Description of document:	National Science Foundation (NSF) Report on the National Ecological Observatory Network (NEON) Operations & Maintenance Review, 2012
Requested date:	11-September-2013
Released date:	16-May-2018
Posted date:	28-May-2018
Source of document:	National Science Foundation Attn: FOIA Officer 2415 Eisenhower Avenue Alexandria, Virginia 22314 Fax: (703) 292-9041 Email: foia@nsf.gov

NATIONAL SCIENCE FOUNDATION
2415 Eisenhower Avenue
Alexandria, Virginia 22314

MAY 1 6 2018

OFFICE OF THE
GENERAL COUNSEL

Via email

Case #13-327F

This letter is in response to your Freedom of Information Act (FOIA) request that the National Science Foundation (NSF) received on September 11, 2013. In your request, you sought "a copy of the recent NSF Operations Review for the NEON Program." We apologize for the delay in our response.

After a thorough search, NSF has located the 35-page NEON Operations and Maintenance Review. We have redacted one page of reviewers' identities under the Exemption (b)(6) of the FOIA and Exemption (k)(5) of the Privacy Act.

Your right of administrative appeal is set forth in Section 612.9 of the NSF FOIA regulations (copy enclosed). Your appeal must be postmarked or electronically transmitted within 90 days of the date of the response to your request.

As part of the 2007 FOIA amendments, the Office of Government Information Services (OGIS) was created to offer mediation services to resolve disputes between FOIA requesters and Federal agencies as a non-exclusive alternative to litigation. Using OGIS services does not affect your right to pursue litigation. If you are requesting access to your own records (which is considered a Privacy Act request), you should know that OGIS does not have the authority to handle requests made under the Privacy Act of 1974. You may contact OGIS in any of the following ways:

National Archives and Records Administration
Office of Government Information Services
8601 Adelphi Road - OGIS
College Park, Maryland 20740-6001
E-mail: ogis@nara.gov
Web: https://ogis.archives.gov
Telephone: 202-741-5770
Facsimile: 202-741-5769
Toll-free: 1-877-684-6448

There is no fee for FOIA services in this instance in accordance with 5 U.S.C. § 552(a)(4)(A)(i) et seq. Thank you for your interest in the National Science Foundation.

Sincerely,

Justin Guz
Government Information Specialist

Enclosures

§ 612.9 Appeals.

(a) Appeals of denials. You may appeal a denial of your request to the General Counsel, National Science Foundation, 4201 Wilson Boulevard, Suite 1265, Arlington, VA 22230. You must make your appeal in writing and it must be received by the Office of the General Counsel within ninety days of the receipt of the denial (weekends, legal holidays, and the date of receipt excluded). Clearly mark your appeal letter and the envelope "Freedom of Information Act Appeal." Your appeal letter must include a copy of your written request and the denial together with any written argument you wish to submit.

(b) Responses to appeals. A written decision on your appeal will be made by the General Counsel. A decision affirming an adverse determination in whole or in part will contain a statement of the reason(s) for the affirmance, including any FOIA exemption(s) applied, and will inform you of the FOIA provisions for court review of the decision. If the adverse determination is reversed or modified on appeal, in whole or in part, you will be notified in a written decision and your request will be reprocessed in accordance with that appeal decision.

(c) When appeal is required. If you wish to seek review by a court of any denial, you must first appeal it under this section.

Report on the NEON Operations & Maintenance Review

1/31/12

FOIA (b)(6) & PA (k)(5)

[redacted]

INTRODUCTION

An Operations and Maintenance review of the National Ecological Observatory Network (NEON) project was held January 3 – 6, 2012 in Boulder, CO under the auspices of the National Science Foundation. The review included presentations by and discussions with the NEON staff.

The committee was impressed with the work accomplished by NEON to date and believes that NEON is ready to start operations at completed sites in 2012 as planned.

NEON has done an outstanding job in developing a detailed M&O Plan including costs, schedules, staffing and a very well thought out prototyping & transition to operations planAlthough we believe it is likely that operating costs can be reduced over time due to possible efficiencies, we do not currently believe a 20 % reduction is possible without significantly risking execution of the approved observatory scope.

We do not support any operating cost reduction that reduces the execution of the approved observatory scope.

Current budgetary estimates are based on best analysis and any improvement requires actual operating experience.

We greatly appreciate the effort to which NEON staffers went to prepare for this review and appreciate their openness and willingness to answer questions.

A summary response to the review charge is presented below followed by more detailed comments on subsections of the project and a list of recommendations that the committee thinks will further improve the likelihood of project success.

SUMMARY RESPONSE TO CHARGE

Is the Panel satisfied that the operations plan will allow the NEON Observatory to deliver the required science data products at the quality level required?

Yes, based on current knowledge. The plan is detailed, well thought out and covers all aspects of NEON operations. There are many uncertainties, particularly in the area of operational efficiencies and community growth that won't be known until additional operational experience is available.

How well is the NEON Operations Plan documented and justified?

The plan is very well documented with a significant amount of supporting data. NEON has done an exemplary job of using the prototype site to gain operational experience including specimen collecting. NEON has benchmarked similar, less complex, facilities to develop their plan.

Are there further efficiencies that could allow NEON to keep the overall O&M costs as low as possible?

Given the high degree of complexity planned for NEON, and its large, distributed nature, it is highly desirable for NEON to gain operations experience and explore the potential for efficiencies before having to make a long-term commitment to a specific operational scope. NEON's plan for deliverables is very ambitious given the resources available. However, NEON's assumption that Moore's Law related gains in computing will be fully offset by increasing demands will result in more than an order of magnitude in capability growth over a decade. There is significant potential for increased computing to offset labor costs and/or for the increase in computing to be slowed that in combination could result in significant ($500K+/yr) savings in the 3-5 year time horizon. NEON should assure that the scale of its computing hardware continues to be driven by the real requirements of the observatory and NEON community as Moore's Law related progress occurs and as decisions about the scope of other NEON activities using computing are made.

Are there sufficient & appropriate metrics to measure the success of NEON Operations?

NEON has provided a large number of metrics to track the effectiveness of operations. NEON has the potential to transform ecological science and it will be necessary to verify whether that is actually happening through metrics. NEON does not have a success threshold associated with its metrics. These still need to be defined in consultation with the user community. NEON does not yet have a well-specified feedback plan for responding to metrics. NEON should attempt to unify its metrics around its originally stated science/education goals.

Has NEON appropriately incorporated EH&S into NEON operations?

Yes. EH&S has been integrated throughout the project at all levels. It is clear the conduct of safe and environmentally responsible activities is a top priority for NEON operations. However, NEON lacks the appropriate in-house skill to review the safety operations of the aircraft operator for the AOP. NEON is planning to develop a safety plan for working with rodents and infectious diseases.

Is NEON's planned interface with its user communities appropriate for NEON operations?

NEON should emphasize its service interfaces (versus portal) for advanced users and use this as a mechanism to minimize scope creep within the project while deepening community engagement. NEON's prototype experience has shown that communication with the local domain community needs to be improved.

Managing the web portal through the E&O group provides an interesting opportunity for the transparent and seamless integration of education and science which is a novel approach. There is great potential here. However, in the absence of specifics, for example, a prototype portal and a plan for community engagement in its development, we cannot comment on the appropriateness of staff level relative to functionality.

There has been no progress interacting with museums and biocollection institutions for bioarchiving samples and associated data.

Is NEON's Educational outreach plan sensible for the operations phase?

The committee thought that the E/O program is off to an impressive (ambitious) operations start. The list of possible activities is long and comprehensive. The question of what NEON can do in education that is unique has yet to be answered.

There is a need for strategic prioritization and prototyping of projects that demonstrate NEON's unique contributions to continental-scale science to its user community of scientists, educators and citizens. Launching a project at the beginning of NEON Operations will provide a direct demonstration of NEON educational impact.

Is the NEON CI Infrastructure and resources sufficient for NEON Operations?

Yes. NEON has done an excellent job in designing the CI and development to date has confirmed the sufficiency of the proposed CI. Similarly, NEON's estimates of operations and maintenance needs are well reasoned and appear sufficient.

NEON is proposing a higher level of automation than existing observatories and thus risk remains–small errors in per sensor/per data product/per user expenses can result in significant uncertainty at the observatory scale.

Relative to known requirements, NEON's estimates of operations costs, particularly for computing resources, are conservative. While appropriate at this stage, NEON should reconsider its assumptions, particularly related to Moore's Law as operational experience is accrued. The committee notes that NEON's planned replacement cycles for computer hardware are longer than the industry standard.

DETAILED COMMENTS

1.0 Cost and Schedule

1. 1. **Overall adequacy of O&M cost model and plan**.

Findings:

The NEON budget for Operations in FY2012 is currently established at $892,900. This increases through the construction-to-operations transition period to $85,219,400 in FY2018. The NEON construction and O&M activities have extensive overlap throughout the construction phase. This overlap requires earlier detailed operations and maintenance planning in parallel with construction. In addition, ramifications for earlier transitions of hiring and staffing functions and funding source management appear to have been well developed by NEON.

