



*LIGO Laboratory / LIGO Scientific Collaboration*

<b>Document Type:</b> Policy	LIGO-M060323-07-A	10 November 2008
<b>The LIGO Laboratory Charter (2009 – 2013)</b>		
LIGO Laboratory Directors		

Distribution of this document:  
LIGO Laboratory website  
LIGO Laboratory Executive Committee.

**California Institute of Technology**  
**LIGO Project – MS 18-34**  
**1200 E. California Blvd.**  
**Pasadena, CA 91125**  
Phone (626) 395-2129  
Fax (626) 304-9834  
E-mail: [info@ligo.caltech.edu](mailto:info@ligo.caltech.edu)

**Massachusetts Institute of Technology**  
**LIGO Project – NW22-295**  
**185 Albany St**  
**Cambridge, MA 02139**  
Phone (617) 253-4824  
Fax (617) 253-7014  
E-mail: [info@ligo.mit.edu](mailto:info@ligo.mit.edu)

**LIGO Hanford Observatory**  
**P.O. Box 1970**  
**Mail Stop S9-02**  
**Richland WA 99352**  
Phone 509-372-8106  
Fax 509-372-8137

**LIGO Livingston Observatory**  
**P.O. Box 940**  
**Livingston, LA 70754**  
Phone 225-686-3100  
Fax 225-686-7189

<http://www.ligo.caltech.edu/>

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## 1) Overview

The Laser Interferometer Gravitational-Wave Observatory (LIGO) is designed to open the field of gravitational-wave astrophysics through the direct detection of gravitational waves. LIGO detectors use laser interferometry to measure the distortions of the space-time between free masses induced by passing gravitational waves. LIGO is a national facility for gravitational-wave research, providing opportunities for the broader scientific community to participate in detector development, observations and data analysis. LIGO consists of the LIGO Laboratory and the LIGO Scientific Collaboration (LSC). Through membership in the LSC, LIGO welcomes the participation of scientists beyond the LIGO Laboratory in all of the activities in the scope of LIGO. Starting in FY2008, the capabilities of the LIGO instruments will be improved in phases beginning with a modest program of technical enhancements and followed by the Advanced LIGO project which is expected to increase the sensitivity and observational range of LIGO by a factor of 10, bringing 1000 times more galaxies into the observational range of LIGO.

The design and construction of LIGO was carried out by LIGO Laboratory's team of scientists, engineers, and staff at the California Institute of Technology (Caltech) and the Massachusetts Institute of Technology (MIT). The responsibilities of LIGO Laboratory include operation of the LIGO Observatory, R&D aimed at the development of advanced detectors that approach and exploit the facility limits on interferometer performance, gravity wave science and public education and outreach. Caltech has prime responsibility for LIGO Laboratory under the terms of a Cooperative Agreement with the National Science Foundation (NSF).

This charter describes how LIGO Laboratory is managed and operates under the current cooperative agreement with the NSF through FY2013.

## 2) Objectives

### a) Scientific Objectives

The scientific objectives of LIGO include research in the fundamental physics of gravitation as well as in astronomy and astrophysics. Possible advances in gravitational physics include:

- tests of General Relativity in the strong field and high velocity limit;
- direct measurement of the polarization and propagation speed of gravitational waves;
- direct observation of the dynamics of black holes.

Possible observations in astronomy and astrophysics that may not be measurable by other methods include:

- the final moments of the coalescence of extragalactic binary neutron star systems, which are the most reliably predicted sources and serve as the design benchmark for the sensitivity and spectral coverage of LIGO;
- the coalescence of black-hole/black-hole and black-hole/neutron-star binary systems;
- the inner dynamics of stellar collapse; the internal and surface dynamics of a neutron star;
- the dynamics of the primordial universe at the earliest stages of cosmic evolution;
- an inventory of the gravitational-wave sources distributed throughout the universe.

It is highly likely, as has been the experience in opening other branches of observational astrophysics, that LIGO will expose new classes of sources. The LIGO facilities are designed to accommodate a succession of detection systems with enhanced sensitivity and adjustable spectral response to retain flexibility in the exploratory phase of the science and to optimize the scientific returns once gravitational waves have been detected.

Advances in the instrument science for gravitational-wave detection have brought advances in the physics of precision measurement, and have promise to bring further advances in the field, specifically

- new forms of laser interferometry, with new levels of precision
- means to exceed the standard quantum limits in interferometric sensing
- unprecedented stability of short-term frequency references
- understanding of and means to reduce the influence of thermal noise in precision measurement

## b) Technical Objectives

The LIGO Observatory infrastructure is designed to provide an environment for detectors of increasing sensitivity and versatility. The buildings and the vacuum system are configured to allow multiple interferometers at both sites; for initial LIGO, two interferometers of 4km and 2km are in operation, and a single 4km interferometer at Livingston.

The initial operational phase of LIGO, which included a continuously operating triple coincidence detector comprising three broadband interferometers, operated at two widely separated sites, culminated with the two calendar year S5 science run, which ended in October 2007. During this run, the initial interferometers performed at or better than the predicted level of sensitivity as described in the 1995 Science Requirements Document.

An important element of the LIGO Mission is to support the development of improved interferometric detectors of gravitational radiation, through the campus activities of the Laboratory and greater LSC, and to accommodate and exploit those improved instruments at the Observatories. LIGO is currently in the improvement and upgrade phase.

### 3) Facility Description

The major LIGO facilities consist of vacuum systems at two widely separated sites - Hanford, Washington, and Livingston, Louisiana. The vacuum systems, in the shape of an L with 4 km arms, enclose laser interferometer beams. The beams originate and are detected at the vertex of the L (corner station) and are reflected from the ends of the L (end stations). At the Washington site, additional mirrors are placed at the midpoints (mid stations) of the arms to establish half-length interferometers. The system comprising three interferometers, a full length and a half-length at Washington and a full length at Louisiana, operate in triple coincidence as a single gravitational-wave detector.

