National Synchrotron Light Source II Project Lessons Learned

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BROOKHAVEN
NATIONAL LABORATORY

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1. INTRODUCTION

Project Title: National Synchrotron Light Source II (NSLS-II)

Project Location: Brookhaven National Laboratory

Description of Project: The NSLS-II is a highly optimized, third-generation synchrotron facility that will enable the study of material properties and functions, particularly materials at the nanoscale, at a level of detail and precision never before possible. NSLS-II will provide world-leading brightness and flux as well as exceptional beam stability over a broad range of photon energies from infrared to hard x-rays. NSLS-II is designed to house at least 58 beamlines and these experimental facilities, once built-out and operational, will support a large user program that carries out research in such diverse fields as materials science, chemistry, environmental science, physics, biology, and medicine. The NSLS-II project, which started construction in FY 2009 and was completed in FY 2015, included design, construction, and installation of the accelerator hardware, and civil construction of facilities including offices and laboratories required to produce a new synchrotron light source. It includes a third generation storage ring, injector, experimental areas, and appropriate support equipment, all housed in a new building. The NSLS-II project scope also provides an initial suite of six "best-in-class" beamlines.

Cost at CD-2 Approval:

OPC ($M)	TEC ($M)	Contingency at CD-2 ($M)	TPC ($M)
$120.8M	$791.2M	$185.8M	$912.0M

Schedule at CD-2 Approval:

Critical Decision	Planned Date	Actual Date
CD-0—Approve Mission Need	May 2007	May 2007
CD-1—Approve Alternative Selection & Cost Range	July 2007	July 2007
CD-2—Approve Performance Baseline	January 2008	January 2008
CD-3—Approve Start of Construction	February 2009	January 2009
CD-4—Project Complete	June 2015	March 2015
Schedule contingency at CD-2:	12 Months	
Schedule contingency at CD-3:	12 Months	

Funding Profile at CD-2 Approval (in $M):

	PY	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	Total
OPC	5.8	22.0	20.0	10.0	2.0	1.5	7.7	24.4	22.4	5.0	120.8
TEC	0.0	3.0	29.7	93.3	162.5	252.9	166.1	57.4	26.3	0.0	791.2
TPC	**5.8**	**25.0**	**49.7**	**103.3**	**164.5**	**254.4**	**173.8**	**81.8**	**48.7**	**5.0**	**912.0**

Current Funding Profile including Changes since CD-2 (in $M):

	PY	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	Total
OPC	5.8	22.0	20.0	10.0	2.0	1.5	7.7	24.4	27.4	0.0	120.8
TEC	0.0	3.0	29.7	243.3	139.0	151.3	151.4	47.2	26.3	0.0	791.2
TPC	**5.8**	**25.0**	**49.7**	**253.3**	**141.0**	**152.8**	**159.1**	**71.6**	**53.7**	**0.0**	**912.0**

2. OVERALL PROJECT

In this section, four of the most significant success lessons and four major areas of potential improvement for the overall NSLS-II Project are highlighted. For the areas of potential improvement, the impacts these lessons had or might have to the overall project are also discussed. The Other Lessons Learned are detailed in the subsequent sections, grouped by similar subjects for easier reference. The 10 subject areas include Project Management, Human Resources, ES&H, Procurement, QA, Conventional Facilities, Accelerator Systems, Experimental Facilities, Accelerator Readiness Process and Project Closeout.

2.1 Success Lessons

Lessons Learned—Successes	Description, Impacts, and Solutions
DOE-BES Committed to project success	• BES Customer was committed to the success of the project from the outset. They remained engaged with the project, holding it accountable for its performance throughout. This is likely the single most important reason for the success of the project
Strong Laboratory support	• Brookhaven National Laboratory delivered strong support to the NSLS-II Project in all areas, including ESH, Procurement, Human Resources and the other science departments and directorates. • NSLS-II was the Laboratory's highest priority during the life of the NSLS-II Project and that was communicated and known across the BNL campus. • Whenever the project reached a critical squeeze on resources, Brookhaven came through with support from around the Laboratory.
Front loaded funding provided by DOE	• Project CD-2 baseline plan had a very aggressive ramp-up of the assumed funding profile which was one of the highest project risks, if not the highest risk. With $150M ARRA funding provided in FY2009, this risk was completely retired at a very early phase of the project. • Reduced other schedule risks by being able to pull-forward high schedule risk activities and increased built-in schedule float.
Successfully recruited and retained key staff	• DOE approved the NSLS-II Project to use an HR Toolkit that included enhanced sign-on capabilities and performance-based incentive pay options for key project personnel. • This incentive program allowed the project to quickly attract and recruit key personnel and gave the project the tools to use when key retention issues arose.

2.2 Areas of Potential Improvements

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions
Proactive staffing plan	• Staffing plan and hiring process were often lagging behind need dates • Delays significantly impacted meeting schedule in some areas of project. • Setting up proactive staffing plan process in early phase of the project would help in preventing these challenges.
Insufficient schedule allocation for procurement process	• Resource loaded schedule initially formulated did not include sufficient resources or schedule durations for the procurement process. • This shortfall was mitigated by consuming cost and schedule contingency throughout the project duration. • Adequate resource and schedule durations from previous experiences should be incorporated in project planning. • Procurement schedule profiles should be adjusted to appropriately reflect the anticipated and then the final contractual milestones. • Plan for obligations in the schedule with either one day activities or a separate resource for obligations which is planned for the first day of the procurement lead times. (This allocates all the funds on day 1 to cover the obligation.)
Full ownership of cost and schedule by CAMs	• Sub-project leaders (lead scientists and engineers) must own the cost and schedule including the schedule logic and activity durations and be able to assess status and Estimate-At-Complete (EAC). • Accurate project status assessment and EAC drives the project to make timely and realistic decisions. • Scrubbing such assessments and the EAC is essential in order to set priorities and tightly manage cost growth, but this was a challenge and it sometimes created less than full ownership of the plan by CAMS.