The NEON Operations & Maintenance Plan has been extensively updated within this year and is well developed for this stage of the project, even considering the early site transitions. The assumptions employed in developing the O&M Plan were reviewed and remain valid at this early stage.

Comments:

Operations planning and budgeting has been extensively informed so far by construction experience and estimating methodologies, but return costs and actual experience are still limited. The O&M Plan will need to be refined as construction and prototyping experience accumulates.

The O&M Plan, budget and schedules at this phase of the project are sufficient to deliver the required NEON science capabilities and data products. In view of the large uncertainties associated with many unique functions within NEON, for which investigated benchmarks can be imprecise, actions recommended elsewhere within this report to seek efficiencies should be implemented carefully until the extent of staffing and information management assumptions at the sites that commence early operations can be validated.

1.2. Validity of O&M budget/schedule assumptions.

Findings:

The NEON O&M Plan was extensively revised and re-issued in December 2011. The plan is comprehensive, and the assumptions contained within the plan were reviewed and remain reasonable and valid at this stage of the project.

The transition period from construction to O&M begins in 2012 and extends through final site commissioning in 2018 and is well defined within the plan as different sites complete construction and commissioning.

NEON O&M planning is based on an assumed construction ramp and tentative O&M budget that has been agreed to with NSF. A definitive FY2012 funding allocation from NSF is anticipated soon but is expected to be close to project plans. In the meantime, NEON is exercising appropriate conservatism in early FY2012 activities and to date has not incurred high risk of significant impact on performance.

NEON has implemented appropriate accounting and business management systems to ensure compliance with federal rules governing separation of MREFC-funded construction activities, staffing and resources and similar categories within R&RA-funded transition to operations activities.

The proposed budget phasing for O&M is as follows:

Fiscal Year	Budget*
2012	$892,900
2013	$13,380,100
2014	$31,343,200
2015	$51,150,200
2016	$71,261,400
2017	$77,308,300
2018	$85,219,400

*Then-Year Dollars

Detailed budget assumptions in field operations, aquatics, and cyber-infrastructure areas were reviewed. Overall these budgets represented an adequate basis of estimate for this stage of the project.

O&M budgets and schedules have been aligned with construction activities and site transition planning; however, additional integration is needed as planning matures (see schedule comments below).

Comments:

From the information examined and presented by the NEON team, NEON should be able to operate to meet planned missions within the proposed O&M budgets. At this early stage of the project, the benefits of prototyping and other activities that could provide for future efficiencies or reduce costs or risk during operations will not be apparent for several years. Strategies to ensure specific benefits to operations efficiencies and learning curves through additional prototyping or other activities after the initial sites are placed in operation should be reviewed with a targeted goal of 5-10% savings in future operations annual budgets.

O&M planning has benefited from the structured estimating and planning approaches and methodologies utilized for the construction phase. Limited return information on early construction procurements, schedule performance and selected on-going prototyping activities was reviewed. This early good performance to construction plans lends some early confidence in initial O&M plans, which will need to be closely monitored and revised as experience continues to accumulate.

1.3. Risk management.

Findings:

NEON has developed a draft O&M risk register in each major functional area in a manner similar to their construction risk management approach. The risk register is still in the development stage. NEON plans to improve the risk impact assessment by including the impacts of all likely occurrences of given risks (right now the impact is limited to a single occurrence of some risks). In addition risk responses, including mitigations, are planned to be added to the register.

The current register contains over 200 O&M risks classified as “high” and “medium” with a combined budget exposure of approximately $15M. The O&M Plan includes guidance on risk management in operations.

NEON staff has developed some hardware-oriented strategies for improving reliability, replacement parts funds pools and programs to reduce the risk. Specifically, this includes a “Mean Time between Unit Replacement” (MTBUR) analysis, implementation of standard systems engineering processes, and a definition of standard interfaces and a fault tolerant strategy.

Comments:

Unlike in the construction phase, NSF does not permit explicit budget contingency in the O&M phase of a facility. This complicates corrective actions because any additional budget that may be required by mitigation needs to be taken from other tasks. This need for reprioritization makes potential corrective actions more complex.

At the present time the O&M risk register is incomplete. For example, funding uncertainties (both in construction and in O&M) are some of the biggest project risks and are not at this time included in the risk register. In addition, the register needs to complete risk impacts and mitigation for all likely occurrences.

1.4. O&M Schedule.

Findings:

At this early phase of construction and with current construction funding uncertainties, a detailed integrated operations schedule has not yet been fully developed or implemented. Currently, NEON schedules (both construction and O&M) exist in three parts:

(1) NEON’s construction phase integrated Primavera Schedule.
(2) O&M transition schedule (Excel document that has been extracted from the Primavera PreCon Construction Completion Milestones (plus 150 days))
(3) O&M Steady State Schedule (MS Project for post-2018 effort)

The steady state schedules (item 3) have a substantial number of activities that are steady level of effort activities.

Comments:

The current schedule system can't easily respond or assess changes in construction activity completions or transition activities. Actual activity progress is not yet available and therefore cannot be used to refine activity estimates. In the future, Maximo asset management software is planned to be used to plan and manage many O&M Activities.

2.0 *Organismal Sampling (FSU) and Archival of Biological Samples*

Summary: The Review Panel breakout group observed that the FSU science operations had completed only part of one field season (2011) at one site (Sterling, CO), and that a full evaluation review of this NEON component would be premature. However, what has been accomplished to date is impressive, and generally appears procedurally and logistically appropriate to fulfill the NEON mission for sampling biological organisms.

The next sections follow the organization of tasks presented in the "Panel Charge" and discuss the topics by subject question. This report does not summarize nor repeat information presented by NEON staff during the panel meetings.

2.1 *Organismal Sampling (FSU)*

Comments

Is the Panel satisfied that the operations plan for the FSU will allow the NEON Observatory to deliver the required science data products at the quality level required?

Generally, yes. Sampling planning, budgeting, training of techs, and logistics appears solid. Areas for improvements include communication and planning between NEON and site hosts, field sampling quality control issues, and specifying the role/scope of museum specimen archival.

How well is the NEON Operations Plan documented and justified for FSU?

Organism sampling ops are well-planned; 2011 partial test at Sterling indicated planned operations were ± 3% of budget; all planned work was accomplished with test crew structure. Weaknesses (e.g., site selection procedures) were identified by NEON staff and corrected. Plans lack QA/QC of biotic sampling via stats analyses and field repetition of measures.

Are there further efficiencies that could allow NEON to keep the overall O&M costs as low as possible in the FSU operations?

The panel concluded that for this topic it is too early to assess. Typically, one would require several years and more sites to be operational to systematically determine whether additional efficiencies are possible. The panel concluded that some efficiencies may be found, but these would be of relatively minor extent. Organismal sampling appears funded at the appropriate level at this time.

Are there sufficient & appropriate metrics to measure the success of NEON FSU Operations?

Generally, yes for organism sampling (e.g., ensuring that all the field sampling work was completed and on schedule). "Success" is dependent upon QA/QC, and this aspect needs expansion to include annual statistical analyses for sampling efficiencies, as well as estimates of sampling bias (e.g., bird sampling, plant diversity sampling) where no archived specimens are involved. For example, NEON field crews could return to randomly-selected study sites for vegetation diversity and re-sample them to estimate "sampling error" from observer bias; alternatively, two different crews could sample the same site, and compare their measurement values. This latter approach could work for bird sampling as well. These QA/QC checks would produce the values for sampling error (bias and precision) that could be incorporated into the overall sampling variance calculations. With regard to sampling efficiencies, annual statistical analyses of the field data for plants, birds and pitfall-trapped ground beetles could determine whether the appropriate sample numbers were being collected. At present, the FSU plan includes 40 pitfall traps (10 sites with 4 traps per site), and it may prove that fewer traps would provide similar means and variances (or possibly that more traps are required). Because the field data from 2011 in the proto-type Sterling, CO, site are not yet available, such analyses could not be started at this time.

Is the transition to FSU operations plan reasonable? Does NEON make a clear distinction between construction costs and operations costs?

Yes, very detailed thus far; but many aspects of the FSU organismal sampling have not been detailed nor tried in the field with NEON domain crews. A full test at the Sterling, CO, site is planned in 2012.

Are the O&M Costs reasonable, well justified and do they provide good value to the NSF in the production of NEON science?

Costs for FSU organismal sampling appear to be "bare bones" and may need increases in the future for domain-level budgets, once all methods are worked out and implemented.

Is the FSU O&M schedule reasonable and well justified? Have the appropriate schedule dependencies been identified?

For organismal sampling, this is directly tied to the schedule of domain site acceptance, and the schedule appears to be appropriate. The domain manager position may need to be started more than one year prior to initiation of operations, to ensure sufficient hiring and training of permanent staff techs.

Has NEON appropriately identified the FSU risks in the O&M phase? Have the appropriate mitigations been identified?

Generally yes for FSU organism sampling, but many aspects of field work are not detailed or tested as yet. NEON domain FSU teams will learn much in the first few years of operations.

