2016 Status Update to DOE's Triennial Review of NSLS and NSLS-II: Response

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Acronyms/Definitions

ABDs – Authorization Basis Documents
ALS – Advanced Light Source
APS – Advanced Photon Source
ARPES – Angle-Resolved Photoemission System
ARR – Accelerated Readiness Review
ASCR – Advanced Scientific Computing Research
ASE – Accelerator Safety Envelope
BDN – Beamlines Developed by NSLS-II
BES – Basic Energy Sciences
BESFCWG – BES Facilities Computing Working Group
BHSO – Brookhaven (DOE) Site Office
BNL – Brookhaven National Laboratory
CA-D – Collider Accelerator Department
CAMERA – Center for Advanced Mathematics for Energy Research Applications
CDI – Coherent Diffractive Imaging
CHX - Coherent Hard X-ray Scattering
CMS – Complex Materials Scattering
CPU – Central Processing Unit
CR – Continuing Resolution
CSX - Coherent Soft X-ray Scattering
DAMA – Data Acquisition Management and Analysis
DOE – Department of Energy
EMG – Executive Management Group
ESH/ES&H – Environment, Safety & Health
ESH&Q – Environment, Safety, Health & Quality
ESM - Photoemission-Microscopy Facility
FIS– Frontier Synchrotron Infrared Spectroscopy
FTE – Full Time Equivalent
FXI – Full-field X-ray Imaging
FY – Fiscal Year
hr – hour
ID – Insertion Device
IR – Infra-red
IRR – Instrument Readiness Review
ISR - In-Situ & Resonant X-Ray Studies
IXS – Inelastic X-ray Scattering
LBNL – Lawrence Berkeley National Lab
LCF – Leadership Computing Facility
LCLS – Linear Coherent Light Source
LDRD – Laboratory Directed Research & Development
LHC – Large Hadron Collider
LINAC – Linear Accelerator
LSSOC – Light Source Safety Operations Council
mA – milli-amp
MET – Magnetospectroscopy, Ellipsometry and Time-Resolved Optical Spectroscopies
meV - milli-electron Volt
MID – Metrology & Instrumentation Development
MLL – Multilayer Laue Lens
NERSC – National Energy Research Scientific Computing Center
NPB – NSLS-II Partner Beamlines
NSLS – National Synchrotron Light Source
NSLS-II – National Synchrotron Light Source II
NYU – New York University
ODH – Oxygen Deficiency Hazards
PDF – Pair Distribution Function
PEMP – Performance Evaluation Management Plan
PPS – Personnel Protection System
PSD – Photon Sciences Directorate
QAS –Quick X-ray Absorption and Scattering
RCD – Radiological Control Division
RCT – Radiological Control Technician
R&D – Research and Development
RF – Radio Frequency
RHIC – Relativistic Heavy Ion Collider
RIXS – Resonant Inelastic X-ray Scattering
SAC – Scientific Advisory Committee
SC – Super Conductivity
SIX – Soft Inelastic X-ray Scattering

SLA – Service Level Agreement
SLAC – Stanford Linear Accelerator Center
SME – Subject Matter Expert
SMI – Soft Matter Interfaces
SPMC – Scientific Program Management Committee
SR – Storage Ring
SRX - Sub-micron Resolution X-ray Spectroscopy
SSC – structures, systems and components
SST – Spectroscopy Soft and Tender
STXM – Scanning Transmission X-ray Microscope
TES – Tender X-ray Absorption Spectroscopy
TLDs – Thermoluminescent Dosimeter
UEC – Users Executive Committee
USI – Unreviewed Safety Issue
VIPIC – Vertical Integrated Pixel Imaging Chip
vs. – versus
XFM – X-ray Fluorescence Microscopy
XFP – X-ray Footprinting for Bio Macromolecules
XPD – X-ray Power Diffraction

Executive Summary

This document is the 2016 status update to the DOE's Triennial Review of NSLS and NSLS-II that took place on September 23-26, 2014. This report addresses the actions and progress taken by NSLS-II to address the seven recommendations made by BES.

Recommendation 1: *Establish mechanisms to improve the communication effectiveness between PSD management, facility staff, and users at all levels.*

This issue remains a concern of the management. In addition to the steps outlined last year, this year we have refined our communications plan and have opened a posting to hire a permanent Communications Manager. We have also instituted "NSLS-II News" a biweekly newsletter to staff keeping them apprised of recent activities and upcoming events.

While this will always remain a concern and a point of focus for the management, we believe we are now on the right track and that the intent of this recommendation has been met.

Recommendation 2: *Evaluate the resource allocation, staffing plan, and organizational structure, and make proper adjustments to develop a cost-effective facility operation model which is sustainable under a realistic budget environment and scalable for the beamline build out and future growth of the NSLS-II facility. A dedicated BES review of the NSLS-II operations budget will be conducted in the third quarter of Fiscal Year (FY) 2015.*

Following the changes begun in FY15, we have made significant additional changes in FY16 in staffing levels, resource allocation and organizational structure. The June 2015 NSLS-II operations review and subsequent recommendations was important input in this process. Significant changes include a reduction and rebalancing of accelerator operations, facility management and ESH&Q, resulting in a FY16 reduction of 13% in these areas relative to the June budget review and taking these areas to below the numbers suggested by BES in the January 2016 analysis. These changes create sufficient budget to operate the existing beamlines, to continue to build all the BDN and NPB beamlines and to start new state-of-the-art beamlines in FY17. However, with the increasing number of beamlines coming into operations, we believe initiating a new beamline in each year with the intention to follow it through to completion on BES operating funds in a flat budget scenario would incur large risks to the scientific productivity of the facility and significantly damage the user community. This is particularly true in FY18 and beyond, when this constraint would require the support levels on the completed beamlines to be reduced to well below minimal levels for productive and safe full time operation of the beamlines. We are continuing to work with DOE-BES to make the tough choices required to balance the need for sufficient operational support of the existing beamlines with the need to develop new beamlines.

We view this recommendation as being in progress.

Recommendation 3: *Evaluate the staffing level and organizational arrangement of the ESHQ Program, and make appropriate adjustments to ensure safe and efficient operation. In addition, the staffing level seems high comparing to other BES light sources.*

To address this recommendation, we have carried out a careful benchmarking activity with the other light sources, discussed in detail below. Following on from this, we have further reduced ESH&Q staff by 2.4 FTEs relative to the June 2015 budget review and moved certain ES&H responsibilities to the central organization. We have also reorganized so that the lead for the ESH activities at NSLS-II is now an NSLS-II employee and reports directly to the NSLS-II Director (previously, this position was a deployed position from the central ES&Q organization at BNL).

We believe this recommendation has now been met.

Recommendation 4: *Complete the installation of the hardware for top-off operation by the end of FY 2015 and implement top-off user operation in 2016*

This activity is complete. Top-off was demonstrated at the end of FY15 and user operations in FY16 are with top-off running. At the end of run 2016-1, this was at a stored current of 250 mA.

We view this recommendation as having been met.

Recommendation 5: *Develop a plan to prioritize all new beamlines that are planned to be constructed from operations funds. These beamlines should be given a high priority and developed in a manner consistent with the NSLS-II operations budget.*

Beamlines developed from operations funds are now managed as a single portfolio, known as "Beamlines Developed by NSLS-II" or BDN. As a result of a prioritization exercise in FY15, work was halted on three beamlines, IXS, MPP and MID. These remain halted. The remaining beamlines on this portfolio are CMS and TES which will complete in FY16, and FIS/MET, XPD-2, QAS, XFM and FXI all of which will complete in FY18 (completion defined as passing their Instrument Readiness Review and entering technical commissioning phase).

In addition in FY15 and FY16, we launched a strategic planning process that resulted in 5 beamlines being selected for development. The two highest priorities of these beamlines are the Bragg CDI beamline and a soft x-ray STXM and nanoRIXS/nanoARPES beamline. NSLS-II is seeking to develop these from operations funds together with potential external sponsors.

We consider this recommendation has been met.

Recommendation 6: *Establish a prioritization and planning process for facility supported R&D projects to ensure the selected projects are in-line with the strategic goals of the facility.*

An external review of the R&D program was held in May 2015, leading to a prioritization of the efforts in x-ray optics and detectors, with strategic decisions made based on the needs of the NSLS-II facility, recognition of the strengths and weaknesses of the respective program areas and taking into account the advice of the external committee. In the intervening year significant progress has been made in both areas, particularly in MLL development, kinoform lenses and in VIPIC detectors. The FY16 annual review of the program will be held on July 18th, 2016.

In addition, we are working to coordinate the R&D program across the DOE light sources. Joint work is currently going on in the field of detectors, metrology and high energy lenses.

While this is an ongoing process, with that process established, we consider this recommendation met.

Recommendation 7: *Develop a detailed strategic plan with timeline of implementation for data acquisition, management and analysis.*

This plan has been developed, externally reviewed and is now being implemented. Significant progress has been made in the past year in the area of data acquisition, management and analysis (DAMA) in the past year. Specific accomplishments include:

- Development and roll-out to the project beamlines of robust python-based environment for data acquisition. Features include handling of 2D detectors, routine handling of large data sets and a "SPEC"-like environment.
- Incorporation of existing analysis code into NSLS-II workflow, including ptychographic code from CAMERA, and tomographic code from APS. In each case the code was further developed by NSLS-II staff contributing to the overall development of the software stack for all light sources.
- Initiation of a highly successful "hack-a-thon" series, in which code developers from BES x-ray and neutron user facilities meet for a week to work together on all aspects of the data problem. Three have been held to date with more scheduled.