The vacuum system consists of two elements: the beam tubes running along the arms of the L and the vacuum chambers and associated tubing at the corner stations, end stations and mid stations (Washington). The vacuum chambers contain the test masses (end points of the interferometer) and their associated seismic isolation systems, the interferometer optics, the optics for beam injection and extraction from the interferometer and the electro-optic and mechanical instrumentation to maintain interferometer alignment and to detect the measured gravitational-wave signal.

The beam tubes are enclosed in a cover for protection and to reduce interferometer noise from scattered light due to wind driven motions of the tubes.

The buildings at both sites are designed to accommodate full exploitation of LIGO by improved and/or multiple detector phases of LIGO. In addition to the vacuum chambers and pumps, the corner station houses the facility and interferometer control systems, the laser power and cooling systems, the data archiving and facility computer systems, office space for staff and visitors, staging areas, equipment receiving areas and small electronic and mechanical shops. The mid-station and end-station buildings are smaller, containing only vacuum chambers, pumps, and equipment receiving and staging areas.

Full bandwidth analog strain signals from the interferometers are digitized and recorded continuously for off-site analysis. Ancillary signals monitoring the state of the instrument, the facility and the environment are archived continuously. Data are analyzed for binary inspirals, coincident bursts, periodic sources and a stochastic background of gravitational waves.

## 4) Mission and Responsibilities

The program and mission of LIGO is to:

- Observe gravitational wave sources;
- Operate the LIGO facilities to support the national and international scientific community;
- Develop the instrument science and technology for advanced detectors that approach and exploit the facility limits on interferometer performance;
- Successfully carry out the Advanced LIGO Project as the first major upgrade to the LIGO detectors
- And, support scientific education and public outreach related to gravitational wave astronomy.

The LIGO Laboratory will:

- Provide necessary support personnel and equipment for the two remote facilities [Hanford LIGO Observatory (LHO) at Hanford, WA, and the Livingston LIGO Observatory (LLO) at Livingston, LA];
- Perform necessary research and development required to support the activities at LHO and LLO;
- Perform opportunistic improvements of the initial LIGO interferometers;
- Operate the LIGO interferometers for science data taking;
- Manage, maintain and distribute the scientific data within the LIGO data archives;
- Process and analyze the science data and publish the results with the participation of the LIGO Scientific Collaboration;
- Provide infrastructure and research support for members of the LIGO Scientific Collaboration participating in the LIGO scientific research program;
- Define interferometer upgrades and carry out a research and development program to underpin future upgrade proposals, with the participation of the LIGO Scientific Collaboration;
- Be responsible for the successful completion of the Advanced LIGO project with the allotted budget and schedule.
- Provide support and guidance for the research and development programs carried out at LSC institutions related LIGO program as described in the LSC development White Papers;
- Support the development of, and coordinated observation by, the international network of gravitational wave detectors;
- Continue to develop and expand an outreach program to interpret LIGO to the public and provide educational opportunities for young people;
- Address new industrial technologies and applications stimulated by the requirements of gravitational wave observation.



## **5) National Science Foundation Cooperative Agreement**

The LIGO Laboratory operates under a Cooperative Agreement between the US National Science Foundation (NSF) and the California Institute of Technology (Caltech). The Agreement defines the obligations of Caltech and MIT in carrying out the mission of the Laboratory. This Charter is incorporated by reference in the Cooperative Agreement in the governance of the LIGO Laboratory.

## 6) Institutional Roles and Responsibilities

### a) Hierarchy

The LIGO Laboratory reporting and oversight is defined in the organizational hierarchy shown in Figure 1.

### b) NSF

NSF is responsible for providing funding, general oversight, monitoring, and evaluation to help assure Laboratory performance in accordance with approved work plans. NSF will strive to obtain funding consistent with the Target Funding Levels set forth in the Cooperative Agreement. The actual funding available for LIGO will be negotiated with the Laboratory on the basis of the Annual LIGO Work Plan that, upon approval by NSF, will constitute the official operating plan for the year. Within the framework of the annual operating plan, NSF will undertake to provide the funding in a timely fashion and to provide the necessary document reviews and approvals as indicated in the Work Plan. NSF involvement includes the following:

- provision of funding and guidance;
- review and, where required by the Agreement, approval of required subcontracts, reports, and plans submitted by Caltech;
- oversight of progress by the NSF Program Manager and external reviewers.

#### i. NSF Program Manager

Within the NSF, the LIGO Program Manager is responsible for scientific, technical, cost and schedule review and agency guidance. Review of progress and programmatic review of annual work plans is the responsibility of the LIGO Program Manager. Direct communication between the LIGO Program Manager and the LIGO Laboratory is the method by which this review and guidance will be accomplished. Performance of work under the Cooperative Agreement is subject to the general guidance and oversight by the NSF Program Manager for LIGO.

#### ii. NSF Division of Acquisition and Cooperative Support

The NSF Division of Acquisition and Cooperative Support is responsible for Cooperative Agreement matters between the NSF and Caltech. Formal communications related to contracts and the NSF Division of Acquisition and Cooperative Support and the Caltech Office of Sponsored Research will accomplish required approvals. Annual funding increments and contractual obligations flow from the NSF Division of Acquisition and Cooperative Support, National Science Foundation (NSF), to Caltech, under the Cooperative Agreement. Major procurements involving substantive subcontracts are approved or concurred with by the NSF Division of Acquisition and Cooperative Support, in accordance with the terms and conditions of the Cooperative Agreement. The NSF Division of Acquisition and Cooperative Support will generally pre-approve such

subcontracts based on information submitted by Caltech/LIGO as part of the yearly work plan and the recognition that the Caltech Procurement System has been fully validated for purchases under federal grants and contracts. In those cases where the NSF Division of Acquisition and Cooperative Support requires additional information to approve a subcontract, NSF will inform Caltech/LIGO so as to allow the needed additional information to be provided in a timely manner.