Is the staffing model for FSU operations including: number of staff, rate of staff ramp up and strategy for acquiring staff appropriate for NEON success?

For FSU organismal sampling at the domain level, staffing may be "bare bones" or too small. Operations at the first few domain sites will be needed to verify for certain. Again, the domain managers may have to be hired more than one year in advance to set up sites and become familiar with the details of their site's FSU operations.

Has NEON appropriately incorporated EH&S into NEON FSU operations?

Yes, although sampling for rodents has not been attempted as yet, and will require additional training not specifically presented (e.g., respirator/PAPR training, sterile technique, handling biological hazardous materials). The NEON FSU staff recognizes the need for this and should have it in place before spring 2012.

Is NEON's planned interface with its user communities via the web portal, data products etc. appropriate for NEON operations?

This topic was not applicable to FSU operations, as this is above the level of FSU organismal sampling operations. The panel noted, however, that procedures for museum loans of archived materials have yet to be detailed.

Is NEON's Educational outreach plan sensible for the Operations phase?

Because the domain crews conducting FSU organismal sampling have no responsibility for educational outreach beyond providing site data, this topic is essentially not applicable. However, the domain manager will be involved with education and outreach at each site.

Is the NEON CI Infrastructure and resources sufficient for NEON FSU Operations?

The CI support for field sampling of organisms appears good (use of field computers, data entry procedures, etc.). However, this has only partially been tested thus far at one site, and additional trial efforts over the coming 2-3 years will be required to verify this aspect.

2.2 Data and Sample Processing, Archiving and QA

How sufficient is the NEON operational model in maintaining NEON and supporting research at regional to continental scale for 30 years?

Findings:

The overall plans for data and sample processing and storage are well thought-out, and theoretically will support NEON's goal of supporting research at a regional to continental scale for 30 years. However, the key word here is "theoretically": many components of the plan (e.g., sample processing and bioarchiving agreements; and database interoperability with NEON's asset management system) cannot be evaluated because they have not yet been negotiated, implemented or tested.

Comments:

Because NEON is just starting construction, there are many important details of sample and data collecting, processing and archiving that NEON has either not been able to prototype or benefit from in-the-field experience. Clearly, prototyping, experience and recommendations from working groups will serve to modify and bring greater resolution to these details. Some areas of NEON's biotic sample/data processing and archiving protocols and processes are more developed and fully documented (AQU/STREON) than others (FSU). For the FSU, there are a number of established and tested protocols operating in the biocollections community for processing and archiving samples that can be used as models. The panel is concerned about the lack of progress on MOUs with biocollections institutions for bioarchiving and specimen data management. This issue needs immediate attention and action because its level of risk is high. Inherent in this concern is the need for clear policy governing the responsibility for maintaining MOU agreements with bioarchive facilities, and maintaining the physical state of samples and their associated data to NEON and community standards. A final issue that requires development in these MOUs is the interoperability and feedback mechanisms between NEON's asset management system and different biocollection and bioarchive database management systems operating in repository institutions that meet community standards of curation and research. NEON's asset management system, as a business DBMS, is satisfactory for tracking objects, but unlike biocollection databases, it is ill-suited to tracking changes of state in that object, e.g., taxonomy, morphological sampling/preparations, genomic sequences.

Is the O&M budget justified? Are there cost savings to be found?

Findings:

Project costs have been clearly and credibly estimated.

Comments:

The panel determined that project costs have been estimated to the best level of accuracy as informed by previous working groups and other similar projects. However, reconstituted working groups and prototyping many of the activities should be able to refine the estimated costs, particularly varying across taxa sampled and analyzed. Also, NEON should anticipate greater efficiencies in the development of faster/cheaper sampling and analytical technologies, as well as a range of costs across different bioarchive and biocollection facilities, which reflect their individual protocols, efficiencies and quality of curatorial and informatics practices.

Have risks been identified and understood?

Findings:

AQU/FSU has done a good job of identifying risks and providing plans for mitigation, except for bioarchiving.

Comments:

Support for maintaining biosamples and biocollections and their associated data to community standards varies considerably, both year to year and among US institutions, including free-standing and university-associated bioarchive facilities. Historically, many of these facilities have been either downsized or shuttered, with their bioarchives orphaned, discarded or transferred in part or in whole to adopting institutions. Therefore, MOUs notwithstanding, NEON should anticipate, monitor and be prepared to navigate around some turbulence in the permanence of their bioarchives during the course of 30 years. This is a credible risk that NEON needs to address, given that NEON estimates bioarchives of ~700,000 specimens/samples annually, or 21 million over 30 years. A second risk is whether any single or group of current bioarchives could accommodate this volume without investing in a major new facility expansion, which NEON funding would not cover.

Is Operations staffing appropriate?

Findings:

AQU and FSU have identified the key personnel that are needed to accomplish the biosampling component of NEON, justified by a detailed analysis and estimate of tasks and effort.

Comments:

Adjustments to current estimates of required personnel and associated costs require at least a year or two of on-the-ground experience across varied domains and sites. There are no evident efficiencies or savings to be accomplished now.

3.0 Sensors (FIU) and Sensor Science

3.1 Sensors – Science and Engineering Summary

Sensor systems (both the engineering and science aspects) of NEON are nearing the operational phase. Near-term transition to O&M is mandatory to provide sensing capabilities at sites scheduled for operations in the next 18 months. NEON is poised to make this transition. Tight integration between science, engineering, and CI staff has led to a well-designed sensing system. Impressive innovations in sensor identification and addressing within the network context, store-and-forward redundancies, and metadata tracking have solved long-standing problems in the design and operations of ecological sensor networks. The end-to-end system–from sensors to site network to central CI–is well conceived and has passed initial testing.

3.2 Sensors: Engineering

Comments

The engineered sensing system has been well-designed for scalability, interoperability of sensors, deployment of sensing packages, and troubleshooting. Sensor specifications and sensing infrastructure are thoroughly documented and well-prepared for operations. The costs for sensors, and their maintenance and operations, are reasonable and well justified. The full simulation, testing and calibration facilities, including an extreme environment chamber, have allowed in depth testing of about 30 of 44 total types of sensors.

There are a few sensors that still need to be tested. For example, aquatic sensors need to be obtained and tested for biofouling.

The Advanced Development Lab has been able to bring new technologies into NEON that will cut costs. There could be diminishing returns going forward though and the ADL should stay focused specifically on technologies to lower O&M costs and have its efforts based on the potential returns.

Many of the remaining challenges are related to scaling from a few well-tested sensors to thousands in the full NEON deployment. Although there is a solid plan for sensor maintenance that includes overlap and redundancy by shipping replacement sensors to site before return shipment from site for recalibration, there has been little opportunity to exercise the overall maintenance system at the scale of the fully envisioned observatory.

The budget is lean. There is little room for reducing personnel costs. Staffing is thin given the magnitude of the project and number of deployed sensors. NEON may experience challenges when key staff are away (vacation, sick leave).

3.3 Sensors: Science

Comments

NEON has developed a very nice end-to-end solution – from sensors to site network to central CI. The data flow is well thought out, and includes QA/C that has ‘eyes on’ for some of the flagged data. Overall sensing system is well-designed for troubleshooting by personnel at NEON central, as well as at deployment sites.

Remaining challenges are associated primarily with development of additional QA/QC technologies and procedures and scaling those to a fully functional observatory network. Sensor data QA/QC process and supporting technologies that include human intervention, though envisioned, have not been developed fully and have not undergone scaling testing. Until this happens, the performance and reliability of sensing systems, which includes coupling of sensing, CI, and human components, cannot be well-quantified.

The budget is lean. There appears to be little room for reducing personnel costs. Staffing is thin given the magnitude of the project and number of deployed sensors. NEON may experience serious challenges in O&M related to sensor data when, for example, key science and engineering staff are away (vacation, sick leave).

Responsibilities and staffing for problem resolution are not clear. Problem resolution is “matrixed” out, and if personnel have OPS jobs, they won’t have time to do both. There is a substantial risk that OPS staff (baseline) will be over burdened with troubleshooting. A potential outcome could be that problem resolution, and QA and other OPS tasks will suffer. This poses a risk to credibility because NEON needs to succeed early and often to build user confidence.

4.0 Cyber Infrastructure, Data Portal, Informatics and Storage

Findings

NEON has done an excellent job in designing the cyberInfrastructure (CI), and prototyping and development to date have provided useful evidence of the sufficiency of the proposed CI. Although full scale tests of the CI depend on the availability of data and data product algorithms, as well as on the arrival of operations-scale computing hardware, prototyping efforts and stress testing of components have yet to raise concerns.

NEON’s estimates of operations and maintenance needs are similarly well reasoned and, although lean, appear sufficient. It should be noted that these estimates rely on staff in other NEON groups (e.g., Central Ops, FSU, FIU, Education, CalVal), with responsibilities for developing and assessing data products and web content that in other projects would be considered as CI staff. Our evaluation of the adequacy of the CI related O&M costs takes the availability of these other NEON staff members into account.

