LTER

Network Office

Operational Plan (2009 – 2015)

Version 2.0, May 5, 2010

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Note: Version 2.0 of the LNO Operational Plan is modified from Version 1.0 to reflect recommendations from the Reverse Site Visit in March 2010 and subsequent decisions on budget reallocation made by NSF in May 2010

Operational Plan for Activities of the LTER Network Office

1. Introduction and goals

The Long Term Ecological Research (LTER) Network Office (LNO) is responsible for planning, implementing, and supporting activities that advance the goals of the LTER Network. With funds from the National Science Foundation (NSF), the LNO carries out these activities as defined in two Cooperative Agreements (CA) with NSF with additional guidance from the Executive Board (EB) of the LTER Network. Specifics of each activity are described in proposals to the NSF that are examined by external reviewers and evaluated by a panel of experts selected by NSF.

In 2008, the LNO submitted a renewal proposal to NSF to continue core operations and add new tasks in synthesis and cyberinfrastructure development, based on the goals of the LTER Decadal Plan (http://www.lternet.edu/decadalplan/). This renewal proposal described 17 activities organized around four thematic areas: Synthesis, Cyberinfrastructure, Core Services, and Development and Outreach. Selected activities described under the Cyberinfrastructure theme are designed to support the research activities under Synthesis through the development of a network information system. The partnerships formed and the training to take place under the Development and Outreach theme inform the development and support the use of the network information system. The Core Services theme describes the underlying role of the LNO in supporting all LTER activities. The NSF funded the renewal proposal in 2009 through two separate Cooperative Agreements.

One of these Cooperative Agreements with the NSF incorporates funds from the American Recovery and Reinvestment Act (ARRA). As part of cost-accounting measures associated with awards using ARRA funds, the NSF requires specific details on the planned expenditure of funds. In the case of the LNO Cooperative Agreement, the NSF requested the development of a detailed operational plan describing the ten activities to be carried out with ARRA funding and the costs associated with those activities. The NSF further requested that the LTER Executive Board be closely engaged in the development of this operational plan by the LNO and that external reviewers inform the development of that plan. The Executive Board further stipulated that all activities carried out by the LNO be incorporated in this plan, including seven activities funded with regular programmatic funds.

The LNO has undertaken to develop an operational plan that provides detailed information on each activity funded by the NSF. With guidance from NSF and the Executive Board, the LNO has prepared standard descriptions of each activity, linking these with effort (Table 1) and cost (Table 2) budgets to provide clear links between activities, personnel, and expenditures. This operational plan has been reviewed by the Executive Board, relevant LTER committees, and a panel of outside experts chosen for their knowledge of the technical aspects of cyberinfrastructure and information management. The operational plan forms the basis for future evaluations of the performance of the LNO.

2. Steps in the development of the operational plan

The terms and conditions of Cooperative Agreement DEB-0936498 to the University of New Mexico (UNM) specify the preparation of an operational plan and describe in general detail the elements of such a plan. Based on these instructions, and with additional guidance from NSF and the Executive Board, the LNO developed a process to draft an operational plan to fulfill the requirements set forth by NSF. This process consists of the following steps.

A. The LNO prepared a general outline of the operational plan with key elements for review and comment by the Executive Board.
B. Once approved by the Executive Board, the outline provided a framework for further discussions of groups of activities clustered into four thematic areas (Synthesis, Cyberinfrastructure, Core Services, and Development/Outreach). Sub-committees consisting of members of the Executive Board were assigned responsibility for detailed review for each of the thematic areas.
C. The sub-committees met in video-teleconference to review LNO activities in each thematic area. The LNO Executive Director presented the details of each activity to the respective sub-committees, who provided comments on the appropriateness of each activity and the allocation of resources.
D. Once the Executive Board sub-committees approved activities proposed in each thematic area, LNO staff undertook to prepare standard descriptions of each activity that included information required by the NSF and the Executive Board.
E. When necessary, LNO staff consulted with the relevant sub-committees to resolve questions on content and presentation of the descriptions of each activity.
F. The LNO proposed members for the external advisory group to the Executive Board, which had final say on the composition of the advisory group.
G. A first draft of the operational plan was prepared by LNO staff under the supervision of the Executive Director. The Executive Board, the LTER Information Management Committee, and the Network Information System Advisory Committee (NISAC) reviewed the draft plan.
H. Based on comments from this review, LNO staff prepared a second draft of the operational plan for review by the external advisory group, the Executive Board, the Information Management Committee, and the Network Information System Advisory Committee.
I. The external advisory group, the Executive Board, and the co-chairs of the Network Information System Advisory Committee met with LNO staff for three days in January 2010 to deliver detailed comments on the second draft of the operational plan.
J. Based on these comments, LNO staff prepared a third draft of the operational plan for review by the Executive Board.
K. After receiving comments from the Executive Board, the LNO prepared the final draft of the operational plan, which was submitted to the NSF along with the comments of the external advisory group.
L. In March 2010, the LNO underwent a reverse site review at NSF. Recommendations from that reverse site visit (Appendix B) have been incorporated into the current version of the LNO Operational Plan.

3. The LNO Operational Plan

The operational plan contains the following information for each of 17 activities in four thematic areas: 1) description of activity, 2) outcomes of activity, 3) operational steps to carry out activity, 4) milestones, 5) process for reviewing progress and evaluating success, 6) benefits to the LTER community, its external partners, and the larger U.S. scientific and education community, and 7) mechanisms to garner feedback from the LTER community and external communities of science and education. The descriptions of each activity are designed to provide sufficient information to understand purpose, outcomes, and impacts. The 17 activities are aggregated below into four task areas: Synthesis, Cyberinfrastructure, Core Services, and Development and Outreach.

3.1 Synthesis

3.1.1 Science Council. Support annual meetings of the Science Council as well as planning meetings in support of its activities.

Background: As part of the new governance structure for the LTER Network, the LTER Bylaws have been amended to create a new entity, the Science Council (SC), comprised of two members from each of the 26 LTER sites and the chairs of standing committees. The SC "has the responsibility to provide leadership and planning for cross-site research and education, to develop proposals for the conduct of Network-level science, to interact with existing and emerging networks, to develop products that synthesize Network-level data and information, and to otherwise manage the science affairs of the LTER Network". The Bylaws require an annual meeting of the SC, and the LNO is responsible for supporting this meeting. The intended long-term impact of SC activities is an increase in operational coordination of science, synthesis, and education across the LTER Network.

Description of Activities: The LNO funds participant travel and lodging for the annual meeting of the SC as well as any additional required expenses (e. g., meeting rooms, audiovisual). The LNO also supports planning and visioning meetings associated with SC activities. The budget associated with the SC is $624,990 for six years to cover participant travel of the SC and 0.15 FTE of personnel time to support the meeting. The Executive Director (ED) and the Director for Synthesis Support (DSS) help develop the agenda, supervise meeting preparations and logistics, prepare materials and online databases, participate in the meetings, and record the accomplishments of the meetings.

Outcomes: Outcomes of the operations of the SC include enhanced Network-level synthesis, increased scientific coordination across and beyond the LTER Network, increased funding for synthesis, evolving strategic plans, and effective governance. Synthesis activities of the SC produce Network-level science publications and synthesis volumes, lay the groundwork for proposals to conduct Network-level science and education, and result in advances to the Network research and education objectives. In addition, the SC performs several administrative functions, including resolution of issues from sites or the Executive Board, approval of Bylaw changes, and election of the Chair. The LNO also supports the SC by producing a persistent record of its activities and decisions.

Operational steps:

1. The ED works with the SC to determine a rotating schedule of host sites.
2. Twelve months prior to meeting, the DSS contacts the host LTER site to prepare overall logistics and venue.
3. The DSS works with EB in determining specific science content for the meeting.
4. The DSS publicizes meeting plans to LTER scientists and establishes a web presence for the meeting.
5. The ED and DSS coordinate efforts of LNO and host site staff for logistic support and overall meeting planning.
6. The ED ensures that all aspects of the meeting related to logistics, including participant travel, lodging, food, and meeting rooms are provided.
7. The ED and the DSS attend the SC meeting and provide logistical assistance in support of science efforts of attendees.
8. The DSS records and preserves all meeting activities and science content such as presentations, working group products and other materials as a permanent record of the meeting.
9. The DSS creates, administers, and analyzes a simple meeting survey to obtain feedback from the meeting from participants.
10. The DSS makes results of the meeting available to LTER scientists.

Milestones:

- ♦ The Chair, the ED, and the host site set meeting dates approximately 12 months before the meeting.
- ♦ The ED contacts the host site to select venues approximately 9 months before the meeting.
- ♦ The ED and DSS work with LNO staff on a monthly basis to coordinate overall meeting logistics including travel, housing and food for attendees.
- ♦ The ED and the DSS attend meeting for coordination, and to provide onsite support for science presentations and working group meetings.
- ♦ The DSS records activities and archives records of meeting including results of working group meetings and other products resulting from the meeting within 30 days of the meeting.
- ♦ The DSS collects and publishes feedback from participants through comments and survey results within 30 days of the meeting.
- ♦ The DSS receives, documents, distributes, and archives subsequent products for on-going and new Network level science efforts.

Evaluation: The EB will annually evaluate the LNO's support of SC science efforts through direct experience and feedback from participants. The overall success of the meeting and science products from the meeting will be evaluated by the SC.

Benefits: SC meetings will increase the pace and scope of synthesis in the LTER Network and contribute to attaining the goals of the Decadal Plan. LTER scientists and educators benefit from coordination of scientific endeavors, strategic planning, and governance activities conducted at SC meetings. Increased funding for synthesis resulting from proposals developed by the SC benefits LTER scientists and educators as well as their external partners. The larger scientific and education community benefit directly from science products (e.g., new theory, insights, knowledge) resulting from SC meetings as well as from new scientific initiatives arising from these meetings.

Feedback: Feedback regarding support of Science Council meetings comes from comments from participants of the meeting and site principal investigators as well as survey results.

3.1.2 All Scientists Meetings. Foster integration within and among Network research projects by organizing periodic meetings of the entire LTER research community.

Background: The LTER Bylaws charge the LNO with organizing and implementing the triennial LTER All Scientists Meeting (ASM). The ASM is a key event for LTER to bring together site scientists, students and staff to plan and organize future scientific endeavors. The ASM is an intensive effort over three and a half days consisting of approximately 800 people with over 400 poster presentations and more than 75 working groups. Ancillary meetings of information managers, students, education specialists, international partners, and other groups are also scheduled before or after the ASM to take advantage of common travel and meeting space. Key results of ASMs include: formation of new collaborations; sharing of data and ideas; integration of graduate students, educators, and international collaborators into the LTER community; advancement of theory through comparison of conceptual models; identification of transformative research; and coordination of research strategies and standards across the LTER Network. The impact of the ASM is an increase in the cohesiveness of the LTER scientific enterprise.

Description of Activity: The total budget for this activity is $200,520 over six years to support 0.20 FTE of personnel time in support of ASMs. Operational costs of the meetings are covered through supplement proposals prepared by the LNO in anticipation of each meeting. The Executive Director and the Director for Synthesis Support supervise the planning and organization of All Scientists Meetings in 2009 and 2012 and plan the 2015 meeting. They coordinate the activities of the LNO staff that provide logistical support throughout the ASM. They identify possible meeting venues for consideration by the Executive Board, contract the meeting venues and make down payments, work with the program committee to develop meeting agendas, coordinate other activities associated with the meetings, work with a professional meeting organizer such as the Schneider Group, contract service providers (e.g., for Internet, audiovisual, poster boards, coffee breaks and refreshments), issue invitations, write supplement proposals to fund half of the participants, and preserve meeting documents and materials.

Outcomes: LNO efforts result in well-organized and cost-effective meetings that meet the varied needs of the LTER community, generate new ideas and synthesis products, and build new partnerships and collaborations that enhance the breadth and productivity of LTER research.

Operational Steps:

1. LNO staff review past efforts from the ASM preserved within the LTER document archive as well as LNO records, invoices, ASM participant surveys and other historical items from previous ASM efforts to prepare cost estimates and form logistical plans
2. Based on planned timing of the ASM as decided by the EB, the DSS investigates potential meeting venues and prepares meeting options for decision by EB.

3. The ED and DSS contact the selected meeting venue and develop a meeting contract that corresponds to UNM regulations, including any required down payments.
4. The ED and DSS act as liaisons between the venue and the LNO for additional planning.
5. Working with professional meeting planners, the DSS develops a list of vendors and services for the meeting and supervises the solicitation of cost estimates by the meeting planners.
6. The ED and/or the DSS visit the meeting venue if needed to determine specific requirements for the ASM
7. The ED and the DSS work with NSF staff to secure partial participant support costs.
8. The ED co-chairs a volunteer program committee of LTER scientists to determine the scientific content for the meeting.
9. Working with LNO staff, the DSS establishes a web presence for ASM planning, logistic coordination, and meeting content as well as publications and products resulting from the meeting.
10. The DSS working with the program committee establishes deadlines for poster abstract submissions, speaker presentations and other meeting content with recommendations by the EB.
11. The DSS works with LTER partners within the broader ecological communities including the International LTER, other agencies, and NSF for collaborative interactions during the meeting.
12. The ED supervises LNO staff in arranging and coordinating travel of participants and guests (speakers, NSF staff and other agency people) for the meeting.
13. The DSS is the liaison with the meeting planners to address any issues from the meeting; they jointly develop function sheets and other planning materials that describe needs and time for required space, audiovisual, vending, and other venue requirements.
14. The ED and DSS attend and supervise all elements of the meeting.
15. The DSS collects, archives, and makes available a persistent record of meeting activities and accomplishments.

Milestones:

- Twelve months before the meeting, confirm venue, potential funding and estimated participation by LTER and the broader community.
- Twelve months before the meeting, organize a LTER program committee for the meeting
- Twelve months before the meetings and as available, provide information to the LTER community and external partners regarding dates, location, travel, lodging, registration, working groups, posters, ancillary meetings and other unique aspects of the ASM.
- Between 3 and 12 months before the meeting, determine all needed logistics for the ASM with venue and associated vendors regarding housing, meeting rooms, food and beverages.
- Eight months before the meeting, implement a web page for meeting content, including meeting registration and working group and poster submission pages.
- Six months before the meeting, provide information on travel support to LTER sites.
- Between two and six months before the meeting, organize speaker presentations, working group meetings, poster presentations and other scientific content for the meeting based on input from the ASM Program committee and the EB.
- During and following the ASM meeting, acquire, archive, and make accessible all products from the meeting.

Evaluation: The performance of the LNO in organizing and supporting the meeting is assessed by the EB in ASM years as part of the annual evaluation of the LNO. The EB's evaluation will be informed by a participant exit survey administered by the LNO that covers important aspects of the meeting, unsolicited comments from meeting attendees, and EB evaluation of the ASM experience.

Benefits: The outcomes from successful ASMs include measurable increases in cross-site and Network-level science, an increased pace in development of synthesis products, the formation of new collaborations, the development of new LTER science themes, and better integration of graduate students and new scientists into the LTER community. These outcomes directly benefit the LTER scientific and education communities and their external partners. In addition, the scientific outcomes from ASMs lead to new ideas and LTER-led initiatives that benefit the larger scientific and education communities.

Feedback: Feedback comes from comments, emails, and other communications directly by meeting participants as well as from the preparation, administration and evaluation of a participant exit survey covering important aspects of the meeting. The results are presented to the EB for specific review and comment.

3.1.3 Research Working Groups. Provide support for Network research goals by funding working groups and intensive research visits for project scientists and facilitating planning and visioning meetings to address the objectives of the Decadal Plan.

Background: The activities that produced the Decadal Plan created new research collaborations among LTER scientists and with scientists from other disciplines, especially the social sciences. These new collaborations need additional resources to encourage their further self-organization. Following guidance from the EB, the LNO provides and coordinates funding to individuals and research groups for this purpose. The working groups that receive LNO support are expected to produce specific products directed at new Network-level research activities. The LNO ensures that proposed synthesis activities are carried out and preserves and documents products from research working groups.

The Decadal Plan also focuses on long-term, social-ecological questions in specific thematic areas that will be targeted for follow-on ASM activities. The Decadal Plan presents the broad outlines of a research program in each thematic area, but additional specifics need to be developed. Planning workshops that ask participants to identify individual questions, observations, experiments, and modeling activities within thematic areas and to specify corresponding education and cyberinfrastructure needs can help develop the details required to advance the Decadal Plan, and the Executive Board has requested the LNO to support these workshops.

In accordance with the guidance of the EB, we have combined research working group opportunities and planning/visioning opportunities into one activity. The total budget for this combined activity is $1,268,458 for six years to support participation in research and planning meetings as well as 0.20 FTE of personnel time annually to manage the disbursement of funds, coordinate meeting logistics, and maintain a database of meeting products.

Description of Activity: Following recommendations of the EB, the LNO supports self-organizing groups of site scientists by funding working groups to produce specific research products such as publications, experimental designs, new databases, or common standards. The LNO also provides support for Decadal Plan visioning and planning activities resulting from Science Council activities related to specific focus areas of the Decadal Plan. The LNO may also provide support to allow LTER researchers to focus on short-term synthesis projects that support the Decadal Plan research objectives. These could be short-period support at a specific institution, LTER site or at the LNO to produce a specific product related to Decadal Plan research efforts. The LNO may also provide funds to support a Site Information Manager in selected working groups to communicate research requirements to Network Information System developers.

The Executive Director and the Director for Synthesis Support ensure logistical support in coordination with other LNO staff. This includes soliciting, and collecting proposals to establish these efforts and coordinating their evaluation with the EB. LNO also organizes and maintains records of annual competitions to disburse funds related to these efforts, with proposals evaluated by the EB or their delegated representatives. The DSS, with support from LNO staff, works closely with all funded research working groups to record, preserve, and publicize all products resulting from the research working group efforts.

The Chief Information Officer (CIO) and the Network Information Manager (NIM) will work closely with research working groups to facilitate discovery and acquisition of data through the Network Information System (NIS). They will also provide working groups with guidelines and best practices established by the Information Management Committee (IMC) to manage derived data products. In some cases, the LNO may provide funding for a Site Information Manager (SIM) to carry out this function. Where applicable, the process for creating derived data products will be captured and used to inform use case scenarios that will inform the development of the Network Information System (NIS).

Outcomes: Research working groups establish new partnerships and collaborations that advance a new body of theory in social ecology as one element of a developing strategy to meet Decadal Plan objectives over a range of funding scenarios. The working groups enhance the breadth of LTER research and increase the pace of synthesis by producing multidisciplinary, multi-site publications such as databases, models, books, monographs, and special issues of journals.

The proposed planning groups will produce detailed steps for achieving the science goals of the Decadal Plan; a timeline for the staged implementation of those steps; and interim objectives for LTER sites and scientists. The proposed workshops will lead to a better balance between support for site-based research and Network-level collaborative synthesis. The eventual outcome will be achievement of the goals of the Decadal Plan.

Operational steps:

1. The LNO solicits proposals annually for research working groups and follow-on collaborative discussions held during ASMs or other interactions.
2. Proposals are collected and organized for review by the EB.
3. Logistics for successful proposals are coordinated by the DSS with LNO staff, including on-site support and collaboration as required by each of the activities.
4. The DSS facilitates identification of pertinent data sets from the NIS.

5. The CIO and NIM (or a SIM) provide guidance on best practices for creating and managing derived data products.
6. The CIO and NIM (or a SIM) collect information on the creation of the derived data products and transmit to the NIS developers.
7. Products of working groups are collected, documented and publicized.
8. Solicitations for support of Network-level planning and visioning projects are made following directions from the EB
9. Logistics and science support of planning and visioning projects are coordinated by the DSS with support from LNO staff

Milestones:

- ♦ The DSS prepares and distributes annual solicitation for research working groups.
- ♦ The DSS arranges for the review of proposed working groups with the EB
- ♦ The DSS provides any required support for funded planning and working group efforts.
- ♦ The DSS acquires, archives, and distributes research products from working groups and planning meetings as they become available.

Evaluation: The EB evaluates performance of the LNO in supporting working groups as part of its annual evaluation.

Benefits: LTER scientists and educators and their external partners are the primary beneficiaries of working groups and planning meetings. Working groups provide opportunities for the LTER community to mature and advance collective ideas and to create products such as publications, reports, proposals, and databases. Planning meetings allow LTER scientists and their partners to construct new initiatives and partnerships that advance the common good. Support, documentation, and preservation of products from research working groups and visioning meetings advance Network-level research at a pace beyond what would be achieved within the previous framework of activities of the LTER Network.

Feedback: Feedback to advance these activities comes from individual working groups, direct comments by LTER scientists, biennial surveys of the LTER community, and review from the EB.

3.2 Cyberinfrastructure

Background: Developments in cyberinfrastructure (CI) that promote connectivity allow the distributed members of the LTER network to act and feel as part of a close community. Transparent email addresses, a common web presence for public access to LTER science, video teleconferencing, an intranet for building the LTER knowledge base, a shared data catalog that provides metadata for all LTER data sets, systems for the hosting and curation of databases, special-interest websites, and more help to create a sense of community that fosters intersite and network-wide synthesis. The LNO supports Network CI by offering services that both meet the needs of the community (e.g., specialized mail lists) and keep pace with evolving technology (e.g., virtual machine hosting). The CI activities described below are supportive of and in harmony with the implementation of the LTER Network CI Strategic Plan, and will provide critical services to the LTER community through four activities:

- improving the operation of the LNO computing, communication, and collaboration infrastructure;
- supporting the development, communication, implementation, and standardization of information management procedures, policies, and practices;
- completing the development and implementation of the LTER Network Information System framework; and
- offering on-site and web-based group and individualized consulting services for improving and maturing site information management practices.

3.2.1 Basic Cyberinfrastructure Support. Provide basic cyberinfrastructure support to the LTER network to enable collaboration, communication, and security.

Description of Activities: The CIO, System Administrator, and Systems Analyst maintain and operate the hardware and software that provide required computing and communication services for LNO and the LTER Network. These include support and management of application servers, support for local and network file services, support for the software development process, and support for training. The supported hardware and software includes five multiprocessor production servers for network mail lists and local mail handling, database management systems, a web content server, the Metacat data catalog, and a virtual machine server hosting 8 lightweight, fail-over, and development machines. Two file servers support administrative applications including home directories and archives, backups, and shared-access storage. LNO staff conduct daily system health checks, security screenings, backups, routine maintenance, repair and replacement of equipment, update verification, system upgrades, and interactions with sites on hosting and email issues. In addition, the CIO, Systems Administrator, and Systems Analyst plan for, implement, and operate collaboration and communication technologies to support video teleconferences. Finally, they administer desktop and laptop computers for all LNO staff and for the LNO training laboratory.

The budget for this activity is $1,977,073 for six years. In addition to 3.35 FTE of personnel time to conduct the activities described above, additional resources are budgeted for recurring costs of computer services (e.g. licenses and maintenance contracts), equipment replacement, materials and supplies, and travel for LNO and Sevilleta LTER (SEV) staff to annual information management meetings.

3.2.1.1 Operation of video-teleconferencing services for LTER committees and working groups. LNO supports high-quality, low-cost, standards-based video-teleconferencing (VTC) for the Network, including regular monthly VTCs for the LTER EB and Information Management Executive Committee (IMExec). This service is made possible by a Polycom teleconferencing bridge and gatekeeper software that is operated by the LNO. The bridge supports up to 48 simultaneous connections.

Outcomes: Video-teleconferencing services increase the level of interaction, by extending access to internet-based video-teleconferencing for synthetic interactions to more LTER scientists. An eventual goal is to find and implement technology that will permit virtual meetings of representatives of the 26 LTER sites, thus increasing the frequency of Network interactions.

Operational Steps:

1. The CIO ensures the communication of accessibility of VTC to LTER members on an annual basis and maintains a web-based document detailing VTC options, pricing, protocol, etiquette, and scheduling information.
2. The CIO maintains communication with UNM Media Technology Services (MTS), where the bridge and server are physically housed, to schedule maintenance and upgrades, and to assure a good working relationship with MTS.
3. The CIO meets with the Systems Analyst twice weekly to discuss the VTC schedule and any scheduling or technology issues.
4. As needed, the Systems Analyst verifies site/researcher access to VTC technologies and facilitates the delivery of hardware and software to new members of specific groups (e.g., EB) along with installation and configuration support.
5. Groups wishing to use the VTC conferencing capability poll their members and contact the Systems Analyst to verify availability of the bridge space and provide a list of conference participants.
6. The Systems Analyst verifies the details of each participant,
7. The Systems Analyst confirms participation of each person and connection accuracy for each participant via phone or email.
8. The Systems Analyst programs reservations for meetings into the bridge management software so that participants are automatically contacted at the correct time.
9. The Systems Analyst establishes the call and monitors the call for quality and connection interruptions.
10. When requested, the Systems Analyst produces and archives a digital recording of the call.

Milestones: Each scheduled VTC becomes a milestone, and the successful completion of each VTC is recorded with pertinent information about purpose and participants.

Evaluation: A summary of annual effort, including number and kind of VTCs supported and the number of participants, is included as part of the LNO annual report to EB and NSF, which informs the annual performance evaluation of LNO.

