NSLS-II Experimental Facilities Beamlines
Baseline Scope and Readiness Plan for CD-4 and Operations

April 30, 2010

NSLS-II Experimental Facilities Division's overall scope in the NSLS-II construction project includes the completion of design and construction of six project beamlines so that they will be ready for photon beam by the project early completion date February 2014. The total budget as specified in the project baseline is $67.8M including some efforts in optics laboratory and other standard components. As stated in the Project Execution Plan, the scope and budget for each individual beamline will be baselined only after the beamline design has been advanced to sufficient design maturity. This document summarizes the proposed NSLS-II beamline baseline scope and the beamline readiness plan for CD-4 and beyond.

Introduction

In 2009 all NSLS-II project beamlines have completed the Conceptual Design Reports. These reports provide sufficient design details and costing information for each beamline, based on close interactions with the beamline advisory teams (BATs). The cost estimates were significantly higher than the CD-3 baseline, by about 20%, mostly due to evolutions of design maturity and additional design considerations beyond the original conceptual design at CD-2.

Since the completion of the Conceptual Design Reports, the NSLS-II Experimental Facilities Division has conducted a series of reviews, including BAT reviews of the conceptual design in the summer of 2009, an external independent Conceptual Design Review, October 14-15, 2009, and an external conceptual design cost review, December 15-16, 2009. These reviews essentially validated the technical designs of the beamlines at the conceptual level and the associated higher cost estimates for the scope presented in the beamline conceptual design reports.

Given all these and the need to stay within the overall cost baseline at this stage of the project, the NSLS-II Experimental Facilities Division has aggressively pursued conceptual value engineering and refined the scope for all project beamlines. The goal of this exercise is to provide a strong initial set of scientific capabilities at the NSLS-II early operations while staying within the overall CD-3 cost and schedule baseline. The purpose of this document is (a) to specify such baseline scope and budget for project beamlines, and (b) to define a set of associated beamline readiness criteria at the early project completion.

Baseline Scope and Cost

The topic of beamline scope in NSLS-II experimental facilities has been amply discussed at various meetings with NSLS-II beamline advisory teams and experimental facilities advisory and review committees. The overall strategy that has been adopted is to optimize the beamline baseline scope to ensure that (a) the beamlines will be science-ready after commissioning to support a broad range of user experiments, and (b) the beamlines are designed with sufficient flexibility and accessibility for future additions and upgrades. The proposed baseline scope and associated cost estimates are listed in Table 1, along with initial set of scientific capabilities.

The proposed baseline scope has been reviewed by the DOE Lehman Review Committee in February 2010, and approved by NSLS-II management in April 2010.

Table 1. NSLS-II Project Beamline Baseline Scope and Initial Science Capabilities

WBS Beamline	Baseline Estimate	Initial Scientific Capabilities
1.4.5.1 IXS	$ 11,107,079	• IXS at ~ 9.1 keV with CDDW scheme or alternative • Single experiment hutch designed for 1 meV & 0.1 meV • Initial 1 meV spectrometer (5 m) w/ improved resolution tail • Incident flux at sample > 10^9 ph/s/meV • Focus at sample ~ 5 μm (V) x 10 μm (H) • Momentum transfer range from 0.1 to ~40 nm^{-1} • Momentum resolution ~0.1 nm^{-1} • Sample environments with cryostat and high-pressure
1.4.5.2 HXN	$ 14,414,915	• Nano-XRF/XRD at 6-25 keV with MLL/FZP or alternative • Beamline design capable of ~ 1 nm spatial resolution • Initial science microscope with ~10 nm to 30 nm resolution • Satellite building for environmental isolation and stability • Optimized for final optic aperture up to ~100 μm • Incident flux in final focal spot > 10^9 ph/s • Advanced fast MAIA detector for nano-XRF imaging • Pixel array detector for nano-XRD and ptychography • Correlative sample environment and prealignment setup
1.4.5.3 CHX	$ 10,061,804	• XPCS at 6-15 keV with >10^{10} ph/s in monochromatic and >10^{11} ph/s in pink beam • Both small-angle and wide-angle XPCS on consolidated endstation instrument/diffractometer • Fast dynamics studies down to sub millisecond range • Initial suite of sample environments including cryo-furnace and flow cells • Micro-SAXS compatible with fixed beam size of ~1 μm • CDI capable with user-supplied sample stage/environment
1.4.5.4 CSX	$ 10,744,939	• Polarization-dependent spectroscopy and coherent scattering at 0.2-2 keV • Flux >10^{13} ph/s for spectroscopy and for coherent scattering • Independent branches for polarization / coherent scattering • Focal spot size at sample from ~50 μm to < 1 μm • Fast circular & linear polarization switching at up to 1 kHz • XMCD with tunable vector magnetic field up to 1 T • Resonant scattering with in-vacuum diffractometer • Sample temperature down to 4 K
1.4.5.5 SRX	$ 11,138,237	• IVU 21 1.5m to provide tunable x-rays in 4.7 – 23 keV, with