Although the staffing levels are well justified in terms of the steady state level-of-effort required, the need to handle emergencies provides additional justification. Specifically, having cross-trained staff whose nominal assignments are to maintain and evolve data products provides capacity to recover from equipment failures, security incidents, etc., as well as to maintain operations if key staff members leave unexpectedly.

Comments

NEON is proposing a higher level of automation than existing observatories, and this in turn creates a risk that small errors in per sensor/per data product/ per user expenses can result in significant uncertainty at the observatory scale. Similarly, failures or outages of the automated systems could quickly overwhelm NEON’s capability to maintain operations while affecting repairs. Although NEON has done a good job of estimating, the simple fact is that the NEON observatory will be operating at a scale and with a level of automation beyond existing experience. Consequently, significant uncertainties remain. We thus concur with the overall panel conclusions that long term operations planning will benefit from operational experience and that any O&M descoping at this point would risk NEON's ability to effectively operate the observatory.

Relative to known requirements, NEON's estimates of operations costs, particularly for computing resources, are conservative in the long term. By 2018, NEON's computing budget is likely to be adequate to acquire a multi-petaflop compute resource – more than 10 times larger than required to produce all currently defined data products, including those that are currently planned to be produced using shared national resources. Although it is prudent to plan for excess capacity, both to support the emerging needs of the NEON community and to enable computing to be used to offset labor costs (e.g. to reduce/replace manual bird sampling with automated acoustic sampling), there is still the potential for some savings ($500 K+/yr) in this area if computing costs continue their current trends. It will be necessary to review the scale of computing resources and associated budget repeatedly throughout operations.

The proposed 5 to 8 year refresh cycle for hardware is longer than industry practice. The potential impact of this is somewhat mitigated by the strategy for a rolling refresh (replacement of a fraction of the infrastructure at multiple points in the overall refresh cycle), but this strategy may raise total cost of ownership (capital cost + electricity and cooling + maintenance) and increase the risk of degraded performance and outages.

Given the high degree of automation planned for NEON and its large, distributed nature, it is highly desirable for NEON to gain operations experience and explore the potential for efficiencies before having to make a long-term commitment to a specific operational scope. Such a plan, e.g. shortening the period of the initial operations funding to three years, has the potential to result in a reduction in long term operational costs.

One of the clear risks NEON faces during operations is that its ability to respond to community requests for new data products, new data delivery and portal-based analysis and visualization capabilities, and management of data from additional sites and sensors could be overwhelmed.

5.0 Field Operations and Human Resources

Field operations include most domain operations, including the implementation of field data gathering, processing, local archiving, and shipping for laboratory analysis. The domain manager serves as the primary NEON liaison to local partners and neighbors for each domain site. Field Operations are coordinated from NEON Headquarters, with strong interfaces with Science, Engineering, EHS, FIU/AQ, and Cyberinfrastructure staff. Because of data collection demands, Field Operations will include the largest proportion of permanent and seasonal NEON staff. Therefore, technical training of staff is a major ongoing focus of Field Operations. Human resources provide support to all NEON operations for hiring, training, support, and staff evaluation.

Findings

Domain establishment and staffing are planned to ramp-up nationally across initial years of operations. Field Operations staffing will increase to approximately 140 FTEs, distributed across headquarters and domains. A domain manager, six technical staff, and two administrative support staff are planned for each domain. Additionally, seasonal crews may include as many as 20 individuals per domain during the growing season; all recruited and hired locally. Although field sample procedures are defined at headquarters, domains carry out those procedures and provide field calibration and routine maintenance. Domain staff will also assist with site decommissioning.

The transition from construction to operations is based on the site acceptance schedule. The process, starting with hiring domain managers, begins about one year prior to start-up. Managers serve as focal staff for establishing partner relationships, securing facilities, staffing, and implementing protocols. So far, Field Operations has limited experience with issues pertaining to the establishment of domain facilities. Needs of each domain are unique but were partially benchmarked using related networks, including OK Mesonet, the U.S. Climate Reference Network, ARM Climate Research Facility (the latter includes ~50% of NEON measurements, all on one site).

NEON is considering various alternative configurations for establishing support facilities based on staffing, travel distance, housing stipends, etc. Each site will include 2-3 purchased vehicles plus leased seasonal vehicles. NEON must find providers willing to enable use of vehicles off-road, and driven by seasonal crew members that are under regular rental age limits. NEON staff announced during the panel that a new agreement has been signed with GSA to provide leased federal government trucks; this would solve the field vehicle problem. NEON is prepared to support a distributed workforce, being registered at state levels and compliant with state regulations. Areas of expertise to be included among field technicians are: tower/soil-based vs. aquatic vs. biological expertise.

Training of field staff includes corporate, safety and on-the-job training for specific protocols. Depending on site owner, certain certifications may apply (e.g., animal handling as specified for a given state/university facility). Headquarters HR maintains information on training status for all staff and contract employees. Regular technicians are to be hired three months prior to operational start. Cross-training is planned to ensure continuity of sampling throughout a given field season (given illness, leave time, etc.). Permanent staff inter-mixed with seasonal staff varies by procedure. NEON anticipates setting up structure from “incoming” “experienced technical” and “leadership” among field staff. Pay grade is set, but regional differences (10% variance) are allowed.

The Colorado prototype worked well during 2011. Staff hiring was successful, and sampling activity was within 2-3% of estimates. The primary lesson learned was that Field Operations staff needed to expend much more effort to talk to site owners and ensure that local-site communication is handled effectively.

Primary risks to Field Operations include field staff recruiting, weather-related field delays, fire at sites and loss. Some staff logistics issues include the fact that plant sampling is initiated in early spring when students are not yet available. Given the needs for considerable staff training, incentives for continuity will be a focus. Ideas include setting up an ‘alumni network’ for field staff to maintain communications, plus providing pay incentives for returning.

Comments

One comment from panel members was “this makes invading Normandy look easy.” However, proximity of initial estimates to first field tests are very close suggesting that the mechanisms they have put in place should work quite well. It is quite likely that additional efficiencies in sample design (stratification, how many samples, frequency of sampling) will be identified during the first 3 years of operations. Similarly, NEON has yet to fully evaluate impact of electronic data loggers on all classes of data to be developed (i.e., reduced processing time).

From the presented material, there appears to be an advisory working group for Field Operations, and Science groups handle the scientific portions of procedures. The Operations working group reports to the director’s office, but it is not clear whether it is intended to support Field Operations as well on the operations pieces. Whether there is sufficient support for the task at headquarters during initial ramp-up also is unclear. The Field staff requires solid sense of which decisions are under their control versus when they must contact NEON headquarters. This will involve a learning curve for the first few domains. NEON is working on plans for periodic communications, weekly regional conference calls and monthly reporting.

Given stated intentions for engaging universities, there is also much potential for collaboration with state agencies, NGOs, and others who have similar needs for field technicians.

Training presents exciting potential to tap into local expertise because NEON is spearheading new ways to gather data and implement procedures in the best ways possible. This approach also potentially provides opportunities for a ‘coordinated research network’ and to obtain funding for that.

Field staff should be able to build upon and share training materials across NEON and related networks. They may be able to contract with developers, along with online sources because the material may be used in online materials for Ecology classes.

6.0 Central Operations, Logistics, and Procurement

Findings:

6.1 Summary

The presentation provided insight into the support functions provided by NEON Central Operations (CO) to the observatory. Functioning roles of the groups for Observatory and Monitoring Quality Control, Relocation and MDP Management, and Environmental Health and Safety were discussed in detail.

Program support provided by Logistics and Procurement were presented as part of the integrated activities.

CO coordinates activities between support functions and operations to ensure that systems supporting the Observatory are performing to the requirements in the Observatory Requirements Document. Roles in management, support and development, sustainment, sample collection, and supporting functions were identified.

CO plays a key role in the sustainment of the observatory with oversight responsibilities for coordinating scheduled maintenance, repair and upgrades of infrastructure and equipment. Maintenance procedures are reviewed and updated. Permit renewals, site use agreements, and facility lease renewals are also the purview of CO.

Monitoring system health is also a key function. Oversight is provided on data and sample quality assurance, asset tracking for sensor calibration and validation, maintenance of records of plot locations, site maps, and geo-spatial records and system monitoring and preventive maintenance. CO takes the lead on coordinating specimen and sample asset tracking, maintenance, and shipments. The NEON Control and Help Desk, located at headquarters, provides operations monitoring and real time live displays of all NEON locations. Responsibilities include internal problem tracking and input from the community on data issues.

CO also has the lead in Relocation and Rapid Response Deployment Management of mobile deployment. Coordination is provided for permitting relocatable site moves, new site selection and the management of design and construction of new relocatable sites. This coordinated approach ensures that the sites are integrated, validated, verified and commissioned. SCI Ops initiates relocation site identification and has responsibility for data quality, problem resolution, and tracking. Central Ops manages system wide upgrades and collection procedures and protocols through the CCB and develops the procedures for rapid response deployment.