Benefits: This activity benefits the LTER Network and its partners by increasing the quality and quantity of productive interactions among LTER scientists and between the LTER Network and other networks, centers, institutes, and agencies.

Feedback: Feedback on this service will be based on questions included in the biennial survey of LNO performance conducted by the EB.

3.2.1.2 Web presence improvements for collaboration and presentation. The LNO maintains web sites targeted at constituencies including the general scientific community, the LTER Network, and specific focal groups. To increase the quality of and access to web-based information content, the Application Support Analyst (ASA) will augment the current web applications to support Network committees, working groups, and special interests with basic web publishing and collaboration tools. To provide sufficient time from regular duties for the Application Support Analyst to evaluate and implement new technologies that meet user needs, the LNO will recruit a new Professional Intern to conduct maintenance activities on the LNO web sites. The professional intern will, in addition to other duties, review content for out of date information, perform regular and time critical updates to web content, conduct tests of web site operation, and respond to user requests for assistance. In addition, the professional intern will make changes to web content as directed by the LTER Network communication plan when it is completed.

Outcomes: This activity will increase the quality of users' web experience and the delivery of web-based content, and provide a better response to user requests.

Operational Steps:

1. The CIO and ASA will annually recruit a web-savvy intern or will evaluate the existing intern for renewal.
2. The ASA will request targeted feedback from committees on their web-based collaboration needs.
3. The CIO, ED, and ASA will discuss and plan annual priorities for web improvements informed by feedback from biennial surveys and unsolicited recommendations from users and the impending communication plan.
4. The CIO and ASA will develop a review schedule for the professional intern to follow providing for content evaluation, link checking, date checking, presentation consistency, regular reviews of committees membership, chairs, etc.

Milestones:

- Annual priorities for web improvements set in January.
- Quarterly reviews of progress for interns.
- Annual web priorities achieved.

Evaluation: Using information from annual reports, outcomes from biennial surveys of users, and performance guidelines established annually, the EB will recommend changes to procedures and priorities.

Benefits: This activity will benefit all visitors to LTER network web sites including LTER scientists, external partners, the larger U.S. scientific and education community, and the general public by providing improved information content and accessibility.

Feedback: Feedback on this service will be based on questions included in the biennial survey of LTER Network Scientists. Feedback from external partners and the larger scientific and education community will be solicited through a feedback form placed on all websites to encourage comments and recommendations.

3.2.1.3 Technology improvements. This activity provides for needed replacement, upgrade, and improvement of LNO computing infrastructure to support network information services, local desktop computing, and training. The LNO CIO and System Administrator will upgrade server hardware and peripherals twice during the CA period to include storage consolidation and a greater reliance on virtual machine systems for non-intensive and fail-over applications (Table 3). The Systems Analyst will upgrade hardware and peripherals in the Informatics Training Laboratory (see Section 3.4.2 below) twice during the CA period. The Systems Analyst will also perform annual updates of desktop computing equipment on a phased schedule that provides replacement or rotation of CPU units roughly every three years.

Outcomes: LTER Network activities serving science and education are conducted in a secure, modern, and efficient computing environment with adequate resources for growth and development.

Operational steps:

1. The CIO, Systems Administrator, and Systems Analyst will develop a replacement/upgrade schedule for servers, desktop computers, and training lab computers.
2. The CIO will discuss configuration and quotes with vendor.
3. The CIO will present a plan during year 2 to the ED for approval and hand-off to administrative staff for procurement.
4. The Systems Analyst will receive and check-in new equipment upon arrival.
5. The Systems Analyst and Systems Administrator will schedule equipment installation, stage the equipment, and do basic system checks prior to software installation and configuration.
6. The CIO, Systems Administrator, and ASA will discuss any configuration issues and schedule the bringing on line of new equipment and services.
7. The CIO will revise the schedule as needed based on requirements and technology changes. Steps 2-6 will be repeated for each year's procurement.

Milestones:

- By the end of 2010, develop a technology enhancement/replacement schedule.
- By the end of each calendar year, deprecated desktop computing equipment has been replaced, refurbished, or recycled and appropriate adjustments made to inventory according to the schedule.
- In year 2011, new virtual machine hardware and consolidated storage are purchased and configured.
- In year 2012, existing servers are retooled to use consolidated storage system.
- In year 2014, new hardware to replace aging production servers purchased according to revised schedule.

Evaluation: Equipment is placed into use/production according to schedule.

Benefits: This activity will benefit the LTER Network, its external partners, and the external science and education community by allowing uninterrupted computing and web-based services in an efficient and cost-effective architecture.

Feedback: Service performance will be evaluated at monthly meetings of LNO staff and through biennial surveys of the LTER community. Comments and recommendations from external communities will be solicited through a feedback form placed on all websites to encourage comments and recommendations.

3.2.1.4 Communication. The CIO and Systems Analyst will acquire, deploy, and maintain "rich media" recorders to capture and stream presentations via the Internet. Through an investment by UNM in this technology, the LNO will be able to leverage an additional recorder for loan to working groups and committees as needed. The annual LTER mini-symposium at NSF, critical science council presentations, and the triennial All Scientist Meeting plenaries are but a few examples of events that should be preserved through recordings. In addition, LNO will use this technology to capture and stream training and security sessions.

Outcomes: The new capacity to record and stream LTER presentations will improve outreach to the LTER and external scientific, education, and information management communities.

Operational Steps:

1. The CIO and Systems Analyst will purchase and set up rich media recorders for operation in coordination with the vendor and UNM MTS.
2. The vendor will train necessary LNO staff in the transport, setup, and operation of the recorders.
3. The Systems Analyst will accompany equipment to NSF to capture and stream annual LTER Mini-symposium.
4. The CIO will communicate the capability to the network and solicit requests for use while developing a plan for prioritization and use of the equipment in coordination with the LTER Network communication plan.

Milestones:

- In 2009, three rich media recorders will be purchased and configured for operation with the UNM MTS servers.
- In 2010, necessary LNO staff including the Systems Analyst will be trained in setup and use of the equipment.
- In March of 2010 and each year subsequent, the Systems Analyst will successfully capture and stream the LTER Mini-symposium at NSF for the broader LTER and external science, education, and information management communities.
- In 2011, the CIO will develop a plan based on 2010 demand, use, and feedback for operation and prioritization of the technology.

Evaluation: Annual milestones are met and use and demand are included in annual report to EB and NSF. The CIO reports results and plan of operation as part of LNO annual report to EB and NSF.

Benefits: This activity will benefit the LTER network and the external scientific, education, and information management communities by enabling communication of LTER science and technology to a broader audience.

Feedback: Feedback will be sought on the effectiveness of this effort by including questions on the biennial survey and providing a feedback form directly from the web application.

3.2.1.5 Cyber-security and Data Management Web-based information events. The CIO, NIM, Systems Administrator, and Systems Analyst will develop and support communications about data management, cybersecurity, and other timely and related computer and data security issues to LTER scientists, staff, and students through webcasts and associated web-articles developed for this purpose. Each year, the LNO will offer four technology transfer web events including "how to" and "best practice" guidelines on network and computer security. This activity is dependent on completion of 3.2.1.4 above.

Outcomes: The activities described above will increase awareness and understanding of data management and security issues for LTER scientists, staff, and students.

Operational Steps:

1. The CIO will garner feedback from a variety of sources on topics of interest and priority security items to be covered and will establish a production schedule that will be made available online.
2. The CIO will work with appropriate LNO staff to script the featured webcast.
3. The Systems Analyst will schedule production, secure space, see to operational readiness of the equipment, and capture and publish each webcast according to the schedule.
4. The Systems Analyst will announce the availability and URL of the next installment.

Milestones:

- By the end of calendar year 2009, production schedule is established and initial security topics identified.
- Annually, beginning in 2010 at least four security topics are produced, widely disseminated, and published to the UNM Mediasite server.
- Late in calendar year 2010, feedback on course effectiveness is sought via short web-based survey.

Evaluation: Annual milestones are met, and report and results of survey are included as part of annual report to EB and NSF.

Benefits: This activity benefits the LTER community by encouraging up-to-date knowledge of cyber and data security issues. Although the primary beneficiaries of this activity will be LTER scientists and information managers, the external scientific, education, and information management communities may also benefit.

Feedback: Feedback on this activity will be gathered via questions on the biennial survey as well as through a feedback form directly on the web application.

3.2.2 Information Management. Improve information management (IM) for the Network by supporting communication and coordination among SIMs, strategic data integration, data stewardship, curated data storage, and other data operations that promote Network synthesis and the creation of data legacies**.**

Description of Activities: The LNO supports meetings of the LTER IMC and the IMC steering committee (IMExec), which plans meetings. The CIO and NIM regularly exchange information with LTER SIMs regarding new technologies and developing information management practices. In addition, the LNO supports short working visits to the LNO by SIMs. The NIM manages the LTER personnel directory, all-site bibliography, site directory, data catalog and several synthetic databases. The budget for these activities totals $1,613,695 over six years and supports 1.60 FTE of personnel time to manage existing database and develop new data modules. In addition, resources are provided for annual and production meetings for information managers and compensation for sites whose information managers dedicate time to NIS activities.

Broader Impacts: New information management approaches will be embodied in new standard procedures and protocols that will be published as “best practices” documents. By improving information management at a Network level, the LTER Network will become a high quality data provider for scientists and educators and a repository of scientifically rigorous, richly documented data available for synthesis.

3.2.2.1 Information Management Committee meetings. The LNO will support annual IMC meetings to develop Network standard procedures and protocols, and to exchange techniques and technical information. The IMExec will meet once a year to plan and address critical issues, with meetings taking place at the LNO to reduce costs and increase interactions with the LNO staff.

Outcomes: These meetings will address Network information management challenges to development of synthetic datasets through the development of standard information management approaches. IMC will produce at least one new or revised IM approach or best practices document per year.

Operational Steps:

1. Every year, the IMExec will develop the agenda for the annual IMC meeting in consultation with the CIO.
2. CIO may present the agenda at the Spring NISAC meeting with support from the IMC members of NISAC.
3. NISAC may make recommendations to the IMExec to align NIS and IMC goals.
4. IMExec will coordinate meeting location and logistics with LNO core services.

Milestones (dates are generalized over 5 years; exceptions may exist):

- ♦ The IMExec meeting generates an agenda with CIO input in January/February.
- ♦ The NISAC reviews agenda in March.
- ♦ The IMExec initiates meeting request form with LNO core services in March/April.
- ♦ LNO core services sends out logistic information to participants.
- ♦ The meeting is held July-September.
- ♦ The IMExec generates annual IMC report to EB in April.

Evaluation: LNO performance in logistical arrangements will be evaluated in annual surveys; IMC performance in improving information management will be evaluated by EB.

Benefits: This activity will benefit the network information system by addressing standards for data content, metadata, and exchange specification. This activity will benefit the LTER Network and external partners by increasing the quality and quantity of data available for synthesis. The activity will benefit the community at large by continuing to contribute to a community 'standard of practice' for information management.

Feedback: LNO will receive feedback directly from participants on the value of the activity drawing on the IMExec post-meeting survey. LNO may receive feedback from NISAC on the value of these meetings to the completion of NIS development.

3.2.2.2 Information Management working groups and Site Information Manager travel The LNO will support working visits to the LNO or other sites by one or two SIMs per year and will support two product oriented workshops each year to address critical IM issues related to participating in the NIS.

Outcomes: Visiting information managers will develop and implement solutions for specific IM challenges affecting the Network including addressing the need for standard specifications for data format, metadata content, quality assurance/quality control (QA/QC), and exchange protocols. Product oriented working groups will each year address critical IM issues related to the NIS. For example, site database personnel will meet to determine functional requirements necessary to implement the water chemistry database requested by the Science Council. Product-oriented working groups may contribute to the development of IM approaches or best practices documents.

Operational Steps:

1. Annually NISAC will make recommendations to the IMC and LNO on priority areas of the NIS development where SIMs could make a valuable contribution.
2. Every year information managers will develop working group proposals and travel proposals.
3. Information managers may discuss proposal ideas with CIO to determine relevance to NIS.
4. CIO will receive proposals from individuals or coordinated through IMExec.
5. CIO will evaluate proposals for alignment with NISAC requests and may request NISAC feedback.
6. CIO will notify working group leaders and IMExec about funding decisions.

7. Working group leaders will complete LNO meeting request forms and arrange logistics with LNO core services.
8. Working groups will provide a progress report to LNO by Spring of the following year. They will complete work prior to the IMC meeting of the following year and provide a final report within 1 month of completion.

Milestones:

- NISAC makes recommendations to IMC and LNO in Q1.
- Proposals received from information managers at LNO by CIO in Q2.
- CIO evaluates proposals and notifies organizers in Q3.
- Meeting request form complete and logistics arranged in Q3.
- Work completed before the next IMC meeting.
- Meeting organizers provide report to LNO within one month of completion.

Evaluation: LNO performance in logistical arrangements will be evaluated in annual surveys; IMC working group performance in contributing to the network information system will be evaluated by EB.

Benefits: This activity will benefit the LTER Network by contributing effort to the completion of the NIS. The activity will benefit the broader scientific information management community by providing contributions to a community 'standard of practice' for IM.

Feedback: LNO will receive ad hoc comments from site management, working groups, and NISAC on the value of the activity.

3.2.2.3 Maintain Network databases. LNO staff manage the personnel, site characteristics, and bibliographic databases for the network. The Network Information Manager will have primary responsibility for the management of these Network databases. Network databases will be upgraded and migrated to a new framework through activities in 3.2.3.2.3. The new framework will include standardized data models based on IMC working group collaborations on this activity and will also include specific web service definitions based on use cases from IMC and others.

Outcomes: The outcome of this activity will be the consistent and up-to-date database of network and site information that can be used to support Network communication and synthesis activities.

Operational Steps:

1. The NIM will begin using existing web-based forms and email-based support system to maintain personnel, site characteristics, and bibliographic data sets.
2. NIM will work with NIS developers and IMC to chart an integration path for personnel, site characteristics, and bibliographic data to the Network Information System framework.
3. NIM will migrate existing data to the new framework.
4. NIM will assist sites in converting to the new framework for managing these data.

Milestones:

- The LNO sponsored working group on network database integration meets in 2010.
- Plan will be developed by the end of year 2 for the future curation of these datasets.
- Migrations and site accommodations will be made by the end of year 4.

Evaluation: Progress on this activity will be reviewed as part of the LNO annual report to EB/NSF.

Benefits: By improving the management of network databases, a greater level of integration can be achieved that provides connectivity between datasets, people, and publications. This interconnected knowledge base will benefit the broader scientific community by increasing the quality and integrity of the LTER data repository.

Feedback: LNO will seek feedback as part of regular surveys and will vet the network database curation plan as a formal request for comment (RFC). In addition, there will be web-based comment opportunities associated with database interfaces.

3.2.2.4 Migrate existing and create new Network databases. The Network Information Manager will work with scientists, the IMC, and sites to migrate existing synthetic data to the LNO and create new synthetic datasets. The NIM will also work with scientists and the IMC to develop new synthetic data products resulting from SC and Decadal Plan activities and integrate them into the NIS framework. The CIO, NIM, Network Developer (ND) will work with IMC and SC leadership to revise the process for inclusion of new data products. See section 3.2.3.2

Outcomes: This activity will increase the accessibility of existing Network data, the number of synthetic data sets, and the quality and number of Network data sets accepted for management and curation by the LNO.

Operational Steps:

1. The NIM will work with staff from the H.J. Andrews LTER (AND) to transition the management and curation of climate and hydrologic databases (ClimDB/HydroDB) to the LNO.
2. The NIM will manage ClimDB/HydroDB in this format until an integration strategy to the NIS has been developed.
3. The NIM will also work with scientists and the IMC to develop new synthetic databases resulting from SC and Decadal Plan activities, along with interfaces to such databases, and integration into the NIS framework.
4. The ED, CIO, ND, DSS and NIM will develop a plan, process, and schedule for integrating new synthetic databases.

Milestones:

- ♦ LNO recruits and hires a new information manager by 1 February 2010.
- ♦ The ClimDB/HydroDB curation is assumed by LNO 1 May 2010.
- ♦ LNO assumes complete responsibility for ClimDB/HydroDB from AND by the end of 2010.
- ♦ Plan for new synthetic database integration developed by July 2011.

Evaluation: Progress on this activity will be reviewed as part of the LNO annual report to EB/NSF.

Benefits: Improving information management at the Network level will benefit LTER scientists and the broader community of scientists and educators by creating a repository of scientifically rigorous, richly documented data available for synthesis.

Feedback: LNO will seek feedback as part of regular surveys and will vet the synthetic database development plan as a formal RFC to an appropriately targeted group.

3.2.2.5 Development of NIS derived data products that extend the LNO EcoTrends data and application work. The Network Information Manager will support the management and curation of data error-checked for EcoTrends and harvested into the NIS. In addition the NIM will collaborate with NIS developers, site scientists, and information managers to implement a dynamic process for the creation of EcoTrends and other derived data products. These products will be selected first as 'low hanging fruit' for proof of concept and later as scientific priorities from datasets that have been error-checked and returned to sites by the EcoTrends Information Manager. Consequently, this activity will start slowly and will not be fully operational until Year 3.

Outcomes: Increase the number of synthetic data sets and increase the quality and number of Network data sets accepted for management and curation by the LNO.

Operational Steps:

1. The NIM in coordination with the EcoTrends project and CIO will identify data sets ready for harvesting.
2. The NIM will validate these datasets for quality of metadata and completeness of data using NIS data validation tools and other methods.
3. The NIM will coordinate harvesting with the SIM and confirm loading of data from site repositories into the NIS Data Cache.
4. The NIM will coordinate the adoption and/or development of program scripts with the Site Information Manager and create workflows to transform data from native formats to the EcoTrends time-series format,
5. The dataset will be reviewed by the CIO and accepted for LNO curation.
6. The process will be repeated for new datasets as identified.

Milestones:

- ♦ Datasets deemed ‘low hanging fruit’ are accepted (2011 Q3).
- ♦ Production begins on datasets deemed scientific priorities (2013 Q4).

Evaluation: Target datasets will be established annually as part of the development of LNO performance criteria for review. Progress on this activity will be reviewed as part of the LNO annual report to EB/NSF.

Benefits: This activity will benefit the LTER Network and the greater ecological community by providing new derived data products for synthesis.

Feedback: Feedback will be included as part of biennial LNO surveys to the LTER community. In addition, priorities for new derived products will be set with regard to the plan developed as part of 3.2.2.4 above.

3.2.3 Network Information System. Complete the design, development, and implementation of the LTER Network Information System in collaboration with NISAC, IMC, and strategic community partners**.**

Background: The mission of the LTER Network Information System is to promote advances in collaborative and synthetic ecological science at multiple temporal and spatial scales by providing the information management and technology infrastructure to increase:

- *availability and quality of data from LTER sites* – by the use and support of standardized approaches to metadata management and access to data;
- *timeliness and number of LTER derived data products* – by creating a suite of middleware programs and workflows that make it easy to create and maintain integrated data sets derived from LTER data; and
- *knowledge generated from the synthesis of LTER data* – by creating standardized access and easy to use applications to discover, access, and use LTER data.

Resources dedicated to the development of the NIS include 4.05 FTE of personnel time and travel to NISAC meetings at a total cost of $2,139,906 over six years. Partial funding for these efforts comes from the NSF Office of Cyberinfrastructure (OCI).

Roles associated with the development of the LTER Network Information System at the LNO are:

- LTER Chief Information Officer (CIO) – responsible for LTER Network Information Infrastructure.
- NIS Developer (ND) – lead developer of LTER Network Information System.
- NIS Analyst/Programmer III (NAP3) – lead programmer of the LTER Network Information System.

- NIS Analyst/Programmer II (NAP2) – secondary programmer of the LTER Network Information System.
- NIS Programmer Intern (NPI) – tertiary programmer of the LTER Network Information System.
- Application Support Analyst (ASA) – LTER Network Office lead web-application developer.
- Network Information Manager (NIM) – LTER Network Office lead information manager.

Roles associated with the development of the LTER Network Information System at the Network are:

- Network Information System Advisory Committee (NISAC) – provides guidance and priorities for NIS development from a domain science and information management perspective.
- Information Management Committee (IMC) – provides planning and reviews input from a site information management perspective; the IMC may filter input through specific individuals or groups within the information management community.
- Site Information Manager (SIM) – site-based information manager.
- Executive Board (EB) – decision making body for the LTER Network; review of overall operational plan.

3.2.3.1 LTER NIS/PASTA framework overview

The LTER Network Information System will utilize the Provenance Aware Synthesis Tracking Architecture (PASTA) framework, which will provide the LTER community a metadata-driven data-flow architecture for automatically loading data from LTER research sites and making it available through a standard and well defined software interface. We distinguish the PASTA framework (Figure 1) from the more generalized Network Information System by classifying framework components as critical and enabling cyberinfrastructure that, collectively, provide the services defined by the above mission. All data products within the NIS will have associated metadata, including provenance information where applicable. We anticipate that sites will make available a majority of their data for harvesting into the NIS, with an initial focus on well documented tabular data, which will be followed by more complex data (i.e., spatial and remote sensing data, and/or video data) at a later date. A key goal of the PASTA framework is to simplify the site's burden of participating in the NIS by only requiring that the data be described with complete metadata using the Ecological Metadata Language standard and having the data accessible through one or more Internet protocols. Adoption of any future LTER data standards at the site is not necessary for harvesting into the NIS, but will facilitate future analysis and/or synthesis of such data by applications internal and external to the NIS. Site data that is harvested into the NIS will be available to the broader community through the NIS Data Portal and through the site's information system (if the site wishes to support such access).

We view participation by the site, and specifically, by Site Information Managers, as critical to the overall success of a fully functional Network Information System by 1) participating in the development of NIS tools and applications that specifically support site information management needs, 2) informing the development of the PASTA framework components through direct and indirect transfer of knowledge and experience to NIS developers, and 3) creating well documented and quality data products for harvesting into the NIS. In addition, the collective or individual components of the PASTA framework may service site needs by providing a centralized and off-site data archive and distribution point, metadata and data congruency checks for quality assurance and correctness, automated metadata generation and management, data access and use audits, and a source of workflow and data transformation algorithms, to mention but a few. We note that site participation will be a function of funding that is available to support Network-level information management goals. Overall, we expect that the completed NIS will reduce the workload (and cost) of sites to participate in Network synthesis and analysis.

The PASTA framework comprises nine functional elements of the LTER Network Information System – 1) the data management suite of components (Data Manager, Data Catalog, Data Loader, and Data Cache), 2) the Workflow Manager, 3) the Metadata Factory, 4) the Data Portal, 5) the Discovery/Access Application Programming Interface (API), 6) the Identity Management Services, 7) the Persistent Identifier Services, 8) the System Monitor, and 9) the Audit Services. Each component will interact to varying levels with an integrated security model. The Data Manager, Data Catalog, Data Loader, Data Portal, and Audit Services (formerly, Data Access Server) have been developed to varying degrees under previous funding, but will require modifications and enhancements necessary for inclusion into the PASTA framework. Identity Management Services and Persistent Identifier Services will be adopted from community and industry standards; PASTA development efforts will consist primarily of integration and deployment. The remaining elements require new development and are addressed as part of this operational plan, as described in detail below.

Site Information Managers will interact directly with the Data Manager component interface to configure and schedule metadata harvests into the Data Catalog and to identify "PASTA-ready" data (i.e., data that are made available to PASTA and conform to the necessary metadata standards). Changes to metadata in the Data Catalog that represent new and/or updated site data will trigger the loading of this data into PASTA by the Data Loader. Once in the Data Cache, the site-based data will be available for synthesis projects to produce value-added derived data by incorporating various workflows into the Workflow Manager. The resulting derived data may become part of a recognized NIS Data Module, which is typically an agreed upon data model resulting from a science-driven goal. Provenance metadata will be captured during processing for derived data products and will be included in the final metadata package generated by the Metadata Factory. Discovery and access of both site-based and NIS Data Module data products will be achieved through a standard interface by value-adding applications, such as the LTER NIS Data Portal. The Audit Services will support and comply with the LTER Data Policy to track LTER data access and usage.

3.2.3.2 LTER NIS data levels

All data products within the NIS will be classified from levels 1 to 4 (level-0 refers only to data located at the site) based on the level of post-processing applied to the original site data. Although there exist many standards for classifying data based on processing (e.g., NASA, CODMAC, EOC, and NEON), we have adopted a modified version of the Ameriflux Network classification scheme because of similarities of definitions for processing level between the two networks. The following classification is suggested and may be modified after further evaluation by NISAC, IMC, or another designated party:

> Level-0 – Site located data (may be raw or modified by the site) that are made available for harvest into the NIS. These data may be accessed directly through the site resource or the Audit Services (if registered). Discovery of Level-0 data may be performed through the LTER Data Portal and/or Discovery/Access API (if the associated metadata are harvested into the Data Catalog and the metadata supports direct data access) or through the site resource.
>
> Level-1 – Data that are harvested into the NIS as archived replicates of the Level-0 site data; the Level-1 storage structure may differ from that of the Level-0 structure. All Level-1 data will have EML metadata documentation identical to the site harvested metadata with the exception to the physical storage description and will be discoverable through the LTER Data Portal and/or Discovery/Access API. Provenance information will include reference to the Level-0 data.
>
> Level-2 – Data are structurally corrected (e.g., realignment or adjustment of columns to match metadata), but retain the same content where possible of the Level-0 data. All Level-2 data will have EML metadata documentation identical to the site harvested metadata with the exception to the physical storage description and/or data description and will be discoverable through the LTER Data Portal and/or Discovery/Access API. Provenance information will include reference to the Level-0 data and any processing correction applied. Level-2 data may or may not be accepted into the NIS depending on the cause for correction and/or changes in LTER policy.
>
> Level-3 – Data that are qualified and processed into one of the NIS Data Modules. Processing may include unit normalization, new label conventions, adjustment to reporting intervals, and reformatting as necessary to be consistent with the target data product. These data will be available through the LTER Data Portal and/or the Discovery/Access API. Provenance information will include reference(s) to the previous metadata document(s) and all processing steps applied to the data to generate the Level-3 data product.
>
> Level-4 – Data that is gap-filled and semantically adjusted to meet the needs of particular synthetic data products. This data level is a place holder for anticipated future use.

