those AIs which are due at the ASC PDR are answered here; the status of other AIs from the ASC DRR2 is also given. The AIs are given in the review report, LIGO-M960681-00-D, and their assignments are given in LIGO-L960724-00-D.

AI1. *Establish that a feasible design can give offsets due to RF pickup which will remain at a level below the required 10^{-10} rad. Use the EMI plan values for allowed EMI to establish means needed to achieve this level of offset with realistic models of culprits and victims. Consider experimental tests.*

Since we are required to align the angles to within 10^{-8} rad of the optimal, RF pickup offsets at the 10^{-9} rad or below would be insignificant. Given the WFS head design described in the ASC PDD, the RF signal at the input to the mixer which corresponds to this angle ranges from $4mV_{pk}$ - $20mV_{pk}$, depending on which sensor; furthermore, since two WFS channels are subtracted to give one angle signals, the relevant level is the difference between the RF in two opposing channels, which is likely to be at least 10 dB lower than the average RF pickup level.

In terms of the RF current induced at the front end by EMI, an RF current *difference* between opposing channels of 0.4 -2 $\mu amps_{pk}$ produces an offset at the 10^{-9} radian level.

These are fairly large levels of RF pickup; with proper shielding of the WFS head and cables, the level of RF pickup should be much below these levels. Typical lab experience shows that with proper shielding the pickup can be reduced to 10’s of nA, referred to equivalent photocurrent.

AI2. *Develop information on expected duration and frequency of diagnostic tests to aid in planning for availability requirements.*

A detailed list of diagnostic tests is given in the ASC Preliminary Design Document, Section 7. A typical test involves taking data with the interferometer in a diagnostic mode for ~ 1 minute. The frequency of such tests during the initial debugging phases of operation is very hard to determine – we will doing these and other tests until the instrument is understood. Once we learn more about the operation of the interferometer, we will know which tests need to be regularly repeated (and at what rate), and which ones don’t yield useful information.

AI3. *Include interferometer temporal imperfections (including but not limited to storage time and length deviations) in calculations of beam jitter misalignment to phase noise.*

This AI has been discussed with its proposer (Jordan Camp) for clarification and resolution. Apropos clarification, another way to state the intent of the AI is: if one of the interferometer lengths has some residual deviation from resonance, is the beam jitter-misalignment coupling any worse? Apropos resolution, we agreed that there is nothing in the previous calculations to indicate an increased sensitivity in the presence of such imperfections. We have thus deferred any further analysis of this effect (indefinitely depending on the decision of the ASC PDR board).

AI4. *Calculate the wavefront sensing system sensitivity to interferometer spatial imperfections, using e.g., FFT modeling techniques.*

This is a non-trivial, though important, calculation to do. We were not able to devote any time to this during the preliminary design phase. We note that the result of any such calculation would not change the ASC design requirements. Rather, the effect influences the performance of the wavefront sensing system in two ways: by changing the wavefront sensing matrix elements compared to the values calculated with no mirror distortions, and by producing offsets in the wavefront signals when the interferometer is in fact optimally aligned. The first of these effects will be accounted for by measuring the sensing matrix in-situ. The second of these effects is potentially more damaging, since the system is a null servo. Even then, if the offsets are relatively stable in time, they can be compensated for with electronic offsets in the servo. One of the ASC Diagnostic Tests is to check for such offsets, and measure and correct for them.

AI6. *IOO should list suspended optics and the sensitivity to motion and alignment of each (resulting beam motion, distortion, effect on phase of light), thus generating requirements for alignment precision for the non-interferometric components.*

This AI was assigned to the University of Florida.

AI12. *Improved models for the slab (Coyne) and for the acoustic environment (Lazzarini) should be integrated into the model which couples atmospheric pressure variations to tilts of the stack.*

The Parson's model for the acoustic pressure fluctuations (i.e., the so-called 'Marshall Long criteria') was compared with the model being used; they are nearly the same in the band of interest.

No refinements on the slab model were made. However, when the environmental model is run using the leaf spring stack transfer functions, the path which couples pressure fluctuations to suspension point motion is no longer dominant (as was the case when using the viton stack). Thus the model no longer predicts that this mechanism leads to angular noise of the optic in excess of thermal noise.

Of the 12 total action items, three others pertained directly to, and were assigned to, the ASC, but were due before the ASC PDR. The status of these AIs is given below.

AI 5. *Specification of responsibility for each suspended optic in IOO is needed. In particular, determine if IOO or ASC carries responsibility for alignment of the MC.* (Due at the IOO DRR)

This has been completed; the ASC is responsible for designing the alignment system for the mode cleaner. This design will be implemented by the University of Florida. Refer to LIGO-T960159 for details.

AI 8. *SUS has a change of scope to accommodate the revised local damping loop for acquisition* *and possibly deal with changes due to the clearer requirements for the WFS input. SUS to integrate the change into their design.* (Due 15 November 1996)

SUS has integrated the change into their design.

AI 10. *An explicit plan for transferring 'brass plugs' from initial surveying to Detector Initial Alignment must be developed early enough to allow planning for CC and VacEq construction.*

The station alignment monument pattern requested by Process Systems, International (PSI V049-PL-248) will also be acceptable for purposes of ASC installation support. LIGO Civil Construction will supply and certify these monuments prior to vacuum equipment installation, and as designed they will remain accessible subsequently for ASC use. LIGO is still assessing the achievable monument surveying accuracy, particularly the angular relationship of the station pattern to the projected beam tube axes; depending on the outcome, modifications to the ASC installation sequence may be required. As insurance we now plan to open gate valves and sight down each evacuated beam tube for calibration, after the relevant vacuum sections are accepted but prior to installation of internal Detector equipment. The schedule impact of this change remains TBD.

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