Training requirements are also a CO responsibility. Job instruction training programs for the observatory will be developed and tracked to ensure necessary training is available and complete. Training objectives will focus on compliance with NEON policy, federal and state OSHA compliance, safe and healthful work environment, competency in use of Jira/Maximo trouble reporting, shipping logistics requirements, and NEON procurement requirements.

CO interfaces and supports the community, the director, and NEON divisions. Central Ops is positioned to be the community interface for the observatory providing external interface to new site stakeholders. Communication is coordinated during relocation and Rapid Response deployments with site hosts and land owners. Assistance is provided to the director's office in developing and reviewing annual budgets and providing analysis of observatory maintenance and equipment replacement to guide budgetary decisions. CO operates a control center and helpdesk to coordinate support with all NEON divisions for cross department activities such as assembly fabrication, sensor repair and calibration, shipping and receiving, and training. Responsibilities also include implementing system engineering processes and life-cycle activities, system analysis and development, and system integration, verification, validation and commissioning and acceptance of the project elements into the observatory.

CO will deploy mobile platforms for research requested by principal investigators . Maintenance will be provided after deployment of the MDP with Field Operations . Support also will be provided to maintain the operations documentation baseline, routine activities, and tasks performed by all divisions for quality assurance.

Budget components were presented with detailed cost breakout for many components.

Several transitional issues were identified. Construction schedules need to be clarified to firm up transition schedule and identify areas where added support is needed. Central Operations training requirements for staff functions need to be developed as well as the requirements for JIRA and Maximo transition. QA/QC requirements for system monitoring and system tracking metrics need to be finalized.

Several challenges need to be addressed. NEON is in the process of hiring a head of Central Operations. CO also needs to initiate and test a problem tracking and reporting system for operations and confirm help desk functionality and processes. Operational deliverable schedules need to be confirmed and a Central Operations job training matrix needs to be developed. Testing should begin on the asset management (sample tracking) with Field Ops.

6.2 Logistics supporting function

Logistics coordinates materials flow, inventory management and fleet coordination. Incoming shipments are received and inspected at the headquarters warehouse before distribution to the requesting office. Data entry is made into the Maximo system for asset tracking.

Support is also provided for field operations. Challenges are to understand site-specific characteristics (e.g. remoteness), determine accessibility, and research alternative drop off and staging points. Coordination is necessary with engineering regarding the shipping of method-staged containers and to quantify materials to be deployed on a site-specific basis. Field samples are shipped and received through headquarters. Logistics will maintain inventory and replenish the supplies. Fleet requirements will also be coordinated through this office.

Logistics has an ambitious schedule in the transition to operations: research packaging alternatives, post construction pre-operation transportation alternatives, develop training programs for in depth understanding of the property management system, and initiate a fleet management program to support field operations. There is also a need to complete a logistics handbook on procedures for logistics activities to support operations on a daily basis and to formalize an inventory process and count strategy. Additional tasks include the development of key performance indicators analyzing supplier performance, carrier performance, transportation cost analysis, internal order turnaround time, and inventory availability and accuracy.

There are a number of initiatives underway. Audit procedures for asset management and inventory control need to be formalized. The warehouse organization will be evaluated once velocity and through put have been determined, to organize a storage strategy of the inventory with the aim of developing efficient picking, put away, and cycle counting. Logistics will pursue identifying transportation training opportunities, (e.g. partner with carriers that are domiciled close to NEON sites) to make the process more efficient and will continue support of engineering from a materials requirement planning perspective.

NEON recently conducted an asset inventory, verifying existence and location of the equipment, as well as recording information on condition and utilization. The inventory was reconciled to the accounting records.

6.3 Procurement supporting function

Procurement and Contracts (PC) provides support for the acquisition of goods and services for the Observatory. Documented procedures are in place to ensure compliance with federal procurement requirements. An internal procurement handbook has been developed to provide guidance to staff on NEON processes and practices. These documents were recently reviewed as part of the NSF's Business System Review and found to be in compliance with NSF requirements with no significant negative findings.

To better serve NEON staff, PC recently piloted a procurement advocacy alignment process. Dedicated specialists are assigned to specific departments to better address their needs and requirements. Staff backup is provided for each position.

Procurement has also pursued opportunities to leverage external procurement resources. Relationships have been established with GSA, State of Colorado, and Cooperative Purchasing Associations to allow NEON to leverage pricing arrangements and contracts that were competed and are maintained by each group.

Comments

6.4 Summary

There is confidence that the policies and plans in place in central operations, logistics, and procurement activities are designed to meet the requirements of the distributed systems. It is anticipated that efficiencies in process and procedures will be gained as the construction project activities move into operations.

The O&M costs for the central operations activities appear reasonable and well justified. General budgets included allocations for employee welfare costs and publications that are typically indirect cost allocations and should be adjusted. It was unclear whether NEON, Inc.'s compensation analysis included market data from not-for-profit organizations (*e.g.,* academic institutions, federal and state governments, and non-profits). NEON, Inc. should work with the NSF Program to review the results and determine the appropriate next steps if excluding the “for profit” comparisons results in significant differences to salary ranges.

The position of the Director of Central Operations will have a critical impact on the community interaction. The selectee should be capable of articulating the scientific mission of NEON and be an advocate for the Observatory. NEON is encouraged to ensure that consideration is provided in the process to ensure that the candidate selected meets these criteria and is sensitive to community and user needs.

It was unclear from discussion whether Central Operations had developed a business continuity plan. Although NEON, Inc. is planning strategies to manage its workforce, these are mostly short-term an informal in practice. More structured short and long-term workforce planning should be developed and written. It should include a consistent approach to aligning the workforce with NEON’s mission and objectives. The staffing strategy for operations has been delayed due to changes in funding. NEON, Inc. should develop a model for more easily determining staffing levels under different funding scenarios.

NEON, Inc. should revisit its plans for implementing an audit and oversight activity and accelerate the standup date. Although function-specific activities and training could continue to be managed in a distributed fashion, a consistent organizational-wide framework to govern operational protocols should be coordinated and managed through a single group. This framework should include roles, responsibilities for ensuring continuous compliance, and corresponding processes with timelines.

CO is responsible for support compliance with safety requirements although these processes are still untested. Further, an emergency response training program has not been developed for field operations. Responsibilities of responders and staff need to be defined and a training coordinator identified.

The change control strategy presented raised some concerns and should be revisited. The problem resolution and tracking system that will be used in operations is under development and unclear. The procedures being developed for field staff should identify explicitly the items which they control, the process for redlining SOPs, and the procedures for submitting trouble tickets. Training should be provided to ensure that only systemic problems, rather than issues stemming from user errors/confusions, or requests for information, are processed. Based on size of NEON staff, it is highly recommend that the ticket access is controlled, and provide through the Education group a way for users to provide inputs/feedback. Education can then determine if a ticket is needed.

The online community portal needs to be defined. Information provided there should include details on algorithms. The portal should also provide and “enterprise” status on NEON sensors, data products, and services to users. NEON should recognize that community activities and experiments may depend on the availability of data and services in ways that NEON staff are not aware.

6.5 **Logistics**

Proposed Logistics group staffing levels seem appropriate for construction phase, but there are a number of initiatives proposed or underway that may need to be finalized before the transition to operations. In particular, there is difficulty assessing the capacity of the Asset Module component of the Maximo system because it has not yet been deployed. NEON needs to develop testing procedures to ensure that the Maximo Asset Module has the functionality to include specimen tracking and sensor tracking. The system should be uploaded with warranty information and tested to ensure that required maintenance reports can be produced.

Although all business and administrative functions will be located at the NEON Boulder headquarters, domain offices will be staffed with at least one person trained in the use of key business systems including inventory management, order management and purchase requisition. A training program should be developed to ensure domain accountability for field operations assets.

6.6 Procurement

The procurement policies, procedures, and staffing are in place to accommodate the construction phase of the observatory as well as the transition to operations. Recently negotiated agreements establishing the relationships with the external leveraged procurement resources will result in efficiencies and budgetary savings. Acquisition plans are in place to accommodate relocatable towers, aquatic array construction, and decommissioning and restoration. Plans are also in place to accommodate LiDAR arrangements, aircraft leases, analysis activities, and data collection and seem to be well thought out.

7.0 Airborne Observing Platform (AOP)

Findings

The NEON/AOP team has done a very good job of preparing for operations of the airborne component of the NEON observatory. Planning for the start of AOP operations has required that the team pay attention to two key elements: 1) instrument payload preparation, and 2) aircraft platform preparation. In regard to the former, the AOP team is on schedule to deliver the three remote sensing instruments (LIDAR, imaging spectrometer, and airborne digital camera) that will comprise each of the three complete airborne payloads. Risks associated with design and delivery of the imaging spectrometer by NASA/JPL that were identified during the construction phase have been successfully reduced by NSF providing stimulus funds for NEON to pursue the design and construction of a design and verification unit for use in early testing. This unit was delivered to NEON in December 2011 and will be flight-tested during spring and summer 2012 during a series of flights in Colorado and California. In regard to the required airborne platform needs, NEON has determined that the use of leased aircraft is most appropriate and will meet the needs of the NEON scientific community. Twin Otter International has been identified as the aircraft operator and will have responsibility for flying and maintaining the three aircraft to be used to fulfill NEON airborne science objectives.