Readiness Preparations	• Accelerator Readiness Review Process needs to be robust, including:
	  • the use of a performance-based approach when preparing for operations
	  • establishment of clear roles & responsibilities for the operating organization
	• See BNL Lessons Learned # 2014-BNL-Linac-0002

3. PROJECT MANAGEMENT

3.1 Success Lessons

Lessons Learned—Successes	Description, Impacts, and Solutions
Effective project management organization	• Committed project management team including DOE-HQ, BHSO, BNL Management and NSLS-II Project team with a shared common goal, trust, and good communication enabled proactive and solution-oriented management of the project. • Shared vision of the project management team enabled trust at all levels, open communications, and constructive criticism. This resulted in active identification and resolution of issues. • Combined knowledge and experience of project management team significantly contributed to successful execution of the project. • Early establishment of effective project leadership attracted qualified staff with strong technical and management expertise.
Clear decision making authority and well defined roles	• Various project management documents clearly defined roles and authorities of individuals who are on the project management team. • Management documents described not only decision making process but also spelled out clear decision authorities and thresholds.
Coordination groups	• Coordination groups were established to integrate WBS work that required resources from a number of different line organizations. This proved to be essential in making sure that work was well integrated, efficient and effective.
Strong Laboratory support	• Laboratory delivered strong support to the NSLS-II Project in all areas, including ESH, Procurement, Human Resources and the other science departments and directorates. • NSLS-II was the Laboratory's highest priority during the life of the NSLS-II Project and that was communicated and known across the BNL campus. • Whenever the project reached a critical squeeze on resources, Brookhaven came through with support from around the Laboratory.
Successful use of tailored peer review process	• Regular and disciplined peer review process was conducted on all aspects of the project, including DOE Office of Project Assessment (OPA) reviews, a number of dedicated project advisory committees, and other topical reviews. All of these mechanisms provided effective external advice and validation. • Tailored approach of review process substantially minimized burdensome oversight process while providing effective feedback and recommendations. • Regularly scheduled reviews added value by helping to incorporate lessons learned from other SC projects and providing strong motivation to the team, pressuring everyone to complete scope and prepare well.

Lessons Learned—Successes	Description, Impacts, and Solutions
Realistic identification and management of Risks	• Identifying all risks, regardless of the owner, allowed for better analysis, mitigation strategy, planning and effective use of resources by focusing on risks with the highest consequence. • Risk management team possessed sufficient expertise which enabled identification of multiple mitigation approaches. • Risks were rated and high risks received priority attention and mitigation actions, while low risks were closely monitored and reassessed regularly. • Risk registry identification and analysis were continuously performed and updated as the project environment and conditions changed.
Regularly perform bottom-up estimate to complete	• A true "bottoms-up" estimate to complete (not the use of a formula) was performed and was effectively used for annual project re-planning. • This exercise was extremely useful in maintaining the integrity of the project plan and supporting the decision-making for the contingency spend plan. • This process provided an independent verification of completed work and verified the accuracy of the monthly project-tracking tools. In addition, it helped to focus the attention of project stakeholders to potential project issues and enabled the realization of productive external reviews.
Design Development	• Design readiness was staged to match the schedule of the major sub-projects and address the most time critical risks. This allowed the project to move quickly from CD-1 to CD-3. • The design for a fully realized facility was developed at CD-2 which was then scaled back to the essential elements for meeting the project KPPs. This design work was available at later stages in the project and guided timely decisions about scope additions when contingency became available.
Plan for the use of contingency for scope enhancements	• The project, after the approval of CD-3, identified, developed, and continually updated a prioritized list of scope enhancements that could be executed in the event that contingency was to become available. • The list was very detailed and included information such as cost of the enhancement item, importance of the item to the project, the duration for item delivery, the decision date on when to accept or reject the item and the item owner. • When additional contingency did become available, many of the items on the list were able to be readily incorporated into the project. • The project required concurrence from the customer (BES) on most all scope additions.
Adaptation and tailored implementation of project management tools	• Project management tools, such as EVMS, risk assessment and risk management were used in a tailored manner in order to maximize the value to the project. • Project avoided wasting effort on tasks that didn't provide sufficient benefit to offset the effort and cost.

Lessons Learned—Successes	Description, Impacts, and Solutions
Document clear, concise and realistic project assumptions	• Clear and concise assumptions document was maintained throughout the life of project. It minimized any confusion on what assumptions were used to formulate scope, cost and schedule of the project. • Realistic escalation and labor rates were used as assumptions rather than strictly following DOE guidance.
Front loaded funding provided by DOE	• Project CD-2 baseline plan had a very aggressive ramp-up of the assumed funding profile which was one of the highest project risks, if not the highest risk. With $150M in ARRA fund provided in FY 2009, this risk was completely retired in a very early phase of the project. • Reduced other schedule risks by being able to pull-forward high schedule risk activities and increase built-in schedule float.
Sufficient amount of built-in schedule float	• For high cost risk or schedule uncertainty items, sufficient amount of built-in schedule float gave more time to evaluate and react to problems if any adjustment to the plan or specification had to be made. • Sufficient amount of built-in schedule float gave us opportunities to negotiate with bidders and contractors and to be able to consider re-sequencing the plan or reducing non-essential scope.
Effective use of EVMS	• Project benefited by having experienced staff who understood Earned Value Management System (EVMS) and who could review the data to ensure its accuracy. • Staff who are experts in EVMS also trained and helped all Cost Account Managers on the project to effectively report, maintain and use EVMS data. • Because the data was well understood by the team, it was an effective tool for managing the project.
90-Day Look-ahead Schedule	• Use a 90-day look-ahead schedule for the project team to monitor and provide early warning of upcoming planned work.
Contractors' Schedules	• As a requirement of each major contract, the supplier should be responsible for providing monthly schedule status on their design/build activities. This proved to be a valuable tool in monitoring not only their progress, but providing our management with the data to track progress (or lack thereof) in the integrated schedule.
CAM Coaching	• Provide the CAMs coaching, in some cases one-on-one, so that CAMs have the tools and basic understanding of the philosophy and terminology utilized in EVMS. This enhanced the training that they received and greatly improved their ability when defending their estimates and schedules during reviews.
Co-location of Project Controls Staff	• Co-locating the project controls staff with the project team increased the level of efficiency when project managers and CAMs were looking for information and needed quick response times.

3.2 Potential Improvements

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions
External Independent Reviews (EIR)	• The project should have input into the External Independent Review (EIR) committee by ensuring that the committee has relevant expertise and experience and is knowledgeable about the project. • Reviews are not just a one-way street. The project can benefit by using the review team to independently assess the project and to use the knowledge of the review to share lessons learned, identify risks, or to solicit solutions to issues.
More formality for meetings	• In the initial phase of the project, frequent meetings between the Integrated Project Team (IPT), regulators, owners, and/or other stakeholders were conducted with minimal formal procedures. • Meetings should be formal as often as possible with agendas, documentation of meeting decisions, action items with due dates and responsibilities for action items assigned, and invited personnel should include those who have the authority to make decisions. • In some meetings, the lack of structure, formality, and focus (especially in an academic environment) resulted in action items not being completed, the same issues repeatedly revisited without any closure, not enough time to discuss issues of importance since trivial issues were raised and took up the meeting time, and sometimes the wrong people were in attendance
Full ownership of cost and schedule by CAMs	• Sub-project leaders (lead scientists and engineers) must own the cost and schedule including the schedule logic and activity durations and be able to assess status and Estimate-At-Complete (EAC). • Accurate project status assessment and EAC drives the project to make timely and realistic decisions. • Scrubbing such assessments and the EAC is essential in order to set priorities and tightly manage cost growth, but this was a challenge and it sometimes created less than full ownership of the plan by CAMS.
Use of historical cost and schedule data for infrastructure and utility systems	• Project heavily relied on historical cost and schedule information from other facilities for planning of infrastructure and utility systems. • Due to different assumptions, requirements, and specifications at NSLS-II, plans formulated based on the historical information were significantly under-estimated. • Cost and schedule estimates for infrastructure and utilities should be either formulated by experts in the respective areas after requirements are well understood and designs are completed or given large uncertainty risk factors with sufficient contingency and schedule float.

