Attachment SUS to the

Memorandum of Understanding (LIGO-M970077-00-M)

between the

German/British Collaboration (GEO 600) for the Detection of Gravitational Waves

and the

Laser Interferometer Gravitational Wave Observatory (LIGO)

August 15, 2005

This Attachment SUS to the Memorandum of Understanding LIGO-M970077-00-M defines the role of the German/British Group (GEO 600) as a Member of the LIGO Scientific Collaboration (LSC) and a member of the Isolation/Suspension/Thermal Noise Development Group (ISTNDG). The period of performance for the activities in this Attachment is from August 15, 2005 to August 15, 2006.

1. Isolation/Suspension/Thermal Noise Development Group - The Isolation/Suspension/Thermal Noise Development Group (ISTNDG) is the scientific collaboration for defining and developing future isolation and suspension improvements for use in advanced subsystems for the initial LIGO interferometers or in entirely new advanced interferometers. MOU Attachments define the roles and responsibilities of groups in this development group.

2. During the period August 15, 2005 to August 15, 2006, the members of GEO 600 Group will participate in ISTNDG in the following areas:

Suspension design for Advanced LIGO and beyond

1) *Activities forming WP1 of UK Advanced LIGO Project – Project Management*
Project management and oversight of all work packages within the UK Advanced LIGO Project will continue to be provided. For further details on this work package refer to the UK proposal "Exploring the Dark Side of the Universe: Proposal for UK Involvement in Advanced LIGO", Issue 2, November 2002 and the website for Advanced LIGO UK (RAL) both of which can be accessed via the Advanced LIGO UK (Glasgow) website available via: http://www.physics.gla.ac.uk/igr/sus/index.html (UK Advanced LIGO Project Team + RAL)

2) *Activities forming WP2 of UK Advanced LIGO Project – Main Suspension Science*
Continuing scientific input to the suspensions for Advanced LIGO based on the development of triple suspension systems for GEO 600. Provision of reaction masses, penultimate masses and silica ears for the suspension systems of Advanced

LIGO. For further details on this work package refer to UK proposal "Exploring the Dark Side of the Universe: Proposal for UK Involvement in Advanced LIGO", Issue 2, November 2002 online via the Advanced LIGO UK (Glasgow) website available via:
http://www.physics.gla.ac.uk/igr/sus/index.html [the website for Advanced LIGO UK gives additional information on this work package] (Glasgow/GEO600 + UK Advanced LIGO Project Team)

3) *Activities forming WP3 of UK Advanced LIGO Project – Main Suspension Systems*
Continuing development of final mechanical designs for the suspensions working from the controls prototype designs as a basis. Manufacture of the noise prototype and final articles for delivery to the LIGO Laboratory. For further details on this work package refer to UK proposal "Exploring the Dark Side of the Universe: Proposal for UK Involvement in Advanced LIGO", Issue 2, November 2002 online via the Advanced LIGO UK (Glasgow) website available via:
http://www.physics.gla.ac.uk/igr/sus/index.html Refer also to the link to the Advanced LIGO UK (RAL) website also accessed from this page. (RAL + UK Advanced LIGO Project Team)

4) *Activities forming WP5 of UK Advanced LIGO Project – Optical Material*
Continuing development towards provision of four silica blanks each of 40 kg for one interferometer (work relevant to polishing and coating the blanks is excluded from this package). For further details on this work package refer to UK proposal "Exploring the Dark Side of the Universe: Proposal for UK Involvement in Advanced LIGO", Issue 2, November 2002 online via the Advanced LIGO UK (Glasgow) website available via: http://www.physics.gla.ac.uk/igr/sus/index.html The website for Advanced LIGO UK (Glasgow) gives additional information on this work package. (Glasgow/GEO600 + UK Advanced LIGO Project Team)

5) *Mechanical design aspects of control and noise prototype suspensions*
Results from controls prototype trial assemblies and tests at Caltech and LASTI will be reviewed and fed into the noise prototype design process. Continuing development of mechanical design of test mass quadruple suspensions for noise prototypes for LASTI. Includes continuing design work on ETM suspension masses, suspension support structure, cantilever blade design and adjustment, blade clamps/blade wire clamps and design of mass catcher/installation jig with earthquake stops for monolithic silica stage assembly. The potential application of drum-ended suspension wires and drum ended wire clamps will be investigated by RAL with input from the other collaborators. General assistance will continue to be provided using Solidworks software for generation of engineering drawings and assemblies of parts. The construction of an all-metal prototype final stage suspension and mock silica stage will continue in Glasgow to aid in design of the mass catcher/installation jig and installation tooling (including CO_2 laser ribbon pulling & welding machine). Scientific and engineering input will also continue to be provided in the evaluation of the effect of the test mass material downselect from sapphire to silica on aspects of the mechanical design for the noise prototype. (Cantley, Jones, Strain, Cagnoli, Plissi + N Robertson (Stanford/Glasgow) + Romie, Torrie et al (Caltech) + Greenhalgh, Wilmut, Hayler (RAL)).

6) *Active damping of suspensions – OSEM development*
We will continue to optimize OSEM mechanical design using insight gained during assembly and testing of the prototype device fabricated by Birmingham and feedback from the US SUS team. We will continue with the migration of prototype electronics boards (OSEM and ESD electronics) to production ready, rack mounted units incorporating the required monitor channels. The mechanical and electronics design will be frozen, ready for noise prototype production pending the outcome of the PDR (July 2005). (Birmingham University + Glasgow/GEO 600 + Strathclyde University + RAL + Caltech).