### **c) Caltech**

Caltech is accountable, as the awardee, for the performance of the LIGO Laboratory, as described in the LIGO Annual Work Plan. Caltech is responsible for staffing the Laboratory, providing institutional support and ensuring adequate oversight of the execution and performance of the program. Caltech's Office of Sponsored Research is responsible for matters between Caltech and NSF that pertain to the administration of the terms and conditions of the Cooperative Agreement and will accomplish this through formal communications with the NSF Division of Acquisition and Cooperative Support. Legal review and matters related to real property and property management will be the responsibility of the Caltech Legal Counsel reporting to the President and the Caltech Vice President for Business and Finance, respectively.

#### **i. Caltech Reporting**

LIGO activities at Caltech, like other research programs in physics, are part of the Division of Physics, Mathematics and Astronomy (PMA) through which academic appointments and educational matters are administered. The Division also provides administrative and logistical support to LIGO and oversight of the Caltech effort on LIGO.

### **d) MIT**

The LIGO Laboratory encompasses a joint effort of Caltech and MIT. The MIT roles and responsibilities are defined through a Memorandum of Understanding (Appendix A) and subcontract with Caltech. The MIT subcontract is subject to NSF approval. The MIT administration shares responsibility with the Caltech administration for overall oversight of the execution and performance of the LIGO program through representatives on the LIGO Oversight Committee. The MIT administration is also responsible for oversight, staffing and support of the MIT LIGO Group and for insuring that it successfully meets its institutional commitments. It is the policy of the LIGO Laboratory to have a fully integrated MIT participation with institutional boundaries minimized.

#### **i. MIT Reporting**

At MIT, academic appointments and educational aspects of LIGO are administered through the Department of Physics; research activities are supported through the Kavli Institute for Astrophysics & Space Research. The Department of Physics and Kavli Institute for Astrophysics & Space Research provide oversight of the MIT effort on LIGO and they report to the President of MIT through the Dean of Science.

### **e) Oversight Committee**

The presidents of Caltech and MIT have established a LIGO Oversight Committee, chaired by a member appointed by the Caltech President and composed of two members from Caltech and MIT appointed by their respective presidents, one appointee each from several other LSC institutions that are major stakeholders in LIGO, and two elected representatives from the LSC who will serve as “technical advisors”. The Oversight Committee reports to the presidents through the Chair of Physics, Mathematics and Astronomy at Caltech and the Dean of Science at MIT. It will regularly provide review of LIGO program status and progress as required. The Oversight Committee functions under a formal written charge.

### **f) Executive Director and Deputy Director**

The LIGO Laboratory Executive Director is appointed by the Caltech President in consultation with the MIT President and with the approval of NSF. The Director performs his/her responsibilities in close association with the LIGO Laboratory Deputy Director, who is appointed by the Director with the approval of the Presidents and the NSF. The LIGO Laboratory Executive Director, in association with the Deputy Director, reports progress on a periodic basis to the LIGO Oversight Committee.

#### **ii. Reappointment and Performance Review of the Executive Director**

The Caltech Chair of the Division of Physics, Mathematics and Astronomy nominates the Executive Director. The nomination is reviewed by the Caltech Provost and forwarded to the Caltech President. The Caltech President, in consultation with the MIT President, appoints the Executive Director as provided above. The appointment is made in writing and the appointment letter states the term of the appointment, up to five years in duration.

Caltech reviews the performance of the LIGO Executive Director at the conclusion of the Director’s term or at any other earlier time deemed appropriate by the Division Chair. Following the review, the Division Chair may nominate the Executive Director for continuation or reappointment or may nominate a new Executive Director. This nomination is reviewed by the Provost and forwarded to the Caltech President for consideration and action as provided above.

## 7) Organization of the LIGO Laboratory

The LIGO Laboratory is a distributed organization in which each site is organized functionally. The LIGO Laboratory has adopted a matrix organization in order to have the flexibility to effectively utilize its human resources for Advanced LIGO, other projects (e.g., enhancements to initial LIGO) and other concurrent operational responsibilities.

The matrix system takes account of the needs of the Laboratory while respecting the need to manage and supervise personnel in such a way that promotes their career opportunities, that provides a fair and transparent process of employee evaluation, and that limits the number of concurrent assignments for any employee to a reasonable level.

Within this matrix system each employee will be a member of one of the LIGO Laboratory groups. An employee may have operational assignments within this or to another operations group, to one or more project assignments or a mixture of both.

LIGO Laboratory also ensures effective use of human resources by implementing common infrastructure at all sites whenever appropriate. This applies, for example, to the IT services across all Laboratory sites, including, but not limited to, business, general computing, data & computing, and cyber security functions.

The LIGO Laboratory organization is illustrated in Figure 2. Detailed discussion of the Laboratory groups, project and special organizational functions are found in Sections 8-10 of this document.

When determined to be in the best interests of LIGO, members of the LIGO Scientific Collaboration from outside LIGO Laboratory may be given responsibility for some aspects of LIGO Laboratory activities through the mechanism of a Caltech appointment as a Visiting Associate in LIGO.