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions
Maintaining global design criteria document	• Global design document is a living document that is meant to be updated as needed by the subproject team. It provides a way of documenting the initial baseline and subsequent changes and evolutions during project execution. It requires a disciplined change control process and fully functioning document management system to keep it up to date. • It was not updated as it should have been throughout the life of the project.
Cost and Schedule Development	• Ensure that CAMs develop their cost estimate and schedule and that they "own" it • Ensure that the early finish schedule for the project is achievable and is a realistic schedule, not the earliest completion date • Apply escalation to direct dollars, then apply overheads to the sum of the direct dollars plus escalation • Provide ample time for the scientist/engineer to develop a statement of work and specification prior to the start of the procurement group accepting receipt of the procurement documentation. • Understand early on what equipment can be capitalized and only apply escalation to the estimate (no other burdens).
Tools for tracking temporary labor costs	• The NSLS II project had a large number of job shop technicians that were needed for installation. These technicians would be assigned to different tasks than what they were originally planned for. This required each group to keep track of the appropriate accounts and make sure their time was charged correctly. A system similar to the way the normal BNL staff record their time was needed to be implemented early in the installation stages of the project.
Improve accuracy of cost and schedule data give to control account managers	• There were times when data given to the CAMs was in error and it would take a considerable amount of time to correct the problem. Most times it was discovered after the monthly reports were done. A variance report would be required to explain the issue. Some resources should be made available to do error checking before the monthly reports are generated. This also included the B&E reports that would have commitments that would stay open long after a procurement was complete.

4. HUMAN RESOURCES

4.1 Success Lessons

Lessons Learned—Successes	Description, Impacts, and Solutions
Successfully recruited and retained key staff	• DOE approved the NSLS-II Project to use an HR Toolkit that included enhanced sign-on capabilities and performance-based incentive pay options for key project personnel. • This incentive program allowed the project to quickly attract and recruit key personnel and gave us tools to use when key retention issues arose.
Dedicated recruiters	• A dedicated team of recruiters worked out in the field with the project staff. They knew their customers well – both the hiring managers and the new employees – and were a key part to attracting and successfully on-boarding a large number of employees.
Career open house for recruitment	• A career open house at BNL drew strong attendance and helped reduce overall recruitment costs. • The open house also resulted in hiring a number of key staff. • See BNL Lessons Learned # 2008-CH-BNL-PE-0001.
Have an experienced and diverse technical team	• Project has more readily overcome technical challenges due to experience and knowledge of team members.
Effective project management training of staff	• Control Account Managers (CAMs) for the project were required to take a number of project management training courses, including EVMS and procurement training.
Co-location of technical and support personnel	• Technical staff and project support staff (project controls, procurement, HR, budget, ESH, and QA) who were working on the same areas or tasks were co-located in the same or near-by buildings as much as possible making communication much easier and faster.
Integrated staffing plan	• Integrated staffing plan for the entire Photon Science Directorate which included all projects as well as operations helped with resource management, especially during transition periods. It was used as a tool to help handle ramp-up and ramp-down of staffing requirements. • Integrated staffing plan also enabled best-matching of staff assignments based on analysis of skill set mix versus requirements and also mitigated potential schedule conflicts from over subscription of specialized technical experts.
Availability of temporary staff	• Early in the project, mechanisms were put in place to make temporary staff available quickly. Those mechanisms include Memoranda of Understanding between NSLS-II and other departments or directorates at BNL, agreements with other DOE laboratories, the use of term appointments when hiring, and the use of contracted or job shopper support. These mechanisms, when used in conjunction with the staffing plan, allowed peak requirements periods to be covered through non-permanent appointments.

Lessons Learned—Successes	Description, Impacts, and Solutions
On-boarding of project staff	• Due to the large number of staff that had to be brought into the project, a formal on-boarding program was put in place and was managed through a SharePoint "New Arrivals" page. This tool made the names of all new staff (hired, MOU'd, contracted, guests, etc.) available and distributed the on-boarding information to all the relevant parties, including IT, HR, telephone staff, admins, etc. When new staff arrived, space was ready, the phones were in place, the computer set up, etc.

4.2 Potential Improvements

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions
Allocate sufficient time for new hires to come on board	• Often unrealistic time allocation or no time allocation was made for new hires to come on board. • Any plans for new hires should include allocation of time required for the hiring process and the average time typically incurred for relocation of such positions.
Proactive staffing plan	• Staffing plan and hiring process were often lagging behind need dates • Delays significantly impacted meeting schedule in some areas of project. • Setting up proactive staffing plan process in early phase of the project will help mitigate these challenges.
Addressing underperforming staff	• Addressing underperforming staff through performance improvement plans or discipline actions takes time and may contribute to schedule delays of planned activities. • Rather than waiting for situations to improve, proactive actions need to be taken to enhance staffing allocation in such areas.

5. ES&H

5.1 Success Lessons

Lessons Learned—Successes	Description, Impacts, and Solutions
Rigorous safety culture	• Safety program was initiated early and built into the project. • Active identification and resolution of issues before they become significant • Integrated safety management program is key for the entire duration of project, especially during the construction and installation period.
Early safety oversight planning	• ES&H oversight was a part of project activities from early in the planning phases. The type and quantity of the estimated effort was included in the project plan.
Strong Laboratory commitments	• Laboratory commitments were delivered by strong support in the areas of Environmental Services, Fire Protection, Industrial Hygiene, Occupational Safety, and Radiation Protection. • Support and services provided by the respective laboratory groups met or exceeded expectations, in some cases requiring efforts greater than estimated. • The early recognition and concurrence regarding the anticipated ES&H effort aided planning and provided additional assurance that support would be available.
Dedicated ES&H staff	• Dedicated ES&H staff for the project was identified from the beginning and part of the project management team as key personnel
Well defined safety roles in early phase of project	• Identify and document roles, responsibilities, authority, accountability and training requirements of staff, subject matter experts, contractors and all other participants
Regular and good communications with technical groups	• ES&H issues and staff were included in regularly scheduled work planning and task discussions
Effective safety incentive program for conventional construction contracts	• Most likely, if the incentive period is too long it becomes more difficult for the goals to be reached (i.e., zero accidents for a one-year period) to be met. The contractor will not be motivated if the likelihood of getting the incentive is improbable. • Shorten the evaluation period since this has a greater chance for the contractor to receive the incentive award and thus be more motivated. • The wrong incentives may lead to under-reporting of safety incidents instead of real safety improvements. • Widely distributed incentive payouts and celebration of good ES&H performance for actual field workers enhance the successful safety program

