# Report of the 40 m TAC October 13 2005. LIGO-T050230-01-R

K.A. Strain (chair)

October 20, 2005

## 1 Introduction and References

### 1.1 Attending:

Rob Ward, Osamu Miyakawa, Dan Busby, Ben Abbott, Alan Weinstein, Ken Strain (chair), Monica Varvella, Rana Adhikari, Valera Frolov, Peter Fritschel, Hartmut Grote, Dennis Coyne, Nergis Mavalvala, David Ottaway, Keisuke Goda, Eugeniy Mikhailov, Dave Tanner, Guido Müller, Daniel Sigg, Kentaro Somiya, Jay Heefner, David Shoemaker.
This version has a few small amendments after feedback from those attending.

### 1.2 Links and references

The slides for most of the presentation by the 40 m team are at

`http://www.ligo.caltech.edu/~cit40m/Docs 40m_TAC_051013.pdf`

Slides 12–17 form the presentation on locking, 18–21 the part on E2E and the remainder on DC readout.
A separate presentation outlines plans for a squeezing experiment

`http://ligo.mit.edu/~nergis/Postings/40m/pac_mtg_051013.ppt`

Some additional details the proposal to test squeezing on the 40 m are at

`http://ligo.mit.edu/~nergis/Postings/40m/T050220-00-R.pdf`

## 2 Report

The core of this report follows the plan of the meeting, with 4 sections covering locking, E2E, DC readout and squeezing. A summary of more general points is found at the end.

### 2.1 Locking

It is good to see excellent progress with this high priority work. It seems very likely that a final approach to correct common-mode arm locking at maximum power can be made in the very

near future. That marks a transition in the 40 m program to a state where it should yield the information that is necessary to enable design progress on Advanced LIGO.

Acquisition and locking reliability have reached the point where experiments, at least at night when seismic noise is low, are reasonably efficient. This has allowed a rapid increase in the rate of progress in recent weeks.

The locking strategy is to have the short degrees of freedom servos continuously on, and to switch the DC arm servos on and off according to the measured power. The usually achieves lock in a couple of minutes or less.

It is noted that the demodulation scheme is working well using only single beat frequency demodulation (simpler to set up).

The DC control of CARM works well up to 85% of the maximum power, at this point the RF signals are quite linear, so a hand-off to RF locking is expected to work well.

It was noted that there have been no issues associated with transitions from under to over coupled cavities (the PR cavity is under coupled on the 40 m). Digital servos help. The main problem with locking has been (frequency) noise, and addressing that has allowed the recent rapid progress. Further work is underway to reduce noise associated with PZT mounted steering mirrors, including a revised driver design.

We were pleased to note that the optical losses and transmission values were now known to reasonable accuracy. This allows the necessary simulation with finesse and will aid E2E modelling.

The committee stresses that success with one RF control scheme should not be taken as the final goal for this aspect of the work, but that alternative control schemes should be investigated. The main aim would be to eliminate the need for VHF modulation, but to ensure the system (eventually) proposed for Advanced LIGO has the best balance of properties (diagonality of sensing matrix, complexity, effort to set up, stability, locking range etc.). It is assumed that such tests can be done quickly since the acquisition problem is largely solved. Other acquisition schemes should, however, also be considered, where they are likely to be appropriate for use in Advanced LIGO.

### 2.2 E2E

Initial results with the, nearly complete, 40 m model were very encouraging. With the inclusion of the controls model, E2E will be ready for intensive comparison with measured 40 m data in preparation for extrapolation of results to Advanced LIGO.

The urgency of this work is high, as there is no other means available to guide the design of the global ISC for Advanced LIGO. The LIGO Lab should continue to ensure this area is well supported. Results will feed into both ISC and SUS.

### 2.3 DC Readout

Following the recent review of this topic (see T050168-00-R), only a few points were raised. Preparation of components for installation is proceeding well.

Mirrors have been sourced from within LIGO Lab, thus reducing the expected cost of the project without significant risk to performance.

There was some discussion of the best material to use for the OMC spacer, leading to the conclusion that copper would satisfy mechanical and vacuum requirements (also as an initial LIGO OMC).

It was recognised that there is a trade-off between screening that DC photodiode module against stray light, and being able to view the spot positions on the diodes. It was felt that the alignment

should be sufficiently stable to reduce the need for visual confirmation.

It was noted that a method to replace a shutter, for photodiode protection, was being considered.

### 2.4 Squeezing

The availability of a practical squeezed-vacuum source encourages a test of this technique on the 40 m. This would not only represent an important demonstration (noise reduction etc.) but would force the solution of a number of technical issues involved in injecting the squeezed light. The suggested program is sufficiently concrete to require that the timing of this project on the 40 m be decided soon. The discussion of this topic drifted into more general considerations of project planning (see the next section).

There were some technical discussions about the appropriate light power, the interferometer configuration and the frequency at which to do the test (to see sensitivity improvement). It was clear that this would be the first of a series of tests of increasing sophistication and performance.

## 3 General recommendations and comments

Progress in all areas has been very good, the program is really getting somewhere.[1]

The main recommendation is that the team produces an experiment plan. This will help scheduling of all the many possible activities that can be done on a working, dual recycled, 40 m.

The plan should include work to complete the lock acquisition studies and to compare alternative RF locking schemes. This should lead to a program of E2E validation. It should show the transition to DC readout. Work to reduce noise should be included when appropriate. The plan should indicate opportunities for incorporation of the squeezing experiment, and consider possibilities for tests of wavefront sensing alignment schemes (although theoretical work is also needed before such schemes are ready to be tested, so this remains a low priority for the 40 m until more work is invested by ISC).

The next meeting is in 4 months time (Feb. 9, 2006).

[1] Even as this sentence was being written in the -00 version of this report the full lock of RSE was achieved by Osamu. Congratulations to all the team!