### a) Directorate

The LIGO Laboratory Directorate consists of the Executive Director, the Deputy Director and the Spokesperson of the LIGO Scientific Collaboration. Although the Executive Director and the Deputy Director have different well-defined primary responsibilities, the overall Laboratory direction is fully shared and either can speak for the Laboratory. Both the Executive Director and the Deputy Director are fully informed on all major decisions and will be mutually involved in the decision making as appropriate. The Executive Director has overall responsibility for the LIGO Laboratory. The Executive Director's primary responsibility is to ensure the development and implementation of the LIGO Laboratory program in a timely and cost effective manner with the goal of detecting gravitational waves and carrying out a program of gravitational wave astronomy. The Deputy Director is primarily responsible for executing the LIGO program and for organizing and directing the Laboratory team composed of Caltech and MIT staff. The Director is the principal point for communication and interaction with NSF, through its LIGO Program Manager. The Executive Director is also responsible for maintaining interactions and collaboration with the scientific community (both national and international). The LSC Spokesperson, as a member of the

Directorate is responsible for working with the Executive Director and the Deputy Director to assure that the efforts of the LSC and LIGO Laboratory are well aligned and that overlapping functions of the LSC and LIGO Laboratory are carrying out in a well integrated manner.

### **b) LIGO Scientific Collaboration**

The LIGO Scientific Collaboration (LSC) carries out the LIGO research and development program, the analysis of data, the publication of scientific results, and it enables participation by collaborating groups in appropriate LIGO activities. The LSC maintains its own governmental structure (governed by its Charter and Bylaws) while its activities are integrated with those of LIGO Laboratory.

Scientists and engineers from the LIGO Laboratory will be full members in the LIGO Scientific Collaboration, and will participate in the full range of its activities.

The LSC reports to the NSF through the LIGO Directorate, and will be reviewed annually by the NSF external panel as part of the LIGO Laboratory review. The LSC will produce an annual work plan and report that will be submitted to the LIGO Directorate and subsequently be part of the LIGO Annual Report and Work Plan.

The LIGO Directorate will be ex officio members of all planning and evaluative bodies of the LSC. Representatives of the LSC will serve as technical advisors to the LIGO Oversight Committee. Representatives of key LSC stakeholder institutions will serve as members of the LIGO Oversight Committee.

To support the Laboratory in its operation of the Observatories, the LSC will offer guidance on issues involving scientific tradeoffs in operations:

- a) the optimization of the scientific returns in the operation of the LIGO Laboratory facilities;
- b) the relative distribution of observing and development time at LSC gravitational wave detectors;
- c) priorities for improvements in the LIGO facilities;
- d) the timing and readiness of major instrumentation changes in the long baseline system.

The LSC is expected to contribute to the complete range of tasks associated with the effort to meet LIGO's goals. Specific responsibilities will be agreed to in the Memoranda of Understanding between groups and the LIGO Lab; the objective is that LSC members in and outside of the LIGO Laboratory will share fairly in these efforts. All Memoranda of Understanding between member groups and the LIGO Lab will be co-signed by the LSC Spokesperson.

Since the LSC's responsibilities form a key part of the overall LIGO program, the LIGO Program Advisory Committee will also advise the LSC in carrying out those responsibilities.

Collaborative work between the LIGO Laboratory and member groups of the LIGO Scientific Collaboration will be defined in Memoranda of Understanding (MOU) between the Laboratory and responsible institutions. Specific tasks will be included in Attachments to these MOUs with defined deliverables and periods of performance.

### **c) Other Scientific Collaborations**

As the field of experimental gravitational wave research develops, it may become appropriate to form additional and independent scientific collaborations. These collaborations will, as well, be governed by MOUs and Attachments.

### **d) LIGO Program Advisory Committee**

The LIGO Program Advisory Committee (PAC) is a principal source of advice to LIGO on scientific policy, technical choices, support of the scientific community and organizational matters. It provides peer review of scientific and technical proposals upon request by the LIGO Laboratory Directorate. This peer review will be considered by the Laboratory Directorate in providing information to the NSF on disposition of proposals from LSC institutions.

A subcommittee of the PAC will serve as the Project Advisory Panel (PAP) for the Advanced LIGO Project. The chair of the PAP will be a member of the PAC. Membership of the PAP may include members of the PAC as well as others selected for their special qualifications.

The Committee meets several times per year and will be asked for advice through a written charge provided by the LIGO Laboratory Executive Director. The Committee's advice will be considered by the Directorate in making decisions.

NSF shall be informed of all meetings of the PAC, shall be invited to attend, and shall receive copies of those materials prepared by the Laboratory and submitted to the Laboratory by the PAC as deemed appropriate by the LIGO Executive Director.

The Committee members are appointed for an initial term of three years, with new members appointed with staggered terms to ensure continuity and renewal of the Committee.

### **e) LIGO Laboratory Board**

The LIGO Laboratory Board is advisory to the LIGO Laboratory Directorate.

The LIGO Directorate will consult with and be advised by the LIGO Laboratory Board concerning significant decisions affecting the LIGO Laboratory as well as significant issues pertaining to the institutional interests of Caltech and MIT. The Board advises on such topics as long-term planning for the LIGO Laboratory, preparation of the annual work-plan, strategic planning for staffing across the Laboratory, and advice on major infrastructure investments. The Board will also be consulted by the Directorate and advise on major decisions that affect LIGO Laboratory's operation and strategies.

The Executive and Deputy Directors are expected to work with the Board to ensure that the three communities they represent (Caltech, MIT, and the institutions and individuals in the LSC) are fully engaged in decisions that affect LIGO's operation and strategies. The membership of the Board will consist of two members appointed by Caltech, two members appointed by MIT, the LSC Spokesperson and one other member designated by the LSC Spokesperson and confirmed by the LSC Executive Committee.