7) *Passive damping of suspensions – eddy current damping development*
The locations of the eddy current damping units will be optimized with respect to performance and available space on the noise prototype. (RAL + Plissi, Cantley, Jones, Grant, Strain, Hough + Torrie/Barton/Romie (Caltech) and N. Robertson (Stanford/Glasgow)).

8) *Electrostatic drives*
A prototype electrostatic drive electronics board has been fabricated (Strathclyde) and test results are feeding into the PDR ESD documentation. We will continue to provide support in the development of the electrostatic drives for global control. (Lockerbie (Strathclyde) + Strain, Jones, D Robertson).

9) *Fabrication of a dummy final monolithic stage for quadruple pendulum*
We will carry out work on the following towards the development of monolithic final stages:

i. *CO_2 laser pulling & welding of silica fibres and ribbons*
   Continuing development of the automated silica ribbon/fibre pulling and welding machine using high power CO_2 laser heating.
   (Cantley, Cagnoli, Heptonstall, Jones, Cumming, Martin)
ii. *Characterization of silica ribbon suspensions*
   Continuing investigation of silica ribbon suspensions with improved welding using CO_2 laser radiation. This will enable more accurate modeling and correlation of suspension behaviour with further investigation of losses at the welded regions. Ongoing investigation of CO_2 pulled ribbon strengths and quality factors and effects of CO_2 welding to silicate bonded attachment ears, in collaboration with Caltech.
   (Heptonstall, Cagnoli, Cantley, Jones, Cumming, Martin, Rowan, Hough, Strain + Armandula (Caltech))
iii. *Silica ear development*
   Continuing development and evaluation of silica ears of suitable design to allow the jointing of ribbons to the Advanced LIGO 40 kg silica masses in collaboration with Caltech.
   (Cantley, Cagnoli, Jones, Rowan, Hough + Armandula (Caltech)).

10) *Violin mode damping of silica ribbons*
The requirement for violin mode damping of the final stage silica ribbons will be determined and possible passive/active techniques investigated. Development of a

suitable system will proceed dependent on requirements. (Strain, Heptonstall, Cantley, Rowan, Hough + Lockerbie (Strathclyde)).

11) *Silica cantilever blade development*
Continuing investigation of the potential application of penultimate mass silica blades for improved vertical isolation in multiple suspensions. This will include investigation of the application of low dissipation protective coatings such as sapphire for improved blade strength and the use of flame and CO_2 laser polishing for improved blade performance. (Cagnoli, Cantley, Heptonstall, Plissi).

12) *Measurements of silicon ribbon flexures*
We will continue our measurements of the loss factors of silicon flexure elements. This work is being carried out in collaboration with colleagues at Stanford who are using their expertise in materials science to fabricate the flexures used in this study. We will also complete commissioning of our 2nd cryostat to enable the measurement of loss factors of bulk substrate materials at low temperature.
(Reid, Murray, Rowan, Hough)

13) *Investigations of charge mitigation techniques*
We will continue our studies of the use of stannous oxide to increase the conductivity of fused silica.
(Holt, Murray, Rowan, Hough)

14) *Thermal noise measurements in Hanover*
The experiment in Hanover to measure coating thermal noise using an ultra-short cavity will continue. It is anticipated that once etalon production difficulties are overcome, initial results will be obtained in early 2006. Work will then continue to improve the sensitivity of the experiment in the region of hundreds of Hz to tens of kHz and finally to compare the measured thermal noise with theoretical estimates. The final goal is to characterize coating thermal noise for a variety of coating materials and treatments.
(Ribichini, Lueck, Danzmann)

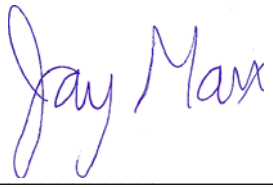
3. Resource Sharing: The LIGO Laboratory will contribute resources including allocation of appropriate scientific and engineering personnel, research facilities and funding in support of the effort in Item No. 2, as indicated below.

   a) Research accommodations for GEO 600 group members while on LIGO research assignment at any LIGO Laboratory site,
   b) Access to LIGO data through established LSC channels in support of this work.

4. Coordination and Reporting – GEO 600 Group will perform this research within the structures established by the LIGO Laboratory and the LSC where appropriate. In particular activities described in Item 2 will be carried out within Isolation/Suspension/Thermal Noise Development Group of the LSC. Coordination will include keeping the Group leaders informed of activities and plans, reporting to the group at meetings and telecons, and through technical documents submitted to the LIGO Document Control Center.

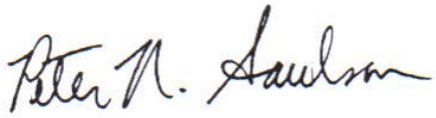
In addition, an annual report will be submitted with the update to this Attachment, giving a summary status on research by topic as indicated in Item No. 2, including progress against the milestones if any, significant accomplishments such as new insights/discoveries or publications, issues of concern if any, and an indication of invested time. This Attachment will be updated at least annually with a plan of activities for the succeeding on-year period. These documents will be due one month before the close of the period of performance under this Attachment.

Approved:



Jay Marx
LIGO Laboratory Director

Karsten Danzmann
GEO 600 Principal Investigator



Peter Saulson
LSC Spokesperson

J Giaime

Digitally signed by J Giaime
DN: cn=J Giaime, c=US, ou=LSU/LLO, email=giaime@phys.lsu.edu
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Joseph Giaime
ISTNDG Leader