With the plan now being implemented, we consider this recommendation as being met.

1. Response to Recommendation 1

Establish mechanisms to improve the communication effectiveness between PSD management, facility staff, and users at all levels.

The NSLS-II Director has established a high priority for increasing the openness and transparency of the NSLS-II community through broader and improved communication, including, most importantly, a focus on outreach and listening to the voices of DOE, users, staff, and other workers. Ensuring broad and timely distribution of information across the organization and maximizing the engagement of all stakeholders in developing new initiatives, making changes, and responding to challenges facing the organization are additional objectives of our communications strategy.

In addition to the use of written materials, a variety of scheduled and spontaneous interactions and conversations are a regular part of the overall communications approach.

Scheduled activities include periodic Director's All-Hands meetings and emails providing necessary information and recognizing and celebrating staff and user achievements. In addition, in FY16 we launched an internal bi-weekly newsletter, "NSLS-II News" that goes to all staff to keep them apprised of recent events and upcoming activities at NSLS-II.

The senior leadership team/Executive Management Group (EMG) meets weekly to discuss issues and share information. The Director also walks through various facilities weekly and holds monthly pizza lunches with groups of workers to gain a better understanding of what is happening "on the floor". Concerns expressed by the participants are assigned to specific managers for follow-up. The Deputies and Division Directors also walk the facilities weekly or more frequently, interacting with staff to share information and hear staff concerns. The Division Directors hold regular meetings with key staff to share information and obtain feedback which is brought to the EMG or other appropriate forum.

We have increasingly used meetings with groups of workers to engage them in initiatives to improve our processes and to help shape solutions to organizational challenges. As an example, we are using this technique to share information on the cluster of low level events we experienced and to solicit improvement ideas from workers. We are also using staff engaged in the engineering process to clarify and streamline it. Recognizing that acting on worker feedback and closing the loop with those who provide it is vital, our managers make every effort to do so; we need to do better, but we are improving.

There is also an increased focus on engagement with the user community. The Director and Deputy for Science meet monthly with the Users Executive Committee (UEC), in addition to the quarterly Town Hall /UEC meetings. The Deputies and Division Directors interact with the UEC Chair and members on a variety of topics specific to their scope of responsibility. The chair of the UEC sits on our SAC ex-officio. The head of the User Office attends the weekly meetings of the Light Source Safety and Operations Council (LSSOC) and brings concerns from the user community and individual users to the table for resolution. A weekly Beamline Operations meeting brings Lead Beamline scientists, partner-users, user office staff, ES&H and operations managers, and others together to discuss progress and identify and resolve issues.

A culture of openness takes some time to build but we feel that the previous compartmentalized culture is changing as a result of all of these efforts and we are on the right track. The Director and other EMG members are becoming recognized as being approachable and open to both criticism and new ideas.

While we believe the approaches described above have been effective at addressing the specific recommendation by "opening up" the flow of information within the immediate NSLS-II community, we recognize the need to do better with our wider group of stakeholders by fully implementing the broader strategy outlined in our Communications Plan. Resource constraints in FY16 have slowed this effort. We made the difficult decision to defer replacing the Communications Manager position (1 FTE) this fiscal year, retaining only the 0.5 FTE of staff writer support which has provided DOE reporting (e.g. Science Highlights), conference communication support, website content refreshing, and support of user communications among other functions. We also receive overhead support from the Lab's Stakeholder Relations Office to ensure that NSLS-II is integrated into the Laboratory's communications strategy including press releases and media relations, planning and managing events (e.g. NSLS-II Dedication, First Light ceremony), interacting with the local community and elected officials and keeping all BNL employees informed about NSLS-II progress.

However, we still have minimal to no presence in social media, have not been able to launch a monthly newsletter, and have not kept our external users updated on status and progress as frequently as we would like, among other shortfalls. To improve this situation we are increasing our support of the supplemental communications effort to 1.0 FTE from the current 0.5 FTE. We envision this person leading a matrixed team of current managers and staff to take our communications efforts to a new level. The position has been posted and we are currently in the process of interviewing applicants. A hire is anticipated to be made by the end of FY16.

2. Response to Recommendation 2

Evaluate the resource allocation, staffing plan, and organizational structure, and make proper adjustments to develop a cost-effective facility operation model which is sustainable under a realistic budget environment and scalable for the beamline build out and future growth of the NSLS-II facility. A dedicated BES review of the NSLS-II operations budget will be conducted in the third quarter of Fiscal Year (FY) 2015.

We are continuing the process begun in FY15 to address this recommendation, motivated by an understanding of the budget environment and the need to evolve NSLS-II from a construction dominated organization to an operations dominated one.

A BES review of the NSLS-II operations budget was held in June 2015. This review was very valuable, allowing us to examine our budget in detail. Subsequent to that review, and following feedback and written guidance from DOE-BES, we went through a significant re-planning of NSLS-II operations budget, organization and processes, as detailed in our February 29, 2016 written response. Specific highlights of this effort include:

- Reduced and rebalanced the accelerator operations, facility management and ESH&Q portions of the organization. This totaled an overall reduction of 13% relative to the June 2015 FY16 budget numbers, and below the numbers suggested by BES in the January 2016 analysis.
- Reduced FY16 accelerator operations by 15 FTEs relative to the June 2015 review, including a reduction of 5 accelerator physicists, while at the same time increasing the preventive maintenance and spares program.
- Reorganized the controls program, moving it from the Accelerator Division to the Photon Science Division to more accurately reflect its major responsibilities.
- Moved certain ESH responsibilities to the central ES&H organization
- Streamlined the IRR and engineering processes. Launched initiative to address overall proceduralization of the NSLS-II organization.
- Moved the ESH&Q manager to report directly to the NSLS-II Facility Director, effective March 20, 2016. Other ESH functions are provided under SLA agreements with the central organization as needed
- Increased preventive maintenance activity by 16.5 FTEs relative to the June 2015 FY16 budget.
- Updated our spares and maintenance plans, tracking causes of downtime, performance of individual systems and emphasizing spares that have high impact on reliability. Increased the spares budget by $300 K in FY16.
- Initiated fabrication of the 3rd SC RF cavity.
- Held a Reliability Workshop on February 24th and 25th 2016 to assess the effectiveness of the programs within NSLS-II.

Particular attention has been paid to the beamline operations component of the budget, since it is a significant driver of the total costs as more beamlines become operational. Again, in the February 29th written response to the review, we outlined our operating costs, having carefully

benchmarked these against the APS operating costs (the benchmarking analysis is included in Appendix 1 here for completeness). In carrying out this analysis, we recognized that some categories of labor scale directly with the number of beamlines (for example number of beamline scientists), and other categories (such as optics metrology, R&D, user office, etc.) do not scale directly and are (approximately) independent of the number of beamlines in operation. A sensible beamline operations benchmarking is thus broken into a comparison of both the scaling and non-scaling components.

As detailed in our response, at the APS there were 52.3 FTEs in 2015 (actual costs) for the component of the budget that does not scale directly with the number of beamlines. At the NSLS-II we had planned 43.1 FTEs for the same work in FY17. We note that for NSLS-II, User Program Support includes the support of remote users at other facilities. While these costs do not scale directly with the number of beamlines, they do grow slightly, in part because of the additional partner beamlines coming online.

We next looked at the effort that scales directly with the number of beamlines. In steady state, we will have very similar support to that provided for APS beamlines (around 4.75 FTEs/ID line). In the initial phase of operations however, we have planned an additional 0.75 FTE/ID line in the areas of controls and scientific computing/data management

This initial controls and data effort is necessary to establish a controls and software architecture that will be able to deliver the very high performance of these beamlines and to handle the very large data sets and very large data rates. Each of these requires sustained effort to fully optimize these systems in order to deliver on the potential of NSLS-II. In the first few years of operations, NSLS-II beamlines will require additional effort in this area since more support is required for new experiment set-ups than for well-developed, efficient experimental protocols. Further, forging new methods at new state-of-the-art beamlines requires deliberate development efforts above and beyond routine operations at mature beamlines. APS has operated for approximately 88000 user beam hours which represents extensive investment in mature experiment development. There remains considerable experiment optimization that is needed for NSLS-II to become an efficient, mature facility.

However, recognizing the budget realities, we have made the painful decision to drop this additional effort after one year of General User operations, as the beamlines move into more mature operations with well-established experimental protocols, reliable workflows, and mature, advanced data pipelines.

It should be stressed that the beamline support effort is matrixed across multiple beamlines and is not dedicated to a single beamline. This allows us to take advantage of efficiencies to be gained from having beamlines with the same hardware, software and controls architecture.

Finally, we note that the budget and organization is part of an ongoing conversation with BES and at the time of writing we are presently discussing these areas in detail.

3. Response to Recommendation 3

Evaluate the staffing level and organizational arrangement of the ESHQ Program, and make appropriate adjustments to ensure safe and efficient operation. In addition, the staffing level seems high comparing to other BES light sources.