## **f) LIGO Academic Advisory Committee**

The LIGO Academic Advisory Council is charged with advising the LIGO Executive Director and Directorate on issues related to education of students and postdocs who are participating in LIGO and to provide oversight of the quality of the education they receive through their participation in LIGO. The responsibilities of the LIGO Academic Advisory Council are to:

- Serve as an advocate with the LIGO Directorate for the educational aspects across all of LIGO for undergraduates, graduate students, and postdoctoral students.
- Provide a mechanism to gather and evaluate information concerning LIGO's educational program and recommend improvements to the LIGO Directorate.
- Meet at least annually with the LIGO Directorate to report on and get input and assignments related to LIGO's educational program.
- Working with LIGO collaborating institutions, help to ensure that the postdoctoral students, graduate students, and undergraduates associated with LIGO get a broad education and quality mentoring in the wide range of science involved in LIGO.
- Provide mechanisms to allocate and protect student research and thesis topics

The LIGO Academic Advisory Council membership consists of three faculty members who are involved in LIGO, one from Caltech or MIT, and two from other LSC institutions. Members are chosen by the LIGO Executive Director with advice from the LSC Spokesperson, the LIGO Laboratory Deputy Director and the leader of the MIT LIGO group and serve for a 2-year term.

## **g) LIGO Visitors Program**

The LIGO Laboratory operates a Visitors Program intended to provide research opportunities for scientific visitors to the campuses and Observatory sites and for visits by Laboratory staff to other research groups and sites. Supported visits are expected to be of significant duration (one month or longer) and are proposed as research projects to the Laboratory Directorate for review and subsequent support. Shorter-term and targeted or informal visits may also take place

## **h) Education and Public Outreach Program**

LIGO shares its exciting research mission through education and outreach programs that involve learners of all ages in explorations of physics, astronomy, mathematics and scientific inquiry. In addition to educating undergraduate and graduate students through traditional science research experiences, LIGO offers formal science education opportunities to K-12 students through Observatory field trips and through classroom visits by Observatory outreach staff. LIGO provides informal education experiences for preschoolers, students and adults through public science activities at the Observatory sites and in the surrounding communities. In these communities, LIGO maintains a focus on reaching groups that are typically underrepresented in science. In concert with other NSF education initiatives, LIGO outreach coordinators participate in the development of educational materials that communicate the elements of LIGO's science framework to teachers and students on a national level. The flagship of the LIGO science education program is the LIGO Science Education Center (SEC) through the partnership of LIGO, Southern University of Baton



Rouge, the Louisiana Gaining Early Awareness and Readiness for Undergraduate Programs (LA GEAR UP), and the Exploratorium, with the support of the NSF. The SEC is located on the grounds of the Livingston, Louisiana Observatory, and provides hands-on science experiences for students and the public through exhibits produced by the Exploratorium of San Francisco. Extensive pre-service and in-service teacher training and professional development occurs at the SEC.

## 8) LIGO Laboratory Groups

Each LIGO Laboratory group reports to the Directorate and is led by a Group Leader and, as needed, a Deputy Group Leader. These positions serve as line management for the respective group. Each group is represented on the Laboratory Executive Committee. Staff assignment to an operational group represents the principal assignment for each staff member. Through a matrix management system, scientific and technical staff are able to participate significantly in activities of other operational groups and projects within LIGO Laboratory. While each group has a primary function and funding allocation, there may be substantial overlap in the activities of groups commensurate with the requirements of scientific research and the Laboratory's mission.

Laboratory groups consist of three site-based groups and several Laboratory-wide groups.

### a) Hanford & Livingston Observatories

The Hanford Observatory and the Livingston Observatory are organized as separate operational groups within the LIGO Laboratory. Each is responsible for the effective operation of the facilities and scientific programs at the respective Observatory site. A scientist who serves as the Head of the Observatory leads each Observatory. In addition, each group includes a Site Manager who is responsible for the technical and operational effectiveness of the site facilities and staff. The Site Manager or a designate serves as the lead Environment, Safety and Health Officer for the Observatory site, reporting to the Head and, in this capacity, directly to the LIGO Laboratory Deputy Director. The staff at each Observatory is structured to support operations, maintenance and the scientific program. The staff is sufficient to assure adequate local human resources for all normal operations including scientific and technical expertise at the site. Each Observatory will work with LIGO staff from the Caltech and MIT groups in executing enhancements, upgrades and new capabilities, including the Advanced LIGO project and in carrying out the scientific program. Staff members from this group who are members of the LIGO Scientific Collaboration may also participate in analysis of LIGO astrophysics data consistent with their other responsibilities.

### b) MIT Group

The MIT Group participates in the LIGO Laboratory program in the full spectrum of Laboratory activities. The members of the group interact closely with the CIT groups listed above to carry out their mission. The functions and activities in this group include Management, Administration, Detector Support, Test Facilities, Data Analysis/Computing, and Advanced Detectors. Staff members from this group who are members of the LIGO Scientific Collaboration may also participate in analysis of LIGO astrophysics data consistent with their other responsibilities.

### c) CIT Optics and Mechanics

The CIT Optics and Mechanics Group is responsible for engineering design and analysis and design drafting for LIGO scientific programs, facilities, and research and development tasks. Members of this group team with LIGO staff and collaborators as needed to support all activities requiring mechanical and optical engineering. This group provides technical configuration management and quality assurance and adheres to the Laboratory's engineering standards and practices. Staff members from this group who are members of the LIGO Scientific Collaboration

may also participate in analysis of LIGO astrophysics data consistent with their other responsibilities.

