Attachment Number A to the Memorandum of Understanding (LIGO-M950061-00-M) between the University of Wisconsin - Milwaukee Relativity Group (UWMRG) and the Laser Interferometer Gravitational Wave Observatory (LIGO) Laboratory February 15, 1998

This Attachment to the Memorandum of Understanding LIGO-L950061-00-M covers the role of UWMRG as a Charter Member of the LIGO Scientific Collaboration (LSC) and a member of the LIGO I Development Group (L1DG). The period of performance for the activities in this Attachment is from February 15, 1998 to August 15, 1998. This period may be modified by agreement to a revision of this Attachment.

1. LIGO Scientific Collaboration - The LIGO Scientific Collaboration will be organized as a separate organization from the LIGO Laboratory. It will include scientists from the LIGO Laboratory, and those from collaborating institutions, and will have its own leadership and governance. The Collaboration will ensure equal scientific opportunity for individual participants and institutions. It will organize the research, publications, and all other scientific activities. The Collaboration will report to the Laboratory Directorate for final approval of its research program, technical work, observational physics publications, and talks announcing new observations and physics results. This will be done through regular reports to the Directorate and its PAC.

2. Charter Membership - An initial period for formation of the Charter group of institutions in the LIGO Scientific Collaboration will commence on March 1, 1997 and will end following the first full meeting of the Collaboration at which the Collaboration Council will assume its role. We expect that this transition will occur within six months. Membership in the Collaboration during this charter period will be initiated by proposal to the LIGO Laboratory Directorate.

   Following the charter period proposals will be evaluated through the Collaboration Council. With Collaboration approval, an MOU with the LIGO Laboratory, including Attachments defining specific work will be required for any participating institutions.

3. This document is an agreement between the University of Wisconsin - Milwaukee Relativity Group (UWMRG) and the LIGO Laboratory concerning the activities noted below, under provision 8, of UWMRG as a Collaborating Institution in the LIGO Scientific Collaboration (LSC) and in the LIGO I Development Group (L1DG).

4. LIGO I Development Group - The LIGO I Development Group will be the scientific collaboration for implementing and exploiting the initial LIGO detector and physics through the initial science data run. Only groups who establish a specific Attachment approved by the LIGO Laboratory, which defines a sufficient contribution and participation in LIGO I development, implementation or data analysis will be part of this initial LIGO data run and science. Participation in future data runs and science that follow LIGO I will be possible for other groups, with guidelines to be determined by the LIGO Scientific Collaboration. It is anticipated that LIGO I data will only be made available through formal collaboration within the LIGO I Development Group during the first two years following its collection.

   The general guideline for institutional membership in the LIGO I Development Group is that the contribution per collaborator of any new group to the design, construction, and implementation of the initial LIGO detector and to the first data run be comparable to that of the LIGO Laboratory scientists.

5. Report of Progress - UWMRG will provide a summary report of progress, monthly, by e-mail to the Collaboration Council and to the LIGO Laboratory Director. UWMRG will submit a complete report on its activities every six months, supply an updated List of Collaborators, and a plan of activities for the next six months. This report should be submitted one month before the updated attachment will take effect.

6. Term of Membership - Membership will be renewed every six months upon evidence of satisfactory performance of agreed upon duties.

7. Intellectual Property Rights - The rights to intellectual property developed under this Attachment will be subject to the National Science Foundation Grant Policy as indicated in Section 730, Intellectual Property.

8. During the period February 15, 1998 - August 15, 1998, the members of the UWMRG who will work in the LIGO I Development Group are: Bruce Allen, R. Balasubramanian (postdoc at Milwaukee), and Adrian Ottewill (Mathematical Physics Professor, University College, Dublin, Ireland).

   The work of the group will be in the area of data analysis code and algorithms. It will develop and implement techniques to use in searching for binary inspiral events and for stochastic background sources. It will also develop and implement vetoing techniques that can distinguish non-Gaussian detector noise events from known types of signals, and will categorize these non-Gaussian events. The work plan for the next six months is:

   a. Benchmarking:
   Carry out any further benchmarking of the data analysis filtering pipeline as specifically requested by LIGO project.

   b. GRASP:
   Continue to maintain/repair GRASP. Use GRASP primarily as a documented archive for different research groups that wish to make their prototype code publicaly available to

record progress and dead ends in the search for useful techniques.

c. Binary Inspiral Search:
Finish the binary inspiral search project, including running code as required to complete data set, completing a publication-quality preprint describing results, maintaining a complete doc umented archive of source code.

d. 40 Meter Lab.
Carry out specific projects as requested by 40-meter lab:
1. Program examples to accept piped data from server;
2. Software to display non-stationary behavior of signals;
3. Automated power spectrum calibration system (see XXX below);
4. Realtime performance monitor using stored and automated calibration;
5. Software oscillation monitor and warning system for known sinusoids.

e. Stochastic Background:
Continue work with Romano to detail the differences between the discrete-time optimal formulation of the filtering/search problem and the continuous-time techniques found in the literature.

f. Software Calibration Loop:
In a three-step procedure, implement an automated calibration system for the 40-meter lab.
Steps:
0. Using the HP system analyzer to calibrate the IFO, monitor the input and output signals of the HP with the DAQ system, and reconstruct the calibration information using data stored in FRAMES.
1. Replace the HP system analyzer with an DAC output channel on the DAQ system, and an ADC input channel, and calibrate a simple RC circuit, where the frequency response is known from first principles. This will be done using swept sine signals,in the same way as the HP system analyzer currently does the calibration.
2. Now calibrate the IFO using the HP system analyzer, then use the automated calibration system which uses the DAQ DAC and ADC channels. When the two calibration curves are in good agreement,
3. Switch over to using the DAQ-based calibration technique.

g. Wavelet Techniques:
Initiate work on using wavelet techniques to characterize the behavior of different IFO channels, and as a possible technique to search for transient sources with poorly-known waveforms, for which matched filtering is not appropriate.

h. Beowulf:
Construct and operate a beowulf system, and use it to carry out and benchmark data analysis activities on the 40-meter data set.

i. Constructing LDAS:
Participate in prototyping and building elements of the proposed LDAS design, including the

communications library, API command set, API modules, filter kernel element, and other components as requested by the LIGO project or the LSC. If appropriate, particular modules of the GRASP library will be recoded in C++ following the class and object conventions specified by LIGO.

j. Regression Techniques:
Continue work on techniques to search for and remove correlations in the IFO output arising from different monitored channels such as the ground acceleration and ambient magnetic fields. Explore the use of compression techniques like Linear Predictive Coding (LPC) to reduce the bandwidth of the data stream.

k. Frame Format Data:
Continue to maintain the translation code which is used to translate old-format 1994 data into FRAME form. Use this data to continually monitor and test the functionality of the FRAME library. Continue to provide tapes of this Nov 1994 data to LIGO collaborators in the latest FRAME format.

l. LIGO Scientific Collaboration
Assist in the formation, organization, and operation of a "Data Analysis Group" within the LIGO Scientific Collaboration (LSC).

Approved:

Barry Barish
Barry Barish
LIGO Laboratory Director

March 12, 1998
Date

Bruce Allen
Bruce Allen
UWMRG Principal Investigator

3/17/98
Date