3.1 ESHQ Staffing Level

This was a topic of much discussion at the BES Operations review in June and in subsequent discussions with BES. This question was addressed in detail in the February 29th written response to the operations review. Here we reproduce that response, updating where appropriate.

We have taken a close look at the ES&H/QA program, particularly in regard to its size and procedure-heavy nature and have already taken a number of actions to reduce the ESH&Q costs since the June 2015 Operations review. These include:

1. As recommended during the review, a benchmarking exercise was held at Brookhaven in September 2015. This exercise included representatives from SLAC, ALS and APS. The details of that exercise are fully explained later in this response, and the full report is included in Appendix 2.
2. Staffing levels supported by operations have been reduced by 2.35 ESH FTEs including elimination of 2 additional RCTs, and the reprogramming of 0.25 FTE radiation physicist and 0.1 ESH Operations staff to projects. These reductions are in addition to the 2 FTEs eliminated in FY15.
3. Negotiations with Radiological Controls Division management have yielded some improved efficiencies in NSLS-II operations and reduction in RCD charges. This reflects the 2 FTE reduction for a savings of $470K.
4. We have agreed with central ESH and CA-D to share resources including up to 0.25 FTE ESH Operations staff and 0.25 FTE radiation physics. This will reduce our costs by 0.5 FTEs. NSLS-II will continue to work with central ESH to share resources to reduce the individual burden on specific operating facilities.

We note that to support the reduction of 2 RCTs, we simplified our procedures such that RCTs are no longer required to be the first to enter the accelerators during a fault or if repair is required. Technicians or operations staff will utilize electronic personal dosimeters set to alarm at a total dose of 3 mrem. If the dosimeter alarms, staff are instructed to leave the area and call in a RCT. Based upon current survey data, unless the fault or repair is located in the injection region, the probability of an alarm condition is extremely low.

Further, RCD has additional RCTs available to support NSLS-II survey needs, especially when commissioning new beamlines. Having supplemental trained RCTs available eliminates the need to have RCTs on 24/7 shift and represents a savings to the NSLS-II organization because of the central ESH services.

We also believe that comparison of the NSLS-II facility to a mature operating facility is inappropriate at this time. Significant effort is still required to:

1. Characterize the radiological aspects of the facility including dose due to gamma and neutron radiation fields; perform beamline specific analyses to ensure operations in top-off are safe for all beamlines and the gas bremsstrahlung scatter is fully understood;
2. Support beamline operations through the preparation and implementation of radiation survey plans and performance of commissioning surveys;
3. Prepare PPS testing documents and implement PPS certifications for new beamlines and for operating beamlines as the stored current is increased;
4. Manage authorization basis documents (ABDs) to ensure they remain consistent with current operations (the ABDs were updated twice in FY15);
5. Apply the USI process to ensure changes to operating conditions, installation of new beamlines, new or modification of procedures, and new or modifications to the PPS logic are consistent with the current authorization bases;
6. Support installation and certification of ODH monitoring systems;
7. Prepare experimental safety reviews for new lab spaces and beamlines as they become ready for user operations;
8. Prepare Instrument Readiness Plans and support Instrument Readiness Reviews;
9. Ensure facilities (lab spaces and beamlines) are ready for general user operations.
10. Provide ES&H support for chemical identification and removal, property inventory and disposition services, and coordination of waste disposal at levels beyond the scope of central ES&H provided services in support of efforts to consolidate our space "footprint", moving out of several legacy buildings.

These efforts are expected to continue at an intense rate through the end of FY17 as new beamlines and front ends are installed and lab spaces built out. However, as that time approaches, we will reevaluate their needs and adjust downwards accordingly.

3.2 Organizational Arrangement

Following discussions with BNL senior management, we have re-aligned the reporting relationship of ES&H such that the NSLS-II ES&H manager will report directly to the NSLS-II Director. This change became effective on March 20, 2016. This modification of the field deployed model more accurately reflects the responsibilities of the position, which is entirely focused on the needs of NSLS-II. The central ES&H Directorate will be responsible and accountable for the quality, timeliness, and efficiency of support services delivered by subject matter experts reporting to the ES&H Manager for their day-to-day supervision through Service Level Agreements (SLAs). We believe that this will create a group that is sensitive to the needs of the Facility and its users. This model also offers the potential for efficiencies through sharing of resources with other organizations within BNL. As detailed above, this has been realized in a number of cases already, notably the RCTs. Going forward, we are looking at identifying further efficiencies that can be made through sharing of resources with other line organizations at BNL, via the deployed service model.

3.3 Benchmarking to Other BES Light Sources

NSLS-II benchmarked their ESH functions with sister synchrotron accelerator labs. On September 21, 2015, BNL hosted a meeting with representatives from SLAC (I. Evans), ALS (J. Floyd) and APS (P. Rossi) to understand the ESH operations at the respective facilities and to compare the FTE level of effort for the functions provided (note that total cost was not reviewed as part of this exercise). The exercise attempted to create an "apples to apples" comparison of services across the laboratories regardless of organizational structure. A copy of the benchmarking report is included in Appendix 2. The exercise showed that ALS and SLAC had significantly lower FTEs when compared with APS and NSLS-II and the APS and NSLS-II models were similar. Notable differences include:

1. PPS certifications at APS, ALS and SLAC are performed by the line or central engineering; ESH does not perform the testing function. At NSLS-II, ESH prepares search and secure procedures, the certification test procedures and implements the certifications. This is to provide some level of independence from the organization designing and building the system.
2. BNL and APS have similar resource loads though APS is slightly heavier in PPS. ALS and SLAC have little PPS resources (established machines with few changes).
3. The ALS does not provide 24/7 Floor Coordinator coverage. SLAC does not provide coverage for the midnight to 8 AM shift. APS and NSLS-II provide 24/7 coverage. Full-time floor coordinator support has been the accepted practice at BNL for decades. At NSLS-II, floor Coordinators are the boots-on-the ground for the operations group and are available to address the immediate needs of the users and control room staff while ensuring the control room is staffed at all times (an ASE requirement). At least for FY16 we will continue this practice.
4. NSLS-II is a developing machine with a lot of resources dedicated to getting new and multiple beamlines up, plus commissioning a machine that has yet to reach steady state operations at maximum current.
5. NSLS-II is the only site with someone dedicated to the authorization basis/USI process and conduct of operations. ALS and SLAC indicate that is part of the manager's job (but SLAC has no identified ESH manager). The NSLS-II USI process is robust and was established in response to the LINAC mis-steering event and in support of the readiness reviews which provide the basis for the DOE approval to operate.
6. NSLS-II has higher resources dedicated to the health physics/radiation physics function. This is indicative of a new facility with new beamlines requiring numerous radiation safety analyses and to support commissioning with heavy demand for surveys to verify and validate shielding for beamlines and the accelerator as it increases stored beam current.

The benchmarking exercise focused much attention on Radiological Control Division support and charges for services such as reading TLDs, TLD exchange frequency and supplemental RCT resources to support NSLS-II when needed. NSLS-II ESH is committed to following up with recommendations presented during the exercise and have already realized some cost savings from

the reduced RCT level of effort. ESH staff have discussed the TLD exchange frequency with the radiological controls division (RCD) and due to software limitations and ITD resource requirements, changing to a quarterly badge exchange is not feasible at this time. Other cost saving initiatives include petitioning the RCD for annual PPS certifications, and this is being actively pursued.

3.4 Procedure Simplification

Several of the reviewers noted that NSLS-II has a burdensome administrative process including management of documents, preparation of procedures, and a "high-effort" USI process. This is a concern we take very seriously and are constantly looking at our processes to ensure they are effective and efficient. The three recent incidents at NSLS-II have heightened this attention.

Many of the administrative and safety processes at NSLS-II were developed as corrective actions to the LINAC mis-steering event and in direct support of the Accelerator Readiness Review (ARR) for Routine Operations. These processes are part of the basis for the ARR, and subsequently, DOE approval to operate. The USI process has been noted as robust and the NSLS-II training material shared across BNL organizations and during the 2015 DOE Accelerator Safety conference held at BNL in September 2015.

However, as we gain operating experience, we are working to streamline our processes and procedures. Actions already taken include:

1. The Instrument Readiness Review (IRR) process has been revamped as recommended to an expedited process staffed primarily internal to NSLS-II with some BNL SME participation. The process is now similar to the process used at APS. We have now used the streamlined process for 6 IRRs to date and it has proven simpler, faster and equally as effective. In addition, we have further delegated some approval levels expediting approvals and the start of commissioning.
2. The Group reviewing the engineering process and associated procedures has made a number of changes including delegating approvals to a lower level and eliminating some low-value-added requirements. While not originally anticipated as part of their scope, they found it necessary to complete a revision of the assignments of Technical Authorities for credited controls and to develop a new approach to assigning "Quality Levels" to structures, systems, and components (SSCs). The revised approach provides substantial additional flexibility, including the ability to assign levels by stages in the lifecycle of an SSC. This flexibility is expected to reduce time and cost in the fabrication, installation and operations phases. The group is now focusing on creating and rolling out the implementing documents
3. A separate group has been reviewing the procedures used by the Beam Operations Group with the same objectives.

Most significantly, we have employed Michelle McQueen from PW Grosser to develop a new approach to developing, reviewing, revising and approving all NSLS-II controlled documents responding to feedback that our previous method of working was too cumbersome, procedure-heavy and approval intensive. This new process is in place now and the new document center will go live shortly. Amongst its many achievements has been a reduction in the number of procedures from more than 330 to only 136 procedures which are clearly identified as Safety Critical Documents.