#### **d) CIT Controls and Data Systems Group**

The CIT Controls and Data Systems Group is responsible for digital electronics and controls engineering and electronics design for LIGO scientific programs, facilities, and research and development tasks. Members of this group team with LIGO staff and collaborators as needed to support all activities involving electronics and controls. This group adheres to the Laboratory's engineering practices and standards. Staff members from this group who are members of the LIGO Scientific Collaboration may also participate in analysis of LIGO astrophysics data consistent with their other responsibilities.

#### **e) CIT Science Group - GW Astrophysics and Instrument Science Subgroups**

The CIT Science Group is made up of two subgroups-- The CIT Instrument Science Group, and the CIT GW Astrophysics subgroup.

The CIT GW Astrophysics subgroup participates actively in the analysis of astrophysics data and publication of results from LIGO. This group is responsible for supporting modeling of sources, algorithm development and for initiating new approaches to the analysis of LIGO data. Data analysis by members of this subgroup is undertaken as part of the LSC data analysis groups and with the advice of the LIGO Laboratory Chief Scientist.

The CIT Instrument Science subgroup is responsible for assuring and improving the performance of the LIGO detector systems used in gravitational wave research, conducting advanced R&D related to Advanced LIGO to develop techniques for risk reduction, solving problems and future improvements, advanced R&D aimed to longer term future to enable future improvements of LIGO's gravitational wave detection capabilities and providing scientific leadership in specifying and introducing detector improvements and upgrades in association with the staff at the Observatory sites. Members of the CIT Instrument Science subgroup participate in advanced R&D in coordination with the LSC and contributor to R&D activities within LIGO Laboratory Projects. Staff members from this subgroup who are members of the LIGO Scientific Collaboration may also participate in analysis of LIGO astrophysics data consistent with their other responsibilities.

The subgroups that constitute the CIT Science Group are expected to interact close, meet often and work together on problems of mutual interest.

#### **f) Laboratory Computing Group**

The Laboratory Computing Group has responsibility within LIGO Laboratory for the hardware and software systems for used for LIGO modeling, simulation and for data analysis. This group carries the primary responsibility for all software standards and software engineering used in LIGO research. Systems for general computing are implemented and supported in this group. The group supports computational technology in support of extraction of astrophysical information. Staff members from this group who are members of the LIGO Scientific Collaboration may also participate in analysis of LIGO astrophysics data consistent with their other responsibilities.

## 9) LIGO Laboratory Projects

LIGO Laboratory Projects include focused activities of finite duration such as the Enhancements Program and the Advanced LIGO Project as well as the campus-based research facilities (LASTI, 40-meter Interferometer, and TNI). Additional LIGO Laboratory projects can be initiated by the Directorate as needed in order to meet the mission of the Laboratory. A process of internally reviewed proposals is used to help set priorities and address needs.

### a) Advanced LIGO Project

The Advanced LIGO Project will be an NSF Major Research Equipment Facilities Construction project managed by LIGO Laboratory under an independent cooperative agreement.

### b) LIGO Enhancements Program

The LIGO Enhancements Program seeks to implement a set of modest enhancements to initial LIGO in order to double the sensitivity of the interferometers. The goal of this program is to build, install and commission these enhancements to allow a significant science run utilizing these enhancements to take place before the initial interferometers are decommissioned for the Advanced LIGO Project.

### c) Campus-based Research Facilities

The campus-based research facilities provide special test and research facilities at MIT and Caltech. These include the MIT test interferometer (LASTI), the Caltech 40 meter test interferometer, and the Caltech Thermal Noise Interferometer (TNI) as well as supporting infrastructure including ancillary facilities used for optics, laser and noise research, metrology and materials research. Each group responsible for one of these facilities is responsible for the readiness and availability of the research facility, and for supporting the research and test activities carried out by LIGO Laboratory and collaborator investigators using the facility. This includes calibration, procedures documentation and training of investigators.

## 10) LIGO Directorate Special Functions

The LIGO Directorate Special Functions include the Laboratory Chief Scientist, the Business Office, oversight of Education and Outreach, Environmental Safety and Health, Cyber Security, the Laboratory Engineering Head and the Executive Committee.

### a) LIGO Laboratory Chief Scientist

LIGO Laboratory Chief Scientist works with the Directorate to define the scientific focus and direction of LIGO Laboratory. The Chief Scientist will work with laboratory scientists to assure that the Laboratory's scientific activities have the potential for real impact, that the scientific activities receive enough support to succeed, that students and post docs have the benefit of quality mentoring and that hiring decisions take account the needs of the Laboratory's science activities.

### b) Business Office

The Business Office has administrative responsibility for the Laboratory's administrative functions.

The Business Office is responsible for program planning support, for business operations including budgeting, funds management, cost accounting, procurement, property management, personnel actions and effort reporting, for document and records management, and for management of Laboratory Policies and Procedures. With direction from the Directorate, the Business Office prepares Laboratory Proposals to the NSF and coordinates all formal communications with the NSF through the Caltech Office of Sponsored Research. The Business Office provides administrative support for the Observatory sites, collaborative matters and administrative assistant and secretarial support to the LIGO Laboratory.

For internal LIGO Operations reporting and management, budgets are established at the beginning of each fiscal year with the approval of the Directorate based on the Annual Work Plan submitted to the NSF, the funding level approved by the NSF, and any guidance provided by the NSF. These budgets are established for each Work Breakdown Structure (WBS) element and cost category. The budgets are distributed to the responsible account managers and constitute authorization to commit funds. Monthly reports track actual costs against the budgets and enable corrective action if required.

Changes in the LIGO Operations budget baseline are initiated through a documented request submitted by the cognizant account manager to the Business Manager. Requests are required for all cumulative budget changes within a subsystem account that exceed \$50,000. The cognizant manager initiates the request, and if the need for a change control action is not certain, the burden on the cognizant manager shall be that a documented request will be made.