3.2.3.3 Software development methodology

The software life-cycle and development process of the LTER Network Information System and PASTA framework will follow the Rational Unified Process (RUP), which is an industry standard for iterative and incremental software development. The RUP is an adaptable framework in which iterative cycles are combined into four primary time-segments (inception, elaboration, construction, and transition) across a single development goal. Each iteration consists of a series of operational steps that vary in effort according to the current time-segment. These steps, and their associated activities, are:

1. Component Modeling – Identification and refinement of component goals, including defining the business goal of the component (i.e., the benefits and/or high-level achievement of the component); identification of current iteration goals,

2. Requirements – Identification of use-case scenarios that define and drive functional and non-functional requirements of the component (use-case scenarios are critical to the initial software development process for identifying system functionality; utilizing use-case scenarios in planning often results in more precise requirements, which generally translates to more accurate and timely deliverables),

3. Analysis & Design – Analysis of use-case scenarios and refinement of requirements; generation of component design (using the Unified Modeling Language); identify relevant technology; identify component unit tests to meet requirements,

4. Implementation – Implementation of unit tests; implementation of component software and evaluation against unit tests,

5. Test – Review and evaluation of completed component software for iteration or overall component; confirm completeness and correctness against unit tests; sign-off of iteration milestone, and

6. Deployment – Place software in functioning environment.

The completion of each iteration progressively achieves the software development goals of the system by incrementally releasing successively more functionality. This incremental process scales throughout the project beginning with each individual iterative cycle, to the completion of a component, to the integration of components into deliverable and testable packages, and finally, to the fully complete and functioning system. Because it is an iterative process, the RUP can adapt to modifications in both goals and schedules without complete restructuring of the operational plan. Each PASTA framework component will follow its own iterative development trajectory, thereby introducing high-frequency release cycles that will allow timely evaluation and feedback by stakeholders. As such, planning details are better defined for earlier cycles; later cycles will be fleshed out in greater detail as they near the present. The development process will also generate comprehensive documentation for the planning of all framework components, including progress reports, which will be made available through the NIS project website.

All software source code that is developed as part of the LTER Network Information System and the PASTA framework will be considered "open source" and will be licensed as "permissive free software". The project will follow the guiding principles of "open source development" – that is, access to software source code, including planning and reference documents, will be unfettered and freely available to the general public for review, comment, and reuse, and the contribution of software improvements and features from the community may be accepted back into the project under a managed process. As such, all software development artifacts will be stored in a revision control system and will be publicly accessible through the LTER Network software repository. Software collaboration and contribution deemed non-critical to the operational functions of the

PASTA framework, but significant to the general Network Information System, will be integrated into the system where and when appropriate. To this end, the specific type of "open source" license and guidelines for the contribution of software from the LTER Network and broader community will be presented to NISAC for evaluation prior to the start of actual development. An "open source" policy statement will be written and clearly presented as part of the LTER strategic communication plan (see section 3.4.1) and on the NIS project website.

Software development and framework component integration will occur in two major phases. The first phase will focus on delivery of core functionality of the PASTA framework and result in an operational prototype by the second quarter of 2012 (Table 4). We will enlist a set of 3-4 "early-adopter" sites to assist in testing and evaluating software of the operational prototype. The second phase will concentrate on extending and enhancing existing components, and include addressing more complex functionality. The complement of remaining sites will be recruited during the second phase. The second phase will end with the production deployment of the PASTA framework in early 2014, which will be followed by an ongoing operational and maintenance period.

Official releases of the Network Information System that represent functional milestones will be designated with a numeric string denoting the *major-minor-revision* version of the release (e.g., NIS 1.3.5). An increment in the *major*, *minor*, and/or *revision* version signifies a forward progression towards the final goal of the system. A *major* version change generally indicates a significant improvement or addition to features/functionality of the software; such changes may not be backward compatible with a previous *major* version. A *minor* version change may also include new features/functionality, but backward compatibility will be retained. A *revision* change simply includes software "bug" corrections and does not generally provide any new features or functionality. The LNO will plan frequent releases that engage the community to generate awareness and excitement for the LTER Network Information System. These releases will strive to provide a sufficiently rich set of features so less technically inclined stakeholders would be able to use its functionality (see "Package Level" in section 3.2.3.6). Such awareness will be critical in the adoption of the NIS, in addition to providing regular feedback to system developers on the capabilities of the PASTA framework. To this end, the LNO will develop a "milestone release schedule" within the first six-month period of active planning, including a list of potential benefits associated with each release. Releases will be announced to the stakeholder community as defined in the LTER strategic communication plan.

3.2.3.4 Design, technical, and data standards

Acknowledging and adopting standards is critical for interoperability between different communities and for improving efficiencies of the overall project development plan. To help disambiguate the standards addressed in this operational plan, we have categorized standards into three categories:

1. Design and usability standards for user interfaces – having to do with the programming of web user interfaces (e.g., Web Content Accessibility Guidelines 2.0, W3C). Due to the extensive use of the Internet, and specifically, web-based user interfaces in the NIS and PASTA framework, we will adopt the applicable guidelines suggested by the World

Wide Web Consortium (W3C) Web Accessibility Initiative for web interface usability and access as specified in the Web Content Accessibility Guidelines 2.0. This standard addresses the accessibility of web-based presentation, primarily for disabled users, but also for agents with limited device capability, such as mobile phones.

2. Technical standards – published and acknowledged standards that define aspects of software development, the interoperability of software components, the structuring, documentation, and communication of data (e.g., Rational Unified Process, Unified Modeling Language, Ecological Metadata Language). Adoption of technical standards ensures interoperability and leads to faster development time through "reuse" of effort performed by other communities. Development of the PASTA framework, and more generally the NIS, builds upon the Ecological Metadata Language (EML 2.1) as the core metadata standard for describing LTER Network generated data. The EML is hierarchical in design (i.e., specified as an XML schema) and flexible in specificity of the information used to describe data. For example, streaming sensor data is now very common across all 26 LTER Network research sites. A standard for streaming sensor data, approved by the Open Geospatial Consortium for describing sensor configuration and measurement processes, is SensorML. We recommend that data generated by streaming sensors be described with the EML standard, which can "wrap" the pertinent SensorML XML in either the "methods" or "additional metadata" section of the EML. It is the high-quality EML that will enable harvesting the sensor data into the NIS. Other standards that are being evaluated for use in the NIS include: Handles, DOIs, PURLs, and LSIDs for persistent identification of digital objects; SKOS and Z39.19-2005 for controlled vocabularies; InCommon, OpenID, and LDAP for user/agent authentication. The software development process will adopt the Rational Unified Process standard for life-cycle management, including the Unified Modeling Language for design.

3. Data standards – project specific specifications for the storage, display, and communication of data products (e.g., NetCDF for climate data). For the Network Information System, data standards provide interoperability through the use of common storage formats (e.g., NetCDF for climate data) and, perhaps more important, the ability to integrate disparate data for generating derived and synthetic ("downstream") data products (e.g., ClimDB/HydroDB and EcoTrends). Identification and adoption of data standards is primarily the domain of the science working groups, but will also require interaction with technical personnel for integration into the NIS.

Although there are standards currently identified for use within the NIS/PASTA framework (e.g., EML), additional standards will be evaluated through a vetting process by NISAC, IMC, and other relevant parties (e.g., domain scientists).

3.2.3.5 Security model

The LTER Network Information System, and more specifically the PASTA framework, provides the opportunity for members of the LTER Network and the broader community to interact directly with an Internet-based system to discover and access LTER Network data products. Equally important, LTER Network site information managers will need access for ingesting metadata and data into, and interfacing directly to tools provided by, the NIS. The LNO acknowledges that the nature of interaction proposed between the LTER Network community and the general public to the NIS dictates that a strong, but open, security model be adopted. We recognize three significant classes of security that must be incorporated into the NIS:

1. Identity/Authentication Management – Members of the LTER Network and related communities often access similar web-based services during daily work routines (e.g., Gmail, MySpace, and Amazon.com). Most, if not all, of these services require a user's identification and an associated password to accurately match (or authenticate) a specific user with their service identity before any transaction can occur. The identification and password information provided by users to these service providers is often called their "credentials". It is a goal of many cyberinfrastructure projects to offer their users a single credential that is accepted across different communities for authentication, thereby eliminating the need for multiple identity recognition efforts for the same user. The current authentication mechanism for accessing LTER Network resources is performed through the validation of a user identity within a local LDAP database. To utilize a broader system, the LNO will adopt the preferred community standard for federated identity management (see section 3.2.3.10.5, Identity Management Services). We will work collaboratively with organizations that research and support federated identity management, like the National Center for Supercomputing Applications' CILogon project, to integrate a comprehensive identity management approach for the NIS so that users will be able to authenticate with the same identity across common service providers.

2. Access Control to Metadata/Data – All metadata and data within the LTER Network should be considered publicly accessible due to its origin of funding support and its importance for public knowledge. Understandably, however, certain metadata and data should be embargoed for limited periods of time (e.g., innovative or novel approaches to research that require further validation) or be banned from general access (e.g., sensitive information regarding endangered species). The Ecological Metadata Language, used to describe LTER Network data products and the key metadata standard identified for the NIS, provides access control directives for both metadata and data. As such, all components and services in the NIS/PASTA framework that interact with metadata and/or data will adhere to the access control rules documented within the EML.

3. System-level Security – The LTER Network Information System, and specifically the PASTA framework, is designed to be Internet accessible and supports interactions with many users. The underlying system software and its hardware, like most cyberinfrastructure, are vulnerable to both malicious and non-malicious events. To this end, NIS software development will embrace security "best practices" (e.g., International Information Systems Security Certification Consortium's Best Practices for Secure Software Development) to ensure that all systems include a committed level of secure operation. Design and implementation practices will be reviewed for consistency in techniques for prevention of malicious activity, while procedures for backup and redundancy will be followed for metadata/data integrity. In addition, administrative

personnel will be trained in protocols for secure management of computer and Internet resources (e.g., LTER Network Office Cyber-security briefings).

3.2.3.6 Community engagement

Success in the development of an information system depends not only on the cyberinfrastructure underlying the system but also on the engagement of stakeholders whose needs define system functionality. Stakeholders must be engaged in a broad range of activities from documenting data to evaluating applications. The underlying motivations for stakeholder engagement in the NIS are the joint responsibility of the stakeholder and developers to make LTER data accessible and the desire to have improved tools for research synthesis. However, to encourage significant and persistent involvement across a broad cross-section of the LTER community, proactive steps must be in place to remove or lower barriers to participation as partners in system design and development. Mechanisms in this operational plan to promote stakeholder engagement are described below.

The most important element in fomenting successful partnerships with LNO stakeholders is frequent and useful communication of progress and of opportunities for involvement. The LNO is committed to insuring that such communication takes place, and to that end will develop a plan that is focused on the NIS as part of the LTER strategic communication plan (see section 3.4.1 for additional detail). As part of this process, the LNO will seek expert advice on the development of partnerships between domain scientists, information managers, and system developers. In addition, the LNO will consider the use of social networking approaches focused on the NIS and submitting a proposal to the CI-TEAM program at NSF to disseminate information to LTER scientists on best practices in building effective partnerships.

The LNO will assist leaders of new LTER Network research initiatives in preparing effective data management schemes and proposals that reflect those schemes. The processes by which LTER research teams standardize and analyze data and synthesize results provide important information for system developers, but defining and capturing the steps of those processes require special effort. To that end, the LNO will also provide support to compensate information managers to implement these schemes for each research group and to translate the analytical processes into functional requirements for the NIS. To build partnerships between domain scientists, information managers, and system developers, the LNO will engage an expert to offer advice in the formation of research teams to this end. The LNO will work with domain scientists and information managers to develop best practices for data management, to formulate data standards for targeted data sets, and to identify non-LTER data that need to be incorporated into the NIS.

Engagement with the LTER community during software development will occur at multiple levels, including at the iterative, component, package, and system levels (see below). Each level defines the granularity of the development effort and will provide a “check point” with a community stakeholder to evaluate and sign-off on the level milestone (Figure 2). The following list provides a general description of the engagement level from the finest to coarsest development effort and the community stakeholder responsible for interaction:

Iterative – The “Iterative Level” is defined as the finest level of effort and consists of a single iteration within the development period of an individual PASTA framework component. Points of engagement will be addressed at the “modeling”, “requirements”, and “testing” steps of each iteration (see section 3.2.3.3 regarding the use of RUP); evaluation and sign-off of the iterative milestone goal will be performed by the community stakeholder at the end of the “testing” step. The community stakeholder at this level is a small number of individuals (e.g., information managers, students, and domain scientists) with a vested interest in the specific component being developed and who agree to provide timely review and feedback to NIS developers throughout the development period. Collectively, this set of individuals is called a “tiger team”. The identification of individuals for a “tiger team” will be the joint responsibility of NISAC and IMC.

Component – The “Component Level” is recognized as the deliverable software of a PASTA framework component when all requirements that have been identified are complete (the sum output of all iterations). The component milestone marks the point of engagement with the community stakeholder. We see the stakeholder at this level as a combination of NISAC, IMC, and/or a designated party who is assigned to the task. The community stakeholder will evaluate the component for completeness and correctness (as defined by its list of requirements). A successful milestone will require that the community stakeholder sign-off on the completion of the component.

Package – The “Package Level” is defined by the successful integration of one or more PASTA framework components into a community usable package that delivers higher level and more complete functionality (e.g., integration of the Data Manager, Data Catalog, Data Loader, and Data Cache will provide a end-to-end metadata and data harvesting package that identifies and loads data from the site and into the NIS). The point of engagement occurs when a fully integrated package is available to the community as a NIS version release (see section 3.2.3.3). The version release will be announced through channels defined by the LTER strategic communication plan and will solicit for “early adopter” sites and individuals who will evaluate and use the package as a prototype of the NIS. Review and feedback of the package will compose an informal “check point”, with positive reaction considered to be successful sign-off from the stakeholders.

System – The “System Level” consists of a fully functioning Network Information System, including fulfillment of all requirements identified for components of the PASTA framework. Points of engagement are coarse grained and are represented by all users of the LTER Network Information System, including LTER Network scientists, information managers, students, and the broader scientific community. Feedback will occur through systematic surveys and reviews, as well as informal forms that will be available through NIS user interfaces. Successful completion of all system goals will result in the LTER Executive Board signing off on the development phase of the NIS (at which point, the NIS will enter an operational and maintenance phase).

The PASTA framework will provide direct opportunities for LTER and non-LTER stakeholders to create applications that interface with the NIS through the Discovery/Access Application Programming Interface. The LNO will also create specific opportunities for the information management community to address site functional requirements through support of product-oriented workshops, release time for information managers, visits to sister sites and the LNO, and formal training exercises.

System developers will set schedules so that software will be released in operational packages that incrementally meet functional requirements and thus provide useful tools to stakeholders (see section 3.2.3.3). In addition to the "requests for comments" directed to a broad stakeholder community, smaller focus groups of students will be used to evaluate release functionality in more detail. By partnering with several early-adopter sites, system developers will receive frequent informal feedback on problems with interfaces to site data systems. Finally, metrics of user satisfaction obtained through biennial surveys of the LTER community and metrics from the annual evaluation of software development by NISAC will provide additional input to the development team.

3.2.3.7 Metrics of progress

Development progress on the NIS will be evaluated annually by the Executive Board with input from NISAC on technical elements. Evaluation of progress requires mutually-agreed upon goals and milestones and metrics to assess whether these milestones have been met. Three kinds of metrics will be documented: 1) metrics of user satisfaction, 2) descriptive (use) metrics, and 3) software development metrics. Metrics of user satisfaction measure whether stakeholder expectations are met within the period under consideration. Questions relating to user satisfaction with the NIS are included in the biennial survey of the LTER community, and changes in user satisfaction will be measured over time. In addition, focus groups for each software package released will provide immediate feedback on user satisfaction. Descriptive statistics measure the how many people have adopted software applications and the intensity of use. The number of data sets in the NIS and the number of people accessing these data are examples of descriptive statistics that will be collected by the LNO. Software development metrics are divided into two kinds: *functional* metrics (e.g., incorporate a search engine) and *non-functional* metrics (e.g., return results from a standard search within five seconds). For each annual milestone set for the NIS, appropriate metrics will be jointly chosen by the EB and NIS developers. NISAC will evaluate annually whether technical milestones have been met using data provided by the LNO.

3.2.3.8 Policies for incorporating external data

The desire to incorporate data external to the LTER Network (e.g., NADP data) in synthesis analyses has been expressed in various contexts. However, because the challenges of incorporating external data are significant and the range of possible data sets large, the incorporation of external data will need to follow a strict policy. LTER data will have the highest priority in the initial stages of NIS development. Synthesis needs as defined by LTER research projects will dictate the scope and priority for eventual inclusion of external data in the NIS. Access to external data will be incorporated into workflows for specific synthesis projects and provided by existing data at sites. In the long run, links to DataONE and other data warehousing projects will provide broader access to data external to LTER.

3.2.3.9 Risk management

Risks are inherent in any cyberinfrastructure/software development project. While it is not efficient use of resources for a project of this size to engage in a comprehensive risk management approach, it is useful to identify the highest known risks and acknowledge that there are unforeseen and unidentified risks. The primary impact of risks in software development projects is schedule slippage, and a general mitigation strategy is to assume the risks through expanded schedule contingency. To address this concern, schedule contingency has been included in our work plan to mitigate the majority of these risks. Other risks might be mitigated through the reallocation of effort and/or of funds identified in salaries, working groups, sub-contracts, and mini-sabbaticals, or project de-scoping. The CIO and Network Developer will monitor risk as part of their regular schedule of project management tasks to make sure that emergent risks are identified early and to account for schedule contingency that has been expended on known risks.

The known high-risks are reported here, along with the mitigation strategy:

1. Analyst/Programmer staffing – The analyst/programmer staffing for the NIS development is small at 2 FTE + 1 FTE annual intern. The risk is that there will be a high level of turnover among these staff leading to schedule slippage, high workload for existing personnel, and potential for low morale as a result. Mitigation of this risk is accomplished by schedule contingency. If monitoring reveals that schedules have slipped beyond the allocated contingency, the approach would be to consider reallocation of resources or de-scoping the project.

2. Software integration challenges – The NIS relies on a number of open-source software components that will be integrated as part of the PASTA framework. The risk is that the software products might not integrate as expected, resulting in some levels of software re-engineering, additional workload, and schedule slippage. Mitigation of this risk is accomplished by schedule contingency. If monitoring reveals that schedules have slipped beyond the allocated contingency, the approach would be to consider reallocation of resources or de-scoping the project.

3. Workflow product complexity – The Workflow Manager component of the PASTA framework will drive the integration and transformation of data into derived data products. Current planning looks to the maturation of workflow products like Kepler and Taverna to fill this role. The risk is that integration of workflow systems into the PASTA framework may prove more complex than anticipated, thereby resulting in additional integration work. Mitigation of this risk is accomplished by schedule contingency. If monitoring reveals that schedules have slipped beyond the allocated contingency, the approach would be to consider reallocation of resources or de-scoping the project.

4. Site metadata quality – The NIS is dependent on high quality EML metadata describing published data products at the sites. The risk is that sites will not be able to participate because of metadata quality issues, lack of preparation, limited resources, or disinterest. This risk is expected to be partially mitigated by the ongoing expenditure of funds to train site information managers in the preparation of metadata for the NIS and in developing

QA/QC metrics that can provide quality feedback to the sites via the Data Manager/Data Loader components.

5. Data Portal product complexity – The NIS Data Portal is the primary access point for LTER data. While basic functionality of delivering LTER data products is assured based on prototypes, the risk is that functional requirements developed from use cases by scientists will prove to be more complex than can be accomplished within the scope of this project. The project assumes this risk and will have to engage in feature prioritization as this component develops.

6. Future budget scenarios do not support NIS maintenance and operations – There is a high risk associated with the completion of the NIS project and having inadequate resources to operate and maintain the NIS. The mitigation strategy here is to develop good estimates of operations and maintenance costs and convey this information to LTER management and NSF program managers as the project moves toward completion.

There are a number of known medium and low risks related to computing and data capacity underestimates that are not elaborated here.

3.2.3.10 Completion of the LTER Network Information System.

The following sub-sections describe in detail pertinent development activities related to the PASTA framework as outlined in the proposal and over the 5-year performance period; these include the data management suite of components (Data Manager, Data Catalog, Data Loader, and Data Cache), the Workflow Manager, Metadata Factory, NIS Data Portal, and Audit Services. Four additional activities, 1) development of a Discovery/Access Application Programming Interface (API), 2) evaluation and adoption of Identity Management services, 3) evaluation and adoption of Persistent Identifier Services, and 4) development of a System Monitor, have since been identified as necessary to complete the LTER NIS.

As described previously, software development of PASTA framework components will follow the Rational Unified Process methodology (see section 3.2.3.3). As such, each component's development life-cycle will follow the same general operational steps (component modeling, requirements, analysis and design, implementation, testing, and deployment). In general, the sequence and description of operational steps are similar for each component. The principal LNO personnel involved in each of the component development efforts include the Chief Information Officer, the NIS Developer, and software developers (Analyst/Programmer 3, Analyst/Programmer 2, and a Programmer Intern). The Chief Information Officer and NIS Developer are responsible for interaction with LTER community stakeholders and developing, along with stakeholders, the overall design and goals of the NIS. The NIS Developer, together with all software developers, will develop detailed design plans and perform the implementation and testing of all system software. Review of completed software will be the responsibility of the Chief Information Officer, the NIS Developer and the designated community stakeholder. Engagement of the LTER community is described in greater detail in section 3.2.3.6.

3.2.3.10.1 Data Manager, Data Catalog, Data Loader, and Data Cache

Description: The Data Manager, Data Catalog, Data Loader, and Data Cache suite of PASTA framework components are tightly coupled services that provide both metadata and data harvesting capability to the NIS. These four components represent the automated extraction and loading process to move Level-0 data into a managed community data cache (Level-1).

Site Information Managers will interact directly with the Data Manager user interface to register metadata for harvest into the Data Catalog on regular intervals. All metadata will conform to the Ecological Metadata Language (EML) standard through established LTER best practices. The same registration process will allow information managers to mark specific data sets identified within the metadata for harvest by the Data Loader. Once a data set is registered, the Data Manager will initiate loading of Level-0 data from the site by the Data Loader only if they are new and/or updated as indicated by changes in the harvested metadata. These Level-0 data will be replicated in the centralized Data Cache using the same general format designated by the site, but in a PASTA-specific structure designed to accommodate the class of data being loaded (e.g., tabular data will be stored as a relational database table, remote sensing data as binary objects, and GIS data in a spatially compatible structure). These replicates will be characterized as Level-1 data. Services of the Data Loader will provide "structural" quality control and error detection of Level-0 data, thus enabling corrections and/or flagging of these data prior to being stored; corrected/flagged data will be characterized as Level-2 data. All errors or flagged data that produce Level-2 data will be reported back to the originating site. The Data Manager service interface will also provide metadata/data quality checking capabilities (i.e., ensuring data formats comply with descriptions in metadata) to site information managers for pre-harvest evaluation of their data packages (metadata and data). All harvest event information will be logged and provided back to the site as regularly scheduled and/or ad-hoc reports.

The Data Manager component will also provide an integration point for site-developed tools, such as the Controlled Vocabulary and Unit Registry. The process of integration will be decided through collaborative planning between site and NIS developers during initial planning of the Data Manager component.

Outcomes: The Data Manager, Data Catalog, Data Loader, and Data Cache will provide automated extraction and loading of site metadata and data into a community repository for centralized access and preservation. The Data Manager user interface will act as a single point of interaction for scheduling metadata/data harvests, serve as the interface for ad-hoc evaluation of data packages, and provide an integration point for site developed tools. All harvest events and related information will be documented and provided to Site Information Managers as regularly scheduled or ad-hoc reports.

Operational Steps:

1. The ND will compose detailed use-case scenarios through targeted requests and/or formal working groups of stakeholders, including SIMs, IMC, and NISAC, that characterize the Data Manager service interface and operations of the Data Catalog, Data Loader, and Data Cache.