We are committed to a continuing improvement of our processes and document handling, and expect this to pay dividends in operational efficiencies in the coming months and years. In addition, in the next phase of this project, we will focus on those processes not critical to safety or operational excellence. Specifically, we will streamline processes and consolidate and reformat existing documents, reformat the "Doc Center" to align with the new approach and bring records management into the same scheme.

4. Response to Recommendation 4

Complete the installation of the hardware for top-off operation by the end of FY 2015 and implement top-off user operation in 2016

All technical interlock systems designed to ensure radiation safety in Top-Off operation (injection with open photon and safety shutters in the frontends) had been completed, installed and tested by the end of August 2015. This included design, construction, installation, and testing of the safety system software for implementing the interlock logics.

Application software had completed development by June 2015. This software automatically keeps the beam intensity constant within a fraction of 1 mA (within the NSLS-II design specification of 1%) and also ensures a smooth intensity profile along the bunch train (bunch intensity varies by not more than 10% between bunches according to NSLS-II design specifications). The software was tested successfully with beam in July 2015 (injection with photon shutters and safety shutters closed).

A condition for top off operation was the submission and approval of an un-reviewed safety item (USI). We received approval of the Top-Off USI from the Brookhaven DOE site office (BHSO) by July 6, 2015. The final step in the Top-Off operation approval process was to carry out and instrument readiness review (IRR). This review was held by September 15 2015, all pre-start findings were resolved by September 17 and approval of Top-Off operations by the Facility Director was received by the operations group the same day.

The NSLS-II accelerators restarted on September 21, 2015 after the August-September summer shutdown. Top-Off operation was successfully demonstrated on September 18. NSLS-II user operation started on October 1st with top-off operation at 150 mA of beam current. After January 21th, 2016, user operations continued with top-off operations with a beam current of 150 mA (The 2nd RF cavity was installed in the winter shutdown November 27, 2015 through January 8, 2016. Operation of two RF cavities allows smooth operation with larger beam current). The Top-Off operation beam intensity was further increased to 175 mA in February 2016. We are currently running routinely at 250 mA in Top-Off injection mode.

5. Response to Recommendation 5

Develop a plan to prioritize all new beamlines that are planned to be constructed from operations funds. These beamlines should be given a high priority and developed in a manner consistent with the NSLS-II operations budget.

Starting in FY15, we have been managing all beamlines funded by operating funds as a single portfolio, named "Beamlines Developed by NSLS-II" or BDN. Last year, management evaluated each of them for their potential impact on the user community, their scientific impact, uniqueness of their capability, fit with the strategic vision of NSLS-II and financial cost. In addition, the original SAC scores from the original proposals were taken into account. The following prioritization was then obtained:

1. FXI: Full field x-ray imaging. Takes advantage of the affordance for such a beamline created within the NEXT project.
2. XPD-2 (now known as PDF): A side station to the existing high-energy powder diffraction line
3. CSX: Adding a canting magnet that will allow the existing CSX-1 and CSX-2 beamlines to run simultaneously.
4. QAS: Provides general purpose "Quick" spectroscopy and scattering in the hard x-ray regime, filling an important capability gap for NSLS-II.
5. CMS: A small angle scattering line. High throughput and complements the program on the existing CHX insertion device beamline.
6. FIS/MET: Far IR spectroscopy, including high pressure and low temperature capability. The first IR beamline at NSLS-II. Needed to carry out the design and fabrication of the large-gap dipole vacuum chamber without which there will be no IR program.
7. TES: High-throughput spectroscopy in the tender x-ray regime, fills in a vital gap in the energy spectrum. Complements QAS.
8. XFM: Fluorescence mapping of large objects with up to 1 micron resolution. Complements the program on the existing SRX insertion device beamline.
9. IXD: Routine high-throughput powder diffraction at 20 keV. Provides wanted diffraction capability for a large user community.
10. MPP: General purpose scattering beamline, complements program on existing ISR insertion device beamline.
11. MID: Metrology and instrumentation development beamline. Important for developing, testing and calibrating new detector technologies.

A final constraint was to not start any beamline without a reasonable expectation of finishing that beamline. With these factors in mind, we committed to beamlines 1-7 on this list in FY15. As of 2/1/15 all activities ceased on IXD, MPP and MID. It is not now anticipated that these beamlines will be restarted. At the time, the expectation was that these 7 beamlines would be finished by 2018.

The overall prioritization of these beamlines has remained unchanged in FY16, however, there have been some modifications including the addition of the installation activities associated with front end and insertion devices for SMI, SIX and ESM. Further, the continuing resolution (CR) at the start of FY16 imposed very tight budget constraints and we placed large parts of the portfolio on hold. Under the CR, strategic choices were made as to what work was to continue. Priority was given to activities and beamlines that were to be finished in FY16 including the PEMP notables beamlines CMS and TES, and to long lead time procurements chosen to least effect the schedules of the remaining beamlines. With the lifting of the CR, work was restarted. Schedules were re-planned. Currently CMS and TES will complete in FY16, while FXI, PDF, QAS, FIS/MET, and XFM will complete in FY18 absent any additional breaks in funding (here completion is defined as completing the IRR, ready to start commissioning).

6. Response to Recommendation 6

Establish a prioritization and planning process for facility supported R&D projects to ensure the selected projects are in-line with the strategic goals of the facility.

Facility supported R&D overall is an integral part of the development of NSLS-II. The role of the R&D program is to leverage the initial capital investment made at NSLS-II and sustain leadership in synchrotron science and technology for the foreseeable future. The primary scope of the R&D program consists of research and development activities in key enabling technologies, such as X-ray optics and detectors. These activities aim to advance the current state-of-the-art in targeted areas of SR technologies that are critical to fulfil the long-term mission of the NSLS-II facility as outlined in the NSLS-II strategic plan. The NSLS-II R&D Plan was developed in May 2015 to address priorities in ongoing and future efforts in optics, detectors, and metrology R&D. While there are other research aspirations at NSLS-II, such as advanced storage-ring lattice and bunch patterns, new insertion devices, etc., these were not addressed within the context of this R&D Plan which is focused on beamline development activities.

The NSLS-II R&D Plan was reviewed by an expert external committee, and their recommendations have guided the approach to setting priorities in these technical areas. The committee was impressed by the quality of the Optics and Detector R&D program underlying the development of the NSLS-II. The committee noted that hard technical challenges have been overcome to reach a point where the NSLS-II is poised to deliver on its vision as the brightest synchrotron source in the world, with unique characterization capabilities. In their final report, they concluded the ongoing R&D program in optics and detectors makes sense in terms of the mission of the facility, shows attention to the opportunities enabled by a new level of source brightness and demonstrates an appreciation for the limited resources available to develop leadership capabilities.

The committee was asked to address specific questions about the Optics and Detector R&D priorities, and about specific thrusts within the R&D portfolio. Their conclusion is that all R&D thrust areas are aligned with the mission of the NSLS-II and most of the thrust areas have well defined goals and credible plans to achieve those goals, although rigorous project engineering with well-established milestones would be helpful.

The committee felt that R&D opportunities that provided broad support for the entire suite of instruments at the NSLS-II should be given additional priority due to their pervasive impact on the science opportunities at the NSLS-II. Indeed the NSLS-II provides major scientific opportunities, but only if the mechanical stability and reproducibility, optical perfection and optical designs are matched to and preserve the source brightness. The committee also recognized that world-leading programs where no comparable developments are possible should be encouraged. These include source/optics simulations; MLL development; kinoform lenses. Detector development and metrology are world class. The committee suggested a list of priorities that recognized world leading and world class efforts already in progress and puts a high priority on signature beamline needs:

1. Nano-positioning developments
2. Optical metrology
3. Detector R&D
4. Optics & source simulations
5. Kinoform R&D
6. MLL developments toward sub-5nm probe
7. Scheme towards ~0.1 meV spectrometer
8. At-wavelength metrology
9. Ion beam figuring of mirror surfaces
10. Crystal optics fabrication

This now serves as a guide to NSLS-II priorities and resource distribution regarding R&D efforts that support broad beamline developments and advancements. Addressing the committee's advice concerning the critical importance of mechanical stability, an effort in mechanical metrology is planned involving mechanical engineering, nano-positioning, and metrology experts in the Photon Science Division.

At a high level, R&D planning is driven by the strategic goals of the facility and must be weighed against the pressures for routine operations support. The NSLS-II Scientific Program Management Committee (SPMC) continues to be the internal group that periodically evaluates progress in R&D areas and makes recommendations to the Facility Director regarding the relative merit and priority for these activities. Progress and future plans are also evaluated annually by NSLS-II management. The FY16 review is scheduled for July 18th 2016. Following this review, priorities may be adjusted according to the overall strategic needs of the facility. The R&D plans are also reviewed periodically by the NSLS-II SAC. It is worth noting that these same priorities are used in selecting LDRD proposals from within NSLS-II that go forth and compete in the lab-wide pool.