For the Operations activity of the LIGO Laboratory, the Business Manager logs each received Change Request and schedules meetings of the LIGO Change Control Board (CCB) to conduct reviews of open Change Requests. The LIGO Deputy Director chairs the LIGO CCB. Members of the CCB include the Observatory Heads as well as the heads for the MIT Group, the CIT Instrument Science Subgroup, the Lab Computing Group, the Advanced LIGO Project and the

Laboratory Engineering Head. The Business Manager is responsible for preparing the agenda and meeting minutes. The CCB reviews each request and makes recommendations to LIGO Executive Director. The Deputy Director issues a written notice of each decision. The Business Manager maintains a log of the status of all Change Requests and retains a file of all approved Change Requests in the LIGO Document Control Center (DCC).

All change request activity and budgetary realignments are tracked and reported to the NSF in accordance with the reporting requirements identified in the Cooperative Agreement and this Laboratory Charter.

### **c) Oversight of Education and Outreach**

The Executive Director is responsible for Directorate oversight of the Laboratory's Education and Outreach activities. The Executive Director assures that these activities are appropriate, effective and consistent with the mission of the Laboratory and the NSF.

### **d) Cyber Security**

The Laboratory Cyber Security program is based on a layered approach that ensures that the most significant assets are fully protected and secure while allowing the flexible access to information required to allow the widely distributed LIGO Scientific Collaboration to effectively analyze the LIGO data. The Laboratory's most stringent requirement applies to the Observatory Security Critical System which comprises the interferometers and data archives. This ensures that interferometer operation and control can take place in a secure environment and that the integrity of archived data is protected.

### **e) The Laboratory Engineering Head**

The Laboratory Engineering Head has the responsibility to ensure that the Laboratory's engineering standards and practices are adhered to in all appropriate Laboratory activities.

### **f) The Executive Committee**

The Executive Committee is the principal management body used by the Laboratory Directorate to review Laboratory program execution and status and to develop the basis for management decisions. The Executive Committee will meet regularly and be chaired by the Director, in association with the Deputy Director. It will consist of the managers of each of the LIGO Laboratory functional groups, LIGO Laboratory senior scientists, and all LIGO professorial faculty members at Caltech and MIT.

### **g) Diversity**

LIGO Laboratory is committed expand the participation of all of our citizens in science and engineering at all levels of the educational process and through professional opportunities to participate in LIGO's cutting edge research. The Diversity Plan (M080380) guides the Laboratory's actions in this area. There is much in our public outreach activities that bears on diversity, and within the Laboratory itself we try to be alert and proactive in providing

opportunities for underrepresented minorities and woman to join our staff and to thrive professionally.

In order to identify additional approaches and mechanisms to improve the diversity of the Laboratory's staff, the position of LIGO Laboratory Diversity Officer has been created. The Diversity Officer reports to the Laboratory Directorate and chairs the Laboratory Diversity Committee.

The Laboratory Diversity committee is made up of Laboratory staff members and perhaps a few knowledgeable outsiders. The committee advises the Laboratory Directorate about actions that can be taken to move the Laboratory forward towards the goal of providing opportunities for underrepresented minorities and women to join the Laboratory staff and to thrive professionally.

## **11) Environment, Safety and Health Protection**

ES&H is a line management responsibility. The LIGO Laboratory Deputy Director is responsible for ES&H programs throughout LIGO, for both the Operations and any Projects underway. At each Observatory site, the Site Manager serves as the primary manager responsible for ES&H programs and in this capacity the Site Manager is directly responsible to the Deputy Director.

### **a) Objectives**

The LIGO ES&H program has the following specific objectives:

- to prevent personnel injury or loss of life;
- to prevent any environmental contamination;
- to prevent damage to equipment caused by accidents;
- to comply with all federal, state and local laws, rules and regulations.

### **b) Responsibilities**

The LIGO ES&H program is the responsibility of the Deputy Director. The Deputy Director has responsibility to insure that LIGO staff members and collaborators identify specific ES&H issues and risks, and establish appropriate safeguards and procedures for addressing those risks.

### **c) Environmental Protection**

The LIGO Laboratory shall follow standards and practices that fully support all applicable environmental protection policies and requirements.

### **d) Safety and Health Protection**

Caltech has an established Safety Office, responsible for the Institute's overall safety and health program, and LIGO management will implement the applicable health and safety program elements as outlined in the Caltech Safety Manual. The Caltech Safety Office policies will be applicable to the Observatory sites, supplemented by additional policies developed by LIGO staff in consultation with the Caltech Safety Office. For work performed at MIT, the safety and health protection measures adopted by MIT will similarly apply.

**e) Employee Training**

Laboratory employees will be provided with procedures, training and information to ensure their safety. Briefings and presentations will be made to managers and supervisors to communicate ES&H policies and procedures.

**f) Contractors, Collaborators and Visitors**

Contractors and visitors to the LIGO operational sites will be informed of ES&H rules and procedures applicable to the specific area. Hosts will be responsible for the safety of visitors.

**g) Documentation**

The LIGO Laboratory shall provide hazard assessments, safety analyses and evaluations as required. Specific procedures and training documents will be prepared and released.



## **12) Governmental Code Requirements**

The LIGO Laboratory, including its contractors, will comply with applicable US Federal Codes, laws and regulations, industrial codes and state rules, regulations and codes. The Business Office, together with the Deputy Director, will be responsible for clarifying compliance requirements and the resolution of safety issues.