2. The ND will analyze use-case scenarios and will formulate functional requirements and an implementation plan for tabular data only (phase 1); the implementation plan will be reviewed by the IMC and NISAC for completeness and correctness.
3. Execution of the implementation plan will be performed by the software developers; incremental releases will include prototypes of the user interface.
4. Review of operational prototype deliverables will be performed by the IMC via a RFC and NISAC via regular annual review process.
5. Review of use-cases and functional requirements, including new use-cases for additional data classes (phase 2), will be performed by the CIO, ND and NISAC during second year review.
6. ND will generate new/additional functional requirements that will be added to the implementation plan.
7. Execution of implementation plan will continue by the software developers (phase 2); incremental releases will include prototypes of the user interface.
8. A final review of deliverables by the IMC and NISAC will be performed to measure success.

Milestones:

- ♦ Use-case scenarios document (phase 1) (2010 Q2)
- ♦ Implementation plan (phase 1) developed (2010 Q2)
- ♦ Operational prototype (phase 1) deployed (2011 Q2)
- ♦ Review of operational prototype (2011 Q3)
- ♦ Use-case scenarios document updated (phase 2) (2012 Q2)
- ♦ Implementation plan updated (phase 2) (2012 Q2)
- ♦ Production deployment of Data Manager, Data Catalog, Data Loader, and Data Cache (2012 Q3)
- ♦ Review of final deployment (2012 Q4)

Evaluation: Criteria for evaluation will be included in annual LNO performance review criteria and will cover delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s). Review of performance will be by NISAC during regular annual reviews.

Benefits: The Data Manager service interface will benefit Site Information Managers by streamlining the process of harvesting metadata/data into the NIS. The LTER community will benefit from data being cached in a community repository in an accessible format that enables persistence through managed curation. The broader scientific community will be able to use this service to perform data quality checks on EML described data.

Feedback: Direct feedback will occur from Site Information Managers to the ND for evaluating the efficacy and efficiency of the Data Manager service interface via an RFC process. Internal NIS metrics will measure the number of harvested metadata and data objects, thereby providing indirect feedback on usage.

3.2.3.10.2 Workflow Manager (Transformation Engine)

Description: The Workflow Manager provides management and execution of workflows by authenticated individuals and/or on behalf of the system. A workflow in the PASTA framework is simply a sequence of computational tasks that perform some action on one or more datasets that reside in the Data Cache. Workflows provide a standardized way to document the processing steps to generate derived data products and the ability to modify and retrace those steps. The level of automation possible and the effort required to develop a workflow is highly dependent on the complexity of both source data and the data model. Source data complexity would be reduced because these data will be described using the EML standard and will reside in a common repository. Data models will be defined in research working groups, and algorithms to generate Level-3 data will be documented by SIMs integrated with the working group. Initial development of the Workflow Manager will rely on manually written scripts and/or executable code that access predefined data sets from the Data Cache for generating derived data products found in existing NIS Data Modules. Future work will allow the user to create workflow sequences by integrating external workflow management systems (e.g., Kepler and/or Taverna) into the Workflow Manager. The Workflow Manager will also include a "state monitor" for system administrators and workflow owners to oversee the execution of one or more workflow sequences, in addition to system reporting of all events related to the Workflow Manager.

A first order Workflow Manager scenario would begin with the installation of one or more executable scripts that read data from one or more predefined Level-1 or Level-2 data sets found in the Data Cache, operate on that data, and then write output to the appropriate NIS Data Module (e.g., the ClimDB for derived climate data). The executable scripts and the script-dependent data sets found in the Data Cache would be registered with the Workflow Manager. When new or modified data are added to the Data Cache (see section 3.2.3.5),, the Data Manager will trigger a "data update notice" to the Workflow Manager. The Workflow Manager will then resolve all data dependencies and execute the appropriate script(s). New derived data will be added to the corresponding NIS Data Module and updated metadata (see section 3.2.3.3) will be added to the Data Catalog.

Outcomes: Completion of the Workflow Manager will provide users with the ability to define a sequence of computational tasks that may be applied to one or more data sets residing in the Data Cache and to have the same tasks executed automatically when new and/or updated data are harvested into the NIS.

Operational Steps:

1. The ND will compose detailed use-case scenarios through targeted requests and/or formal working groups of stakeholders, including site scientists/researchers, SIMs, IMC, and NISAC, that characterize the Workflow Manager services, including levels of interoperability, interface requirements, and workflow library interactions.
2. The ND will analyze use-case scenarios and will formulate functional requirements and an implementation plan for manually generated scripts and executable code (phase 1).

3. The implementation plan will be reviewed by the IMC and NISAC for completeness and correctness. The implementation plan will utilize one or more of the current NIS Data Modules (e.g., ClimDB and/or HydroDB) as a baseline example.
4. Execution of the implementation plan will be performed by the software developers to demonstrate an operational prototype that can execute workflows either manually or on a schedule.
5. The CIO and ND will evaluate off-the-shelf workflow process management solutions (phase 2).
6. Review of operational prototype deliverables will be performed by the IMC and NISAC.
7. Review of use-cases and functional requirements, including new use-cases for integrating more complex workflow applications (e.g., Kepler and/or Taverna) (phase 2), will be performed by the CIO, ND and NISAC during second year review.
8. ND will generate new/additional functional requirements that will be added to the implementation plan.
9. Review of updated implementation plan will be performed by the IMC and NISAC.
10. Execution of implementation plan will continue by the software developers (phase 2); incremental releases will include prototypes of the user interface.
11. A final review of deliverables by the IMC and NISAC will be performed to measure success.

<u>Milestones:</u>

- ♦ Use-case scenarios document (phase 1) developed (2011 Q4)
- ♦ Implementation plan (phase 1) developed (2011 Q4)
- ♦ Operational prototype (phase 1) deployed (2012 Q1)
- ♦ Review of operational prototype will be performed by IMC and NISAC (2012 Q2)
- ♦ Review of off-the-shelf workflow process management solution by CIO and ND (2013 Q1)
- ♦ Use-case scenarios document updated (phase 2) (2013 Q1)
- ♦ Implementation plan will be updated (phase 2) by ND (2013 Q2)
- ♦ Production deployment of the Workflow Manager performed (2014 Q1)
- ♦ Review of final deployment will be performed by IMC and NISAC (2014 Q2)

<u>Evaluation:</u> Criteria for evaluation will include delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s). Additional criteria will include the validation of derived data products (Level-3) as output from the Workflow Manager.

<u>Benefits:</u> The Workflow Manager will benefit Site Information Managers and scientists/researchers by providing a framework for the development, storage, and automated execution of computational tasks against Level-1 and Level-2 data. This work will also benefit communities that are engaged in workflow integration into production data management systems.

<u>Feedback:</u> Direct feedback will occur from site scientists/researchers to the ND for evaluating the efficacy and efficiency of the workflow integration process, including the steps required for loading a workflow and monitoring its activity. Indirect feedback will be obtained by reviewing system reports. The system will be reviewed by NISAC during annual reviews. Communities that are involved in similar workflow manager integration applications, such as the National

Center for Supercomputer Applications, may provide additional feedback on efficacy of the Workflow Manager.

3.2.3.10.3 Metadata Factory (Provenance Tracking)

Description: The Metadata Factory will be responsible for generating metadata using the Ecological Metadata Language (EML) standard format, including provenance information, for all Level-1 and Level-2 data found in the Data Cache and, more importantly, all derived data products (Level-3) that are produced by the Workflow Manager. Each EML document produced by the Metadata Factory will be harvested into the Data Catalog, thereby making it (and associated data) available for future discovery.

Provenance metadata for each derived data product will include one or more references to metadata documents (also as EML found in the Data Catalog) that describe the original site-based data set(s) (Level-1 or Level-2) used to generate Level-3 derived data products. A natural language description of the program used to generate the derived product will be included in the metadata, as well as the source code of any script or executable code used to generate the derived data, including configuration and steps that are part of an external workflow package. The Metadata Factory will generate metadata sufficient to recreate a derived data product based on its Level-1 or Level-2 inputs and the computational tasks used in the process.

The metadata structure that will be used to store provenance information is the "methods" sub-tree of EML. This sub-tree will contain core elements of the original EML that describes the Level-0 data and Level-1 and/or the Level-2 data that are used to produce any derived data product, including a direct reference to these documents within Data Catalog – we refer to this reference as a "metadata chain". The "methods" sub-tree will also contain available source code and/or a description of the executable used in the workflow sequence.

Outcomes: Completion of the Metadata Factory will result in ongoing and automated metadata documentation of all Level-1 or Level-2 data in the Data Cache and derived data products (Level-3), including provenance information. The Metadata Factory will enable researchers to determine the data and workflow versions that lead to any derived data product.

Operational Steps:

1. The ND will compose detailed use-case scenarios by closely reviewing the operations of the Workflow Manager and assessing the steps required by the Metadata Factory; these use-case scenarios will be reviewed by the IMC and NISAC.
2. The ND will analyze use-case scenarios and will formulate functional requirements and an implementation plan for generating metadata as EML for Level-3 data; the implementation plan will be reviewed by the IMC and NISAC for completeness and correctness. The implementation plan will utilize one or more of the current NIS Data Modules (e.g., ClimDB /HydroDB) as a baseline (phase 1).
3. Execution of the implementation plan will be performed by the software developers to demonstrate an operational prototype.
4. Review of operational prototype deliverables will be performed by the IMC and NISAC.

5. Review of use-cases and functional requirements, including new use-cases for integrating more complex metadata associated with workflow applications (e.g., Kepler and/or Taverna) (phase 2), will be performed by the CIO, ND and NISAC during second year review.
6. ND will generate new/additional functional requirements that will be added to the implementation plan.
7. Execution of implementation plan will continue by the software developers (phase 2).
8. A final review of deliverables by the IMC and NISAC will be performed to measure success.

Milestones:

- Use-case scenarios document (phase 1) developed (2011 Q4)
- Implementation plan (phase 1) developed (2011 Q4)
- Operational prototype (phase 1) deployed (2012 Q1)
- Review of operational prototype performed by IMC and NISAC (2012 Q2)
- Use-case scenarios document updated (phase 2) (2012 Q2)
- Implementation plan updated (phase 2) (2012 Q1)
- Production deployment of the Metadata Factory (2013 Q2)
- Review of final deployment will be performed by IMC and NISAC (2013 Q3)

Evaluation: Criteria for evaluation will include delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s). Additional criteria will include the validation of generated metadata as output from the Metadata Factory.

Benefits: A key issue facing scientific data delivery systems today is the lack of effective traceability from derived products to source data. Scientific data repositories (e.g., DataONE) will benefit from a standard approach to provenance tracking that is metadata-based and system independent. The broader scientific community will benefit from the metadata generated by the Metadata Factory by 1) making such derived data discoverable and 2) having adequate provenance information to be able to recreate the derived data. In addition, communities that require provenance tracking may utilize techniques pioneered by the Metadata Factory in their own projects.

Feedback: Direct feedback from the user community to the ND for evaluating the correctness and efficacy of the metadata which describes derived data products. Indirect feedback will be generated based on the number of discoveries and access events to derived data that occur through the Data Catalog.

3.2.3.10.4 NIS Data Portal

Description: The NIS Data Portal (herein, Data Portal) will be the LTER community's web presence for discovering, accessing, and exploring LTER site-based and derived data products. The Data Portal will provide interfaces for user authentication, data discovery, data access (download), data exploration, personal data management (e.g., saving search results), and user feedback. In addition, the Data Portal will be customizable by the user by setting preferences for the "look and feel" of their browser view of the Data Portal and criteria for data discovery and access. The Data Portal will set the standard for key "portlets" that may be reused by other web-based portals (in support of the LTER community "skin" adoption of the current LTER Data Catalog web presence). The Data Portal will not be tightly coupled to any other PASTA framework component.

A typical use-case scenario will begin with a user authenticating to the system by entering their community credentials into the authentication interface. Once authenticated, the user may be greeted with news of another month of data being added to a data set that they are watching. The user may then navigate to the catalog webpage that contains hierarchical lists separated by different thematic or geographic categories (e.g., Climate-Temperature-Surface Temperature or North America-United States-California). Following the catalog link in the geographic category to California, the user may search for all LTER data sets that originate in the state of California. Finding a particular tabular data set of sea-level height, the user may plot this data set against other data sets that were saved in their personal data management space. Being satisfied with the quality and usability of the data set, the user may then download the data set and its associated metadata to their local work station for further analysis.

Outcomes: Completion of the Data Portal will secure a web presence for LTER site-based and derived data products, and provide a single point of access for LTER scientists/researchers and the broader community to such data. The Data Portal will become a local research home page for many scientists/researchers who regularly access ecological data of the LTER Network.

Operational Steps:

1. The ND will compose detailed use-case scenarios through a series of concept working groups involving SIMs, site scientists/researchers, IMC, and NISAC, that characterize the Data Portal services.
2. The ND will analyze use-case scenarios and will formulate functional requirements and an implementation plan (phase 1) for creating the Data Portal web application.
3. The implementation plan will be reviewed by the IMC and NISAC for completeness and correctness. The implementation plan will build upon past experience gained from the current LTER Data Catalog and the EcoTrends web portal.
4. Execution of the implementation plan will be performed by the software developers to demonstrate an operational prototype; incremental releases will include prototypes of the user interface.
5. Review of operational prototype Data Portal will be performed by the IMC and NISAC.
6. Review of use-cases and functional requirements, including new use-cases for integrating more complex features (e.g., data exploration and advanced discovery) (phase 2), will be performed by the NISAC during second year review.
7. ND will generate new/additional functional requirements that will be added to the implementation plan.
8. Execution of the implementation plan will continue by the software developers (phase 2); incremental releases will include prototypes of the user interface.
9. A review of deliverables by the NISAC and site scientists/researchers will be performed to measure success.

Milestones:

- Concept working group (2013 Q4)
- Use-case scenarios document (phase 1) developed (2011 Q1)
- Implementation plan (phase 1) developed (2011 Q1)
- Operational prototype (phase 1) deployed (2011 Q2)
- Review of operational prototype performed by NISAC and site scientists/researchers (2011 Q3)
- Use-case scenarios document updated (phase 2) (2013 Q4)
- Implementation plan updated (phase 2) (2013 Q4)
- Production deployment of the Data Portal (phase 2) (2014 Q1)
- Review of final deployment performed by NISAC and site scientists/researchers (2014 Q2)

Evaluation: Criteria for evaluation of the Data Portal will include delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s). Additional criteria will include meeting web accessibility standards as specified by the Web Content Accessibility Guidelines.

Benefits: The Data Portal will provide a single point of access to LTER site-based and derived data for LTER scientists/researchers and the broader community. Users will be able to discover such data through multiple interfaces and download the data and associated metadata to their local workstation. In addition, the Data Portal will serve as a local home page to many scientists/researchers who regularly access LTER data; the Data Portal will support many personalized features related to managing discovered data sets.

Feedback: Direct feedback from the scientist/researcher user community to the ND for evaluating the efficacy of the Data Portal, including accuracy of searching for data sets and ease of managing data sets. The Data Portal will include a "feedback" interface for ad-hoc interaction.

3.2.3.10.5 Discovery/Access Application Programming Interface

Description: The Discovery/Access Application Programming Interface (API) will be the standard interface by which external web-based applications will interact with the LTER Network Information System and, more specifically, PASTA framework services. The Discovery/Access API will provide a web-services interface that follows a Service Oriented Architecture (SOA) design, thereby supporting a neutral programming layer that may be used by multiple applications regardless of their hardware and software preference. The Discovery/Access API will support a core set of services to provide discovery and accessibility to LTER site-based (Level-1 and Level-2) and derived (Level-3) data products. In addition to the core services, the API will also support user authentication for single sign-on through the Identity Management Services (section 3.2.3.6),, system information (including, state of health), site-developed applications and tools (e.g., Controlled Vocabulary and Unit Registry), and Project Specific Data Services (section 3.2.3.11.4) (e.g., CUAHSI Hydrologic Information System (HIS), DataONE Member Node, National Ecological Observatory Network (NEON) functions). The Discovery/Access API will be an abstraction layer that removes (or minimizes, at the very least) tightly-coupled dependencies between underlying PASTA framework components from external applications; as such, framework components may evolve as necessary without adversely affecting applications that are built on top of the Discovery/Access API.

An example use-case scenario would be that of the NIS LTER Data Portal (section 3.2.3.4). The Data Portal would configure its discovery engine to query the Discovery/Access API discovery service using standard query syntax (*in lieu* of connecting directly to the Data Catalog). The discovery service would then translate the standard query syntax into the specific syntax used by the Data Catalog. Upon completing the query, a Data Catalog formatted query result would be returned to the Discovery/Access API discovery service. The discovery service would then translate the Data Catalog query result format into a standard format, and return it to the Data Portal for final processing.

Outcomes: Completion of the Discovery/Access API module will provide a standardized application programming interface by which external web-based applications will discover and access LTER site-based (Level-1 and Level-2) and derived (Level-3) data products. The Discovery/Access API will support industry standard web-services using SOA principles to provide access for external applications. The Discovery/Access API abstraction will insulate external applications from evolving PASTA framework components.

Operational Steps:

1. The ND will compose detailed use-case scenarios through targeted requests and/or formal working groups of stakeholders, including Site Information Managers (and programmers/developers), community programmers/developers, and NISAC, that characterize the Discovery/Access API; additional review of existing systems (e.g., Virtual Data Center) will inform use-case scenario development.
2. The ND will analyze use-case scenarios and will formulate functional requirements and an implementation plan (phase 1) for creating the Discovery/Access API and associated services. The implementation plan will build upon past experience learned from similar projects (e.g., EarthGrid).
3. The implementation plan will be reviewed by the CIO, ND, and NISAC for completeness and correctness.
4. Execution of the implementation plan will be performed by the software developers to demonstrate an operational prototype.
5. Review of operational prototype deliverables will be performed by the IMC and NISAC.
6. ND will publish Discovery/Access API specification to the broader community.
7. Review of use-cases and functional requirements, including new use-cases generated during phase 1 from community input for integrating more complex features (e.g., user authentication, system state of health, or external project support) (phase 2), will be performed by the CIO, ND and NISAC during second year review.
8. ND will generate additional functional requirements from new use-case scenarios that will be added to the implementation plan.
9. Execution of implementation plan will continue by the software developers (phase 2).
10. A final review of deliverables by the IMC and NISAC will be performed to measure success.

Milestones:

- ♦ Use-case scenarios document (phase 1) developed (2010 Q2)
- ♦ Implementation plan (phase 1) developed (2010 Q2)
- ♦ Operational prototype (phase 1) deployed (2011 Q1)
- ♦ Discovery/Access API specification (phase 1) published (2011 Q1))
- ♦ Review of operational prototype performed by IMC and NISAC (2011 Q2)
- ♦ Use-case scenarios document updated (phase 2) (2012 Q2)
- ♦ Implementation plan updated (phase 2) (2012 Q2)
- ♦ Production deployment of the Discovery/Access API (phase 2) (2013 Q1)
- ♦ Discovery/Access API specification (phase 2) published (2013 Q1))
- ♦ Review of final deployment will be performed by IMC and NISAC (2013 Q2)

Evaluation: Criteria for evaluation of the Discovery/Access API will include delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s). Additional criteria will include service up-time as defined by non-functional requirements.

Benefits: Separation of underlying PASTA framework components from external applications through a published interface will benefit LNO Analysts/Programmers, Site Information Managers, and community developers/programmers by eliminating direct dependencies that may otherwise affect such external applications. Community developers will benefit from having programmatic access to LTER data and metadata through an SOA supported interface for development of external web-based applications.

Feedback: Direct feedback from the developer community to the ND for evaluating the efficacy of the Discovery/Access API interface specifications and services; indirect feedback will include measuring the number and correctness of service calls performed in a given period.

3.2.3.10.6 Identity Management Services

Description: The Identity Management Services module will provide support for user single sign-on authentication to access the LTER NIS services. Single sign-on implies that a user may authenticate at one, of perhaps many, authentication interface points associated with the LTER Network (including the broader community of service providers) and would not have to re-issue the same authentication credentials at each service that requires user authentication; the credential or token representing the user provides short-lived authentication on behalf of the user to services requiring authentication. Because of the complexity and widespread need of such services, the design and implementation of the Identity Management Services will be developed collaboratively through multiple working groups within the community, including the CILogon project at the University of Illinois Urbana Champaign (http://www.cilogon.org) and DataONE (http://dataone.org) project at the University of New Mexico.

One use-case scenario for Identity Management Services would include the authentication of an LTER Site Information Manager, who may have dual roles when interacting with the LTER NIS. In one role, the Site Information Manager may be a user of the Data Manager interface for scheduling new metadata harvesting; and in a second role, the Site Information Manager may be a user of the Data Portal when searching for LTER data products. To schedule a new harvest, the Site Information Manager would authenticate with the Data Manager authentication service by entering credential information. After configuring the new harvest, and while still logged into the NIS web-based interface, the Site Information Manager loads the Data Portal interface into the local web browser. Using a session token, the Data Portal recognizes the Site Information Manager and performs an automatic authentication using the token, at which point the Information Manager has full access to the Data Portal.

<u>Outcomes:</u> The Identity Management Services module will support session-based single sign-on of users for authentication to access services of the LTER NIS.

<u>Operational Steps:</u>

1. The ND will compose detailed use-case scenarios through targeted requests of stakeholders, including Site Information Managers (programmers/developers), site scientists/researchers, community programmers/developers (e.g., CILogon and DataONE), and NISAC, that characterize the Identity Management Services.
2. The ND will analyze use-case scenarios and will formulate functional requirements of the Identity Management Services.
3. The ND will work collaboratively with leaders of community projects working toward similar single sign-on goals and jointly develop an implementation plan.
4. The implementation plan will be reviewed by the IMC and NISAC for completeness and correctness.
5. Execution of the implementation plan will be performed by the software developers to demonstrate an operational prototype.
6. A final review of deliverables by the CIO, ND, and NISAC will be performed to measure success.

<u>Milestones:</u>

- Use-case scenarios document (phase 1) developed (2010 Q4)
- Implementation plan (phase 1) developed (2010 Q4)
- Operational prototype (phase 1) deployed (2010 Q4)
- Review of operational prototype performed by IMC and NISAC (2011 Q2)
- Collaborative implementation plan (phase 2) developed (2013 Q1)
- Production deployment of the Identity Management Service (2013 Q4)
- Review of final deployment performed (2014 Q1)

<u>Evaluation:</u> Evaluation will be performed by NISAC during annual reviews of LNO performance. Criteria for evaluation of the Identity Management Services will include delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s). External projects (e.g., CILogon and DataONE) will be asked to evaluate deliverables for correctness and to ensure interoperability.

<u>Benefits:</u> The Identity Management Services will simplify access to NIS services and resources for all users, including the broader scientific community, by supporting a single sign-on

authentication service, thereby eliminating the need for repeated authentication by users. The implementation of the Identity Management Services will act as a guide and model to community developers of other cyberinfrastructure projects requiring similar authentication infrastructure. For example, the DataONE (http://dataone.org) project at the University of New Mexico is now reviewing existing authentication protocols and procedures for implementing identity management. The Identity Management Services of the LTER NIS may demonstrate techniques that can be reused within DataONE.

Feedback: Direct feedback from the NIS user community to the ND will occur for evaluating the correctness of the Identity Management Services; indirect feedback will include measuring successful access to LTER NIS services and resources.

3.2.3.10.7 Persistent Identifier Services

Description: A problem that often occurs when digital objects are identified with absolute locations, such as a web URL to a data set, is that the direct link to the object "breaks" when the object is moved to a new location or the domain name of the web server is changed. To overcome the limitation of absolute identifiers, persistent identifiers use a relative identification scheme that maps the identifier to the current location of the object. As such, the user of a persistent identifier can be assured that the identifier will always resolve to the object, regardless of its physical location. The Persistent Identifier Services that will be adopted by the PASTA framework will provide persistent identification of (and resolvability to) digital objects (including metadata documents and data sets). In addition to object persistence, the Persistent Identifier Services will ensure that once an object is identified by a unique identifier, no other object within the operational domain may be identified with the same identifier.

Persistent and unique identification systems are now under review by many cyberinfrastructure projects, including the biodiversity Taxonomic Data Working Group project and the DataONE (http://dataone.org) project at the University of New Mexico. The Persistent Identifier Services will utilize the method for assigning and resolving persistent identifiers that is adopted by the broader community, thereby maintaining interoperability between organizations. An alternative system will also be identified if the community does not adopt one method within the time-scope necessary for the NIS development.

The use of persistent identifiers will be optional for LTER Network data that resides in a site-based information system and is referenced through a site-generated EML document found in the Data Catalog. All metadata and data found in the PASTA framework, however, will be identified with a persistent identifier.

Outcomes: Completion of the Persistent Identifier Services component will ensure persistent identification and access to LTER data for users and services from within the PASTA framework and for external users and services. In addition, by adopting a community standard, interoperability between organizations will be maintained.