Lessons Learned—Successes	Description, Impacts, and Solutions
Early vetting of safety requirements	• Select contractors with solid corporate safety commitment and results • To the extent possible, a clear definition of the project requirements prior to or early in the project can greatly reduce both cost and schedule risks. • The project should thoroughly vet the criteria including applicable codes, standards, and regulations. • Involve appropriate subject matter experts for advice and counsel early in the design phase. This requires care, as it can be unproductive to attempt too much detail in a specification.
Onsite medical provider at conventional construction site	• Availability of an Onsite Medical Center and NYS licensed EMTs at the conventional construction site prevented potential major health risks by providing fast response and treatment for all workers.
Well planned and executed BORE process	• Beneficial Occupancy Readiness Evaluation (BORE) benefited from the advanced planning. • Assignment of a dedicated BORE coordinator to interface with the lab BORE team and the project worked very effectively. • A BORE website to post all materials associated with BORE process served as a good communication tool for both pre-BORE walkthroughs and BORE process. • Pre-BORE walkthroughs brought the BORE team up to speed and identified major items to be addressed prior to the actual BORE.

5.2 Potential Improvements

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions
Resource for specialized safety design and engineering tasks	• When available resources for the overall project are tight, inadequate resources could be allocated for specialized safety tasks such as radiation shielding analysis and design of PPS & EPS. Such a plan could have a significant long term schedule impact as well as increase in cost. • Ensure adequate resources are allocated
Standing external advisory committee	• A standing external advisory committee for ES&H with balanced and experienced composition of membership could provide an extensive peer review process for the assessment of the planned safety program as well as the ability to benefit from good practices and lessons learned from other facilities and organizations.
Standardizing PPE requirements	• Different PPE requirements for different activities at the same or close work areas (eg. conventional vs accelerator in the Ring Building) sometimes caused confusion and the perception that the rules were different for different staff. Also individuals working at different/multiple sites may have to follow different PPE rules. • Standardizing PPE requirements as much as possible would help.

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions

Readiness Preparations	• Accelerator Readiness Review Process needs to be robust, including:
	  ◦ the use of a performance-based approach when preparing for operations
	  ◦ establishment of clear roles & responsibilities for the operating organization.
	• See BNL Lessons Learned # 2014-BNL-Linac-0002

6. QA

6.1 Success Lessons

Lessons Learned—Successes	Description, Impacts, and Solutions
Tracking system for recommendations from reviews	• Recommendations from all reviews conducted from the beginning of the project have been tracked using a recommendation tracking database to ensure all recommendations are properly addressed and responses to recommendations are up to date.
Effectiveness of traveler system	• Traveler system was implemented for the production, fabrication, and acceptance of technical components and was a very effective tool to track and maintain QA data.
Close working relationship with technical staff	• Technical staff and the QA group were co-located in the same or near-by buildings as much as possible. This enabled them to work closely on given tasks with good communication.
Frequent vendor site visits	• Frequent vendor site visits were conducted which included technical staff and QA staff and thorough site visit reports were submitted. This practice resulted in an effective QA program.
QA program and testing of components prior to installation	• The project had an effective policy for QA and testing of components and all custom fabricated components were tested prior to installation. • Because all components were effectively checked out and properly set prior to installation, commissioning went smoothly. • This resulted in fairly minimal incidents for uninstallation of components, check and repair of components, and reinstallation of the components. • This resulted in significant schedule and cost risk mitigation for the project.

6.2 Potential Improvements

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions
Functioning document management system	• Document management system was not fully implemented until very late phase of the project. As a result, document filing and approval process could not be streamlined. • Develop and implement functioning document management systems during the early phase.
Transition to operations	• The time and effort required for the transition to operations for the QA program was underestimated. • Planning and scheduling for the transition from a project, where emphasis is on engineering design, production, installation, and acceptance, to commissioning and operations, where emphasis is on conduct of operations procedures (including validation and training), and operational configuration management of key safety systems the transition from a project to commissioning and operations should be included early in the project. • Assessments of operating procedures should be planned prior to, and performed during commissioning.

7. PROCUREMENT

7.1 Success Lessons

Lessons Learned—Successes	Description, Impacts, and Solutions
Dedicated procurement staff co-located with project team	• The project had a dedicated procurement group within the project organization. • Procurement staff working on the project were co-located in the same or a near-by building as much as possible as this makes communication much easier and faster. • It is important that the dedicated procurement group remain stable during the life of the project and not routinely pulled back to central procurement to fill gaps.
Procurement oversight	• The project had a dedicated senior federal contracting officer in the site office involved in overseeing the procurement effort. This greatly streamlined federal oversight and facilitated rapid review of major schedule sensitive procurements.
Advanced Procurement Planning	• In anticipation of CD-3, advanced procurement plans should be prepared that identify all the major procurements in the schedule and include the initial planning associated with each procurement. The type of procurement, the expected need date, the dollar amount and the potential suppliers should be included. This advance planning allowed the schedulers to add the appropriate procurement lead times to the schedule and helped to refine the procurement support estimates so that the right number of procurement staff could be available when the technical team was ready.
Involvement of technical staff	• Involve all relevant technical staff before awarding contract • Especially for best value selections, the project benefited greatly by following a solid process involving all knowledgeable evaluators including technical, QA and ES&H staff.
Contractor selection process	• Contractors for most major procurements were selected based on "Best Value" criterion. This resulted in technical staff satisfaction and also greatly reduced and even almost eliminated bidder complaints on the award process. • As a result of proactive outreach program, there was sufficient turn out of bidders for most of the major procurements, providing a fair and competitive bidding process. • Use of the Best Value selection criteria should continue for many conventional as well as technical component contracts.