In general, the NEON/AOP team has carefully considered the staffing and budget requirements associated with operation and maintenance of the aircraft and the remote sensing payloads. The team is paying particular attention to the importance of safety, compliance, and testing. A flight safety plan is currently under development, and the AOP team is intending to conduct annual safety reviews of AOP procedures, incidents, and audits and will also conduct annual field safety training for personnel who will be flying on the aircraft and supporting ground data collection efforts. The AOP team has developed a staffing plan to ensure that experienced science staff will be available to support deployment of the remote sensing payloads. A particularly noteworthy element of the AOP staffing plan involves the inclusion of post-docs as flight crew members. This will serve as an innovative and valuable way to preparing an upcoming generation of researchers in the operation and application of crucial and unique remote sensing technology.

Although scientific staffing is well accounted for in the NEON/AOP operations plan, the inclusion of an individual with aircraft operations experience appears to be lacking. Such an individual is needed to serve as an interface between AOP scientific team members and the aircraft operator and to ensure that seamless integration between scientific and flight operations is maintained.

The resolution and image analysis capabilities to be made possible by the AOP remote sensing payloads are very promising, and very precise information should be achievable from the flight transects to be flown. Participation in the AOP Pathfinder flight campaigns provided AOP personnel with valuable, early opportunities to prototype field sampling for validation and scaling of airborne data and to conduct field sampling for data validation and build-up of a spectral database. These flight campaigns have put NEON in a strong position to begin the development of algorithms and procedures prior to the start of formal NEON operations.

Comments

The decision made by NEON to use an aircraft operator has been well-justified and makes sound financial sense. However, NEON still bears responsibility for the overall safety of AOP operations and must maintain visibility into the appropriateness of Twin Otter International's flight operations plans and procedures. One risk associated with use of an aircraft operator is the potential for the operator to go out of business at some point in the future, leaving NEON with a need to identify an alternate operator and secure a pathway for transitioning the remote sensing platforms to new aircraft with a minimum of disruption to the overall NEON observing schedule. Continued volatility in oil prices could adversely impact aviation fuel costs, leading to negative impacts on the NEON/AOP operations budget. NEON/AOP personnel must remain cognizant of this risk and should plan accordingly in their budgeting and risk management efforts.

The NEON/AOP team concedes that planned staffing levels for the AOP aircraft are currently quite lean. As with other elements of the NEON observatory, operational experience must be gained before the AOP team can fully assess the suitability of proposed flight instrument operator staffing levels. The Panel notes that plans for the hiring of an individual with aircraft operations experience appear to be missing.

The hiring of such an individual is viewed as essential to ensure that science and aircraft operations requirements are integrated in an appropriate fashion.

AOP team members have established technology-refresh plans for the airborne sensors that appear to be reasonable. These plans have been incorporated into overall NEON operations and maintenance budgeting and planning efforts. However, each of the three airborne payload components are complex in nature, and greater understanding of the mean time-to-failure of major elements within each remote sensing instrument is required for AOP personnel to ensure that replacement budgets have been suitably structured.

In the larger scheme of NEON, the use of an "in house" AOP program turned out to be logistically more efficient and economically less costly than using contractors to perform the same mission tasks. Logistically, NEON personnel are able to modify the aircraft to accommodate both LiDAR and multi-spectral instruments simultaneously, which some contractors would not be able or willing to do. In addition, overall costs for operating the AOP are less than "market rates"; for example, the NSF-sponsored National Center for Airborne Laser Mapping (NCALM) at the University of Houston charges nearly \$500/km^2 for LiDAR mapping (point density of 9-24 points/m^2), whereas the comparable cost for NEON's AOP is ~\$300/km^2 (although resolution is less, at ~1 point/m^2, but still sufficient for the NEON mission). Thus, the "in house" AOP program is justified financially by showing a nearly 40% savings over contractor rates.

8.0 STREON/Aquatics

How sufficient is the NEON operational model in maintaining NEON and supporting AQUATIC research at regional to continental scale for 30 years?

Findings:

The detailed plans for data collection, analysis, sample processing, and QA are all well thought-out and will most likely support NEON's goal of supporting aquatic research at a regional to continental scale for 30 years. Development of published protocols, partnerships and training operations is underway and has integrated input from appropriate working groups. Participation at national meetings has helped to inform potential partners of opportunities for future collaboration and to identify standard protocols.

Comments: Because NEON is just starting the construction phase there are many details that have not yet been prototyped regarding analysis of samples and long-term storage of some collections. The current detailed plans likely will be modified as experience is gained in the field. Most areas of NEON's analyses of aquatic biodiversity and stream ecosystem processes are fully documented.

There are existing models for processing samples and assuring statistical appropriate sampling that can be used to improve for reliability and efficiency in sampling protocols. Developing these protocols may be supported in part by new partnerships with user groups who need high-quality assurance of stream biotic sampling. Water chemistry sampling and analysis is well designed.

The number of lakes to be sampled/monitored in the aquatic portion of NEON (8) is insufficient to provide information on regional- or continental scale status or trends. Inclusion of remotely-sensed information on such measures as chlorophyll, water clarity, and CDOM, all of which can be determined readily for the much larger numbers of lakes covered in the AOP over-flights could provide spatially extensive information to complement the spatially sparse but temporally intensive data from the lakes with in situ sensor platforms. This approach would help to mitigate an important deficiency in NEON's aquatic program at very low cost.

How well is the NEON Operations Plan documented and justified relative to STREON and related AQUATIC research?

Findings

Plans are exceptionally well done for most activities that integrate the AQUATICS sampling and coordination with STREON experiments. The STREON Working Group continues to discuss options regarding some standard procedures with the AQUATICS Working Group. An AQUATICS Technical Working Group will be formed in the near future.

Comments

The inclusion of STREON, an experiment based on the 2007 Request for Information (RFI) and a series of workshops in 2008, led to proposed comparisons among nutrient enriched and consumer manipulated site with reference sites at headwater streams in 10 of the 20 domains. The RFI stimulated discussions among a large number (> 100) stream ecologists, who helped design the experiments and select appropriate sites. The current STREON Working Group is composed of 17 members who advise NEON scientists on preparations for the replicated experiments to begin in 2013. Recent funding by the NSF Macrosystems Program's five-year research grant (SCALAR) will help fund experiments and will provide an example of how cross-site experiments can make use of NEON reference sites to expand the scale and scope of STREON findings. The experience gained in organizing and conducting this research will help NEON and the ecological community to develop procedures for team-based studies and for providing open access to data that are obtained by NEON-based research. How the STREON example is handled will be important in regard to setting precedents and community perceptions. Consequently, we recommend that all NEON-funded data streams (which include STREON) should fall under the current NEON data policy for core NEON measurements; specifically, no group (or individual) should have privileged access to NEON-generated data prior to those data becoming available to the community at large.

It may be timely to consider an additional workshop composed of individuals with different levels of experience in joint research projects to review governance principles and to work out some persistent sources of uncertainty. The Long Term Ecological Research Network has developed some guidelines that might prove useful. The size of the Working Group may need to be reconsidered to improve effective decisions.

Are there further efficiencies that could allow NEON to keep the overall O&M costs as low as possible for AQUATICS research?

Findings:

The current plans provide an excellent basis for beginning operations. Outsourcing some analyses of chemical analyses and archiving samples will likely be cost effective although some risks remain.

Comments:

Efficiencies may increase in the future but the staff has identified a strong plan that provides support for the current NEON scope. The core staff is likely to need assistance as the project expands efforts across all the Domains.

Are there sufficient and appropriate metrics to measure the success of NEON Operations in AQUATICS?

Findings

Continued participation at national meetings that result in peer-reviewed, frequently cited publications will provide recognition of timely, effective NEON research.

Comments:

Past poster sessions have been successful and current plans are for a special symposium on aquatic research at a national meeting,

9.0 Education

Comments:

The panel thinks that the E/O program is off to an impressive and ambitious operations start. The E/O team has done much high level thinking about NEON and its potential to transform how we do education and science. They should be commended for their plan to integrate education so intimately with the research.

The list of possible education activities is long and comprehensive. It was not clear whether the strategic goals of NEON map onto the educational strategies. The committee discussed how prioritizing might happen and suggested that a possible context could be based on the consideration of the skill sets necessary for training/educating next generation of people.

The public face of NEON, the web portal, is managed by the E/O group. This is a different model from many science/education groups and it should promote the integration of the entire NEON operations, as well as make both science and education processes more transparent to the community. There is great potential here. However, the specifics of the web portal were unclear, as was the plan for community engagement in its development. The committee was concerned that so few details were provided.

The lack of specificity in programming was a challenge for reviewing the details of the program (budget or otherwise). It is understood that specificity will come during construction but the panel would have liked to see some prioritizing of those planned projects around a theme that demonstrates NEON's unique contributions to continental-scale science.