Operational Steps:

1. The ND will compose detailed use-case scenarios involving the use of persistent identifiers in the PASTA framework through the evaluation of community adopted solutions.
2. The ND will analyze use-case scenarios and will formulate functional requirements of the Persistent Identifier Services.
3. The ND will work collaboratively with leaders of community projects working toward similar persistent identifier goals and jointly develop an implementation plan.
4. The implementation plan will be reviewed by the NISAC for completeness and correctness.
5. Execution of the implementation plan will be performed by the software developers to demonstrate an operational prototype.
6. A final review of deliverables by the NISAC will be performed to measure success.

Milestones:

- Use-case scenarios document developed (2011 Q2)
- Collaborative implementation plan will be developed by ND and other community project leaders (2011 Q2)
- Review of implementation plan by NISAC (2011 Q2)
- Production deployment of the Persistent Identifier Services will be performed by ND and NAP3/NAP2 (2011 Q3)
- Review of final deployment will be performed by CIO, ND, and NISAC (2011 Q4)

Evaluation: Persistent Identifier Services will be evaluated based on the delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s). This evaluation will be performed as part of the NISAC review of LNO performance.

Benefits: The Persistent Identifier Services will benefit all end users and services of the LTER NIS by ensuring that identifiers used by metadata and data objects will accurately obtain requested objects regardless of their physical location.

Feedback: Direct feedback from the NIS user community to the ND will occur for evaluating the accuracy and persistence of requested metadata and data objects as identified through the Persistent Identifier Services. Communities that are involved in similar persistent identified-based applications, such as the Global Biodiversity Information Facility, may provide additional feedback on efficacy of the Persistent Identifier Services.

3.2.3.10.8 System Monitor

Description: The System Monitor provides system state-of-health information for all modules/services. The System Monitor will consist of a number of component tests that evaluate the state of specific services and/or entire components; each test will be measured from a known performance base-line; therefore, changes in performance (either positive or negative) may be noted. The System Monitor will operate as a background process from which state-of-health alerts and reports may be continually generated. External applications will be able to access a subset of System Monitor functions through the Discovery/Access API (section 3.2.3.5).

A typical use-case scenario would be for the System Monitor to track performance of the Data Catalog at 10-minute intervals to determine overall responsiveness based on a specific query. The System Monitor would issue the query and measure the response time of the Data Catalog. If the response time increased above some threshold, the System Monitor would send an alert to the LTER NIS system administrators.

Outcomes: Completion of the System Monitor will ensure that the LTER NIS continues to operate a measured level of service. In addition, the System Monitor will provide near real-time alerts in the event of any service and/or module failure. Regular reports will be generated for evaluating the overall performance of new or modified services and/or components.

Operational Steps:

1. The ND will compose detailed use-case scenarios through targeted individuals, including NIS Analysts/Programmers and NISAC, which characterize the System Monitor.
2. The ND will analyze use-case scenarios and will formulate functional requirements.
3. The ND will evaluate existing system monitoring applications (e.g., Cacti, Hobbit, or Nagios). Based on such evaluations, an implementation plan will be developed for developing the System Monitor.
4. The implementation plan will be reviewed by the NISAC for completeness and correctness.
5. Execution of implementation plan will be performed by the software developers; incremental releases will include prototypes of the user interface.
6. A final review of deliverables by the NISAC will be performed to measure success.

Milestones:

- Use-case scenarios document developed (2013 Q4)
- Implementation plan developed (2013 Q4)
- Production deployment of the System Monitor (phase 2) (2014 Q1)
- Review of final deployment performed NISAC (2014 Q2)

Evaluation: The System Monitor development will be evaluated as part of the regular NISAC review of LNO performance. Criteria for evaluation of the System Monitor will include delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s).

Benefits: The System Monitor will benefit all users of the LTER NIS by ensuring that the system is operating at an optimal level. In addition, the System Monitor will benefit the NIS system administrators by providing up-to-date and timely information on the state-of-health of PASTA framework services and/or components.

Feedback: Direct feedback from the System Monitor, in the form of alerts and reports to the ND, will occur for evaluating the overall performance of the PASTA framework services and/or components.

3.2.3.10.9 Audit Services (formerly, Data Access Server)

Description: The Audit Services will record all metadata/data access events and provide key services in compliance of the LTER Data Policy, including authentication, reporting, and notification. Specifically, the Audit Services will support the replacement of direct access URLs to all LTER metadata and data products within the PASTA framework with the use of a proxy URL that will route such requests through its logging, authentication, reporting, and notification services. The Audit Services will support the use of persistent identifiers for object identification and resolution as part of the proxy URL.

The Audit Services will also be available for use by LTER information managers to replace direct access URLs with proxy URLs for any network accessible location outside of the PASTA framework (e.g., site web pages), thus continuing support provided by the original Data Access Server.

A typical use-case scenario would begin with a user requesting access to a specific data set. The user will be required to authenticate by using their community credentials, unless previously authenticated at another interface point. Once authenticated, the access event will result in the generation of an audit record that documents the event and a pair of notifications (e.g., email, SMS text message, or instant message) that are sent to 1) the data set owner/manager alerting them of the access event and 2) the user who is accessing the data with suggested citation information. The data are then passed through the proxy server and back to the requesting user.

Outcomes: The Audit Services will support compliance to the LTER Data Policy without separate and additional effort on behalf of LTER Site Information Managers, and with the added benefit of data use statistics and reporting.

Operational Steps:

1. ND will review use-case scenarios and functional requirements for the Audit Services, including new use-cases for integrating standard persistent identifier protocols.
2. ND will generate an implementation plan based on functional requirements.
3. The implementation plan will be reviewed by IMC and NISAC for completeness and correctness.
4. Execution of implementation plan will be performed by the software developers; incremental releases will include prototypes of the user interface.
5. A final review of deliverables by the IMC and NISAC will be performed to measure success.

Milestones:

- Use-case scenarios document developed (2011 Q4)
- Implementation plan developed (2011 Q4)
- Production deployment of the Audit Services (2012 Q3)
- Review of final deployment performed by the IMC and NISAC (2012 Q4)

Evaluation: The Audit Services will be reviewed as part of the regular NISAC reviews of LNO and NIS performance. Criteria for evaluation of the Audit Services will include delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s).

Benefits: The Audit Services will benefit the LTER scientists/researchers and their funding agency(s) by tracking, in a consistent manner, the access to LTER site-based and NIS derived metadata/data and provide standard use statistics. Site Information Managers will also benefit from the Audit Services since they will be able to use an LTER-wide application for complying with the LTER Data Policy and will not be required to develop a site-based solution.

Feedback: Direct feedback from the LTER scientists/researchers to the ND for evaluating notifications and their impact on user citation of LTER data use. Additional feedback will include response from Site Information Managers concerning ease-of-use of the Audit Services service interface and reporting. Indirect feedback on the Audit Services will include data access statistics.

3.2.3.11 Integration of Network databases into the LTER NIS.

The LTER Network supports a number of existing synthesis database applications, including EcoTrends and ClimDB/HydroDB, which are maintained as isolated projects and without direct coordination between one another. As part of the development process of the LTER NIS, these separate database applications will be integrated into the PASTA framework, thereby taking advantage of the structure and coordination of PASTA framework services and/or components. In addition, derived products from the ClimDB/HydroDB NIS Data Module will be exposed through a Consortium of Universities for the Advancement of Hydrologic Science, Incorporated (CUAHSI) Hydrologic Information System (HIS) web-service for subsequent discovery and access to users from CUAHSI. The following sections describe in detail activities of the integration tasks.

3.2.3.11.1 Integration path for EcoTrends and ClimDB/HydroDB

Description: The existing synthesis database applications (EcoTrends and ClimDB/HydroDB) of the LTER Network all follow similar processing steps: 1) collect site data and organize it into a standard format, 2) store restructured data into a common relational database schema, and 3) provide discovery and access tools via a web-based interface, including basic analytical applications. Each one of these applications, however, requires separate management and maintenance resources (this is especially true between EcoTrends and ClimDB/HydroDB because of their very different architectures). In some cases, applications require additional resources at the site-level to reformat data into a standard structure. As such, integrating these independent database applications into the LTER NIS will provide scalability and ensure data integrity by utilizing a common application framework (PASTA) that supports automated data harvesting and quality assurance checking. New features of the PASTA framework will become directly available to the integrated database applications without additional effort at the sites.

This task will focus on development of an integration trajectory for each of the existing database applications (EcoTrends and ClimDB/HydroDB). It will require understanding the underlying processes of the current systems, including stakeholder (both data providers and consumers) requirements and dependencies, data transformation issues, and the methods employed for discovery, access, and analysis. The process of integration will require that end products be similar, if not identical, as provided by the original applications, while at the same time introduce efficiencies brought about by the common PASTA framework.

Outcomes: Completion of the integration path for the existing synthesis database applications (EcoTrends, ClimDB/HydroDB) will provide a structured and well managed step-wise sequence for integrating existing synthesis database applications into the common PASTA framework.

Operational Steps:

1. The ND will perform a detailed analysis of the operations and processes of the existing synthesis database applications, looking particularly at data origination issues, transformation issues, and end-user tools (discovery, access, and analysis); this analysis will include direct communications with SIMs, site scientists/researchers, NISAC, and the broader community that utilizes the current applications.
2. The ND will compose detailed use-case scenarios based on the analysis in 1 above.
3. The ND will analyze use-case scenarios and will formulate functional requirements and an implementation plan for performing the integration
4. The implementation plan will be reviewed by the CIO, the IMC, and NISAC for completeness and correctness.
5. Execution of the implementation plan will be performed by the NIM, NAP3, and NAP2.
6. A final review of deliverables by NISAC will be performed to measure success.

Milestones:

- Use-case scenarios document developed (2010 Q4)
- Implementation plan developed (2010 Q4)
- Production deployment of the database application performed (2011 Q3)
- Review of final deployment will be performed by NISAC (2011 Q4)

Evaluation: Integration of Network databases will be reviewed as part of the regular annual review of NIS carried out by NISAC. Criteria for evaluation of the integration path for existing synthesis database applications will include: 1) comparison and validation of end products (derived data) to that of the data produced by the original application, 2) availability of data products as compared to the original application, and 3) ease of data harvesting at the site.

Benefits: All end users of the existing applications will benefit by having the applications integrated into a common framework that supports automated metadata and data harvesting and quality assurance checking. Site Information Managers will benefit by having additional data reformatting requirements removed from their responsibility.

Feedback: Direct feedback from end users of the existing synthesis database applications to the ND will occur for evaluating accuracy and efficiencies of the integrated applications. This feedback will be gathered as part of the biennial survey process.

3.2.3.11.2 Online analysis and processing of LTER NIS data

<u>Description:</u> Site-based data (Level 1 and Level 2) and derived data (Level 3) that will be accessible from the LTER NIS through the Discovery/Access API (section 3.2.3.10.5) will have great value. Tools for discovering and exploiting such data will also benefit the community. A certain number of these tools exist today, but many of them do not meet the full needs of the user community. This task will identify, plan, and develop online analysis and processing tools for data within the LTER NIS through a comprehensive RFC process that will solicit input from the LTER and the broader ecological community. Such tools may include enhanced data discovery through knowledge-based and semantic approaches, sub-setting and integration of data, and descriptive analysis of data.

<u>Outcomes:</u> Completion of this task will result in a set of online analysis and processing tools that may be applied to data within the LTER NIS. These tools will be at the request of the LTER Network and broader ecological community as specified in a formal RFC process.

<u>Operational Steps:</u>

1. The ND will compose a set of RFC documents for specific online analysis and processing tools, including enhanced data discovery, data sub-setting and integration, and descriptive analysis. These RFC documents, as informed by the research working groups, will be sent to stakeholders, including LTER scientists/researchers and other end users of the ecological community, for soliciting inputs on the benefits, design, and function of such tools.
2. The ND will perform an analysis of RFC responses and generate use-case scenarios.
3. The ND will analyze use-case scenarios and will formulate functional requirements and an implementation plan for each tool; the implementation plan will be reviewed by the IMC and NISAC for completeness and correctness.
4. Execution of the implementation plan will be performed by the software developers.
5. A final review of delivered tools by the NISAC will be performed to measure success.

<u>Milestones:</u>

- RFC documents developed (2013 Q1) for each tool
- Use-case scenarios developed for each tool (2013 Q1)
- Implementation plan developed (2013 Q1) for each tool
- Production deployment of each tool performed (2013 Q4)
- Review of final deployment of each tool performed by (2014 Q1)

<u>Evaluation:</u> The on time and on target completion of these tools will be reviewed as part of the regular review of the NIS carried out annually by NISAC. Criteria for evaluation of each online analysis and processing tool will include delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s). Additional criteria will include evaluation of tool's end product for correctness and accuracy. The usefulness of these tools to the scientific community will be assessed via the biennial survey of the LTER Network.

Benefits: More flexible and interoperable access to LTER data provided by the NIS will stimulate and increase LTER science, improve the quality of LTER data and metadata, foster the use of data for synthetic projects, and thereby enhance both national and global research. Online analysis and processing tools for LTER site-based data (Level 1 and Level 2) and derived data (Level 3) found within the LTER NIS will benefit LTER scientists/researchers and others involved in research from the broader ecological community by providing enhanced data discovery through knowledge-base and semantic tools, data sub-setting and integration tools, and descriptive data analysis tools.

Feedback: Feedback will be requested from LTER scientists/researchers and end users from the broader community of the efficacy of the online analysis and processing tool. Additional feedback will come from the metered use of such tools.

3.2.3.11.3 Site-based data integration into LTER NIS Data Modules

Description: The existing network-supporting database applications (site characteristics, personnel, bibliography) of the LTER Network will be integrated into the LTER NIS. The existing network-supporting databases will be redesigned and integrated as NIS Data Modules and their content will be made available through the Discovery/Access API. These network database applications currently follow site practices for generating NIS specific data, which are then imported into existing data modules for use by LNO, Site Information Managers and LTER scientists/researchers. A goal of the LTER NIS is to support the integration of these applications into the NIS without increased effort. As such, the Network Information Manager will support Site Information Managers to transition their data preparation effort from a localized process to an automated process as part of the PASTA framework.

Outcomes: The network-supporting databases will be accessed directly through the Discovery/Access API (as web-services). The Network Information Manager will assist in the transition of site-based data preparation from local SIMs to that of an automated PASTA framework process, increasing the overall data quality and reducing the overall effort of the Site Information Managers.

Operational Steps:

1. The associated product oriented working group will meet to determine needs.
2. The ND will compose detailed use-case scenarios based on output from the product oriented working group.
3. The ND will analyze use-case scenarios and will formulate functional requirements.
4. The implementation plan will be reviewed by the IMC and NISAC for completeness and correctness.
5. Execution of implementation plan will be performed by the software developers and the Network Information Manager.
6. A final review of deliverables by the NISAC will be performed to measure success.

Milestones:

- ♦ Working group product(s) delivered (2011 Q2)
- ♦ Use-case scenarios documents developed for network-supporting databases (2011 Q3)
- ♦ Implementation plan developed (2011 Q4)
- ♦ Production deployment of the integration process performed (2012 Q3)
- ♦ Review of final deployment will be performed by NISAC (2012 Q4)

Evaluation: This effort will be evaluated as part of the regular review of NIS activities by NISAC. Criteria for evaluation of site-based data integration of databases and applications will include delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s). Additional criteria will include the validation and verification of correct data harvesting into the PASTA framework and availability of network-supporting data through the Discovery/Access API.

Benefits: Completion of site-base data integration will benefit SIMs by reducing overall effort applied to manually preparing data for ingestion in the current NIS Data Modules and make accessing network-supporting data more efficient.

Feedback: Feedback will be gathered from Site Information Managers regarding the efficacy of automated processing and preparing of site-based data and accessing network-supporting data. Additional feedback will include automated data quality and validation testing as part of the Data Loading module (section 3.2.3.10.1).

3.2.3.11.4 Project Specific Data Services

Description: Project Specific Data Services will be a set of custom web-services of the Discovery/Access API that may be developed in support of projects that are synergistic or closely related to the mission of the LTER Network Information System. Examples of projects include the Consortium of Universities for the Advancement of Hydrologic Science, Incorporated (CUAHSI) Hydrologic Information System (HIS) web-services, DataONE (Observation Network for Earth) Member Node services, and/or the National Ecological Observatory Network (NEON) data interface. Any services development will be based on available support and required effort and its importance as decided by the LTER Executive Board. The CUAHSI HIS web-service has been previously identified by NISAC as a potential candidate as a Project Specific Service. The following sections assume acceptance of the CUAHSI HIS web-services as a Project Specific Data Service.

Outcomes: Completion of the CUAHSI HIS web-services integration into the Discovery/Access API will expose ClimDB and HydroDB data from their respective NIS Data Modules to CUAHSI and broader communities who are performing hydrologic research.

Operational Steps:

1. The ND will review and analyze the set of CUAHSI HIS web-services.

2. The ND will formulate an implementation plan for the CUAHSI HIS web-services; the implementation plan will be reviewed by the CIO, ND, NISAC, and representatives of the CUAHSI HIS technical team for completeness and correctness. The implementation plan will build upon past experience learned from the current LTER Data Access Server.
3. Execution of the implementation plan will be performed by the software developers.
4. A final review of deliverables by the CIO, ND, NISAC, and representatives of the CUAHSI HIS technical team will be performed to measure success.

Milestones:

- ♦ Implementation plan developed by ND (2013 Q4)
- ♦ Production deployment of the CUAHSI HIS web-services performed (2014 Q1)
- ♦ Review of final deployment performed by NISAC, and representatives of the CUAHSI HIS technical team (2014 Q2)

Evaluation: This activity will be evaluated as part of the regular annual review of NIS activities by NISAC. Criteria for evaluation of the CUAHSI HIS web-services will include delivery of all functionality as described by the requirements and implementation plan on the scheduled date(s). Additional criteria will include testing and validating output from the web-services by both the ClimDB and HydroDB data providers and CUAHSI scientists/researchers.

Benefits: The integration of CUAHSI HIS web-services into the Discovery/Access API will expose LTER ClimDB/HydroDB data through a public and standardized interface, thereby benefiting CUAHSI and broader communities who are performing hydrologic research.

Feedback: The ND will receive direct feedback from both scientists/researchers from CUAHSI and broader communities who are performing hydrologic research on the efficacy, correctness, and ease-of-use of the data from the LTER ClimDB/HydroDB. Additional feedback will include measuring the number of access events to ClimDB/HydroDB through the Discovery/Access API CUAHSI HIS web-services.

3.2.4 IT, Data base, and Web Consulting. Provide IT, database, and web consulting to LTER sites and synthesis working groups**.**

Background: Resources available to LTER sites to participate in Network data standards and applications are limited. The LNO has successfully gained site participation in Network standards and synthesis activities through the use of individualized consultation and ‘hands on’ technical help for issues ranging from web site design to EML implementation. LNO will now fill the majority of these generalized needs with web-based and targeted in-house training. However, one-on-one support provides an opportunity to help sites over minor hurdles that may be delaying their participation. This activity will develop a process to identify and prioritize these opportunities. The budget for this activity is $184,535 over six years to support 0.30 FTE of personnel time.

3.2.4.1 Technical support – The CIO will evaluate and prioritize needs and requests to provide a limited amount of information technology, database, and web application consulting services from existing labor pools to sites and working groups.

Outcomes: Individualized technical help provided to LTER sites at critical junctures increases their capability and desire to participate in Network science and education goals defined in the Decadal Plan. Synthesis working groups will leverage their analytical work by producing published data products.

Operational Steps:

1. CIO develops a process for evaluation in coordination with ED and ND.
2. CIO vets process with NISAC and IMEXEC.
3. CIO identifies sites/groups in need of assistance based on technical support requests or by other means during establishment of annual performance criteria.
4. CIO and ED evaluate requests for impending calendar year and rank based on the likelihood of increasing site participation in Network standards.
5. CIO develops a scope of work and a schedule based on resource availability.

Milestones:

- CIO develops and vets process for evaluating requests by Q4 2010.
- Sites and groups are identified during establishment of annual LNO performance criteria.
- Scope of work established and scheduled.
- Work completed.

Evaluation: Performance will be evaluated as part of LNO annual performance review. Participants will be asked to evaluate the effectiveness of the help.

Benefits: The broader scientific community will benefit from a greater number of site and synthesis data products being available online.

Feedback: Feedback will be requested as part of regular LNO surveys of sites.

3.2.4.2 Site visits – The CIO and selected LNO staff may travel to LTER sites during the performance period to consult and evaluate site-specific issues related to participation in the Network Information System and meeting Network standards for information management. The intent is to be able to visit all sites twice during the performance period if needed with the understanding that there are economies of traveling to multiple sites, opportunities when traveling on other business, and not all sites will desire the visitation.

Outcomes: Face-to-face interactions with site personnel are the most productive way to understand site needs and plan optimally crafted technical solutions. The outcome of LNO site visits will be improvements in information management plans and techniques across the LTER Network that increases the overall quality of Network data products.

Operational Steps:

1. The CIO identifies sites wanting assistance in preparing for review, working on renewal proposals, or improving their information system to meet Network standards.
2. The CIO fields ad hoc requests during the performance period and evaluates the requests based on priority and resource availability.
3. LNO personnel visit the site to develop an understanding of the site's requirements and help evaluate the level of effort required to make needed improvements.
4. LNO personnel provide a written evaluation within 2 weeks following the visits.

Milestones:

- Sites are identified during establishment of annual LNO performance criteria.
- CIO and ED evaluate requests.
- LNO visit scheduled and completed for each site.
- LNO written evaluation delivered to each site.

Evaluation: Performance will be evaluated as part of LNO annual performance review.

Benefits: Some sites will benefit from having additional expertise and perspective on specific components of their site IM and CI. The LTER Network will benefit by LNO facilitating broader site participation and accessibility. The LNO external CI partners and broader scientific community will benefit from having better overall access to quality data products.

Feedback: Feedback will be requested as part of regular LNO surveys of sites.

3.3 Core Services

The LNO provides many services to LTER scientists, sites, and the Network, some of which date to the original call for proposals for a Network office. Many of these services have been automated and only require routine maintenance (e.g., the Network bibliography). However, several core services require substantial effort, and therefore require more resources. While these services are varied, they have the common goal of enabling the network of sites to function efficiently. The five core activities described below provide critical services to the LTER community:

1. Facilitation of Meetings and other LTER Activities
2. Persistent Record of LTER Activities
3. Acquisition of Data, Hardware, and Software
4. Coordination of Proposal Preparation
5. Management and Reporting

3.3.1 Facilitation of Meetings and other LTER Activities. Provide financial and logistical support for meetings of Network governance and scientific committees**.**

Background: This activity has a budget of $1,059,665 over six years to maintain 2.45 FTE of personnel time as well as all materials and supplies costs for the LNO and participant support costs for the Executive Board and National Advisory Board meetings. Clerical and accounting personnel manage arrangements, reimbursements, and accounting for the meetings detailed below.

The LTER Network Bylaws and the Decadal Plan provide for meetings of key Network committees to advance research and education goals and to govern the Network. The LNO supports or facilitates almost all of these meetings, including:

- annual meetings of the Science Council, the Information Management Committee, and the LTER National Advisory Board (NAB);
- semiannual meetings and frequent videoconferences of the EB, the IMExec, and the NISAC;
- the annual LTER Network science forum to present research results for agencies at the NSF; and
- meetings and VTCs or teleconferences for up to 20 research working groups active at any time.
- When possible, the LNO facilitates ad hoc meetings of other standing committees such as Education, Publications, Graduate Students, Climate, International, and Social Science.
- In addition to research and governance meetings, the LNO supports and organizes triennial All Scientists Meetings (ASM) involving 800 participants from the 26 LTER sites and other national and international networks and research sites. Organization of these meetings requires significant LNO staff time during the year preceding the meeting.

Description of activity: Under the general supervision of the Senior Program Manager, the Office Manager, Accounting Technician, and Administrative Assistant facilitate efficient and cost-effective meetings by encouraging pre-planning, including the development of budget goals. The LNO helps meeting organizers identify venues and arranges support services. An agreement with a local travel agency allows the LNO to pay airfares directly, thereby controlling costs and eliminating the need for payments by individual meeting participant. Similarly, the LNO negotiates prices with other vendors and sometimes pays meeting costs directly to reduce the burden on participants. The LNO reimburses participants and vendors, provides cost accounting, and maintains a record of meeting participation.

Outcomes: On average, the LNO supports 30 meetings a year involving 400 participants. In 2009 and 2012, the LNO will organize ASM. The LNO’s central facilitation of meetings:

- Reduces the organizational burden on sites and individuals,
- Increases efficiency and productivity,
- Controls costs by reducing redundancy and by negotiating reduced prices for lodging and related meeting costs, and
- Provides clear communication of meeting logistics.

Operational steps:

1. Organizers of each regularly-scheduled or ad hoc meeting inform the LNO of details of the planned meeting (e.g., dates, number of participants, location, space requirements) through a web-based meeting form.
2. The LNO Office Manager and staff contact the meeting organizers to engage in pre-planning for the meeting.