In addition to the internal R&D program, there is also increasing collaboration across the DOE complex and in particular within the BES Light Sources. In particular, in the areas of detectors (VIPIC for example), high energy lenses (kinoforms) and wavefront preserving mirrors. Following on from these initial steps, and under the leadership of the NSLS-II Director, management from the five Light Sources will meet on Oct 5th, 2016 at SLAC to discuss the R&D needs of the facilities and where increased collaboration makes sense. These discussions will be motivated by a coherent picture of the beamline development program across the complex, by the strategic needs of the facilities to take advantage of their respective strengths and weaknesses and by the requirement that unnecessary duplication of effort be avoided. It is expected that coming out of this meeting there will be a more coherent view of the R&D plans across the complex and this will serve as additional input into our own R&D planning into FY17 and beyond.

7. Response to Recommendation 7

Develop a detailed strategic plan with timeline of implementation for data acquisition, management and analysis.

A detailed plan for NSLS-II Data Acquisition, Management, and Analysis has been developed. This plan outlines a tiered approach to data collection and management to manage the complex data produced during NSLS-II experiments and to permit subsequent access to data and analysis. Each beamline has tailored computational resources (network, disk space, memory, CPU) and analysis codes to enable users to visualize results and perform preliminary analysis in nearly real-time. After a reasonable time, based on the local beamline's storage resources and convenience, the user's data will be moved to a centrally managed data center where the same analysis codes for evaluating and processing data are made available. This readily available data and subsequent data archiving are made available to remote users for a length of time that is largely determined by policy and resource constraints.

An external review of the plan and architecture was held in May 2015, and found that the overall architecture/framework design is well thought out and represents several best-of-kind open source approaches. The use of Python throughout, as well as modular components was seen to reflect solid scientific software engineering. The review team also recognized that the framework under development is quite ambitious and very different from that used at existing synchrotron facilities, and recommended that wherever possible, Python data acquisition and data analysis solutions in place at other synchrotron facilities should be implemented at NSLS-II.

To explore how facilities can be more effective, the BES Facilities Computing Working Group (BESFCWG; Note at the time of these meetings, this was the name of the working group. At the time of writing, it is in the process of renaming itself.) was charged by the five BES Light Source Facility Directors to evaluate potentially significant benefits from better coordination and collaboration on data issues that would leverage existing efforts at major user facilities. On May 22, 2015, the BESFCWG met at Brookhaven National Laboratory (BNL) to discuss its response to this charge. Specifically, the group was charged to answer the following:

1. What are the best opportunities for collaboration across the BES user facilities?
2. What strategies can be used to facilitate these? On what time scale would benefits be realized?
3. If there are no additional resources available, what can be achieved leveraging existing efforts? What are the priorities?
4. What would be the highest impact use of limited additional resources?
5. Is there merit in sharing data analysis, workflow, and data transfer packages across facilities such that users can use the same experience at different facilities? For which, if any, techniques would such an approach make sense?
6. Are there any foreseen changes in the strategic landscape for data that will require a step-change in our current activities? If so, describe how best these can be tackled.
7. What can we learn from what has been done in Europe and elsewhere?
8. Explore the efficacy of converting existing analysis code to run on high concurrency platforms such as those fielded by ASCR (NERSC and LCF).

While their written report serves as a guide, there is now direct evidence of the value of increased interactions. A series of “hack-a-thons” have been held to address specific topical issues in detail. These week long meetings are working meetings where codes are developed and shared, and establish an environment that facilitates collaborative interactions. The first 3 Hackathons were:

- BES Facilities Computing Working Group (BESFCWG) First 'Hackathon' at BNL 7-11 December 2015
- Hackathon on network performance held at Berkeley 23-26 February 2016
- 3rd Hackathon/Workshop on Multimodal Data Processing at Argonne 4-8 April 2016.

Further evidence for improved coordination across the BES facilities is demonstrated by a proposal for *New Science at Exascale-enabled Light Sources: The Exascope* developed by APS (Argonne), ALS and CAMERA (LBNL), LCLS (SLAC), and NSLS-II (BNL) and submitted to DOE-ASCR.

In regard to the NSLS-II software stack (data acquisition, management and analysis), several notable accomplishments occurred in the past year, including:

- Development and roll-out to the project beamlines of robust python-based environment for data acquisition. Features include handling of 2D detectors, routine handling of large data sets and a “SPEC”-like environment.

- Incorporation of existing analysis code into NSLS-II workflow, including ptychographic code from CAMERA, and tomographic code from APS. In each case the code was further developed by NSLS-II staff contributing to the overall development of the software to the entire community. These codes are already having impact, significantly speeding up data visualization at the beamline.

Finally, Brookhaven Lab has made considerable progress with the Computational Science Initiative, which leverages computational science expertise and investments across multiple programs—including NSLS-II, RHIC and the LHC — to tackle the big data challenges at the frontiers of scientific discovery. Key partners in this endeavor include nearby universities like Stony Brook, Columbia, Cornell, NYU, and Yale, and companies such as IBM Research. The long term vision at BNL includes a central computer and storage facility. NSLS-II intends to join this facility to take advantage of significant cost savings, both in initial capital costs and in operating costs by sharing common infrastructure. This central facility will meet the majority of NSLS-II users’ needs for computer and storage resources. For the most demanding applications, however, we will utilize the supercomputer facilities particularly those at NERSC, LBNL, utilizing codes developed in collaboration with CAMERA and others.

Appendices

1. APS and NSLS-II Beamline Operations Benchmarking Exercise
2. DOE Light Sources ESH Benchmarking Report

Appendix 1

APS and NSLS-II Beamline Operations Benchmarking Exercise

Report of benchmarking session held at Argonne National Laboratory on 10 December 2015.

Introduction

During the June 2015 DOE Budget Review of the National Synchrotron Light Source II (NSLS-II) at Brookhaven National Laboratory, it was recommended by several reviewers that "NSLS-II should perform a more accurate and comprehensive benchmarking with other light sources." This report represents a benchmark comparison of beamline and experimental operations, comparing Advanced Photon Source (APS) at Argonne National Laboratory with the NSLS-II. It was determined that the APS and NSLS-II comparison represented the most equitable comparison of beamline scale and complexity.

Basis for Comparison

Since 2015, APS has used a Work Breakdown Structure (WBS) for operations, so a detailed view of how effort is applied to various work functions is available. The APS WBS is broken into 4 major (Level 2) areas:

- APS.01-**APS Operations Support** (includes effort, M&S and travel for overall support of the facility),
- APS.02-**Accelerator Operations** (includes effort, M&S and travel related to the operation and technical strategic planning for, and development of, the APS accelerator and all accelerator subsystems),
- APS.03-**Beamline Operations** (including Optics, Metrology, Detector R&D, Nano-positioning, User Program support, and APS x-ray-based research)
- APS.04-**Research and Future Concepts** (Long-term, strategic research and future concepts).

Tasks in some areas are broken down as far as Level 6 in the WBS, and all work is then charged to one of these areas at the proper level WBS element.

The NSLS-II also uses a WBS for operations, so a similarly detailed examination of where work is planned and costed is available. The NSLS-II WBS is different, but similar to that of the APS:

- NSLS-II 4.1 - **Facilities Management** (including effort, M&S and travel for management of the facility, including space and power)
- NSLS-II 4.2 - **Accelerator Operations** (includes effort, M&S and travel related to the operation and development of, the NSLS-II accelerators and all accelerator subsystems)
- NSLS-II 4.3 - **Experimental Operations** (including Optics, Metrology, Detector R&D, Nano-positioning, User Program support, and Beamline and laboratory operations).

The effort associated with Beamlines Developed by NSLS-II (BDN) and Partner Beamline Management (PBN) is included in the experimental operations budget, but is excluded from this benchmark exercise. The focus of this benchmarking is largely a comparison of APS.03-Beamline Operations with NSLS-II 4.3 - Experimental Operations, although there are a few relevant elements included in APS.01 APS Operations Support and APS.04 Research and Future Concepts.

Since the detailed breakdown of lower level elements of each WBS is different, the benchmarking considers several common categories, and the elements of the WBS are assigned to one of these categories.

Some categories are recognized to scale directly with the number of beamlines (for example # of beamline scientists), and other categories (such as Optics) are recognized as not scaling with the number of beamlines. Accordingly, these categories are divided as follows:

Effort that scales directly with the number of beamlines

- Program/Group management
- Direct Technical/Scientific staff effort at ID Beamline
- Direct Technical/Scientific staff effort at BM/3PW Beamline
- Engineering & Design
- Computing & Software
- Controls
- Safety Systems (PPS/PSS/BLEPS)
- Maintenance

Effort that is approximately independent of the number of beamlines

- Management & Admin (Division)
- Research Operations Support
- User Program Support
- Nano-positioning
- Optics
- Metrology
- Detectors
- CAT/Partner User support
- Computing, IT, network infrastructure
- Special Projects

Note: ESH&Q has been removed here since this area was considered in a previous benchmarking of ESH activities.

These categories are further described in Note 1 at the end of this document.

For work that scales with the number of beamlines, effort that is applied to a specific beamline is charged against that beamline, and effort that supports general beamline operations not associated with a specific beamline are charged to one of these categories. For example, work on the liquid nitrogen distribution system would be attributed to the "Maintenance" category, but servicing a cryo-cooler would be attributed to the "Technical/Scientific support effort at ID Beamline" category for that particular beamline. In this way, all effort associated with operating a specific beamline can be understood.