NEON has the potential to transform ecological science. It will be necessary to understand whether that is actually happening through the use of specifically designed metrics to continue receiving support from the community and funding agencies.

There was some question about phasing-in of projects aligned with construction because it does not appear that these things could/should scale with construction.

It was stressed to us by NEON staff that NEON is a facility, not a mentoring program; nonetheless, the education program includes undergraduate, graduate and postdoctoral training. We had some confusion about this discrepancy; it suggests a lack of integration among programs and some opportunities lost.

We noted confusion among the entire panel about the E/O program name. As the name education/outreach has a specific meaning in the community that is much more restrictive than what is planned under this program, we suggest that NEON consider renaming the program. It is more than education and outreach, and the name and staff titles should reflect that.

Closer engagement of NEON with the science user community will help ensure the success of the observatory. The ecology science community motivated the NEON project and defined the science objectives. Now is the time to realize the maximum science benefit.

There are several ways that such an engagement might be accomplished. Perhaps the most valuable way to pull the users actively into the observatory would be to sponsor a science users organization. An active users organization would yield several valuable benefits, but NEON would have to embrace the users organization as a partner that would provide both guidance and support. When the science advisory working groups follow the transition to the operations, they could become a conduit for science guidance from the users.

At the same time the observatory could call on the users organization for support. The users, suitably organized, could take on the task of taking on the next level of data quality monitoring as part of the data analysis. The users organization could encourage the formation of groups interested in the different science problems to work together on the analysis in a way the individual researcher could not, given the size and breadth of the data set. Users could develop a common library of analysis tools. Users could contribute to the development of aspects of the web portal. They could develop outreach materials for use in schools near the collection sites including perhaps an eco-kit of basic measuring instruments. A visitor's center at the NEON head quarters also might be another suitable users project.

The NEON Users organization would be a strong, visible manifestation (to the NSF) of the interest and support of the community for the NEON science.

The observatory also should try to incorporate students and postdocs into the fabric of the organization. This will provide valuable training in the hands-on experience of collecting data and ensuring its quality. When analyzing and interpreting data it is important to see how the instruments work in the field and appreciate their quirks and short comings. These students will be, after all, the future researchers that will lead the analysis of NEON data. Economies in operations might be achieved by use of students as an additional benefit. A final comment: Several breakout groups did not articulate an education presence/activity during presentations and the committee was surprised at the absence. Although the committee understood from other presentations and conversations that there is significant interaction among the groups, we would encourage the various groups to identify that important interface in presentations.

10.0 Savings and Efficiencies

Findings

In response to estimated steady-state M&O budget needs, the NSF requested that NEON, Inc. identify ways to reduce the estimated budget needed by 20%. NEON presented to the panel approximately 16-19 $M of options to reduce the budget that were a combination of transferring taskable (request-based) facility operations to external funds; reducing maintenance (increases in efficiency may offset the impact of reduced maintenance); scope reductions that increase risk and uncertainty (for example by reducing replication); and scope reductions that delete or defer key science capabilities identified in the observatory requirements.

NEON has not yet done an exercise of thoroughly identifying the interactions of the various de-scoping options they presented, although some conflicts between different options were identified for the panel.

NEON has done a bottoms-up estimation of M&O budget needed with supplied bases of estimate, although they did not use the standard "project" tools of a WBS dictionary and corresponding cost book to document the process. In some cases (e.g., travel and items used in construction), the construction project provided solid data for these estimates. Most of the labor was based on engineering estimates, using the experience of team members and information from other operations that were deemed comparable.

NEON has not had much time to identify/analyze many smaller potential cost savings, such as special contracted rates for renewal of large numbers of sensors over time, savings from "Moore's Law" , reductions in cost/performance or required cooling/performance of computing equipment.

NEON has not yet done any trade and learning curve studies to identify potential savings in O&M.

Comments

NEON has done a good job of accumulating a bottoms-up estimate of O&M costs to date, but could benefit from further work to refine these estimates and discover savings and efficiencies.

The opinion of the panel is that there is not yet enough of a basis of experience with maintenance and operations of installed and operating NEON sites to understand the feasibility or the impacts of many of the options for savings that were presented to the panel.

Furthermore, there is no similar facility of this nature or any tradition of collaboration on large facilities within the biology and ecology user communities that will exploit NEON. This especially affects the estimated ability to achieve savings while building community capability by transferring elements of M&O responsibility to the community through operating partnerships. As a result, the O&M model strategy currently in place is closer to a "retail" model, in which "producers" are clearly separated from "consumers", rather than the more collaborative models now employed in some other fields (e.g., physics and more recently engineering and astronomy) that have been early adopters of large scientific facilities to achieve large science missions.

In some cases, such operating partnerships sharing O&M scope could generate significant savings to NSF by bringing other agency funds into play, where the data and agency missions overlap. In other cases, NSF would still be funding the same scope among NEON, Inc. and NEON-users. In these cases, the efficiency gains from competition for these scope elements may be offset by inefficiencies in spreading scope across multiple institutions, but experience in other fields indicates that a greater collaboration on M&O tasks generally broadens the scientific capability across a user community.

Because NEON have no proprietary data-access privileges for collaborators in M&O activities, some other form of providing incentives for collaboration would need to be identified to entice partnerships that share M&O scope.

Reserving some research time for staff scientists can be an effective tool in building effective collaborative partnerships and strengthening the capacity of the user community. This leveraging factor should be taken into account before trying to achieve savings by eliminating such research time. Fractions of staff scientist time reserved for research involvement as small as 15-20% have provided effective leverage elsewhere.

There are several good reasons for integrating the NEON science user community more closely into the operation of the observatory. One of these is improved efficiencies in data taking, quality monitoring and processing. Students (and postdocs) are highly motivated and hard working. With the same training given to new staff, students could be a low-cost offset to the costs during peak collection times while the students gain valuable hands-on experience in the field and in working with the data in real time. Indeed this could be an essential part of their education. Even more benefits will accrue in the future as this set of students and postdocs become the next generation of research leaders in NEON. It is also noteworthy that shared appointments of students and postdocs provide effective ways to bridge work activities between NEON, Inc. and other institutions.

Given the above comments, the panel concludes that it would be unwise at this time to commit to a long-term O&M funding profile, such as the eight-year time frame being considered at the beginning of this review. Using the first three years of operations – during which real domain installations are completed and end-to-end exercising of the operating infrastructure for these domains is achieved and is used by the community for science – to build a basis of experience and test assumptions that drive M&O budget elements would be preferable. This would provide a much more solid basis for projecting M&O expenses for the next five-year period during which steady state NEON operations would be achieved. It would also provide time for building the partnerships and collaborative relationships that could result in significant savings by cost-sharing or capacity building for the community served by NEON.

It appeared to the panel that NEON had not yet done the exercise of separating elements of the budget required for good stewardship of the capital investment in NEON from the budget required for performing the science mission. This is important for exploring options for savings. Poor stewardship (losing significant amounts of data or allowing the facilities to decline) is not a viable option, but savings that may cause delays in publication of results could be viable, although not desirable.

If the recommendation to adopt a three-year initial O&M plan were followed, it would be advisable to aggressively pursue cost savings that do not de-scope achievable science. For example, one should pursue aggressively bargaining for favorable contract rates for supplies and refresh equipment replacements, attempt and evaluate alternate strategies to lean-out the manpower required to achieve availability goals, and conduct other trade and learning curve studies that could result in more cost-efficient operations. Because the number of sites involved is a small fraction of the total and any mistakes do not accumulate for long time, the planning can assume risk in this early stage and correct for lessons learned before the scale and duration of operations increases. It also would be advisable to identify the most cost-sensitive lessons that could be learned about the actual density of sampling in space and time required to achieve the science goals; these items are currently scoped on the best guesses from simulations and small amounts of data, rather than comprehensive end-to-end testing.

RECOMMENDATIONS

1. The panel recommends that the first eight years of operations be divided into an initial three-year cooperative agreement and follow-on 5-year agreement. The initial period should be used to acquire real end-to-end operating experience with many sites over several Domains and to aggressively test scenarios for achieving greater efficiency and savings.

2. The panel recommends that NEON identify and prioritize trade and learning curve studies that might result in savings and greater efficiency in achieving scope with limited funds. For example, Fermilab was able to achieve higher availability at significant cost savings when it switched from a fixed-interval maintenance schedule (currently assumed for the NEON Domains) to a "run until it breaks" strategy. A similar strategy may not work for NEON, but it provides an example of creative alternate strategies that may be available.

3. Refine O&M plans, budgets and staffing as soon as there is sufficient return data from several early-commissioned sites and prototype activities to validate initial planning assumptions.

4. NEON's current operations plans appropriately include funding to run the observatory given current efficiencies and to enable the observatory to serve as a platform for the community. In the analysis of descoping options, NEON should further explore options to improve efficiencies and to transfer scope to the community before selecting an option that would impact the science scope or increase risks of achieving that scope.