3. The Office Manager and the Accounting Technician define budget goals with the meeting leader.
4. If requested, the Office Manager arranges lodging, catering, meeting space, and audiovisual equipment for the meeting. This may involve price negotiations with hotel, catering, and local transportation vendors.
5. The Office Manager maintains a log of participants for each meeting.
6. The Office Manager and the Accounting Technician process payments to vendors.
7. The Office Manager and Administrative Assistant process reimbursements to participants.
8. The Office Manager performs cost accounting upon completion of the workshop or meeting.
9. The Account Technician confirms that charges have been made to the appropriate account codes and indices.
10. Before a working group meeting is closed, the Office Manager obtains reports and products from the organizers.
11. The Office Manager closes the meeting and enters meeting data into the meeting database

<u>Milestones:</u> Regularly-scheduled meetings (e.g., Science Council, Executive Board, National Advisory Board, LTER science forum, information management committee, and information management executive committee) are conducted annually under the parameters set by the organizing committees. The number and size of these meetings are fixed by the LTER bylaws and previous practice. In addition, a variable number of synthesis and planning meetings are conducted each year, as directed by the Executive Board. Each meeting has an associated set of milestones.

<u>Evaluation:</u> The EB assesses the effectiveness of the LNO in conducting this activity through its annual evaluation. This evaluation is informed by a biennial survey of the LTER community that addresses timeliness and completeness of meeting information, simplicity of meeting logistics, speed and ease of reimbursement, and documentation of results from the meeting. In addition, the EB relies on individual experience and unsolicited comments from meeting participants to evaluate LNO performance. The EB also reviews the activities of each LTER committee annually as well as the level of resources assigned to each committee.

<u>Benefits:</u> The primary benefits of meeting facilitation accrue to the LTER community and its external partners. These benefits include:

- Increased connectivity among sites,
- Increased number of collaborations in support of network science,
- Increased number of multi-disciplinary collaborations in accordance with the Decadal Plan, and
- Increased pace of synthesis as evidenced by publications, authors per publication, and longevity of projects.

<u>Feedback:</u> The LTER community will provide feedback through the survey administered every other year on the types of meetings and workshops attended, LNO support services, ease of travel and logistics, and timeliness of reimbursements.

3.3.2 Persistent Record of LTER Activities. Ensure a persistent record of LTER activities, achievements, and decisions by creating, acquiring, and archiving datasets, documents, still and video images, and audio recordings.

Background: In its 28 years of operation, the LTER Network has produced an extensive record of its activities that includes publications, reports, minutes, notes, datasets, audio recordings, and visual images. The LNO acquires, archives, and manages these records and makes them accessible. The LNO adopts or adapts new technology to improve accessibility and security of the LTER archive, which will provide an historical record of LTER Network activities for future generations, increasing understanding and appreciation of accomplishments of LTER Network, and allow for more effective governance.

Description of activity: The LNO dedicates 1.15 FTE of personnel time to this activity at a cost of $99,714 over six years. Under the general supervision of the Senior Program Manager and the direct supervision of the Office Manager, an Administrative Assistant maintains electronic and paper files documenting the activities of the LTER Network. The LNO maintains an extensive database of information related to LTER personnel, bibliographies, site capabilities, committee activities, research, scientific initiatives and collaborations. The LNO documents the achievements and decisions of the Network by establishing a record of meetings and their minutes by acquiring and archiving datasets, documents, audio, and still and video images. Through database activities, web content generation, and data curation, the LNO maintains an active on-line archive of information and activities of the LTER Network.

Outcomes: The LNO provides easily accessible information from persistent printed and digital records of key Network products and decisions. Database products resulting from these efforts form the primary content for the various LTER web pages. These outcomes may be measured by easily accessible information. Evidence of service delivery includes:

- Easily accessible information from a persistent printed and digital record of: LTER personnel, publications, site capabilities, committee activities and decisions, research accomplishments, scientific initiatives, governance meeting records and minutes, data managed, correspondence, multimedia video, and still and video images, and
- Reports, papers and synthesis volumes from: Science theme workshops, annual science council meetings, All Scientists Meetings, research working groups, and mini-symposiums.

Operational steps:

1. The LNO consults with a professional archivist to create a best practices approach to the LTER archive.
2. LNO staff supply documentation of LTER Network and Network Office activities, including products from working groups, to the Administrative Assistant,
3. The Administrative Assistant files paper documents in the appropriate storage space using a specialized file code,
4. The Administrative Assistant passes electronic documents to the professional intern who maintains the dynamic digital archive of information,
5. As time permits, the Administrative Assistant creates digital copies of key paper documents to back up archived information, and

6. The Administrative Assistant implements new archival technologies as directed.

Milestones: Timely acquisition and archiving of datasets, documents, recordings, and still and video images that provide an historical record of meetings and minutes.

Evaluation: Metrics of the growth of paper and digital archives provide a quantitative measure of information accession. Accessibility of information will be quantified by focal questions on the biennial survey of the LTER community. The EB will include these measures as part of its annual evaluation of the LNO

Benefits: The LTER community, external partners, and greater scientific and education community will benefit from this activity in the following ways:

- There will be an accessible record of LTER scientific accomplishments
- Documentation of relationships between resources and outcomes will be possible
- Historical records will facilitate well-informed and consistent decision making
- An archive of LTER planning and key governance decisions will facilitate smooth transitions in leadership
- There will be an historical record of LTER Network activities for future generations of LTER scientists as well as for academic studies of the LTER Network as a scientific community.
- A well-maintained archive of accomplishments will lead to an increased understanding and appreciation of accomplishments of the LTER Network.

Feedback: Feedback will be gathered from the biennial survey and directly from users of the archives.

3.3.3 Acquisition of Data, Hardware, and Software. Facilitate the acquisition of commercial and public data, hardware, and software products for site-based and Network synthesis activities**.**

Background: Communication and data sharing are facilitated by common hardware and software, which can often be acquired at reduced cost through joint purchases. On several occasions in the past, the LNO has served as the Network's agent in acquiring common cyberinfrastructure, and it will act in this capacity more frequently in the future to fulfill the goals of the Decadal Plan. The Network research and education goals developed in the Decadal Plan emphasize synthesis using comparable datasets over broad spatial scales. To address issues of land use, climate change, and invasive species, LTER scientists will require time series of remotely-sensed data. Specific examples of such data sets include: satellite data collected by mission oriented agencies such as NASA, NOAA, or DOD; field data collected through networks of monitoring stations; and photographic images. The LNO facilitates collection of such data by interacting with LTER sites and the data providers to ensure accurate and complete geographic coverage of LTER sites.

Description of activity: This activity has a budget of $200,877 over six years that supports 0.45 FTE of personnel effort so the Network can respond opportunistically to improve hardware, software, and data capabilities. Because these opportunities are not known at this time, the plan describes the modes of response without identifying specific hardware, software, or data acquisitions.

Hardware/software: The LNO works to fulfill needs for cyberinfrastructure and communication tools as identified by sites and the goals of the Decadal Plan. By evaluating the utility and cost-effectiveness of different alternatives, the LNO assists the Network in making decisions about hardware and software acquisitions. Through proposals and partnerships, the LNO obtains resources to acquire common cyberinfrastructure and communication tools. Network-level acquisition and implementation includes communication and coordination with site personnel for site-specific needs, negotiations of costs for hardware and software, and distribution of resources across the LTER Network.

Data: The LNO works with private vendors and with partners at UNM centers, NASA, USGS, DOD, and other agencies to identify and acquire data that contribute to LTER research and education goals. The Director for Synthesis Support oversees the collection of information on site needs and the communication of this information to the data provider. The Chief Information Officer is responsible for ensuring delivery of the acquired data to LTER users through a web portal. When required, the LNO provides or requests funding for data acquisition.

Outcomes: Central acquisition of cyberinfrastructure, communication tools, and data reduces cost and improves interoperability while reducing redundant effort at each LTER site, as measured by the following outcomes:

- The consistent acquisition of standard and new data products across the LTER Network provides opportunities for cross-site synthesis.
- Direct collaborations with private companies and government agencies reduces redundancy of effort by individual LTER sites and enhances access to a variety of data including remote sensing data products.
- Centralized common acquisition of hardware, software, and data translates into savings in time and money by individual LTER sites.

Operational steps:

1. By the end of 2009, the LNO will complete a draft operational plan to update LTER Network spatial data holdings in conjunction with the LTER Spatial Data and Analysis Committee directives and Executive Board review.
2. On an annual basis thereafter, the LNO will engage in communication and coordination with LTER committees such as the Information Management Committee and the Spatial Data Analysis Committee as well as site personnel to identify needed new research resources.
3. The LNO will consult with the EB to prioritize requests and to identify sources of funds to acquire, hardware, software, or data.
4. When necessary, the LNO will prepare proposals and supplement requests for acquisitions.
5. The LNO will provide central coordination for acquisition of various hardware, software, and data.
6. The LNO will engage in negotiations for best costs with vendors of hardware and software.
7. The LNO will purchase and distribute new hardware, software, and data.

Pursuant to the internal LNO Business and procedures manual the processes for purchase include the following steps:

1. Initial request for the acquisition of hardware/software or data,
2. Check for availability of funds,
3. Identify vendor(s) and negotiate for specific costs,
4. Comply with approved and audited internal UNM purchasing processes: purchase requisition, purchase order, tracking and receipt of goods, inventory placement and tracking,
5. Implementation of hardware/software or data, and
6. Maintenance of hardware/software or data.

Milestones:

- ♦ By the end of the 2009, the LNO will complete a draft operational plan to update LTER Network spatial data holdings.
- ♦ The LNO will perform an annual evaluation of Network needs for hardware, software, and data.

Evaluation: Annual prioritized requests for hardware, software, and data will be incorporated into performance criteria defined by the EB. The annual report by the LNO to NSF and the EB will describe progress under each milestone of the performance criteria to inform the annual review process by the EB.

Benefits: Overall, this activity will enhance access to a variety of hardware, software, and data including remote sensing data products. In the long term (7-10 years), this will increase levels of network coordination and standardization through the consistent use of hardware and software. Ultimately, there will be an enhanced ease of cross-site data exchange and use, particularly for LTER scientists and educators and their external partners.

Feedback: Feedback will be gathered from the biennial survey and directly from users of the acquired data, hardware, and software.

Hardware/software: The LTER community will provide feedback through the survey administered every other year on the types of hardware/software requested, received, and used, along with support.

Data: As databases are accessed within the website, numbers of users will be monitored. Feedback may be indirectly parsed out of the volume and diversity of data requested by the number of users or through direct feedback on the website from a form that may be filled out in response to users' satisfaction.

3.3.4 Coordination of Proposal Preparation. Coordinate the preparation of proposals and supplements to respond to opportunities for Network funding.

Background: Opportunities to obtain resources to advance Network goals come in many forms, including development of collaborative partnerships, sharing of resources with other networks or centers, and acquiring new funding through proposals. Certain opportunities for funding, such as the periodic supplements provided by NSF for LTER ASM, require a proposal from the LTER Network. Other opportunities may arise suddenly and require an immediate response. In both cases, the LNO takes the lead in preparing proposals. The impact of these activities is an increase in Network resources to achieve the research and education goals of the Decadal Plan.

Description of activity: The LNO budget allocates $39,153 over six years to support 0.25 FTE of personnel time of the Senior Program Manager and the Accounting Technician for budget preparation and proposal submission. The Executive Director is responsible for proposal text with assistance from senior staff as needed.

The LNO prepares timely responses to funding opportunities related to Network-level initiatives and manages subsequent funding. The LNO distributes information about funding opportunities and helps to identify appropriate partners within the LTER Network. LNO staff members facilitate meetings and video conferences to develop ideas for proposals that benefit the Network.

Outcomes: The LNO will produce an average of two successful proposals a year that result in new or increased Network funding for activities such as:

- Acquisition of data, hardware and software,
- Increasing numbers of participants in triennial ASM,
- Increased funding for Network research and synthesis, and
- Increased resources to LTER sites.

Operational steps:

1. In conjunction with the EB, the LNO will set annual goals for funding requests, based on the needs of the LTER Network as determined by discussions with relevant LTER committees.
2. LNO staff will poll sites and monitor funding agencies for programs that might provide resources to meet identified needs.
3. The LNO will distribute information about funding opportunities to the LTER Network.
4. When appropriate, the LNO will facilitate or lead proposal preparation

Milestones: The EB and the LNO will set annual goals jointly at the beginning of the calendar year. The EB will evaluate progress as part of its annual review of the LNO.

Evaluation: Number of proposals produced and success rate will be the primary metrics for this activity. This information will be incorporated into the annual reports required by the National Science Foundation, the National Advisory Board, the Executive Board, and the University of New Mexico.

Benefits: This activity will benefit LTER scientists and educators and their external partners by increasing the number of participants in the triennial All Scientists Meeting, increasing funding for Network research and synthesis, and acquisition of hardware, software, and data.

Feedback: The LTER community will provide feedback through the biennial survey on LNO performance. LTER standing committees will provide additional feedback through annual reports to the Executive Board.

3.3.5 Management and Reporting. Manage the LTER Network and the LNO and report on the fiscal and administrative activities of the LNO.

Background: A fundamental responsibility of the LNO is to manage and properly account for the funds received through the CA and associated cost share, supplements to that agreement, and other monies received through competitively-funded projects. In addition, the LNO is responsible for reporting its activities as described in the CA. To fulfill these responsibilities, the LNO dedicates a portion of the effort of its supervisory staff to management and reporting tasks. In addition, the LNO provides funds to support salary of the LTER Chair.

Description of activity: This activity has a budget of $709,210 over six years to support 0.88 FTE of personnel time to manage the LTER Network and to track expenditures and report on the activities of the LNO. Specific activities supported include:

- Leadership - The LTER Chair leads the governance activities of the LTER Network.
- Planning – Senior staff conduct annual reviews of the goals described in the LNO Strategic plan and the associated Implementation Plan. These reviews lead to revisions in office priorities and re-allocations of resources to meet planning goals. Planning efforts are coordinated with the Chair and the EB.
- Planning – The LNO will prepare an operational plan for expenditure of ARRA funds in consultation with the EB.
- Administration of funds – LNO staff administer funds from the CA, supplements, and other grants by documenting expenditures, reconciling accounts, and providing reports to the NSF.
- Annual reports – The LNO prepares separate annual technical reports to NSF (2), the National Advisory Board, the LTER Network, and UNM.
- Annual reviews – The LNO prepares for and undergoes annual reviews by the LTER EB, the NAB, and the College of Arts and Sciences at UNM (resulting from its association with the Center for Research Excellence in Science and Technology). As part of the review by the EB, the LNO administers a biennial survey on office performance with questions developed in coordination with the EB.
- Personnel reviews – Supervisory staff conduct annual performance reviews of staff and determine salary increases.
- Mid-term review – The LNO prepares for and undergoes a mid-term review of performance by NSF. Three such reviews will be conducted during the next five years. In addition NSF will conduct a reverse site visit to evaluate the operational plan.

Outcomes: The outcomes of management and reporting activities include close coordination of Network and LNO objectives, adaptive management to address new issues and opportunities, an increased emphasis on broad impacts in LNO reports, a stable and efficient management structure with clearly-defined responsibilities for senior staff, low staff turnover, and a better understanding of LNO activities by NSF and the LTER Network.

The products of LNO management and reporting activities include:

- A continuously updated LNO Strategic Plan and Implementation Plan to guide office operations,
- Contributions to long-range planning within LTER,
- Adaptive adjustments in staff to meet changing network needs,
- Quantitative measure of LNO performance and site satisfaction, and
- Timely and accurate annual and final technical and fiscal reporting to EB, NAB, NSF, and UNM.

<u>Operational steps:</u>

1. The Network Chair acts as liaison between the Executive Board and Science Council to implement project oversight and guide scientific synthesis as outlined in the Decadal Plan. As prescribed by the LTER Network By-laws, the Chair shall:
   a. Preside at all meetings of the Science Council and Executive Board, and along with the Executive Board, generally oversee and supervise the governance of the LTER Network,
   b. Facilitate communication to Network sites regarding decisions of the EB,
   c. Provide a receptive ear for any Network member who wishes to raise an issue of concern,
   d. Serve as or appoint liaisons to NSF, other agencies, associations, networks, the public, and to Network committees.
2. The Executive Director acts as Principal Investigator to the LNO Cooperative Agreements and:
   a. Oversees the activities of the LNO, recruits and supervises senior staff, and is responsible for fulfilling the obligations of the Cooperative Agreement,
   b. Serves as an ex officio member of the Science Council and EB, in which capacity he contributes to and supports the activities of these groups,
   c. Serves on other Network standing committees as required,
   d. Serves as principal point of contact between the LNO and NSF,
   e. Acts as representative of the Network in interactions with Federal agencies, other research centers and networks, and the media,
   f. Reports on accomplishments of the LNO to the NSF, EB, LTER sites and committees, the LTER National Advisory Board, and UNM,
   g. Prepares proposals for funding activities of the LNO and oversees management of funds from these proposals according to NSF guidelines and UNM regulations, and
   h. Is responsible for the strategic planning for the LNO.
   i. Coordinates and implements activities to develop mutually beneficial relationships between LTER and Federal agencies, international research programs and other networks,
   j. Facilitates joint development and dissemination of CI for LTER through long-term partnerships with leading institutions in relevant disciplines,
   k. Oversees outreach activities to the LTER sites, the broader scientific community, agencies, policy makers and the public through the supervision of the Public Information Officer,
   l. Leads development of the LTER communication plan and manages the Eco informatics training program.

3. The Chief Information Officer oversees the Cyberinfrastructure of the LNO by leading and supervising the technical staff responsible for operations and maintenance of the LTER Network cyberinfrastructure, development and implementation of the Network Information System, and management of Network databases and websites. The CIO shall be responsible for:
    a. Planning and implementing cyberinfrastructure and information management standards to support the mission and goals of the LTER Network in coordination with the IM Committee and the NISAC,
    b. Acting as the expert member of the team responsible for implementing the LTER Network CI Strategic Plan,
    c. Representing the LTER Network to national and international efforts to coordinate shared cyberinfrastructure and standards of interoperability,
    d. Assuming the duties of the Executive Director in his absence, and
    e. Participating in the preparation of reports on LNO activities and interacts with NSF on Network CI issues.
4. The Director for Synthesis Support works with the SC, EB, and LTER sites and scientists to facilitate synthesis activities. To accomplish these tasks, he shall:
    a. Determine the goals and products of each meeting and identify the support necessary to achieve the stated goals,
    b. Work with the LNO Office Manager, to establish benchmarks and timelines for organizing each meeting,
    c. Work with the EB to determine priorities for disbursement of LNO support for research working groups,
    d. Summarize evaluations of the proposals and accumulate reports and other products from each working group,
    e. Work with the SC to plan and document science theme meetings and meetings to implement the Decadal Plan,
    f. Prepare supplemental proposals for funding to support ASM, planning meetings, and research working groups,
    g. Organize and carry out Network-level acquisition and management of remotely-sensed data and provide access to these data via the Internet, and
    h. Provide expertise to document and guide the acquisition of new technology and cyberinfrastructure for the LNO and LTER sites.
5. The Senior Program Manager performs the following duties and operational steps to ensure successful project implementation:
    a. Participates in the development, implementation, and maintenance of policies, objectives, and short and long-range planning,
    b. Oversees facets of daily operations of the LNO, ensuring compliance with UNM, state, and federal laws and regulations,
    c. Oversees the supervision of personnel, including work allocation, training, problem resolution,
    d. Develops and implements programmatic activities to accomplish established goals,
    e. Writes proposals and negotiates research contracts,
    f. Develops annual operating budgets and provides fiscal direction to the LNO as well as manages budgets for the organization and performs periodic cost and productivity analysis, and

g. Works with the Executive Director and various staff in the development of new proposals and coordination and administration of existing projects.

Milestones: Over the course of the current Cooperative Agreements, the LNO will:
- ♦ prepare an annual report to the EB and the National Advisory Board by January 20 of each year
- ♦ prepare two annual reports to NSF by January 30 and June 2
- ♦ prepare an annual report to UNM by February 1
- ♦ submit a final report for the previous CA by March 1, 2010
- ♦ prepare an operational plan for ARRA funds by February 28, 2010
- ♦ engage in a reverse site visit based on the operational plan (March 3, 2010)
- ♦ participate in NSF site reviews of the LNO in 2011, 2012, and 2013
- ♦ prepare final reports for both Cooperative Agreements
- ♦ prepare a renewal proposal for continued support of the LNO.

Evaluation: The EB evaluates LNO performance annually based on a wide range of feedbacks from the LTER community.

Benefits: The primary benefits of this activity accrue to LTER governance, the LTER community, and the NSF. Specific benefits include:
- Close coordination of Network and LNO objectives
- Adaptive management to address new issues as well as opportunities
- An increased emphasis on the broad impacts of LNO activities
- A stable and efficient management structure for the LNO and
- An increased understanding of LNO operations by NSF, NAB, EB, and LTER sites and scientists.

Feedback: Feedback on this activity will be gathered through the biennial survey if LNO performance and through the annual review of LNO by the EB.

3.4 Development and Outreach

3.4.1 Strategic Communication Plan. Create a strategic communication plan for better enhancing public information and outreach for the Network via a seamless system of information and outreach to the public.

Background: Increasingly, LTER science is benefiting society by enhancing understanding of complex socio-ecological phenomena and providing information that underlies sound decision-making in the public arena. Therefore, demonstrating the capabilities, achievements, and value of the work by Network scientists and educators is a major objective of all LTER communications. In conjunction with several volunteer communication specialists from LTER sites, the LNO Public Information Officer recently identified the communication and public relations methods used within LTER to reach its various clients and inventoried communication materials developed by the LTER Network Office. This study revealed that communication and outreach to the public by LTER sites and the Network have been largely ad hoc and reactive rather than proactive in seeking publicity for LTER. Clear opportunities exist for better coordinating public communication and outreach across the Network and for improving the dissemination of information to LTER clients and the public. The LTER Executive Board has asked the LNO to develop a Strategic Communication Plan for the LTER Network.

Description of Activity: This activity has a budget of $50,228 over six years to support 0.10 FTE of personnel time to manage the process of creating and updating a strategic communication plan. The LNO will use the same procedure employed to develop the Network Office Strategic Plan to create a communication plan that will encompass both strategic goals and implementation steps. The plan will solicit input from all LTER sites and advice from the broader community of communication experts. The plan will address: (1) *who* LTER wishes to communicate with; (2) *why* LTER wants to communicate with them; (3) *what* LTER desires to communicate; (4) *how* the information can be communicated most effectively; and (5) *when and how often* LTER needs to communicate with its stakeholders. The plan will include suggested public communication and outreach tools and products; proposed activities and tasks (e.g., development of an LTER media kit); and timelines, metrics and milestones.

One key group of stakeholders is the community of LTER scientists and information managers involved in the development of the Network Information System. Progress on NIS development and opportunities to engage in specific tasks need to be communicated frequently and clearly to this group of stakeholders. Thus, the development of the strategic communication plan will specifically target this group. An expert in the communication of technical information will be included in the team that will develop the implementation steps for the strategic communication plan.

Outcomes: The LNO will produce a "living" Strategic Communication Plan for the LTER Network that will guide allocation of resources. The plan will provide an integrated suite of tools and strategies for disseminating information about LTER scientific achievements. The strategic plan will encourage LTER sites and the Network to become more proactive in seeking publicity for achievements by LTER scientists and educators.

Operational steps:

1. The LNO will poll LTER sites to identify an experienced person to facilitate a contextual scan.
2. The facilitator, with the assistance of the LNO Executive Director and Public Information Officer, will conduct a contextual scan that will develop communication objectives of the LTER Network, identify stakeholders, examine external drivers, and summarize site and Network communication activities.
3. Under the leadership of the facilitator, a planning team consisting of members of the Executive Board, experienced volunteers from LTER sites, and the LNO Executive Director and Public Information Officer will conduct virtual and face-to-face planning meetings to review the contextual scan; assess LTER strengths, barriers and opportunities; identify and prioritize strategies, tactics, and actions; develop timelines, metrics and milestones; and assign responsibilities.

4. The facilitator, the LNO Executive Director, and the Public Information Officer will create a *Draft Strategic Plan*.
5. The Executive Board and Science Council will review the plan, and the facilitator, the LNO Executive Director, and the Public Information Officer will revise it accordingly.
6. Under the leadership of the facilitator, an implementation team consisting of expert advisors, the LNO Executive Director, and the Public Information Officer will conduct virtual and face-to-face meetings to identify implementation steps.
7. The facilitator, the LNO Executive Director, and the Public Information Officer will create a *Draft Strategic and Implementation Plan*.
8. The EB will review the draft plan for revision by the LNO Executive Director and the Public Information Officer.
9. The LNO will publish the Strategic Communication Plan and a summary pamphlet, and the members of the LTER Network will communicate the existence of the plan to relevant stakeholders.
10. The Public Information Officer will gather performance data, provide progress reports to the LTER Executive Board, monitor external events, and make recommendations to the EB for changes in the Strategic Communication Plan.
11. The LTER Executive Board will review performance data every three years and recommend modifications to the *Strategic Communication Plan.*
12. The Public Information Officer will implement modifications to the *Strategic Communication Plan.*

<u>Milestones:</u>

- ♦ By the end of 2009, the LNO will submit a schedule for the planning process to the EB.
- ♦ By February 2010, the LNO will identify a facilitator and members of the planning team for approval by the EB in its February meeting.
- ♦ By March 2010, the facilitator and the planning team will conduct the contextual scan and submit to the EB for review at its April meeting.
- ♦ By May 2010, the facilitator and the planning team will develop a draft plan and present it to the Science Council.
- ♦ By June 2010, the facilitator and the ED will identify experts for the implementation meeting.
- ♦ By July 2010, the facilitator will organize and carry out a meeting of the expert advisors.
- ♦ By August 2010, the facilitator will complete a draft of the implementation plan for review by the EB. By September 2010, the facilitator will present a draft Strategic Communication and Implementation Plan to the LTER Executive Board.
- ♦ By January 31, 2011, the Executive Director and the Public Information Officer will produce a final draft of the Strategic Communication Plan and an accompanying brochure for publication.