Actual effort levels at APS in FY2015

From the actual costing for APS operations in FY2015, the total effort applied to the benchmark categories are available. These are shown in Table A-1.

As shown in the table, there were 211.3 FTEs working on support of experimental operations at APS in FY2015. Of these, 159 FTEs are in the category that scales with the number of beamlines, and 52.3 are in the category that doesn't.

Table A-1: Benchmark categories and actual APS effort in FY2015

Effort Scaled with # BLs	Total Staff (FTEs)
Direct staff effort at BM beamline	25.9
Direct staff effort at ID beamline	92.4
Program/Group management	11.33
Engineering & Design[1]	0
Scientific Computing & Software	9.46
Controls	6.30
PSS/BLEPS	9.67
Maintenance	3.95
Effort not scaled with # BLs	
Management & Admin (Division)	2.04
Research Ops Support	3.41

User Program Support	8.90
Nano-positioning	0.99
Optics	6.10
Metrology	6.92
Detectors[2]	8.96
CAT support	3.16
Computing, IT, network infrastructure[3]	10.9
Special Projects	0.93
Total FTE effort scaled with # of beamlines	159.02
Total FTE effort not scaled with # of beamlines	52.30
Total FTE effort included[4]	211.3

[1] Engineering/design effort associated with a specific beamline included with direct technical support at the beamline
[2] Includes detector pool
[3]Technical computing, IT, network infrastructure support included in APS.01-APS Operations Support WBS area
[4] Total does not include 7.81 FTE ESH support that is included in the ESH benchmarking

Planned effort levels at NSLS-II in FY2017 for work that does not scale with the number of beamlines

To compare the staffing levels for work that doesn't scale with beamlines, the FY2017 budget plan for NSLS-II operations is used. In this budget plan, there is effort assigned for Optics, Nano-positioning, Detector R&D, Partner User support, Research operations support, User Program support and special projects. For NSLS-II, the "Special Projects" only includes effort for development of future beamline concepts, proposals and plans. The "User Program support" includes effort for the User Office (all proposals, reviews, user guest processing, record-keeping), Industrial research support, and remote user support for former NSLS users to keep continuity with NSLS-II beamline development time lines. Support for partner user beamlines assures all beamlines are appropriately maintained and available to NSLS-II users.

Table A-2: Benchmark comparison of effort that does not scale with the number of beamlines.

Staff not scaled with # BLs	APS	NSLS-II
Management & Admin (Division)	2.04	3.02
Research Operations Support	3.41	4.20
User Program Support[1]	8.90	7.63
Nano-positioning	0.99	4.33
Optics	6.10	3.33
Metrology	6.92	4.13
Detectors[2]	8.96	5.00
CAT/Partner support	3.16	4.95
Special Projects	0.93	0.50
Computing, IT, network infrastructure[3]	10.9	6.00
Totals	52.30	43.09

Notes: [1]The NSLS-II User Program Support will reduce in FY18 as remote support for users at other facilities ceases. [2]For direct comparison, 1 FTE was moved from NSLS-II Research Operations Support to Detectors since the Detector Pool at APS is included with Detectors, while the NSLS-II Equipment Pool is included within Research Operations Support. [3]The Computing, IT, Network infrastructure category is included in the APS facility WBS area, APS.01-APS Operations Support.

Given the maturity of the APS, it is to be expected that the direct operating effort for APS is slightly higher than for NSLS-II.

Number of operating beamlines

The APS is currently contributing to the support for 42 beamlines. Of these, 31 are ID beamlines, and 11 are BM beamlines. Of the 31 ID beamlines, 21 are considered as 100% operating commitments that run all the time. The remaining 10 beamlines either share a common port and only operate part-time, or have shared operational responsibility. These 10 partial beamlines amount to 4.77 full-time equivalent operating beamlines. Of the 11 BM beamlines, 8 are full-time operational commitments that run 100% of the time, and the other shared/split operations amount to 1.62 full-time equivalent operating beamlines. So, the APS directly supports the equivalent of 25.77 ID beamlines and 9.62 BM beamlines.

The expected effort levels for projected NSLS-II operations can be anticipated from the schedule of beamlines under development and their planned transition into operations. Presently, the NSLS-II supports 7 full-time operating ID beamlines, but plans to ramp up operations by FY2019 to directly support 19 beamlines (14 ID beamlines and 5 3PW/BM beamlines), and partially support a further 8 beamlines.

Assessment of effort required for average NSLS-II beamlines

For NSLS-II beamline operation planning, it was determined that for safe, effective and productive operations, the average ID beamline would require 3 technical and/or scientific staff members. Similarly, the average 3PW/BM beamline would require 2 technical and/or scientific staff members. This assessment considered the required tasks, estimated time required for these tasks, and the number of user groups expected at each beamline. In addition, the effort for operations support for an average beamline in other areas was carefully assessed. This assessment is included as Note 2.

Comparison of ID beamline effort

Table A-3:

Effort Scaled with # ID BLs	FTEs/BL APS ID	FTEs/BL NSLS-II ID (Initial Phase)
Program/Group management	0.32	0.3
Direct staff effort at ID beamline	3.58	3.82
Engineering & Design	0.00	0.3
Computing & Software	0.27	0.5
Controls	0.18	0.35
PSS/BLEPS	0.27	0.08
Maintenance	0.11	0.22
Totals	4.73	5.56

Comparison of BM/3PW beamline effort

Table A-4:

Effort Scaled with # BLs	FTEs/BL APS BM	FTEs/BL NSLS-II BM (Initial Phase)
Program/Group management	0.32	0.3
Direct staff effort at BM beamline	2.70	2.72
Engineering & Design	0	0.3
Computing & Software	0.27	0.45
Controls	0.18	0.3
PSS/BLEPS	0.27	0.08
Maintenance	0.11	0.22
Totals	3.85	4.36

The effort per beamline for effective and productive operations has been carefully evaluated. This thorough benchmarking comparison with APS beamline operations reveals very similar levels of support are planned for NSLS-II beamlines in all areas except controls and scientific computing/data management. Here, the effort in these areas to establish an efficient, effective, smooth operation is expected to be higher for the first few years of operations, but will taper off as the beamlines move into mature operations with well-established experimental protocols, reliable workflows, and mature, advanced data pipelines.

Note 1.

Brief definitions of the categories used for benchmark comparison (those that scale with # of beamlines)

Program/Group management: Includes general effort and M&S expenses that are required for managing and developing appropriately grouped beamlines, including activities such as management, administration, travel, purchases, training, etc… that are not associated with other specific activities.

Direct staff effort at ID Beamline: Includes the scientific and technical effort, M&S and travel in support of operation, maintenance and below threshold improvements and R&D of a particular ID beamline, including computing, software, controls, and direct User support at the beamline.

Direct staff effort at 3PW/BM Beamline: Includes the effort, M&S and travel in support of operation, maintenance and below threshold improvements and R&D of a particular 3PW/BM beamline, including computing, software, controls, and direct User support at the beamline.

Engineering & Design: Includes technical effort, M&S and travel in support of Design & Drafting and Mechanical engineering for operating beamlines; including efforts for development of new sample handling and environments, detector mounting, and new beamline configurations.

Computing & Software: Includes creation and modification of computer programs used to conduct, monitor, model and analyze experiments performed at beamlines. Includes work on computer software that performs, automates or simplifies experimental data collection. Includes work on computer software that allows instrument operators to transform, modify, integrate, merge, etc. or examine experimental data. Includes work on computer software that interprets, fits models to or simulates experimental data. Only applies to scientific software engineering and data management not specific to a particular beamline.

Controls: General beamline control and data acquisitions systems, software controls or data handling tools that can be used across many beamlines. General administrative and management effort and M&S beamline controls expenses. Only applies to technical development of hardware and software beamline control systems that are not specific to a particular beamline, for example EPICS development and maintenance.

Maintenance: Includes all effort (technical, managerial, and administrative), M&S, travel, and training in support of installation and maintenance of beamline mechanical, water, and vacuum systems, and common infrastructure shared by multiple beamlines.

Safety Systems (PPS/PSS/BLEPS): Includes effort (technical, managerial, and administrative), M&S, travel, and training in support of installation and maintenance of PSS safety interlock infrastructure and related EPS systems infrastructure not specific to a particular beamline or for infrastructure used by many beamlines.

Brief definitions of the categories used for benchmark comparison (those that do not scale with # of beamlines)

Management & Admin (Division): Includes general effort and M&S expenses that are required for managing and developing Division activities, including activities such as management, administration, travel, purchases, training, etc… that are not associated with other specific activities.

User Support: Includes effort, M&S and travel in support of user program administration, General User and Partner User proposals and agreements, user access, review panel meetings, User Meeting and Workshops, and statistical reporting.

Research Operations Support: Includes effort, M&S and travel in support of general research operations support; beamline support not associated with a particular beamline; operation and maintenance of general and specialized support laboratories; support for beamline engineering design reviews and professional services.

Nano-positioning: Includes effort, M&S and travel in support of research and development of beamline nano-positioning system not specific to a particular beamline or for infrastructure common to many beamlines. Includes the associated resources/materials needed in support of developments and improvements for beamlines.