		precision gap scanning mechanism • Micro-XRF imaging with spatial resolution down to 100 nm with fast MAIA detector • Chemical speciation with micro-XANES • Tomographic micro-XRF imaging capability • Correlative sample environment w/ prealignment microscope • Imaging of radiation sensitive specimens by freeze-drying or chemical fixation • Beamline designed to incorporate zone-plate canted branch in mature scope
1.4.5.6 XPD	$ 9,420,707	• Powder diffraction in tunable energy range of 40-70 keV • High flux > 10^{12} ph/s at sample in variable 0.5-2 mm focus • High resolution powder diffraction with $\Delta d/d \sim 10^{-3}$ to $2x10^{-4}$ • Time-resolved capability in the sub-second range • Suite of sample environment with temperature control of 80-1500K, and high-pressure settings up to 10^2 GPa • Automated high-throughput analysis robotic sample changer • Environment table for user-supplied large sample apparatus • Initial PDF capabilities, with upgrade in mature scope to dedicated PDF side-branch
Total	$ 66,887,682	

Baseline Comparisons and Risk Assessment

As shown in Table 2, under the proposed baseline plan, the combined baseline budget for WBS 1.4.5 (user instruments) and 1.4.7 (optics laboratory) will remain the same as the CD-3 baseline implemented in November 2008. This ensures that the overall budget for NSLS-II experimental facilities will stay within the current baseline at this stage of the project. For comparison, the budget estimates in Conceptual Design Report (CDR) and in November 2009 are also shown.

In addition, a bottom-up risk assessment and associated cost impact has been performed at WBS level 5, using the same NSLS-II Risk Assessment Guideline developed prior to CD-2. The rolled-up cost impact for each beamline is shown in Table 2. This represents about 20% cost uncertainty for the *defined baseline scope*, with ~45% of the cost impact amount attributed to accuracies in labor estimates.

Table 2. Baseline Scope and Cost Estimates for NSLS-II Project Beamlines

WBS	Beamline	CD-3 Baseline	CDR Estimate	Jan-2010 Baseline	Risk
1.4.5.1	**IXS**	$ 10,435,753	$ 14,590,079	$ 11,107,079	$ 2,406,235
1.4.5.2	**HXN**	$ 13,501,681	$ 17,682,581	$ 14,414,915	$ 3,289,185
1.4.5.3	**CHX**	$ 10,041,839	$ 12,137,124	$ 10,061,804	$ 2,006,875
1.4.5.4	**CSX**	$ 11,239,960	$ 12,487,939	$ 10,744,939	$ 2,306,978
1.4.5.5	**SRX***	$ 10,707,773	$ 12,134,737	$ 11,138,237	$ 2,301,264

1.4.5.6	**XPD**	$ 9,897,480	$ 10,888,707	$ 9,420,707	$ 1,896,039
1.4.7	**Optics**	$ 2,072,160	$ 2,072,160	$ 1,076,012	$ 107,601
	Total	**$ 67,896,646**	**$ 81,993,327**	**$ 67,963,694**	**$ 14,314,177**

Beamline Readiness for CD-4 and Operations

It is expected that the initial scientific capabilities listed in Table 1 will be achieved only after certain time period of beamline commissioning, not immediately after the completion of the NSLS-II construction project (CD-4). Table 3 shows the planned beamline transition to operations and the required beamline readiness at each stage of beamline readiness and commissioning (CD-4, technical commissioning, science readiness, and user operations). The estimated time duration for each stage is based on the number of beam hours needed for commissioning each technical component, and the assumption of usable stored beam availability. The actual time required may vary from beamline to beamline.

Table 3. NSLS-II Beamline (BL) Readiness for CD-4 and Transition to Operations

	Construction Completion (CD-4 Ready)	Beamline Commissioning (Technical Readiness)	Transition to Operations (Science Readiness)	User Operations
Timeline	Constr. Complete February 2014	+ 9 months	+ 9 months	
Usable Beam Availability	0%	30%	50%	70%
General User Beam Time Percentage		0% Staff/BAT only	25% BAT/Commissioning Users	80% General Users
Beamline Readiness Goals	• BL subsystems installed & tested, incl. enclosures, beam transport, PPS & EPS, utilities, and controls systems • Main optical systems installed at BL and diagnostic system installed at endstation to enable BL commissioning	• BL shielding verification completed • BL main optics commissioned • Beam properties optimized and characterized (energy, flux, ΔE/E, tunability, stability, etc.) • Endstation installed and commissioned	• Endstation fully characterized for phased initial science capabilities • BL and endstation debugged for initial science experiments • Data acquisition software debugged and functional • Example science experiments performed and preliminary results	

		• Basic operations procedures established	analyzed	
Safety and Administrative Approval Procedures	• BL safety configuration review & walkthrough • Operation readiness evaluation by BNL • BL readiness technical review (internal, BAT, & external) • BL readiness report to XFD Director	• BL shielding certified for operations by ESH • BL user access & safety procedure fully established and tested • BL user training courses developed and tested • BL commissioning report endorsed by BAT and approved by XFD Director	• BL science readiness report endorsed by BAT and submitted to XFD Director • Beamline User Readiness Review by NSLS-II SAC • Approval for BL user operations by XFD Director	