<u>Evaluation:</u> The EB will evaluate the successful completion of the activity by 1) reviewing progress against approved milestones, and 2) reviewing the quality and completeness of the draft Strategic Plan.

Benefits: The LTER Network will benefit from the activity by having a focused, proactive approach to the dissemination of LTER accomplishments. LTER scientists and educators and their external partners will benefit by having their findings increasingly cited in important media outlets (both professional and public), and by increasing participation in public decision-making (e.g., providing expert testimony). LTER will achieve greater name recognition throughout the world for the quality of site and Network science. The strategic plan will specifically address new ways to employ information technology to engage underserved groups in the research and education activities proposed in the Decadal Plan.

Feedback: Communication efforts will include explicit opportunities to provide feedback on effectiveness to the Public Information Officer, who will make improvements as necessary. The biennial survey of the LTER community will request feedback on communication efforts. The Public Information Officer will gather performance data on each mode of communication. The EB will review these sources of feedback every three years and recommend changes to the Strategic Communication Plan.

3.4.2 Communication and Outreach. Effectively communicate information about the LTER Network—purpose, activities, and achievements—through an array of proven, high-visibility mechanisms.

Background: The LNO budget allocates $770,311 to support 1.10 FTE of personnel time as well as participant support costs, publication costs, and travel to disseminate information about the accomplishments of the LTER Network. Efforts to communicate information about the LTER program to its various constituencies have grown over the years and adopted new technologies as they have come in to common use. The LNO has gradually shifted from an early reliance on printed documents to a mix of print, multimedia, and web-based communication approaches. In the absence of clearly-defined Network goals for communication and outreach, the LNO has used simple and cost-effective media approaches to reach perceived key constituencies. Increases in the size and scope of the Network and interest in the Network from new audiences have complicated communication and outreach efforts and led to the initiation of a strategic communication plan.

Description of Activity: The LNO Public Information Office, working with other members of the LNO staff and Network governance committees, communicates information about LTER to the LTER research and education community and its partners, the external scientific community, funding agencies, policy makers, and the public. Primary means of communication include web portals, video and presentations, a traveling multimedia exhibit, and a variety of print materials. Core activities that presently form the foundation for the LNO communication and outreach program include: (1) publication of LTER Network Newsletters, site and Network brochures, and flyers and occasional publications; (2) maintenance and continued upgrading of the LTER Network and LNO web sites; (3) periodic revision of the LTER traveling multimedia exhibit, presentations, and posters; and (4) representation of the LTER Network at scientific meetings such as the American Association for the Advancement of Science (AAAS), ESA, and SACNAS. A Strategic Communication Plan presently under development likely will lead to the modification of some existing communication and outreach activities as well as to the addition of new activities that are approved by the Executive Board.

Outcomes: LNO communication and outreach activities will increase understanding of LTER capabilities, achievements, and contributions to science and society, especially with respect to understanding complex, long-term phenomena and to informing decision-making on ecological issues.

Operational steps:

1. Until the Strategic Communication Plan is completed and approved, the Public Information Officer and the Application Support Analyst, supervised by the Executive Director, will continue ongoing communication and outreach activities, including:
   a) Publication of the Spring and Fall LTER Network Newsletter
   b) Production of two revised site brochures annually
   c) One or more revisions of the LTER Network brochure
   d) Maintenance and regular updating of the LTER and LNO web sites
   e) Re-design of the traveling multimedia exhibit in Year 1 and the addition of one or two revised poster modules annually
   f) Production of flyers, posters, and occasional publications as requested by the Executive Board
   g) Outreach to annual meetings of ESA and SACNAS
2. Upon acceptance of the communication plan, the Executive Director and the CIO will review new tasks in the plan and match tasks with existing expertise and effort levels.
3. The ED and CIO will re-allocate effort and other resources to address new tasks.
4. If necessary, the ED and CIO will revise position descriptions of the Public Information Officer.
5. If necessary, the Public Information Officer will undergo training to meet new responsibilities.
6. If necessary, the ED and the CIO will recruit new staff to complete the skill set needed for new tasks.

Milestones:

- By 2010, the Public Information Officer will complete a re-design of the traveling multimedia exhibit; one or two revised display modules will be added annually in subsequent years.
- Beginning in 2009, the LNO will publish annual Spring and Fall LTER Network Newsletters unless contraindicated by the Strategic Communication Plan.
- Beginning in 2009, the LNO will assist two sites in revising their brochures annually unless contraindicated by the Strategic Communication Plan.
- Beginning in 2009, the Public Information Officer will create or acquire updated content for LTER and LNO web sites at least quarterly.
- Beginning in 2009, the Public Information Officer will deploy the multimedia exhibit at the annual meeting of the ESA.
- By 2012, LNO staff will publish a revised LTER Network brochure unless contraindicated by the Strategic Communication Plan.

- By 2012, the LNO will modify or enhance staff to address new skills required by the Strategic Communication Plan.

Evaluation: The EB will evaluate the successful completion of the suite of communication and outreach activities by 1) reviewing progress against approved milestones, and 2) reviewing the quality of communication and outreach products, 3) inspecting the results of the biennial survey of LNO performance, and 4) analyzing performance metrics defined in the Strategic Communication Plan.

Benefits: The LTER Network and its external partners will benefit from an increased understanding and appreciation of their work by targeted audiences. The larger scientific and education community will benefit from easily accessible information about LTER activities, including research results, learning tools, opportunities for engagement, information management standards and practices, training opportunities, and future plans.

Feedback: The EB will receive formal feedback on communication and outreach activities from the biennial survey of LTER scientists and educators and informal feedback from the communities reached by LNO communication and outreach activities.

3.4.3 External Relations. Build and maintain strategic partnerships and collaborations that benefit science, cyberinfrastructure development, and education in the LTER Network, as well as the broader community of scientists, students, and educators.

Background: Following recommendations made in the 10- and 20-year reviews of the LTER Network and responding to directives in Cooperative Agreements with NSF, the LNO has participated in a number of partnerships and collaborations that have benefited LTER and the broader community. Partnering activities have included developing or sharing research resources and cyberinfrastructure, creating informatics research and training opportunities, and designing and coordinating efforts among environmental observatories, organizations and societies to improve efficiency and cost-effectiveness of the LTER scientific enterprise.

Description of the Activity: This activity has a budget of $109,690 over six years to support 1.00 FTE of personnel time to build and maintain mutually-beneficial partnerships between the LTER Network and other networks, centers, institutes, and programs. LNO staff will work with the EB, other relevant LTER committees, LTER sites, and existing external partners to identify opportunities to develop valuable strategic partnerships. Potential partnerships will be evaluated, prioritized, and approved in the context of research and education goals set out in the Decadal Plan, the Strategic Communication Plan, and the LNO Strategic Plan. Where appropriate, the LNO may enter into collaborations directly or facilitate collaborations between elements of the LTER Network and other networks, centers, institutes, or agencies. Coordination and communication with partners and collaborators encompass a range of activities that are necessary to build and maintain a collaboration including: email, phone and videoconferences among the collaborators; reports of activities and results to participants and the broader community; and reports and contracts that meet the requirements of funding agencies and Memoranda of Understanding that may exist among the partnering institutions. LNO staff will facilitate communication between the LTER Network and other scientific, cyberinfrastructure development, and education enterprises and disseminate information regarding pertinent activities and opportunities to LTER sites and scientists.

Outcomes: Outcomes will include increased opportunities for training of LTER scientists, CI staff, and students; increased numbers of LTER personnel engaged in collaborative research and CI activities across networks; increased funding for cross-network and cross-agency activities; and increased leveraging of partner contributions (e.g., CI interoperability) to achieve LTER goals.

Operational steps:

1. LNO staff will perform an in-house review of existing partnerships and collaborations, including origins, benefits, and costs of each.
2. The Executive Director and the EB will analyze the results of this review to assign priorities to existing partnerships and collaborations
3. Depending on the results of the previous analysis, ongoing collaborations will continue at the same effort, receive increased or diminished attention, or be terminated. These collaborations include: (1) the LTER—NBII Partnership that supports Iñigo San Gil and his efforts to upgrade metadata management systems across the LTER Network (central activities include support and enhancement of the metadata editor/entry tool, outreach efforts to promote adoption of the metadata editor, training sessions, editor usability tests and focus groups to improve the tool, continued help-desk support for assisting LTER sites with data and metadata management, designing protocols for QA/QC and metadata content enrichment, and creating tools that facilitate data integration and synthesis); (2) LTER and NCEAS support of www.ecoinformatics.org—a community web portal that provides access to open source cyberinfrastructure for ecologists and information managers; (3) LTER engagement in the Kepler Core Project—a follow-up effort to the SEEK Project that is providing free and open access to powerful scientific workflow software (i.e., Kepler) for use by LTER scientists; and (4) partnering with the Organization of Biological Field Stations (OBFS) in development of mutually beneficial research, cyberinfrastructure development, and training activities such as those supported in the recently completed Research Coordination Network project.
4. The same analysis will be performed on recently initiated partnerships and collaborative opportunities that benefit the LTER Network, including:
   - Participation in proposals and strategic planning sessions with the Internet2 and National Lambda Rail to enhance high-bandwidth connectivity across the Network and to add new, powerful collaboration technologies to LTER sites.
   - Collaboration with the Oak Ridge National Laboratory Digital Active Archive Center, the two major synthesis centers supported by NSF-BIO (NCEAS, NESCent), the digital library community, NSF-funded supercomputer centers (e.g., SDSC, NCSA, NCAR), NBII, and the Global Biodiversity Information Facility to enhance LTER archive and preservation capacity and to promote interoperability across related research networks and archives.
   - Communication and coordination with research networks (and their supporting agencies) that overlap to some extent in membership and mission with LTER, for example, the USGS National Phenology Network, NEON, WATERS, OOI, the USDA-FS

experimental forest network, the Urban Long Term Research Areas (ULTRA; USDA FS), and the Long Term Agricultural Research Network (LTAR; USDA Cooperative State Research, Education, and Extension Service).

5. For each continuing collaboration, the Executive Director and the EB will determine the appropriate level of effort, leadership, participants, reporting frequency, and means for evaluation of the collaboration.
6. The EB will review progress of each collaboration periodically to re-assess priorities.

Milestones: By the end of 2011, the Executive Director will conclude a review of existing partnerships and collaborations. The EB, working with the Executive Director, will assess the importance of each partnership and determine priorities by the end of 2012.

Evaluation: Evaluation of the activity outlined above will be conducted once by the EB, with their evaluation based on adherence to the milestone schedule and the thoroughness of the review of partnerships and collaborations. Subsequent evaluations will be based on the success of each partnership in achieving its goals.

Benefits: The benefits accruing to LTER vary among partnerships and collaborations. Some partnerships (e.g., the National Phenological Network, NBII) have direct benefits to LTER site and Network science and information management, respectively. In other partnerships (e.g., OBFS), short-term benefits may favor the partner, with potential benefits to LTER coming over the long term. Some collaborations (e.g., NEON, WATERS, OOI, the USDA-FS experimental forest network, ULTRA, LTAR) have the potential to become mutually beneficial. Other collaborations (e.g., NCEAS, Kepler Core Project, NESCent, ORNL DAAC, SDSC, NCSA, NCAR) have already proven their value through successful results (e.g., EML, Metacat, Morpho) and funded proposals (e.g., SEEK, VDC, Dryad, DataONE). In addition to the direct and tangible benefits received from each of these partnerships, the LTER Network also receives the immeasurable benefit of playing a central role in the development of a national infrastructure for the science of ecology.

Feedback: Each partnership and collaboration has an internal process to provide feedback on its successful operation. Overall, feedback from LTER scientists and sites will indicate the success of the suite of external relationships developed by the EB. This feedback will be delivered through the annual Science Council meeting as well as unsolicited comments to the Chair and the EB. Feedback from external sources will come through decadal reviews of the LTER Network, evaluations by NSF, annual reviews by the National Advisory Board, and unsolicited testimonials (e.g., the Distinguished Scientist Award from AIBS).

3.4.4 Training. Provide or coordinate training for LTER scientists and information specialists in support of Network science and CI development.

Background: The dissemination of technical information throughout the LTER Network raises understanding to a common level, facilitating productive interactions and promoting the adoption of best practices. As new analytical techniques and technical tools come into use, a regular program of training opportunities presents the most efficient approach to disseminating standard practices across the LTER Network. In the past, LTER scientists and information managers have participated in various LNO training exercises funded through external partnerships with the Organization of Biological Field Stations and the SEEK project. The success of these training exercises and the repeated requests for additional learning opportunities prompted the LNO to initiate a regular program of training.

Description: A budget of $310,054 over six years will provide support for 0.10 FTE of personnel time to organize training activities for LTER sites and scientists as well as materials and supplies for meetings and participant support costs for trainees. Each year, the LNO will organize and host one or two three-day training workshops that reach scientists or information managers at the 26 LTER sites. As part of this exercise, the LNO will coordinate workshop planning and training activities, cover participant support costs, capture lectures and live demos on a rich media recorder, and produce formative and summative evaluation tools. Technology training for scientists could alternate with information technology training. LTER information managers have proposed several possible IT training topics, including cybersecurity and advanced GIS analysis. Possible science technology training topics include: creating and running scientific workflows for complex analyses (e.g., Kepler) and establishing sensor networks for *in situ* measurement programs (e.g., communications, QA/QC, analysis).

Outcomes: Training sessions will increase the use and proficiency of use of advanced technologies across the LTER Network as well as leading to increases in standardization of methods among sites. Increased proficiency and standardization will lead to an increase in cross-disciplinary and cross-site publications based on use of new technologies or scientific approaches. Recorded lectures and demonstrations will provide the means to reach a larger audience as well as to prepare newcomers to the LTER Network.

Operational steps:

1. The Executive Director will prepare an annual call for suggestions for training workshops from scientists, information managers, technical staff, and students, to be submitted simultaneously with proposals for research working groups.
2. Interested groups will submit short descriptions of proposed training activities to the LNO, where they will be evaluated for practicality, breadth of interest, availability of appropriate trainers, relevance to LTER goals, and cost.
3. The Executive Director will present the proposed training activities to the EB along with results of the LNO evaluation and recommendations on funding.
4. The EB will determine which proposed activities will be funded.
5. The Executive Director will inform the LTER Network of the decision of the EB and open enrollment for the highest priority training activity. Sites will be allowed to nominate one trainee per year. If space remains after enrollment is closed, sites will be allowed to nominate a second trainee up to a total enrollment of 26. If the number of nominations exceeds the spaces available, trainees will be chosen by lot.
6. The Executive Director will recruit trainers and set the dates and location of the training. In most cases, the training will take place in Albuquerque, New Mexico, except when an alternate training facility specializing in the training topic is available.
7. Trainers will be responsible for the content of the training.
8. The LNO will organize and pay for travel and lodging for the workshop.

9. The LNO Systems Analyst will prepare the training laboratory for the workshop and be responsible for assisting the trainers during the workshop.
10. The LNO Systems Analyst will make video recordings of the training workshop and archive those recordings along with any audiovisual or written materials used in the training. The Systems Analyst will make these materials available to LTER scientists and information managers.
11. Formative and summative evaluations of the training will be completed by workshop attendees, and reviewed by the Executive Director.
12. Should training funds accumulate over time because of cancellations or other reasons, the Executive Director may schedule a second training activity in a single year. In that case, he will select the proposal ranked second in priority by the Executive Board.

<u>Milestones:</u> By 2014, each LTER site should have had the opportunity to participate in five training exercises.

<u>Evaluation:</u> The EB will evaluate each annual training workshop to modify future training priorities and the process for selecting training workshops. The Executive Director will evaluate each training opportunity from the perspective of trainee satisfaction and cost effectiveness. These evaluations will inform future decisions on training topics and venues.

<u>Benefits:</u> LTER scientists and information managers will be the primary beneficiaries of training.

<u>Feedback:</u> Feedback on the training exercises themselves will be acquired through formative and summative evaluations of the training by participants. Feedback on the LNO's role in organizing the training will be received through the biennial survey of LTER sites.

4. Tables and Figures

Table 1. Person effort in full-time equivalents (FTE) for LNO staff

Table 1. Person effort in full time equivalents (FTE) for LNO staff		Synthesis			Cyberinfrastructure				Core Services					Development/ Outreach			
	FTE	1.1 Science Council	1.2 All Scientists Meetings	1.3 Research Working Groups	2.1 Basic CI Support	2.2 Information Management	2.3 Network Information System	2.4 IT, Database, and Web Consulting	3.1 Facilitation of Meetings	3.2 Persistent Record of LTER Activities	3.3 Acquisition of Data, Hardware, Software	3.4 Proposal Preparation	3.5 Management and Reporting	4.1 Strategic Communication Plan	4.2 Communication and Outreach	4.3 External Relations	4.4 Training
Executive Director (UNM)	1.00																
Director Synthesis Support	0.75	0.15	0.20	0.20		0.05	0.05				0.05		0.05				
Chief Information Officer	1.00				0.25	0.25	0.25	0.10			0.05		0.10				
Application Support Analyst	1.00				0.30	0.30		0.20							0.20		
New Professional Intern 1	1.00				1.00												
System Administrator	1.00				1.00												
Systems/Analyst	1.00				0.80						0.10						0.10
New Information Manager	1.00					1.00											
NIS Developer	0.75						0.75										
NIS Programmer/Analyst III	1.00						1.00										
New NIS Programmer/Analyst II	1.00						1.00										
New Professional Intern 2	1.00						1.00										
Senior Program Manager (CREST)	0.50								0.05	0.05	0.05	0.15	0.20	*Year 1 only			
Office Manager	1.00								0.70	0.10	0.10		0.10				
Accounting Technician	1.00								0.70		0.10	0.10	0.10				
Work Study Student 1	1.00									1.00							
Work Study Student 2	1.00								1.00								
Public Information Officer	1.00													0.10	0.90		
Administrative Assistant	1.00															1.00	
Chair of the Science Council													0.33				
Total FTEs	18.00	0.15	0.20	0.20	3.35	1.60	4.05	0.30	2.45	1.15	0.45	0.25	0.88	0.10	1.10	1.00	0.10
Sub-total - FTEs by category of activity			0.55				9.30				5.18				2.30		

Table 2. Total LNO budget by 17 tasks

Table 2. Total LNO budget by 17 tasks	1.1 Science Council	1.2 All Scientists Meeting	1.3 Research Working Groups	2.1 Basic CI Support	2.2 Information Management	2.3 Network Information System	2.4 IT, Database, Web Consulting		
Salaries/Wages/FB	$ 150,390	$ 200,520	$ 200,520	$ 1,443,949	$ 810,241	$ 1,988,106	$ 184,535		
Computer Services	$ -	$ -	$ -	$ 180,000	$ -	$ -	$ -		
Equipment > $5,000	$ -	$ -	$ -	$ 160,124	$ -	$ -	$ -		
Materials and Supplies	$ -	$ -	$ 300,000	$ 160,000	$ 90,000	$ -	$ -		
Participant Support Costs	$ 454,800	$ -	$ 767,938	$ -	$ 305,798	$ 118,800	$ -		
Publication Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -		
Sub-awards	$ -	$ -	$ -	$ -	$ 381,256	$ -	$ -		
Travel	$ 19,800	$ -	$ -	$ 33,000	$ 26,400	$ 33,000	$ -		
Total	**$ 624,990**	**$ 200,520**	**$ 1,268,458**	**$ 1,977,073**	**$ 1,613,695**	**$ 2,139,906**	**$ 184,535**		
	3.1 Meeting Facilitation	3.2 Persistent Record of LTER Activities	3.3 Acquisition Data, Hardware, Software	3.4 Proposal Preparation	3.5 Management and Reporting	4.1 Strategic Communication Plan	4.2 Communication and Outreach	4.3 External Relations	4.4 Training
Salaries/Wages/FB	$ 494,465	$ 99,714	$ 200,877	$ 39,153	$ 656,410	$ 39,228	$ 435,391	$ 109,690	$ 34,054
Computer Services	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Equipment > $5,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Materials and Supplies	$ 321,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 18,000
Participant Support Costs	$ 244,200	$ -	$ -	$ -	$ 33,000	$ 11,000	$ 39,600	$ -	$ 258,000
Publication Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ 90,720	$ -	$ -
Sub-awards	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Travel	$ -	$ -	$ -	$ -	$ 19,800	$ -	$ 204,600	$ -	$ -
Total	**$ 1,059,665**	**$ 99,714**	**$ 200,877**	**$ 39,153**	**$ 709,210**	**$ 50,228**	**$ 770,311**	**$ 109,690**	**$ 310,054**
Grand totals	$ 11,358,079								
Equipment totals (F&A Excludable)	$ 160,124								
Participant totals (F&A Excludable)	$ 2,233,136								
F&A (TDC - Equip and Part Costs)	$ 4,304,283								
Grand Total	$ 15,662,362								

Table 3. Server replacement schedule

Draft LNO Server Hardware Replacement and Upgrade Schedule (10-21-2009)

SERVER NAME	Year in Service	Hardware (Dell and Intel)	OS	Function	Disk Space (used/total) %	%Disk Used
Production						
Canyon	2007	PE 2950 2-Xeon X5355 QC, 2.66GHz, 16Gb	Ubuntu Linux 8.04	Mail server, list server, and mail archive	61/854Gb	7
Mountain	2007	PE 2950 2-Xeon X5355 QC, 2.66GHz, 16Gb	Ubuntu Linux 8.04	Database server, backup LDAP	23/963Gb	2
Temperate	2007	PE 2950 2-Xeon X5355 QC, 2.66GHz, 16Gb	Ubuntu Linux 8.04	Web server, content management system, site photo/document archive	41/911Gb	5
Tropical	2007	PE 2950 2-Xeon X5355 QC, 2.66GHz, 16Gb	Ubuntu Linux 8.04	Data Catalog (Tomcat, Metacat, Postgres)	196/963Gb	22
Ecotone	2007	PE 2950 2-Xeon E5430 QC, 2.66 GHz, 16Gb	Ubuntu Linux 8.04	VMware virtual machine server (8 virtual machines)	800/1167Gb	67
Urban	2007	PE 2950 1-Xeon E5335 QC, 2GHz, 4Gb	Ubuntu Linux 7.10	File server, tape server, shared storage, source code control system, image archive	1638/2765Gb	63
Longterm	2002	PE 6600 4- 80528 SC 1.4GHz, 4Gb	Windows 2000	Deprecated database server	44/237Gb	18
Savanna	2003	PE 2650 2 -80532 SC 3.06GHz, 2Gb	Red Hat Linux ES	Deprecated web server	62/99Gb	63
Prairie	2004	PE 2650 2-80532 SC 3.06GHz, 533MHz, 2Gb	Ubuntu Linux 8.04	Ecotrends (Tomcat, Metacat, Postgres)	34/155Gb	18
Ecosys	2007	PE 1950 1 Xeon 5130 DC, 2GHz, 4Gb	Ubuntu Linux 8.04	LDAP for Network authentication	64/129Gb	53
				Disk space usage in production	**2.89/8.05Tb**	**36**
Backup						
Polar	2006	PE 2850 1-80551 DC, 2.8GHz, 2Gb	Ubuntu Linux 8.04	Backup data catalog (Tomcat, Metacat, Postgres)	200/1126G	20

Draft LNO Server Hardware Replacement and Upgrade Schedule (10-21-2009)

Local						
Butte	2007	PE 1950 1-Xeon 5130 DC, 2GHz, 4Gb	Ubuntu Linux 7.04	Local Samba Windows domain controller	1.4/121Gb	1
Mesa	2007	PE 1950 1 Xeon 5130 DC, 2GHz, 4Gb	Ubuntu Linux 8.04	Local Samba Windows backupdomain controller	1.4/121Gb	1
Habitat	2003	PE 2650 2-80532 SC 3.06GHz, 2Gb	Windows 2003	Deprecated local file server, tape server	683/852Gb	80
Alpine	2007	PE2950 1-E5335 QC, 2GHz, 4Gb	Windows 2003	Local file server, conscripted for web and database for ClimDB migration	430/1106Gb	40

Replace in FY 10-11 with virtual-based server and consolidated storage for all failover servers
Upgrade in FY 11-12 to function with consolidated storage solution
Replace in FY13-14 with new hardware or upon failure after 2011
Replace on failure with available hardware