Optics: Includes general expenses related to x-ray optics that are not associated with another specific activity: management, administration, travel, purchases, training (including ESH), etc… Includes operation of equipment, maintenance and improvements, and fabrication of crystal or multilayer optics. Includes the modeling and simulation of beamline optical components and beamline layouts, and includes all effort and M&S associated with fabrication and testing of focusing optics such as MLLs.

Metrology: Includes general expenses related to mirrors, multilayers and metrology that are not associated with a specific activity: management, administration, travel, purchases, training (including ESH), etc. Includes operation of equipment and maintenance and improvements or characterization for mirrors, multilayers and metrology.

Detectors: Includes procurement, maintenance, and distribution of detectors for experiments on the experiment floor. Includes general expenses for the X-ray Detector Pool that are not associated with a specific activity: management, administration, travel, purchases, training (including ESH), etc. Includes operation of equipment and maintenance and improvements for the detector pool. Includes all effort and M&S associated with detector R&D activities.

CAT/Partner User support: Includes effort (technical, managerial, and administrative), M&S, travel, and training in support of CAT or Partner beamline operations. Includes IT (network, desktop, servers, etc.); beamline controls and data; engineering and design; vacuum, water, and mechanical technical services; safety systems; etc. provided by the facility to enable appropriate beamline operational readiness.

Computing, IT, network infrastructure: Includes effort, M&S and travel required to support facility software and computing, to include computing infrastructure. Includes software general effort and M&S expenses that are not associated with a specific activity. Includes effort, M&S and travel required to support installation and maintenance of network and server instrumentation and software, tools, and training of IT personnel.

Special Projects: Includes effort, M&S and travel required to support development of facility improvements that benefit many beamlines, or improvements above a threshold for individual beamline operations. Also includes effort for developing new proposals and concepts.

Note 2.

Build-up of estimated effort for minimal support of NSLS-II beamline operations

Table A-5: Insertion Device Beamline

Benchmark Category	Beamline Support Areas	Level of Effort	ID Beamline	ID Beamline
Program/Group management	Program Management	1 FTE for 5 beamlines	0.2	0.3
	Admin support	1 FTE for 10 beamlines	0.1	
Direct staff effort at ID beamline	ID Beamline Scientists &/or Science Associates	3 FTEs per beamline	3	3.815
	ID Beamline Technician Support	1 FTE for 4 beamlines	0.25	
	ID Computing & Software	1 FTE for 5 beamlines	0.2	
	ID Beamline Controls	1 FTE for 6-7 beamlines	0.15	
	ID Beamline Maintenance	Variable	0.215	
Engineering & Design[1]	Beamline Engineering support	1 FTE for 5 beamlines	0.2	0.3
	Mechanical Design support	1 FTE for 10 beamlines	0.1	
Computing & Software	Controls Engineer for DAQ Support	1 FTE for 10 beamlines	0.1	0.5
	Computational Scientists for Data Visualization & Analysis	1 FTE for 5 beamlines	0.2	
	IT professional for Data Storage & Processing & Sys Admin	1 FTE for 5 beamlines	0.2	

Controls	Experimental Controls Technician	1 FTE for 10 beamlines	0.1	0.35
	Experimental Controls Electrical Engineer	1 FTE for 10 beamlines	0.1	
	Experimental Controls Engineer	1 FTE for 6-7 Beamlines	0.15	
PPS/BLEPS/PSS	PPS maintenance Engineer and/or Technician	1 FTE for 12 beamlines	0.08	0.08
Maintenance	Mechanical utility maintenance engineer	1 FTE for 40 beamlines	0.025	0.215
	Mechanical utility maintenance technician	1 FTE for 20 beamlines	0.05	
	Electrical designer	1 FTE for 25 beamlines	0.04	
	Electrician	1 FTE for 20 beamlines	0.05	
	Vacuum Engineer and/or Technician	1 FTE for 20 beamlines	0.05	
Totals			5.56	5.56

Table A-6: Bending Magnet Beamline

Benchmark Category	Beamline Support Areas	Level of Effort	3PW/BM Beamline	3PW/BM Beamline
Program/Group management	Program Management	1 FTE for 5 beamlines	0.2	0.3
	Admin support	1 FTE for 10 beamlines	0.1	
Direct staff effort at BM beamline	BM Beamline Scientists &/or Science Associates	2 FTEs per beamline	2	2.715
	BM Beamline Technician Support	1 FTE for 4 beamlines	0.25	
	BM Computing & Software	1 FTE for 6-7 beamlines	0.15	

	BM Beamline Controls	1 FTE for 10 beamlines	0.1	
	BM Beamline Maintenance	Variable	0.215	
Engineering & Design[1]	Beamline Engineering support	1 FTE for 5 beamlines	0.2	0.3
	Mechanical Design support	1 FTE for 10 beamlines	0.1	
Computing & Software	Controls Engineer for DAQ Support	1 FTE for 10-12 beamlines	0.1	0.45
	Computational Scientists for Data Visualization & Analysis	1 FTE for 5-6 beamlines	0.2	
	IT professional for Data Storage & Processing & Sys Admin	1 FTE for 6-7 beamlines	0.15	
Controls	Experimental Controls Technician	1 FTE for 10 beamlines	0.1	0.3
	Experimental Controls Electrical Engineer	1 FTE for 10 beamlines	0.1	
	Experimental Controls Engineer	1 FTE for 10 Beamlines	0.1	
PPS/BLEPS/PSS	PPS maintenance Engineer and/or Technician	1 FTE for 12 beamlines	0.08	0.08
Maintenance	Mechanical utility maintenance engineer	1 FTE for 40 beamlines	0.025	0.215
	Mechanical utility maintenance technician	1 FTE for 20 beamlines	0.05	
	Electrical designer	1 FTE for 25 beamlines	0.04	
	Electrician	1 FTE for 20 beamlines	0.05	
	Vacuum Engineer and/or Technician	1 FTE for 20 beamlines	0.05	
Totals			4.36	4.36

Appendix 2

DOE Light Sources ESH Benchmarking Report

Photon Sciences Directorate

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Managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

date: December 29, 2015

to: J. Hill

from: Robert J. Lee R. Lee 12/29/15

subject: Finalization of ESH Benchmarking Exercise

As you are aware from September 21 to 22, 2015, the NSLS-II ESH Group hosted representatives from the Stanford Linear Accelerator Center, Lawrence Berkley Laboratory Advanced Light Source and the Advanced Photon Source at Argonne. The purpose of the meeting was to benchmark Environment Safety and Health Services across the DOE Light Source community and to identify cost saving measures. The benchmarking session was held in response to the June 2015 DOE budget review. The minutes from the meeting have recently been finalized though the ALS has not responded to the most recent request for user information.

The review focused on cost savings associated with Radiological Control Division charges. In particular rates for TLDs, frequency of TLD changes and Radiological Control Technician allocations were areas that the group felt NSLS-II could target for cost reductions. As you are aware we have already reduced RCT allocations and have worked with the Radiological Control Division to allow Floor Coordinators the ability to screen areas during off hours. Total annual cost savings for these actions alone are approximately $0.5 M. We will continue to pursue cost reductions for TLDs in both the rate and frequency of change; however, unlike the other facilities, NSLS-II is new and will require full radiological characterization at full beam energy before significant cost savings will be realized.

If there are any questions regarding the benchmarking effort, please don't hesitate to contact me at Extension 7936.

cc: A. Ackerman
M. Bebon
M. Benmerrouche
L. Stiegler

Benchmarking ESH Services: **Report of benchmarking session held at Brookhaven National Laboratory on September 21, 2015**

Issue: During the June 2015 DOE Budget Review of the National Synchrotron Light Source II (NSLS-II), the ESH budget and staffing levels were viewed as too large when compared with comparable DOE supported light sources. The Advanced Light Source (ALS) at Lawrence Berkeley Laboratory and the Advanced Photon Source (APS) at Argonne National Laboratory were held up as examples of facilities with smaller ESH staffing levels. NSLS-II defended its staffing levels based upon prior benchmarking exercises and the realization that ESH service models across the DOE complex vary and side by side comparison between sites is difficult. Of particular note is the level of G&A supplied resource vs direct labor charged to the program. In follow-up, the NSLS-II, ALS and APS agreed to hold a benchmarking session to develop a common platform from which to compare resources. An invitation extended to the SLAC National Accelerator Laboratory at Stanford was welcomed. Since the 2015 Accelerator Safety Workshop was already scheduled to be held at BNL from September 22 - 24, 2015, the workshop was looked at as an opportunity to hold the benchmarking exercise. Representatives from the 3 visiting laboratories arrived a day early (i.e., Monday 9/21), and meeting facilities were arranged by BNL staff. Table 1 below provides some data for each of the facilities:

Table 1: DOE Synchrotron Light Source Inter-comparisons

Attribute	LBNL (ALS)	ANL (APS)	BNL (NSLS-II)	SLAC (LCLS/SSRL)
Total Employees	4119	4424	2846	1509
Gross Sq. Ft.	1.7 M	4.8 M	4.9 M	1.6 M
Budget Authority (new)	$784 M	$757 M	$602 M	$428 M
Ring size	210 m	1100 m	780 m	1600 m /234 m
No. Beamlines operating	40	60	7	7/16
No. of beamlines in design/construction	NR	0	21	1
No of proposals (annual)	NR	5720	350-400 (E)	400/700
No. of annual users	NR	21242 (5331 unique)	450 (E)	LCLS: 839 (onsite) SSRL: 1280 (onsite) /346 (remote)

E: Estimate for FY16 NR: Not Reported

Description of Benchmarking Exercise: The benchmarking session was held at BNL on September 21, 2015. In attendance were Paul Rossi from the APS, Ian Evans representing both SLAC facilities (LCLS and SSRL), and Jim Floyd from the ALS. The NSLS-II was represented by A. Ackerman, R. Lee, M. Bebon, M. Benmerrouche and L. Stiegler.