## 13) Procurements and Subcontracts

### a) Policy

LIGO procurements occur at both Caltech (including the Caltech-managed Observatory sites) and MIT. These are processed according to the procedures established by the Purchasing Department at the host institution and approved by the Office of Naval Research under OMB requirements.

All LIGO facilities and equipment procurements will be processed and administered by the Caltech or MIT Purchasing Department depending upon the institution originating the procurement, assisted by the LIGO Laboratory staff.

Major procurements involving substantive subcontracts must be approved or concurred with by the NSF Division of Acquisition and Cooperative Support, in accordance with the terms and conditions of the Cooperative Agreement. The NSF Division of Acquisition and Cooperative Support will generally pre-approve such subcontracts based on information submitted by Caltech/LIGO as part of the yearly work plan and the recognition that the Caltech Procurement System has been fully validated for purchases under federal grants and contracts. In those cases where the NSF Division of Acquisition and Cooperative Support requires additional information to approve a subcontract NSF will inform Caltech/LIGO so as to allow the needed additional to be provided in a timely manner.

LIGO Laboratory staff performs subcontract technical and programmatic management. All procurements and subcontracts will be subject to the terms and conditions of the Cooperative Agreement and the requirements of land sale and lease documents pertaining to the LIGO Observatory sites.

### b) Responsibilities

The LIGO Deputy Director is responsible for ensuring that all aspects of LIGO facilities and equipment procurement are managed and planned successfully. An acquisition plan will support the procurement approach for major procurements. The Deputy Director, in association with the Executive Director, shall approve all major subcontracts. The Business Office is responsible for preparing, facilitating and administering the documentation associated with major LIGO procurements. The cognizant technical Task Leaders will initiate subcontracts and procurements. Working closely with the Business Office, the Task Leaders will be responsible to assure that all procured components, items, services and construction are produced and delivered as required to support the LIGO Laboratory objectives. The Task Leaders will also provide technical direction and oversight of these contracts and procurements.

### c) Approach

Procurement policies and procedures, embodied in the Caltech Purchasing Policy and Procedure Manual, will be utilized for all facilities and equipment procurement actions originating at Caltech. This manual establishes compliance with the NSF Cooperative Agreements. All major procurements that require NSF concurrence will be identified and scheduled in the annual Work Plan. Similarly, LIGO Laboratory procurements originating at MIT may be placed using

corresponding policies and procedures at MIT. Both Caltech and MIT have procurement systems approved by the Office of Naval Research under OMB requirements.

## 14) Reporting and Reviews

### a) Annual Report

The LIGO Laboratory through the Caltech Office of Sponsored Research will submit an Annual Report to the NSF by September 1 containing a summary of overall progress during the past year, including results to date, and a comparison of actual accomplishments with the proposed goals of the currently approved Work Plan; an indication of any current problems or favorable or unusual developments and any other pertinent information. The Annual Report will also contain the annual Work Plan and funding request for the one-year period beginning October 1. The Work Plan will summarize the proposed goals for R&D, science and collaborative programs for the program year for which funds are sought. Proposed staffing levels, significant staffing changes, an organization chart, and an explanation of changes in the LIGO organization will be presented.

The Work Plan shall include a calendar of proposed meeting dates for the LIGO Program Advisory Committee, scientific workshops and reviews and an acquisition plan for all procurements in excess of the current level that requires NSF approval, including the proposed date of submission to NSF and the type of procurement.

The Annual Work Plan is prepared in accordance with the most current version of the NSF Grant Proposal Guide.

### b) Reporting

The Caltech Office of Financial Services submits to NSF a quarterly reconciliation report covering all NSF sponsored grants at Caltech, including LIGO. This report identifies the incurred expenditures for the quarter, cumulative expenditures effective at the close of the quarter, and the available balance against the allocation for the LIGO Laboratory.

Caltech will submit for approval by NSF all collaborative Memoranda of Understanding.

### c) NSF Site Visits/Panel

The NSF will conduct periodic site visits to review LIGO activities.

The NSF will convene Panels to conduct periodic reviews of the LIGO Laboratory, covering technical and management issues. NSF shall provide the Laboratory with a copy of the charge to the Panel prior to the review, with adequate time to agree on the agenda and to prepare the necessary presentation material.

## 15) **Workshops**

The LIGO Laboratory will sponsor or participate in workshops on specific topics relevant to the development of gravitational-wave interferometers. The frequency of such workshops and the topics they address will be determined in consultation with interested outside scientists, such as the LIGO Scientific Collaboration and the other international groups pursuing laser interferometer gravitational-wave detection.

## 16) **Technical Reports**

To enhance the participation of the general scientific community in gravitational wave research, the LIGO Laboratory will continue the publication of research results in refereed journals, and will make unpublished internal technical reports available to the NSF and to the general scientific community on request.

## 17) References

LIGO Umbrella Cooperative Agreement 2008-2016, PHY-0328418 between the National Science Foundation, Washington, D.C. 20550 and the California Institute of Technology, Pasadena, CA 91125, dated April 2008.

Cooperative Support Agreement 2009-2013, PHY-0757058 - The Operation and Maintenance of LIGO, between the National Science Foundation, Washington, D.C. 20550, and the California Institute of Technology, Pasadena, CA 91125, dated October 2008.

Advanced LIGO Cooperative Support Agreement 2008-2015, PHY-0823459 - The Construction of Advanced LIGO, between the National Science Foundation, Washington, D.C. 20550, and the California Institute of Technology, Pasadena, CA 91125, dated April 2008.

Proposal PHY - 6679387, LIGO Continuing Operations (FY 2009 – FY 2013), September 2007.

<http://www.ligo.caltech.edu/>

<http://www.ligo.org>

Figure 1 LIGO Organization

# LIGO Organization