Table 4. Timeline of major development tasks

	WBS	Name
1		End of Project
2		Project Life
3		Operational Plan
4		Review Planning
5		Operational Prototype
6		Production Deployment
7		Transition/Maintenance
8	**3.2.3.10**	**⊟Network Information System**
9	**3.2.3.10.1**	**⊟Data management suite**
10		**⊟Phase 1**
11	3.2.3.10.1.1	Data Manager
12	3.2.3.10.1.2	Data Catalog
13	3.2.3.10.1.3	Data Loader
14	3.2.3.10.1.4	Data Cache
15		**⊟Phase 2**
16	3.2.3.10.1.1	Data Manager
17	3.2.3.10.1.2	Data Catalog
18	3.2.3.10.1.3	Data Loader
19	3.2.3.10.1.4	Data Cache
20	**3.2.3.10.2**	**⊟Workflow Manager**
21		Phase 1
22		Phase 2
23	**3.2.3.10.3**	**⊟Metadata Factory**
24		Phase 1
25		Phase 2
26	**3.2.3.10.4**	**⊟NIS Data Portal**
27		Phase 1
28		Phase 2
29	**3.2.3.10.5**	**⊟Discovery/Access API**
30		Phase 1
31		Phase 2
32	**3.2.3.10.6**	**⊟Id Management Services**
33		Phase 1
34		Phase 2
35	3.2.3.10.7	Persistent ID Services
36	3.2.3.10.8	System Monitor
37	3.2.3.10.9	Audit Services
38	**3.2.3.11**	**⊟NIS Database Integration**
39	3.2.3.11.1	Integration Path
40	3.2.3.11.2	OLAP NIS Data
41	3.2.3.11.3	Site-based Data Integration
42	3.2.3.11.4	Project Specific Data Services

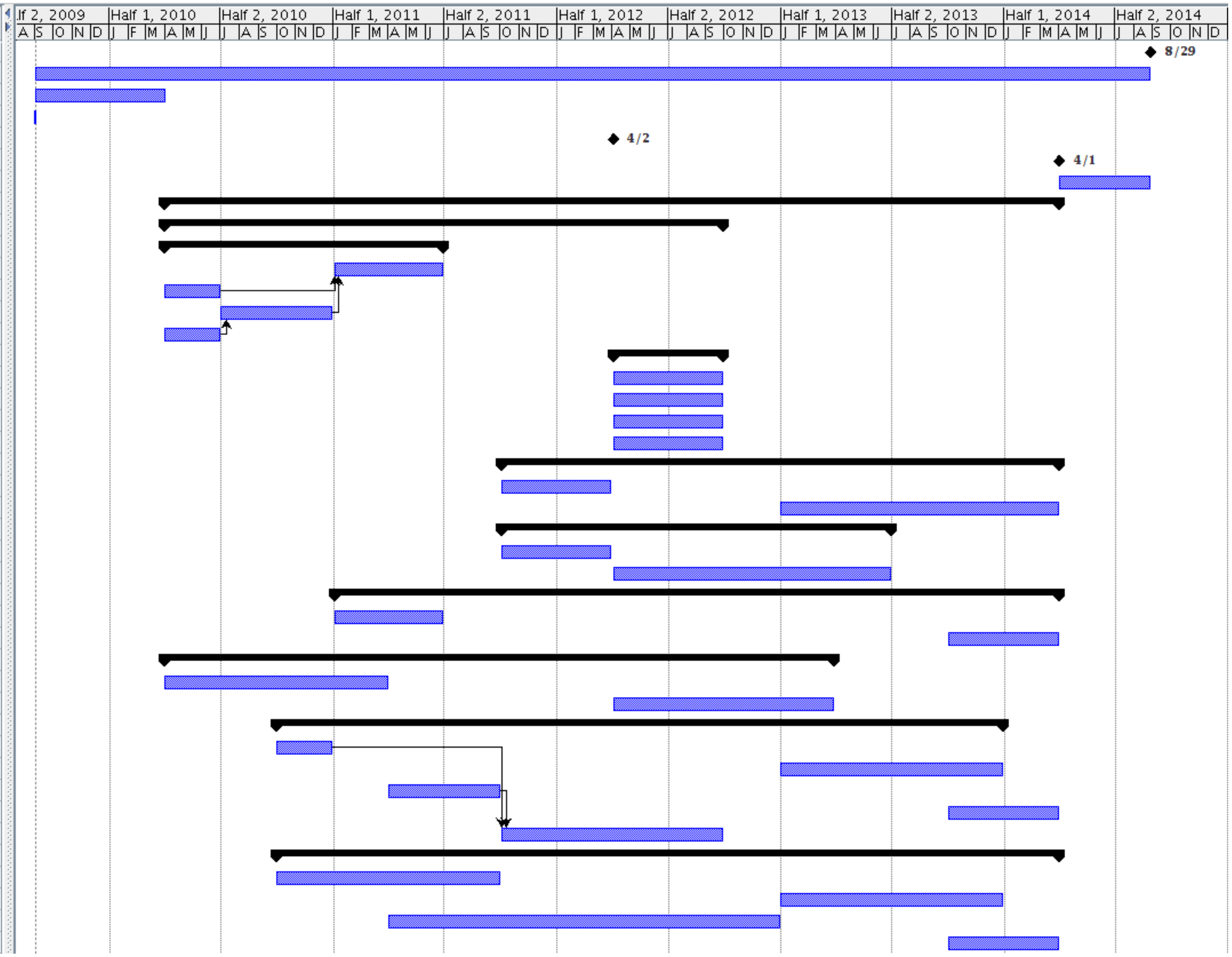


Figure 1. Provenance Aware Synthesis Tracking Architecture (PASTA) framework

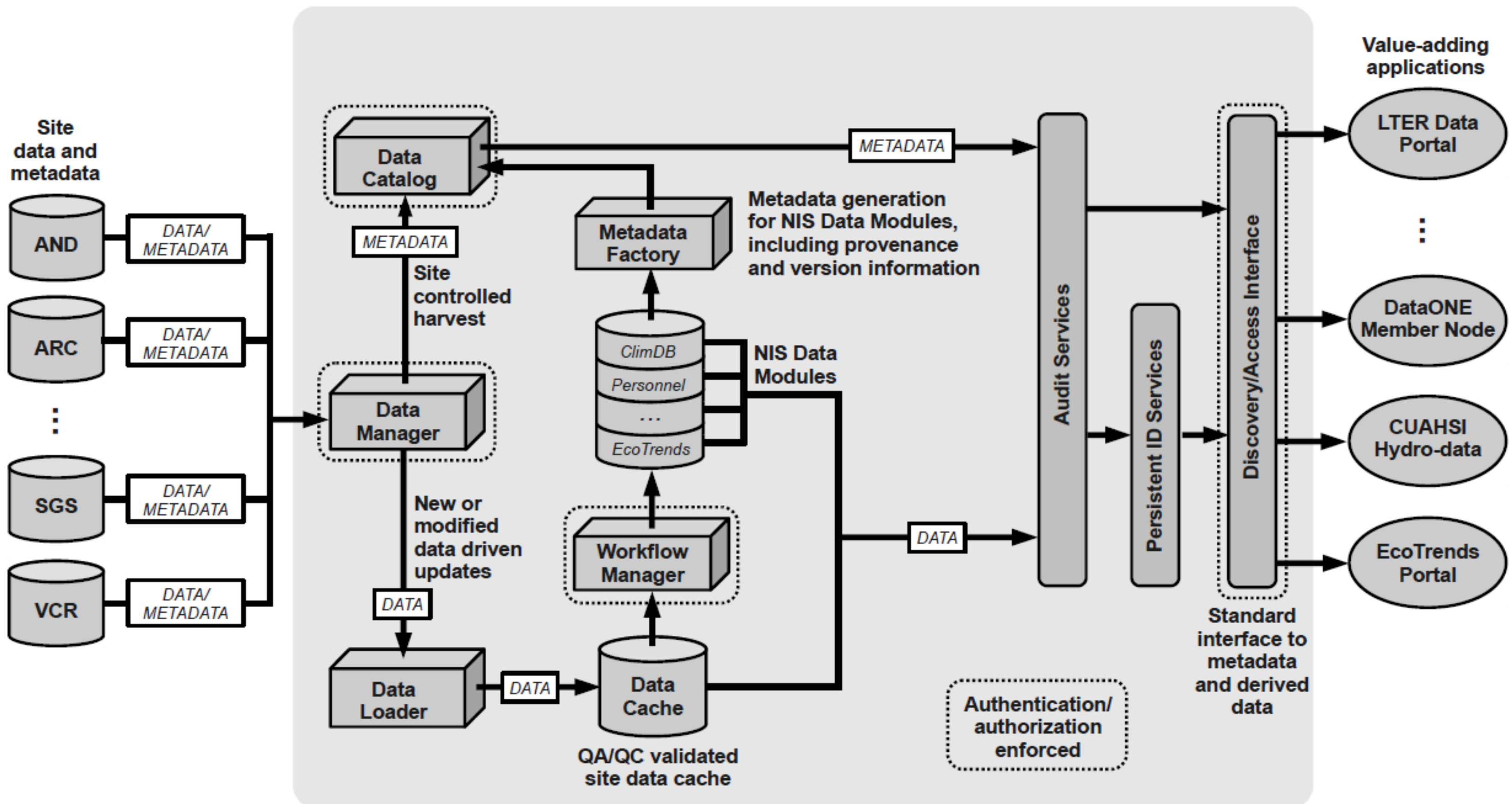
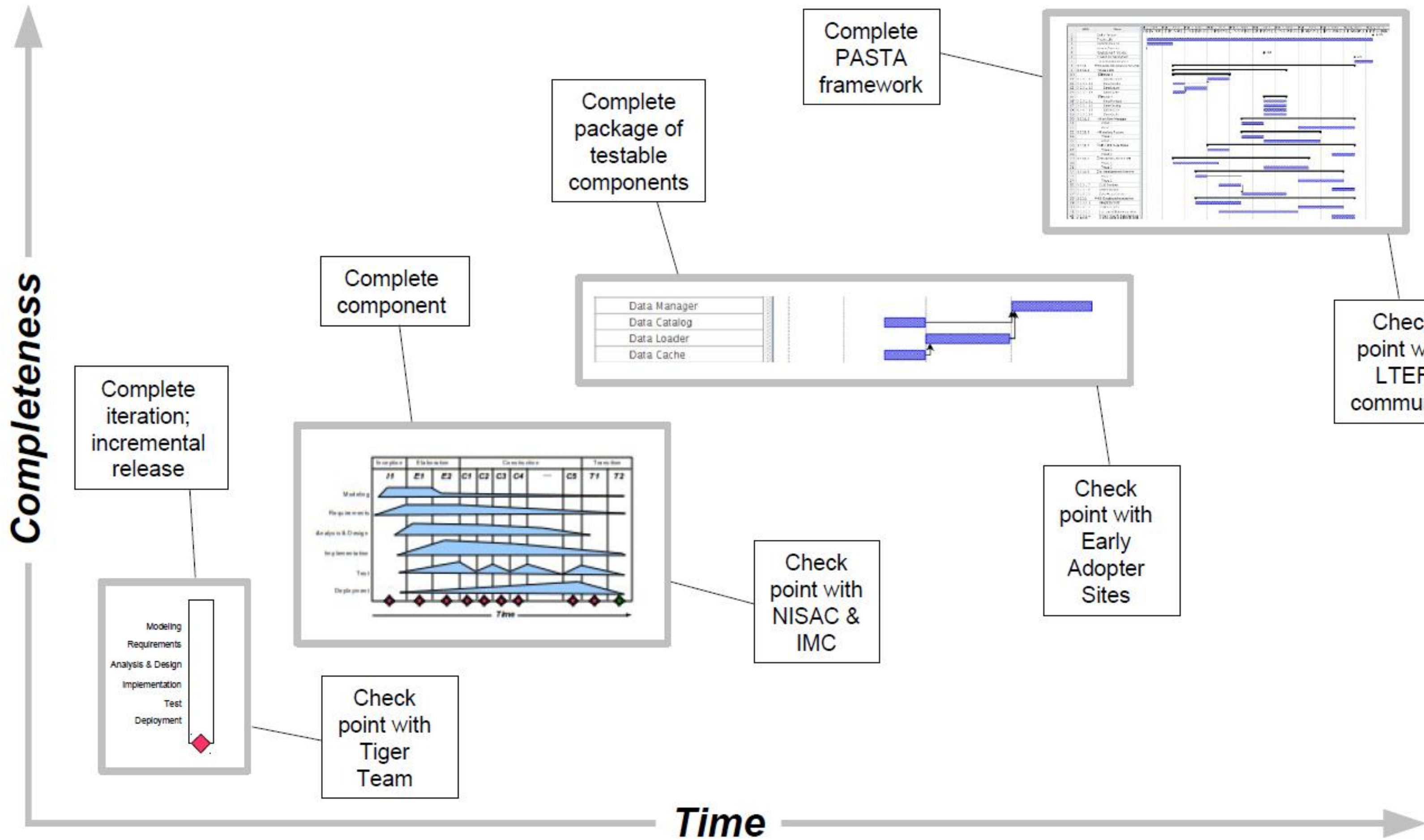


Figure 2. Levels of engagement with the LTER community



Appendix A. List of acronyms used

AAAS – American Association for the Advancement of Science
AIBS – American Institute of Biological Sciences
ARRA – American Recovery and Reinvestment Act
ASA – LNO Application Support Analyst
ASM – LTER All Scientists Meeting
CA – NSF Cooperative Agreement
CI – Cyberinfrastructure
CILogon – NCSA supported to facilitate secure access to CI
CIO – LTER Network Chief Information Officer
ClimDB/HydroDB – LTER Network climate and hydrology databases
CPU – Central Processing Unit
CUASHI – Consortium of Universities for Advancement of Hydrologic Science, Inc.
CUASHI HIS – CUASHI Hydrologic Information System
DataONE – Data Observation Network for Earth
DOD – US Department of Defense
DOE – US Department of Energy
DSS – LNO Director of Synthesis Support
EB – LTER Network Executive Board
ED – LNO Executive Director
EML – Ecological Metadata Language
ESA – Ecological Society of America
FTE – Full-time Equivalent
GBIF – Global Biodiversity Information Facility
GIS – Geographic Information System
IM – Information Management
IMC – LTER Information Management Committee
IMExec – LTER Information Management Executive Committee
LNO – LTER Network Office
LTAR – Long Term Agricultural Research Network
LTER – Long Term Ecological Research
MTS – UNM Media Technology Services
NAB – LTER National Advisory Board
NAP2 – LNO NIS Programmer Analyst II
NAP3 – LNO NIS Programmer Analyst III
NPI – LNO NIS Programmer Intern
NASA – National Aeronautics and Space Administration
NBII – National Biological Information Infrastructure
NCAR – National Center for Atmospheric Research
NCEAS – National Center for Ecological Analysis and Synthesis
NCSA – National Center for Supercomputing Applications
ND – LTER Network Information System Developer
NEON – National Ecological Observatory Network
NESCent – National Evolutionary Synthesis Center
NIM – LTER Network Information Manager

NIS – LTER Network Information System
NISAC – LTER Network Information System Advisory Committee
NOAA – National Oceanographic and Atmospheric Administration
NSF – National Science Foundation
NSF-BIO – NSF Biology Directorate
OBFS – Organization of Biological Field Stations
OCI – NSF Office of Cyberinfrastructure
OOI – Ocean Observatory Initiative
ORNL – Oak Ridge National Laboratory
ORNL DAAC – ORNL Distributed Active Archive Center
PASTA – Provenance Aware Synthesis Tracking Architecture
QA/QC – Quality Assurance / Quality Control
RFC – Request for Comments
RUP – Rational Unified Process
SACNAS – Society for Advancing Hispanics/Chicanos and Native Americans in Science
SC – LTER Network Science Council
SDSC – San Diego Supercomputer Center
SEEK – Science Environment for Ecological Knowledge
SEV – Sevilleta National Wildlife Refuge LTER
SIM – LTER Site Information Manager
ULTRA – Urban Long Term Research Areas
UNM – University of New Mexico
URL – Uniform Resource Locator
USDA – US Department of Agriculture
USDA FS – USDA Forest Service
USGS – US Geological Survey
VDC – Virtual Data Center INTEROP Project
VTC – Video-Teleconference

Other terms:
Controlled Vocabulary Working Group – IMC working group developing an LTER specific controlled vocabulary.
Unit Registry Working Group – IMC working group developing a database and interface for vetting EML custom units.
NIS Developers – LNO NIS personnel
Chair – The chairperson of the LTER Network Science Council and Executive Board

Appendix B. Report from the Reverse Site Visit

LNO ARRA OPERATIONS PLAN
REVERSE SITE VISIT REPORT

LNO ARRA award number: R09
Project title: Operations Plan (2009-2014)
LNO reverse site visit date: March 3, 2010
Members of NSF LNO reverse site visit team: Todd A. Crowl (LTER), Peter McCartney (DBI), Matthew Kane (LTER/DEB), Philip Bogden (OCI), Manish Parashar (OCI), Kathie Weathers (DEB), Robert Sanford (DEB)

Members of LNO project team: Robert Waide (director and lead PI), Phil Robertson (Chair, LTER Executive Board), James Brunt, Mark Servilla, John Vande Castle.

I. Background

The Long Term Ecological Research (LTER) Network Office (LNO) is responsible for planning, implementing, and supporting activities that advance the goals of the LTER Network. With funds from the National Science Foundation (NSF), the LNO carries out these activities as defined in Cooperative Agreements (CA) with NSF with additional guidance from the Executive Board (EB) of the LTER Network. Specifics of each activity are described in proposals to the NSF that are examined by external reviewers and evaluated by a panel of experts selected by NSF.

One of these Cooperative Agreements with the NSF incorporates funds from the American Recovery and Reinvestment Act (ARRA). As part of cost-accounting measures associated with awards using ARRA funds, the NSF requires specific details on the planned expenditure of funds. In the case of the LNO Cooperative Agreement, the NSF requested the development of a detailed implementation plan describing the ten activities to be carried out with ARRA funding and the costs associated with those activities. The NSF further requested that the LTER Executive Board be closely engaged in the development of this operational plan by the LNO and that external reviewers inform the development of that plan.

The LNO has undertaken to develop an operational plan that provides detailed information on each activity funded by ARRA. With guidance from NSF and the Executive Board, the LNO has prepared standard descriptions of each activity, linking these with effort (Table 1) and cost (Table 2) budgets to provide clear links between activities, personnel, and expenditures. This operational plan has been reviewed by the Executive Board, the relevant LTER committees, and a panel of outside experts chosen for their knowledge of the technical aspects of cyber-infrastructure and information management. The final operational plan will form the basis of future evaluations of the performance of the LNO with regard to work supported by ARRA funds.

II. Statement on LNO ARRA Operations Plan

The operational plan contains the following information for each of 10 activities in four thematic areas: 1) description of activity, 2) outcomes of activity, 3) operational steps to carry out activity, 4) milestones, 5) process for reviewing progress and evaluating success, 6) benefits to the LTER community, its external partners, and the larger U.S. scientific and education community, and 7) mechanisms to garner feedback from the LTER community and external communities of science and education. The descriptions of each activity are designed to provide sufficient information to understand purpose, outcomes, and impacts.

As part of the development of the plan being reviewed, the Network Office, with advice from the LTER Executive Board employed an ad hoc review committee (committee external review report attached) to comment on an earlier draft of this document. The document reviewed here includes changes as per the ad hoc review committee and Executive Board's suggestions.

III. The Operation Plan Development Process

This plan is based heavily on the LTER Decadal Plan cyber-infrastructure plan which was developed by the entire LTER Network. The proposal was much larger than would typically be submitted but was encouraged by the NSF Program Officers (H. Gholz and D. Childers). Following the proposal submission, an NSF-organized site review was held. The Site Review Team (report in jacket) recommended full funding. NSF subsequently asked the LNO to split the proposal into a standard renewal proposal and a Cyber-Infrastructure Development and Synthesis Activities Project, including a 5-year plan as a first step.

The first proposal was funded as a Cooperative Agreement using FY 2009 moneys. The second proposal was funded as a Cooperative Agreement using FY2009 ARRA funds. As part of the special reporting requirements for ARRA funds, NSF included a list of Special Conditions and Requirements (see diary note in jacket) including the development and review (this reverse site visit) of this Operations Plan.

The key points from this process highlight the need for the continued information exchange and communication between the LNO, NIS and the site-level scientists. To facilitate this, lead PI Waide will develop an additional communication plan.

IV. Key activities and objectives

a. Network Information Management System

The overall mission statement and many of the stated goals come directly from the 2005 NIS Strategic Plan and the Cyber-infrastructure Strategic Plan (2007). The critical elements of managing the Network Information System (NIS) will require communication, managing risk, and evaluation. Toward this end, the Operations Plan provides specific milestones and metrics. NISAC and LTER-EB provided continual oversight in all aspects of the NIS development and communication.

The LNO has proposed a new position to oversee NIS communication. They will also facilitate committee recruitment, staffing and scheduling. The plan also calls for the use of Tiger Teams to provide feedback from the user community to the LNO.

Major likely risks have been identified and include staffing, software integration, metadata quality, data portal product complexity and M&O transition.

Metrics for success identified to date include iterative software process milestones, software release milestones, and trailing metrics of success, user satisfaction and descriptive statistics on use.

b. Cyber-infrastructure development and deliverables

NIS mission statement and characteristics set the stage for PASTA development and the NIS architecture. First, the ecological metadata language (EML) is central to allowing these activities succeed. Because the scientists, sites and network have adopted EML, there is a common structure that allows the data harvesting activities to succeed. The ‘controlled vocabulary’ group has completed their tasks.

c. Development and Outreach

To fully integrate the community, the LNO will provide an additional Communications Plan that details the feedback pathways and mechanisms between the LNO , the individual LTER sites and user community.

V. Feedback regarding the submitted 5-year operations plan

a. Summary statement

The panel is truly impressed by the level of thought and effort that went into the Operations Plan. The proposed activities and potential achievements are based on the considerable skill and management that the LNO has assembled. It is clear that the LNO through the activities presented here are helping to the lead the LTER sites toward a better integrated, more functional true network through data accessibility and availability and most importantly, by allowing LTER and other scientist answer large scale questions heretofore, inaccessible.

b. Specific observations and recommendations

1. PASTA is described in the proposal as "a conceptual model for transforming LTER data in to network ready Products". This sounds much more experimental than it is, or at least that description does not help the general science user appreciate what parts of this are more mature than others.

2. Risks are all discussed in very high-level units (workflow system, data portal, system integration) that are difficult to assign any mitigation strategies to. A little more break down here would help address the problem stated above.

3. Milestones are defined in terms of CI development, not data products or science impacts. There is a need for early releases, but those should be measure ultimately by the science they enable and not just by the progress they represent in the iterative development path to PASTA 1.0.

4. The proposal, the OP and the external reviews don't really address the science rationale for the NIS in general and for the new infrastructure proposed here in particular. Given the similarities with the general goal of this system with many other data management systems (KNB, SEEK, OOI, NEON, GEON, GLEON, etc), it would be helpful to keep stating what seems patently obvious as a mechanism for ensuring that there is a science driver defining the functional design.

5. Many parts of the scope of work are for fundamental middleware components that do not pose any specific ecoinformatics challenges and are universal elements of most cyber-infrastructures. Even EML has virtually no tags unique to ecological data. Are there some components that could in fact be supplied with commercial products and licensing? Is there a strategy for decision-making and modular design that leaves flexibility in replacing components should an external one become available competitive?

6. Is there a strategy for de-scoping that enables LNO to drop certain functionality in the face of components that fail, or prove too risky or costly to develop? Can the impact of that de-scoping be accounted for in terms of science functionality? what kinds of datasets or what kinds of capabilities are lost or preserved in the event of some part (say, the metadata generator) either failing or falling short of expectations?

7. Transitional risk - the current LNO will end in 5 years and will be re-competed. What will happen to all of the efforts and products outlined here if this group is not awarded the contract? We must insure that these products are readily transferable. The LNO should identify the parts of the CI and IM that are completed along the way and easily transferable. The data portal complexity issue can be largely avoided if the deliverables are phrased in simpler data products than the overall completion of the PASTA project like CLIMDB, HYDRODB and Ecotrends.

Overall, the seven specific points above suggest that the LNO They would benefit from aligning their design, work plan, budget, risk register and schedule around a tiered set of data-product deliverables that:

1. Trace to meaningful science impacts that clearly reflect LTER program goals,
2. Start appearing early on, and
3. Lets them incrementally grow the system by layering in new functionality.

c. More minor observations and considerations

1. Be sure to engage graduate students and post-docs in this process; they are likely to be the most engaged and have the time and inclination to use this information and any new advances developed.

2. The Metrics should also include non-LTER users. What about the overall effect on ecosystems science?

3. It would be helpful if the various emerging networks and information systems (e.g. NEON) could adopt common naming conventions. NEON uses 1-5 for their data levels and the LNO uses 0-4; is there a community standard?

4. The way this is designed, the burden is on the sites is for EML compliance and quality. How can feedback be provided to the sites so that the individual node heterogeneity is minimized. Right now, there are no best practices, but there seemed to the suggestion that the LNO will identify which sites have the easiest flow and then hope the other sites will follow.

Overall, the panel found the five-year operational plan to be well thought out, delivered and consistent with the intent of the ARRA award. We offer these suggestions for your consideration as you move forward and as a guide for our evaluation of your progress as you move into the development and delivery of the various aspects of this project.