One week prior to the meeting Ian Evans circulated a table of functions for each site to complete. The table included services/activities provided through the ESH, line or G&A functional elements and was intended to capture all ESH efforts regardless of the funding source (i.e., program vs G&A). The initial focus was on FTE levels and not total budget. Each site completed the table and submitted to the group for review and open discussion. Each site then updated their table based upon discussions held during the benchmarking session. Copies of the individual final tables are attached to this report. Table 2 below provides a roll-up for direct comparison of FTE levels.

Comparison of the data shows that the APS and NSLS-II models in terms of total FTEs are near identical

Table 2		Light Source ESH FTE Benchmarking				
	Function	**ALS**	**APS**	**LCLS**	**SSRL**	**NSLS-II**
User Safety	Exp. Review Coordinator/ESH Professional/User lab support	1.9	2.65	1.5	2.45	1
	Laser	0.15	0.5	0.25	0.15	0.25
	Mechanical Eng.	0.15	0.1	0.5	0.5	0
	Electrical Eng.	0.15	0.15	0	0	0
	Bio	0.3	0.5	0	0	0
	Waste	0.1		0.05	0.05	0.45
	Database mgmt..	0	0	0.1	0.1	0
Accelerator/ beamline	Health Physics	0.5	1	0.8	0	1.25
	RCTs	0.4	2.9	0.25	2.5	2.8
	Radiation Physics	0.3	0	1.2	0.8	1
	Dosimetry/Telemetry/Inst cal.	0.25	0	0	0	0
	Floor Coordinators	1.9	6	5	5	6
	ESH Coordinator	0	0	0	0.45	0
	Interlocks Testing			0	0	0.65
	Interlocks design and install	2.2	12	1.2	3	9
	Review Committees (Beamline/Acc)	1	1	0	0	0
	Laser Interlocks	0	0	0.75	0	0
Common	Authorization basis/USI	0	0	0	0	0.9
	Procedure development /document control	0.5	0	0	0	1.5
Staff Safety	Work Planning	0.5	0.5	1	0.5	0.5
	Electrical	0.1	0.5	0.1	0.1	0.1
	Assessments/Inspections	0.35	1	0.1	0	0.8
	Emergency Planning	0.2	0.1	0.1	0.1	0.3
	General ESH Support	0.25	1.5	0.25	0.25	3.35
	General ESH Support (G&A)					0.25
Mgt.	Manager	1	1	0	0.1	0.5
	Administrator	1	0.4	0	0	0.8
Sums		**13.2**	**31.8**	**13.15**	**16.05**	**31.4**

though the distribution of labor categories varies a little. The SLAC models for LCLS and SSRL and the ALS show significantly lower FTE levels, but are similar between the two labs. Closer examination of the data shows that the sites show significant differences in the level of PPS staffing. APS and NSLS-II show 12 and 9.65 FTEs respectively whereas; ALS and SLAC show from 1.95 to 3 FTEs. The NSLS-II has significant need for PPS staff as it continues to build out the facility and develop testing procedure for new beamlines. NSLS-II is also required to test the PPS systems twice per year while most other sites only test once. Also noted is that SLAC and ALS systems are tested by the line which is not included in the staff totals presented. A second area of significant difference is the floor coordinator staffing levels. The ALS only provides floor coordinator coverage from 7:00 am until 8:00 pm whereas the remaining sites provide 7 day coverage; the NSLS-II provides 24/7 coverage which benefits both the user and the accelerator operators by providing boots-on-the ground support for science. The SLAC is considering following the ALS model and reducing floor coordinator levels. Its noted that the floor coordinator and PPS staff roles are not inclusive to the NSLS-II ESH but are provided through the accelerator group.

One other area of notable difference is the general ESH support with NSLS-II at 3.35 FTEs, APS at 1.5 FTEs and the remaining sites at ¼ FTE. The NSLS-II ESH staff provide extensive support to the installation activities, preparing beamlines for operations, managing the safety approval form process and experimental safety review process, managing ODH system calibrations, testing all PPS systems and performing routine inspection/assessments of the workplace (e.g., Tier I inspections). Many of these lab-level requirements are not performed at the other sites. Also noted is the lack of ESH management and administrative help at SLAC. BNL is the only site that identified resources toward maintaining authorization basis documents and managing the Unreviewed Safety Issue process. The ABDs at NSLS-II have changed frequently as the machine has moved from commissioning to operations and then into the Top-Off mode of operations. The USI process established at NSLS-II is very robust and has been cited by many as an example. The ARRs performed for the NSLS-II, as well as much of the accelerator community, found the NSLS-II USI process robust and have requested the USI training modules that NSLS-II has developed.

Due to the intense schedule for performing readiness reviews for new beamlines at the NSLS-II each site shared their process for assuring beamline readiness. ALS indicated that they have a standing beamline review committee, but noted that they have few reviews and each review is projectized. At SLAC, each technical group signs off that their systems are ready then the ESH group approves. The APS also has a standing beamline review committee then the Deputy for Operations approves the beamline. The NSLS-II readiness review process was witnessed as part of the ARR for operations and the process sanctioned by ARR team. The process requires a review and signoff by each technical group then an Instrument Readiness review is performed by a team consisting of specialists outside of the beamline being reviewed to verify beamline readiness. Once the prestart findings from the IRR are completed, the NSLS-II Director approves beamline operations. Preparations for the IRR including formalizing and completing an Instrument Readiness Plan are resource intensive. Once approved for operations the ESH staff is integral to getting the beamlines ready for operations including preparing radiation survey plans, implementing the plans to ensure the experimental enclosures are radiation safe and meet the NSLS-II shielding policy.

Much attention was placed on the BNL radiological control costs both in FTE support and cost for the personnel and passive dosimetry program. The following recommendations were identified:

1. TLD charges seem high when compared to commercially available services ($10.00/TLD vs $33.00/TLD). Most sites use a quarterly TLD exchange for personnel and an annual exchange for passive dosimeters; BNL uses monthly and quarterly respectively.

2. Use of Radiological Control Technicians is planned as part of work planning at several sites alleviating the need to have RCTs on full-time coverage. In addition several sites do not require RCTs to be the first entrants to the accelerators following a maintenance problem due to limited history of activation. The NSLS-II requires the RCT to perform activation checks prior to work being performed.

Gail Mattson, Jean Ramirez and Henry Kahnhauser were asked to join the discussion to address the BNL Radiological Control program charges. The BNL Radiological Controls program maintains a DOE-LAP certified personnel monitoring program including TLD, and whole body counting capabilities. The ability to change to quarterly and annual badge change frequencies is hampered by the software used to manage the program. The IT Division has balked at rewriting the software since they are not in the business to write code and charges would likely be high to hire someone to specifically address the issue. Going to quarterly and annual badges changes has the potential to save significant resources and alleviate the pressures on the Personnel Monitoring staff; consequently, the software changes necessary to effect the change in badge exchange frequency should be pursued. Use of personnel TLDs will continue at NSLS-II until the full radiation field is understood at maximum beam operating conditions which will not occur until 2017. Once full beam intensity is realized two to three years of operations will be required before the TLD requirements can be relaxed.

In summary, all participants agreed that the effort was worthwhile and all organizations walked away with a better understanding of each sites model. Each representative then modified their table of resources to ensure it included all support FTE efforts. Some additional points to consider include:

1. RadCon charges at BNL seem excessive. Going to a quarterly/annual TLD exchange period may save money (see earlier discussion). While the benchmarking team suggested that BNL should revisit make/buy options for TLD services; a make/buy evaluation was performed in FY13 and presented to the BNL Institutional Risk Management Committee and a decision made to keep the program as it exists. BNL will continue to discuss the possibility of going to less frequent badge changes.
2. Planning for RCT coverage is exercised more effectively at other sites. At NSLS-II schedules change almost daily due to problems with keeping the machine up or if activities complete earlier than anticipated. For example getting consistent beam at 225 mA has been impossible resulting in a lot of inefficient RCT staff time. NSLS-II will better manage and schedule RCT resources to reduce idle time.
3. PPS certifications at APS, ALS and SLAC are performed by the line or central engineering; ESH does not perform the testing function. At NSLS-II ESH prepares search and secure procedures, the certification test procedures and implements the certifications, providing some level of independence from the organization designing and building the system.
4. BNL and APS have similar resource loads though APS is slightly heavier in PPS. ALS and SLAC have little PPS resources (established machines with few changes) and ALS does not provide 24/7 coverage for FLOCOs.
5. NSLS-II is a developing machine with a lot of resources dedicated to getting new and multiple beamlines up plus commissioning a machine that has yet to reach steady state operations at maximum current.
6. NSLS-II is the only site with someone dedicated to the authorization basis/USI process and conduct of operations. ALS and SLAC indicate that is part of the manager's job (but SLAC has no identified management).
7. There are no consistent models between the labs.