Lessons Learned—Successes	Description, Impacts, and Solutions
"Bundled" procurements for economy of scale	• Cost savings from vendor due to economy of scale • Less lab procurement resources (less travel, less personnel, less paperwork, etc.) were needed since the number of procurements were smaller • Improved or consistent quality of product since the source of the products was the same Note: The disadvantages of the bundled procurement approach are the potential loss of innovation and competition from having multiple vendors and possibility of schedule risk.
Limited vendors with limited capacities	• Procurement and technical staff work closely with vendors • Regular weekly conferences from the beginning
Appropriate packaging of the procurement	• With appropriate packaging of the procurement, project could exercise optional scope additions, deletions or alternates based on the bidding environment and remaining contingency situation.
Exercise alternative contracting/construction methods	• Identify and evaluate alternatives in order to minimize cost and schedule risks
Vendor oversight	• Obtaining accurate and timely information from suppliers on their progress, delivery schedule, and installation requirements was a challenge but resulted in avoiding further change orders and minimizing cost overrun and schedule risks.
Procurement Training	• Project staff should be trained on their role in the procurement process. Procurements in an R&D environment are, for the most part, different than those in a project environment. Quantities may be much larger than single, more collaborative arrangements that scientific staff are accustomed to. Technical staff have to defer to procurement on contractual issues. Procurement training helps to define the roles of the participants in the process.
Procurement Liaisons	• Hiring procurement liaisons to work with the technical staff, as part of the technical team, helped bridge the gap between procurement expectations and the ability of new technical staff to deliver procurement documentation. They should be brought on early in the project lifecycle. Administrative support can help to keep documents moving through the approval cycle.
Weekly Procurement Meetings	• As a project approaches CD-3 and the authorization to begin procurements, weekly procurement meetings help to keep everyone informed of issues. Advanced procurement plans are tracked and if statements of work and specifications are late, CAMs discuss the issues as an agenda item for the meeting. If the project technical team has problems with suppliers or getting traction on procurements, they add agenda items to the meeting. It helps to have senior managers at the meeting so that decisions can be made and pressure can be applied where necessary to keep the process on track.

7.2 Potential Improvements

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions
Insufficient schedule allocation for procurement process	• Resource loaded schedule initially formulated did not include sufficient resources or schedule durations for the procurement process. • This short fall was mitigated by consuming cost and schedule contingency throughout the project duration. • Adequate resource and schedule durations from previous experiences should be incorporated in project planning. • Procurement schedule profiles should be adjusted to appropriately reflect the anticipated and then the final contractual milestones. • Plan for obligations in the schedule with either one day activities or a separate resource for obligations which is planned for the first day of the procurement lead times. (This allocates all the funds on day 1 to cover the obligation.)
Templates and example procurement packages and documents	• In the early phase of the project, technical staff wasted a fair amount of effort and time to produce procurement packages on their own. • Assembling and providing a good set of templates and example procurement packages and documents in the early phase of the project will help saving both effort and time.
Communicating project expectations to new contractors	• New contractors can introduce additional risks. The project needs to ensure that the new contractor fully understands DOE and BSA requirements and expectations. • Key personnel and their experience must be appropriately assessed during the evaluation process of the bid prior to contract award.
Multiple vendors for one items create additional costs	• As a risk mitigation issue, the project awarded magnet contracts to multiple suppliers. While this mitigated risk, it also increased the procurement, administration, and quality efforts to track progress from multiple vendors. Additionally, maintenance cost during operations will be more because items are not identical.
Rapid changes in vendor capacity/capabilities	• Status of commercial vendors can change rapidly, so advice based on any previous experience can be mis-leading.

8. CONVENTIONAL FACILITIES

8.1 Success Lessons

Lessons Learned—Successes	Description, Impacts, and Solutions
Enhanced contractor outreach efforts	• Proactive contractor outreach meetings at BNL drew strong interest from general contractor firms, improved bid response, and ensured competitive bids. • Holding pre-bid meetings for potential bidders was a very effective vehicle to communicate the expectations of the project and laboratory and resulted in better quality proposals.
Pre-construction contract management service and value engineering	• Pre-construction CM services added value to estimate validity and constructability as well as value engineering. • Value engineering (VE) was critical during the design phase to achieve performance objectives and to stay within costs.
Specifications with sufficient input from scientific staff	• Scientific staff must be part of the team to insure that scientific requirements are met including defining building and utility requirements early and continuously during design to avoid changes during and after construction. • Role of interface managers for Conventional Facilities, Accelerator Systems and Experimental Facilities has been key in minimizing costly changes after the start of construction.
Use local firms for conducting independent cost reviews	• The project used two firms to perform independent cost estimates of various systems and facilities. • Comparison of the ICEs and the bids received by vendors showed that the local company estimates were consistently more accurate than those estimated by a national company. • The local firm was familiar with local economy, requirements, resource availability and other factors that made the estimate more realistic. • The local firm also had a database based on local historical data that is more accurate.
Have commissioning agent involved in the project as soon as possible	• Commissioning agent was hired at the start of design and was involved with the project until completion. • The commissioning agent provided valuable recommendations to the design for improving facility capabilities. During construction, additional recommendations by the agent on latest materials available and installation techniques resulted in cost and time saved to the project. • The commissioning agent also regularly communicated with the project stakeholders (facility operations and maintenance) to enhance the building capabilities early in the project. • Commissioning process was very smooth and relatively easy because of extensive involvement by the agent throughout the project.

Lessons Learned—Successes	Description, Impacts, and Solutions
Understand and keep current on the requirements	• The project was well aware of the latest requirements on High-Performance and Sustainable Buildings and incorporated the new requirements into the design. As a result, the contracts included the costs associated with implementation of the requirements. • Because all necessary requirements to meet sustainability and energy conservation were incorporated in the original design, no expensive and time-consuming design changes were needed.
Effective construction management team	• CM staff augmentation coupled with owner CM team was very effective in responding to changing project demands.
Contractor Training	• BNL successfully provided project/site specific training courses for the contractors and subcontractors. • Establishing sufficient contractor training resources as part of project planning can help ensure contractors meet training expectations and requirements.
System coordination tool	• 3D modeling by contractor as a part of system coordination was a very effective tool and should become a requirement in future construction projects. • Designs for new facilities should utilize building information management (BIM) and 3D modeling as a standard design practice for major facilities.
Plan of Day meetings	• Contractors' Plan of Day meetings proved useful. Feedback and contractor experience resulted in improved work coordination and schedule performance. • The Plan of Day meetings are recognized as a vital element in the implementation of Integrated Safety Management.
Full-time safety professional	• The decision to have full-time onsite safety professional on the NSLS-II Project team was a great benefit. Although the contractor's safety professional was also a benefit, the contractor's safety personnel have a potential conflict between job safety and company profitability. • The additional safety oversight from the contractor, including the full-time, project-based personnel and additional BHSO personnel, helped to reinforce job safety.
Effective safety incentive program	• Safety incentive program can be effective but administration requirements must be streamlined so that the payment can be dispersed in a timely fashion. • The safety incentive programs implemented by the contractors were revised based on feedback and field experience in order to streamline the process and maximize the incentives to work safely.
Dig permit process	• Obtaining individual BNL excavation permits for each excavation could have been a time consuming and expensive process. • Rather than planning for multiple BNL dig permits, the project obtained a global dig permit for all work that was contained within the construction site over the project duration and required the contractor to implement an excavation permit process to assure protection of installed work.