5. NEON should review, and consider augmenting where appropriate, current O&M planning, prototyping or other similar strategies to provide a basis for future learning curves and targeted efficiencies in the operations phase

6. NEON and NSF should identify and agree upon the portion of NEON scope and budget required for good stewardship of the capital investment in facilities, which is a paramount NEON, Inc. responsibility, and the portion that provides capability to pursue the science mission which is a responsibility shared between NEON, Inc. and its user community.

7. NSF should consider investing in research across its divisions to accelerate development of methods to automate or minimize the need for field sampling by a large labor force to acquire required NEON field data.

8. Complete the O&M Risk Register for the major programmatic (e.g., funding) risks, and when construction funding is fully defined add likely funding risks and their associated impacts.

9. As O&M planning proceeds, integrate the three parts of NEON schedules.

10. NEON needs to implement QA/QC for field sampling (e.g., sampling redundancy) to estimate sampling and observer bias, and to plan for annual statistical analyses for assessing FSU sampling efficiencies.

11. NEON should foster an independent user's organization to provide guidance and support to the observatory. STEAC could play a role in developing this group.

12. NEON should proactively incorporate students, post-docs, and other agencies (e.g., state agencies and NGOs) into field operations including organismal sampling. This would have the advantage of efficiently identify and retain high-quality assistance while providing important

training and field experience for the researchers who will ultimately be using the field samples and data for research.

13. Agreements with established museums and natural history collections need to be developed as quickly as possible, including accession, archival and data management costs, curation procedures, and loan policies.

14. NEON should Track and document effort, timing, and costs associated with sensor O&M as sites come online. Consider simulated scaling to identify bottlenecks that are difficult to anticipate – especially those that result from the testing and maintenance facility and staff being located in Boulder while problems may occur at sites.

15. Expand and diversify the end-to-end sensor data flow to test scaling of CI infrastructure and nascent QA/QC system and protocols. While testing with simulated data would be helpful to root out serious problems, testing with the real field data that begins flowing from the ten sites will be essential to proving the performance of the system.

16. Open a risk on manual QA/C systems and operations to address staffing model and potential large backlogs that could result from untested QA/QC scaling.

17. Given that NEON's success will drive requests for additional NEON data products and services at a scale beyond NEON's operations budget, NEON should be very explicit in setting community expectations and prioritize the development and promotion of interfaces and services that enable to community to support itself and contribute to NEON's evolution over the next 30 years.

18. While CI O&M cost estimates are appropriate at this stage, NEON should reconsider its assumptions as operational experience is accrued. Further, should descoping become necessary, NEON should assure that its reserve computing capacity is matched to its overall ability to take advantage of that reserve. In particular, the use of shared national resources for computing and data storage should be considered before any reductions that would impact NEON's scientific scope. In the long term, reduction of CI computing resource expenses by $500K+/year could be possible.

19. NEON should also review and justify its hardware refresh strategy in terms of total cost of ownership and, for the disk subsystem in particular, in terms of the potential for degraded performance (as the system recovers from individual disk failures).

20. NEON's service interfaces should be defined and announced as early as possible during construction, and emphasis should be placed on documenting how new services, portal widgets, and data products (particularly level 4) produced by the community can be integrated into NEON during construction and operations community engagement. These activities should be seen both as a mechanism to minimize scope creep and risk within the project as well as a

means (with appropriate metrics) of deepening community engagement and evolving community practices.

21. NEON needs to quickly reconstitute the working groups responsible for biosampling, bioarchives and biocollections/biosample databases to inform (1) the detailed, taxon-specific protocols, processes and schedules governing sample and specimen collecting in the field; (2) issues and elements of MOU agreements with bioarchive and biocollections institutions; and (3) the requirements for voucher/sample database interoperability and feedback mechanisms. In order to assure efficiencies of design, economies of scale and compliance with community standards, NEON should include representatives and input from the NSF-funded and expert Biotic Survey and Inventory community, the Natural Science Collections Alliance, and the Society for the Preservation of Natural History Collections.

22. As soon as is possible, begin prototyping all FSU processes.

23. Because bioarchiving is an essential, long-term element of NEON, the risks of bioarchive capabilities and potential default need to be articulated, analyzed and incorporated into a mitigation plan.

24. Reconstitute Operations Working Group to be sure that they include support to Field Operations; and that group should include representatives from institutions with comparable field operations to NEON.

25. Consider needs for enhancing feedback between Field Operations and Science with regard to sampling design. Given needs to gauge uncertainty, precision, and efficiency of sampling for the change detection mission of NEON, statistical analysis of field sample data should provide needed information for refinements to sampling design. There may be additional needs for statistical analysis capacity to maximize NEON effectiveness as related to this issue.

26. Provide for both internal and external review process for protocol documents; as they will develop and need that outside engagement.

27. Field Operations should give added attention to communications within each Domain; from reaching out broadly and regularly to the local research community all the way down to the local neighbors (e.g., using successful examples like local 'adopt a sensor' programs). Be sure to be perceived as 'a giver' rather than continuing to ask for more from them.

28. NEON may require additional lead time to get facilities and staff established on schedule. Consider scoring sites from "easy" to "moderate" to "challenging" and plan for more or less start-up lead time (by e.g., 3 months).

29. Recruiting and retention of Science and senior Field Operations staff may be challenging because of conflicted desires for conducting research and publication. NEON leadership should continue to look for ways to head off these conflicts, e.g. continually refine expectations during

recruitment and incentivize the staff to advance scientific inquiry while retaining a clear focus on keeping observatory operations as their first priority.

30. Build capacity into the on line community portal to provide detailed Performance Metrics (algorithms, enterprise status) and information to users. Performance Metrics should be accompanied by the appropriate success criteria.

31. Revisit change control process strategy for O&M. Establish guidelines for submittal, review, and processing of Trouble Tickets. Central Operations should develop a direct process method with dedicated training provided to field staff.

32. Develop an emergency response training program for field operations defining responsibilities of personnel.

33. Develop a Business Continuity Plan. While NEON, Inc. are planning strategies to manage their workforce, these are mostly short-term and informal in practice. More structured short and long-term workforce planning should be developed and written to ensure continuity of operations. The plan should include elements of command, control, notification and communication. It should include a consistent approach to aligning the workforce with NEON's mission and objectives.

34. Test functionality of Maximo Asset Module. Review elements should include specimen tracking/sensor tracking / preventive maintenance schedules. Ensure that the property management system has the functionality to record warranty information and produce the required maintenance reports. Ensure that the property management system accurately reflects current inventory. This is an important component for management of property, particularly at remote sites, and NEON is encouraged to proceed quickly with this functionality implementation.

35. NEON should consider the potential for Twin Otter International to go out of business and should develop cost and operational scenarios pertaining to the need to identify a new aircraft operator.

36. NEON needs to identify and implement a plan for external audit of flight operations. A federal government entity (e.g., the USDA) may be able to provide support for such audits.

37. NEON should include the hiring of an individual with aircraft operations experience in the AOP staffing plan. This individual will serve an important role in liaising between AOP scientific team members and the aircraft operator and will ensure that scientific, operations, and safety issues are addressed in an integrative and consistent manner.

38. NEON should re-visit the probability and occurrence cost associated with the risk of rising fuel costs in light of current volatility of fuel prices. NEON should consider raising the probability value and increasing the occurrence cost to guard against significant shortfalls in the budget.

39. NEON should develop mean time to failure information for all major instrument components of concern to: a) understand what major risks might be, and b) to ensure that suitable costs for major components are realistically accounted for in AOP O&M budgets.

40. Add a level 4 data product to AOP to produce chlorophyll, water clarity, and CDOM for lakes covered in AOP flights.

41. Develop new sensors for measuring concentrations of pigments produced by cyanobacteria in streams and lakes. These data would help track seasonal and inter-annual changes in cyanobacteria that are expected to increase in dominance if warmer waters occur across latitudes.

42. NEON should work with other NSF facilities and federal agencies to archive and process the AOP data as a way to reduce cost and improve efficiency

43. We recommend that all NEON-funded data streams (which include STREON) should fall under the NEON data policy for core NEON measurements---specifically that no group (or individual) should have privileged access to NEON-generated data prior to those data becoming available to the community at large.

44. Continue participation in professional society activities and focus on team-authored, peer-reviewed publications.

45. Develop a common educational vision across all of NEON. NEON should articulate how it will help transform the field of ecology; education could identify the experiences and skill sets necessary to realize those goals, and then map them clearly onto the educational deliverables

46. Prototype educational product(s) as part of transition into operations beyond Project Budburst. We suggest prioritizing these programs to best reflect the unique role of NEON in contributing to continental-scale science. For example, an education product based on STREON efforts (or leadership training, and/or postdoc program) could be developed early on in the project. Prototyping does not need to wait until all, or most data are online.

47. Consider prioritizing and structuring the education programs based on the <u>unique</u> role that NEON can play in science/education.

48. NEON has the potential to transform ecological science. It will be necessary to understand whether that is actually happening to continue receiving support from the community and funding agencies. Therefore it is imperative that NEON develop or adopt metrics that assess transformative change. We recommend that NEON hire/work with assessment people who can help develop and define metrics of “transformative change.”