Lessons Learned—Successes	Description, Impacts, and Solutions
Effective QA/QC programs based on scientific and technical modeling and analysis	• Computer modeling of vibration analysis carried out by our own staff was very important in resolving design issues and keeping fast paced design on schedule. • Infrared survey of large metal skinned buildings was very effective at finding defects in installation and it should be a standard practice for future construction projects.

8.2 Potential Improvements

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions
Improve contractor submittal expectations	• The quality and timeliness of submittals should be clearly set in the contract documents. Set ground rules for document preparation and submittal expectations before issuing the notice to proceed. • Poor performance on document submittals by contractors resulted in increased effort by the project
Schedule float in contractor's plan	• The schedule provided by the contractor did not sufficiently plan for potential weather impacts. • An allowance for weather impacts must be included within the contractor's schedule, for example including an allowance for rain or snow days.
Contractor involvement with risk analysis	• The contractor may identify risks, mitigation strategies and potential impacts not considered by the project. Input from the contractor in some regular duration could be beneficial.
Improve change order timeliness	• Contract provisions establishing the time frame and process for change orders must be enforced as well as the expected quality of the change order.
Emphasize and clarify safety requirements to contractors	• Although safety expectations were discussed during the pre-bid and post-award kick-off meetings, expectations may not have been made sufficiently clear at senior levels of the company. • The project and BNL's expectations must be further articulated to the executive management of the contractor at the beginning phase of the construction.

9. ACCELERATOR SYSTEMS

9.1 Success Lessons

Lessons Learned—Successes	Description, Impacts, and Solutions
Prototyping	• Early prototyping was very beneficial in most cases (except for the case of storage ring magnets), by providing useful information during fabrication and installation. • Prototyping identified technical and manufacturing issues and challenges that could be planned for the actual production. • Prototyping allowed better understanding and planning for where bottlenecks are in the work process. • Minimized the time and cost of modifications to the mainstream effort, due to understanding gained from prototyping. • Caution is required, however, as prototyping vendors can be excluded from the bidding process. Procurement should be involved early in the planning to navigate this process.
Strong and centralized installation manager	• Appointment of centralized and well organized installation manager was essential factor for successful installation by being able to prioritize schedule, allow manageable resource leveling, more efficient use of resources and equipment, and improve safety. • It also resulted in better engagement of the labor force, easily facilitating feedback to the design team and facilitated the smooth coordination with conventional facilities and experimental facilities management team.
Advanced planning and progress of controls system	• Standalone testing, integrated testing and commissioning of various subsystems substantially benefitted from well advanced planning and development of the control systems. • Such advanced progress of controls systems minimized potential schedule risks throughout the project construction and commissioning phase.
Tight and rigorous vendor oversight	• Accelerator systems management, technical staff and procurement staff provided very tight and rigorous vendor oversight by conducting regular and frequent site visits, weekly teleconference meetings, and daily phone meeting, minimizing schedule delays. • Extended visits (7~10 days) by NSLS-II technical staff in an early stage of manufacturing major components were very effective to ensure successful productions. • Stationing a remote representative at vendor locations also helped in keeping suppliers on track.

Lessons Learned—Successes	Description, Impacts, and Solutions
Multiple magnet contracts	• Magnet production schedule was very tight which presented a significant schedule risk due to limited production capacity in all of potential vendors. • In order to meet the schedule requirements, magnet contracts were grouped by different magnet types. • Although this strategy required more effort for contract management, it eliminated a risk from the limited production capacity. It also provided potential solutions for the project in case one production site failed to deliver by reserving options to move scope to other production site(s) which were producing similar type of magnets. • See BNL Lessons Learned # 2014-BNL-NSLS-II-0001
Valuable internal technical reviews	• Project conducted internal topical reviews by external review committee members with technical expertise for areas such as insertion devices, instrumentation and diagnostics, power supplies, control systems, high level applications, interlock systems, radiological safety design, top-off safety, lattice and accelerator configurations, and magnets. • These reviews provided valuable assessment and advice for successful design, production, and implementation.
Early establishment of project's Global Requirements Document	• Early establishment of a single, global-level requirements document that specifies the performance requirements for the accelerator was effective to ensure all technical requirements were clearly stated and agreed upon.
Strong project management support to develop in-house instrumentation, if necessary, to meet requirements	• Several instrumentation systems were available off-the-shelf but either just a few that barely met the requirements or didn't have the needed future capabilities. With an open mind, project management, group leader and group members were encouraged to explore several in-house developments. The RF beam position monitors were one of the key instrumentation systems which were successfully developed in-house.
Technical Change Request Process	• A technical change process took into account a comprehensive assessment of a change prior to approval.

9.2 Potential Improvements

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions
Resource for specialized safety design and engineering tasks	• When available resources for the overall project are tight, inadequate resources could be allocated for specialized safety tasks such as radiation shielding analysis and design of PPS & EPS. Such a plan could have a significant long term schedule impact as well as increase in cost. • Ensure adequate resources are allocated. • See BNL Lessons Learned # 2014-BNL-Linac-0001
Premature Failure of Electro-Mechanical Switches due to Inadequate Installation	• Design review process should ensure that all systems are reviewed by an appropriate team of engineers and/or technical staff. In this instance, the review was conducted only by electrical engineers when it should have included mechanical engineers also. • See BNL Lessons Learned # 2014-BNL-NSLS-II-storage ring-0001
Technical specifications for procurement packages	• Technical specifications should come from a unified and well-defined process that is developed early in the project by technical subject matter experts as well as input from ES&H and procurement.
More collaborative effort between technical and procurement experts	• In the early stages of the project, there should have been training sessions to inform the technical staff of the expectations in developing procurement packages. There were a lot of conflicts and delays, mostly due to lack of communication and with little collaborative spirit. It did get better as time passed, but a lot of time was wasted.
Rigorous engineering and installation interface	• Although mostly successful, all installation drawings and documents should have been completed before starting installation in order to avoid any rework.
Material handling and tracking system	• The NSLS II project had tens of thousands of parts needed for installation. There was no formal project-wide process to control the inventory of these parts. Each group had to manage their own MRP (Material Requirement Planning). This required a considerable resource to correctly manage. If implemented early in the project it would have improved the installation schedule greatly.
Installation staff home locations	• The NSLS II staff that supported the accelerator installation were located in many different buildings away from the installation activities. This caused inefficiencies in getting to and from the work sites. Space should have been planned for the installation staff to be co-located with the installation activities. This should also include the supervisors and engineering staff so timely technical decisions could be made.
Instrumentation system installation estimates	• The instrumentation system installation cost estimate only included the effort needed by the instrumentation group members. However, several instrumentation systems require support from other groups such as utility, vacuum and mechanical groups. To get a better cost estimates, all group efforts must be included.

Lessons Learned—Potential Improvements	Description, Impacts, and Solutions
Early value engineering	• Value engineering done early in the project was "one dimensional" showing savings, for example, for a narrow tunnel, for thin concrete walls without high-density concrete, for high temperature cooling water and tunnel air. These presumed cost savings efforts resulted in higher than normal costs later in the project for insertion devices, extra shielding and lower performance for the insertion devices and mirrors.
Information technology	• The lack of a data sharing mechanism between BSA and suppliers made it difficult to transfer big data files to share the same checklist for progress monitoring. • BSA's strict policy to limit network access from the outside made software debugging by vendors inefficient and expensive. • The lack of a unified data server for all documents made it difficult to locate files. Some items were on SharePoint, some in DB, some drawings in Vault, procurement-related documents on a Windows server with access restrictions.
Insufficient design support	• An underestimation of designer effort led design to become the rate limiting step for many activities.

10. EXPERIMENTAL FACILITIES

10.1 Success Lessons

Lessons Learned—Successes	Description, Impacts, and Solutions
Engagement of scientific community	• Instituting a Beamline Advisory Team (BAT) for each beamline enabled engagement and direct integration with the science community throughout the project lifetime, starting from the conceptual design and through the formulation of early science program. • BATs provided independent, valuable input and advice from the potential user point of view.
Standardization of components	• Standardization of various infrastructure and common system components significantly benefitted installation planning and execution and will provide streamlined maintenance and spare inventories in operations. • It also enable "bundled" procurements to take advantage of economies of scale
Coordinated engineering team and common design	• Grouping instrument engineers together in one team increased efficiency, uniformity and helped share good ideas, designs and practices. • Common equipment minimized spares inventory and will improve maintenance and installation.
Consideration of alternatives for state-of-the-art components	• Project baseline was formulated with enough flexibility to continuously identify and evaluate alternatives for the state-of-the-art components such as detectors and optics elements. • As a result, project was able to equip with more capable devices for the same cost.
Early establishment of interface documents	• Early establishment of an interface document for each beamline with respect to the building, infrastructure, and accelerator was effective in ensuring that all interface requirements were clearly stated and agreed upon.

10.2 Potential Improvements

Lessons Learned Improvements	Description, Impacts, and Solutions
Clear definition of project completion	• Verify by equipment acceptance tests plus measurement and calculations of integrated performance without beam • Includes passing Instrument Readiness Review (ready to open the shutter and take beam) • Formal process requiring sign-offs should be in place as early as possible. • Require instrument acceptance by separate divisions and groups helps ensure integrity of process.
Metric vs. English Units	• For foreign vendors, need to ensure proper units are used to prevent misunderstanding, and to minimize resources needed to convert differing units.

11. ACCELERATOR READINESS PROCESS

11.1 Success Lessons

Lessons Learned - Successes	Description, Impacts, and Solutions
Readiness objective established early by senior management	• Project Director set the tone at the top at the outset of the series of readiness reviews. • Objective of the readiness process was not to "pass" the reviews and obtain approval to start commissioning or routine operations; objective was to identify and eliminate any gaps or weaknesses in accelerator safety that could be the root or contributing cause of a future incident or accident. • This message was repeated frequently throughout the planning and execution of the series of internal – Instrument Readiness Review (IRR) - and external – Accelerator Readiness Review (ARR) –reviews. • Project Director demonstrated sustained commitment to this objective by delaying reviews when work in place was not sufficient to ensure all potential safety issues could be identified by the IRR or ARR team.
Readiness Process Manager appointed (NSLS-II Start-Up Manager)	• A senior Lab manager was appointed as NSLS-II Start UP Manager to manage the readiness process prior to the Booster Commissioning IRR • The Start-Up Manager's in-depth knowledge of the Laboratory's ES&H and operational programs and staff facilitated selection of IRR team members, development of new processes, and responsive and timely closure of IRR and ARR findings.
Well established Training Group and Procedures Group	• Experts in coordinating the development and review of procedures by accelerator and beamline technical managers were used to ensure procedures were developed with worker involvement and, where appropriate, walked down and validated in the field before use. • Experienced training professionals developed training associated with the procedures and other operational requirements.
Frequent communication with key stakeholders	• The Start-Up Manager briefed the Project Director approximately every two weeks on progress of the readiness process. • NSLS-II managers and staff working on the readiness program had frequent interactions with the DOE Site Manager and Site Office SMEs and FacReps, with the DOE Office of Science Accelerator Safety Officer, and with the IRR and ARR team leaders during the planning and execution of the IRRs and ARRs and while working toward closure of the team's findings. • NSLS-II technical staff were encouraged to, and did, interact freely with team counterparts during all phases of the reviews to ensure clear understanding of findings and planned actions to close them.

Lessons Learned - Successes	Description, Impacts, and Solutions
Use of VideoTeleconference (VTC) and Team Website	• About 2 weeks prior to the team's arrival, NSLS-II staff posted relevant documents on a dedicated website for the review. • NSLS-II Readiness Staff conducted a 2-3 hour VTC before each ARR Team review to present the status of readiness, cover the modifications to the SAD and ASE for the next phase, brief on ES&H hazards and PPE associated with the on-site portion of the review, gather team members' initial requests for documents, and answer questions. • NSLS-II and Team members found great value in these approaches to information sharing in advance of the team's on-site review.
IRR teams led by experienced accelerator safety managers, external to BNL	• From the Booster commissioning IRR through the IRR for "Routine Operations", all teams were led by personnel experienced in accelerator safety in the DOE complex. • The team leaders were also selected based on their familiarity with the DOE Accelerator Safety Order and Guide and their experience in leading IRR and ARR teams in the DOE complex. • Seasoned team leaders enabled the team to focus in on the significant issues and concerns quickly and provide excellent feedback. • These IRR team leaders were also very familiar with the expectations of the ARR team which helped us to be better prepared.
Pre-Start Closure Memos and Report	• A "Closure Memo" was prepared for each of the ARR "pre-start" findings for each of the ARRs. The memo described the thought process behind the actions taken to close the finding, put the "evidence files" in context and, where applicable, described modifications to the finding based on NSLS-II staff discussions with the author of the finding. • The memos were rolled-up into a "Pre-Start Findings Closure Report" for each ARR.

11.2 Potential Improvements

Lessons Learned Improvements	Description, Impacts, and Solutions
Orientation to BNL Lab-level requirements and NSLS-II processes	• Briefing external IRR and ARR team members on the Laboratory's requirements delivery system (the "Standards-Based Management System") and the relationship between SBMS and NSLS-II policies and procedures would have eliminated some confusion at the outset of the review. • Flow-charting some key processes developed to support accelerator and beamline operations would have made it easier for team members to understand these processes and made their evaluation of them more efficient

Lessons Learned Improvements	Description, Impacts, and Solutions
Team members' requests for documentation and records	• NSLS-II makes extensive use of SharePoint for documents, however, the documents and records were not always readily found. This led to delays in responding to team members' requests for documents and a less than optimum use of their time. • In later reviews, multiple points of contact were established to ensure team members' requests for documents were expedited. • A 'standard" of a maximum 1 hour turnaround time was established and sustained.
Scheduling IRR and ARR reviews	• A total of 9 IRR and ARR reviews were conducted in approximately a 1 year period. On a few occasions, reviews were scheduled too close to one another – in one case, back to back – preventing the desired level of preparation. • IRRs and ARRs should be spaced at least one month apart to allow sufficient time to plan and prepare. • IRRs and ARRs were scheduled about 1 month in advance (lead time needed to coordinate schedules of external reviewers and team leaders), based on forecasted completion of all work needed to declare readiness. • In most cases the estimates were too aggressive and 100% readiness was not always achieved at the time of the review. • This necessitated the use of "mini-IRRs" and the return of select ARR team members to review scope completed after the IRR and ARR.
Routine Operations IRR/ARR Scope	• The scope of topics to be reviewed during the "Routine Operations" IRR and ARR was not explicit in the Accelerator Safety Guide. • Since almost all "hardware" had been reviewed during the commissioning IRRs/ARRs, the scope was developed to include "processes" that would be used during operations, for example, the process to review the safety of new accelerator components and beamlines that would be installed in the future. • Some reviewers were concerned that this approach did not address the Accelerator Safety Guide mandate to conduct "performance-based" reviews. • Addressing "Routine Operations" ARRs in the next version of the Guide would help eliminate this concern and also ensure all safety-significant topics are covered.

12. Project Closeout

12.1 Success Lessons

Lessons Learned—Successes	Description, Impacts, and Solutions
Early completion of closeout actions	• Many closeout actions can be started and nearly ready well before the project is complete. Lessons Learned documentation and the project closeout report were in draft a year or more before the project actually completed. • As activities completed project accounts were closed as soon as possible reducing the workload at the end of the project and reducing the likelihood of errant charges to accounts that should be inactive. • In most cases contracts were formally closed as soon as possible after their scope was completely delivered. This is important, since some, like the conventional construction contracts took over a year to come to closure.
Scope Verification	• At the request of the customer, a process was developed to independently verify that the scope of the project was delivered consistent with the WBS. • An independent panel, which included site office participation, was formed to conduct a performance based review which included walking down the facility. • Discrepancies (generally errors in the WBS dictionary) were identified and rectified quickly, providing assurance that the full scope of the project had indeed been delivered.
EAC development	• The project instituted annual bottoms up EAC estimates to help guide decisions regarding utilization of contingency for scope enhancements • For the last year of the project, the EAC was developed monthly from the ACWP and the individual CAM Estimates to Complete. This shifted focus to those activities (and costs) that were essential to delivering the final scope of the project.

12.2 Potential Improvements

Lessons Learned – Improvements	Description, Impacts, and Solutions
Early completion of closeout actions	• While the project was successful in closing out most of its over 12,000 requisitions in a timely fashion, the order of 200, mostly small accruals remained to be resolved at the end of the project. • These were generally errors in vendor invoices, but a few were 'real' commitments which needed to be cleared. • Each of these accruals and contracts required investigation, which can be time consuming, and difficult for stale (in some cases years old) commitments on the books. • For future projects, factoring resources to support investigation and timely closure of these type of transactions would be helpful in completing financial closure of the project.
Scope Verification	• The need for an independent scope verification process was identified fairly late in the project, so collection of information related to scope completed early in the project was time consuming • For future projects if a scope verification process is contemplated, the information should be systematically gathered as scope is completed. This will make performing an independent assessment much easier.
EAC development	• The transition from 'traditional' to monthly ETC based estimates of EAC was not smooth. While the process served its intended purpose well (knowing and containing final project cost), the timing of accruals at the transition as well as the skill of the CAMs in making reliable ETCs was not adequately factored into the conversion. • The process for compiling monthly ETCs was very labor intensive and for future projects could be included as part of the monthly status routine and maintained within the project controls toolset rather than as a standalone spreadsheet. • It might be worth considering piloting the monthly ETC method for a quarter or so before the intended transition time, which should be 12 to 18 months out from anticipated early project completion.

Submitted by:

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Steve Dierker, Contractor Project Director Date

9/10/15

Frank Crescenzo, Federal Project Director Date

ACRONYMS

ACWP	Actual Cost of Work Performed
ARR	Accelerator Readiness Review
ARRA	American Recovery and Reinvestment Act
ASE	Accelerator Safety Envelope
BAT	Beamline Advisory Team
B&E	Budget & Expense
BES	DOE Basic Energy Sciences
BHSO	Brookhaven Site Office
BIM	Building Information Management
BNL	Brookhaven National Laboratory
BORE	Beneficial Occupancy Readiness Evaluation
BSA	Brookhaven Science Associates
CAM	Control Account Managers
CD	Critical Decision
CM	Contract Management
DOE	Department of Energy
DOE-HQ	DOE-Headquarters
EAC	Estimate at Complete
EIR	External Independent Review
EMT	Emergency Medical Technician
EPS	Equipment Protection System
ES&H	Environment, Safety and Health
ETC	Estimate To Complete
EVMS	Earned Vale Management System
FY	Fiscal Year
HR	Human Resources
ICE	Independent Cost Estimate
IPT	Integrated Project Team
IRR	Instrument Readiness Review
IT	Information Technology
MOU	Memorandum of Understanding
MRP	Material Requirement Planning
NSLS-II	National Synchrotron Light Source II
NYS	New York State
OPA	Office of Project Assessment
OPC	Other Project Costs
PPE	Personnel Protective Equipment
PPS	Personnel Protection System
QA	Quality Assurance
QC	Quality Control
R&D	Research & Development
RF	Radio Frequency
SAD	Safety Assessment Document
SBMS	Standards Based Management System
SC	Office of Science
TEC	Total Estimated Cost
TPC	Total Project Cost
VE	Value Engineering
WBS	Work Breakdown Structure