HIGH-ENERGY ENGINEERING X-RAY (HEX) BEAMLINE

PROJECT ASSUMPTIONS
FOR
SCOPE, COST AND SCHEDULE

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REVISION 2

HEX BEAMLINE

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SCOPE, COST AND SCHEDULE

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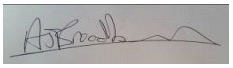
X 

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REVISION HISTORY

REVISION	DESCRIPTION	LIST OF REVIEWERS	DATE
1	Interim version, prepared along with PMP, prior to CDR. **Note**: Document will be updated and fully signed when new VAB rates are available	See page ii	17OCT2017
2	Final version, prepared prior to PDR with updates to rates and burdens based on VAB	Page ii	12APR2018

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1 SCOPE ASSUMPTIONS

Scope that is included in the project is defined in detail in the HEX Beamline WBS Dictionary. Items that may require further clarification include:

- Beamline scope includes installation, subsystem testing, integrated testing, and initial commissioning with synchrotron beam (x-rays to the sample position).
- The formal handover to operations will occur after x-rays have been demonstrated at the sample position. Operations will cover the costs of technical and scientific commissioning as well as User operations.
- The HEX project includes all costs associated with adding the beamline to the NSLS-II complex including the source (superconducting wiggler), required changes to the accelerator, Front End, infrastructure costs and the costs of the satellite building construction.
- Based on the project risk analysis and recognizing no contingency available, the scope of the project will be adjusted to fit within the allotted funding provided by NYSERDA and NSLS-II. A detailed review of scope and budget will be done by the Project at the time of placement of Satellite building and Hutches contracts. There are a number of potential scope reductions and these are documented elsewhere.
- The major sub-systems and project support functions include:
  - Source (superconduting Wiggler) and straight modifications
  - Front End
  - Beamline components, including monochromators, diagnostics, radiation safety components, transport pipe, vacuum equipment, control systems
  - Beamline utilities packages
  - Personnel safety and equipment protection systems
  - Project controls, ESH, QA, and Budget group staff have been estimated based on the planned needs of the project
  - Project support resources, including procurement, human resources, will be covered by overhead

2 COST ASSUMPTIONS

2.1 Key Assumptions for Estimating Cost

The following key assumptions were used to establish the cost estimate for the project:

- Type of funds included: NSLSII Ops Funds (BNL), NYSERDA (SPP)
- Base Fiscal Year: FY18 (provided by NSLSII Business Ops)
- VAB burden rates effective from FY19
- Base Estimate Includes: Direct Cost, Escalation, burdens including S&S and LDRD
- Base Estimate Does not Include: FCR (exempt)
- EPR Approved: Yes

2.1.1 Burden Rates

Burden	Rates FY18	Rates FY19 Onwards
General & Administrative (G&A)	16.40%	20.71%
Traditional	5.30%	4.6%
Common Support	11.10%	15.4%
Laboratory Directed Research and Development (LDRD)	2.30%	2.30%
Full Cost Recovery	N/A	N/A
Safeguards and Security	4.00%	4.30%
Material Burden	7.50%	7.50%

2.1.2 Total Burdens by Resource Category

Resource Category	Total Burden Rate FY18	Total Burden Rate FY19 Onwards
Labor	23.17%	27.88%
Recharge *	17.75%	27.88%
Purchases less than $25K	32.41%	11.89%
Special Material over $25K	16.96%	11.89%
Capital Equipment	11.54%	11.89%
Large Procurement (portion over $2M)	2.30%	2.30%

* e.g., BNL trade labor such as riggers, electricians, carpenters and Project Controls staff

2.1.3 Escalation

Escalation reflecting the latest guidance from the BNL budget office will be incorporated in the next version of this document by Preliminary Design Review, or when the rates are available.

If multiple effective dates are not used, the assumption is that escalation rate is same for all fiscal years through out the project (this assumption will change with the updated numbers).

Resource Type	Effective Date	Escalation Rate
Labor	1-Oct-18	3.10%
Recharge Labor	1-Oct-18	2.30%
Non Labor	1-Oct-18	2.30%

2.1.4 Rates

Salary estimates that were used for development of the baseline are determined based on average labor band rates within the NSLS-II Department. Fringe and paid absence are included in the average labor band rates.

The building trades rates are from FY18 Standard Rates

The rates below were burdened using a TMC (Total Modified Cost) methodology for FY18 and VAB (Value Added Base) methodology from FY19 onwards. These used the Budget Office's guidance on indirect rates published October 2017.

Average FY17 base year rates shown in the table below:

P6 Res ID	P6 Resource Name	Direct Rate FY18	Burdened Rate FY18	Burdened Rate FY19 with Esc
BTA_HEX2	Building Trades Assigned	97.41	114.70	127.44
BTAC_HEX2	Building Trades Carpenter - Assigned	97.41	114.70	127.44
BTAE_HEX2	Building Trades Electrician - Assigned	97.41	114.70	127.44
BTAP_HEX2	Building Trades Plumber - Assigned	97.41	114.70	127.44
BTAR_HEX2	Building Trades Riggers - Assigned	97.41	114.70	127.44
BTU_HEX2	Building Trades Unassigned	113.49	133.63	148.48
BTUC_HEX2	Building Trades Carpenter - Unassigned	113.49	133.63	148.48
BTUE_HEX2	Building Trades Electrician - Unassigned	113.49	133.63	148.48
BTUP_HEX2	Building Trades Plumber - Unassigned	113.49	133.63	148.48
BTUR_HEX2	Building Trades Riggers - Unassigned	113.49	133.63	148.48
MO1_HEX2	ME - Survey Engineer	94.78	116.74	124.97
MO2_HEX2	ME - Survey Technician	72.02	88.71	94.97
MO3_HEX2	ME - Utility Engineer	94.78	116.74	124.97
MO4_HEX2	ME - Utility Technician	72.90	89.79	96.13
MO5_HEX2	ME - Vacuum Engineer	94.78	116.74	124.97
MO6_HEX2	ME - Vacuum Technician	72.90	89.79	96.13
MO7_HEX2	Project Engineer	94.78	116.74	124.97
NA1_HEX2	Manager	163.94	201.92	216.16

NA2_HEX2	Administrative	64.83	79.86	85.49
NA3_HEX2	Administrative Secretary	53.43	65.80	70.44
NA4_HEX2	ES&H Professional	104.42	128.61	137.68
NA5_HEX2	QA Professional	99.28	122.28	130.90
NA6_HEX2	Other Professional	97.17	119.68	128.12
NA7_HEX2	IT Professional (Software)	87.23	107.44	115.02
NB1_HEX2	Project Controls	126.40	148.83	165.37
NB2_HEX2	Business Ops	64.83	79.86	85.49
NB3_HEX2	Procurement	64.83	79.86	85.49
NE1_HEX2	Electrical Engineer	97.78	120.43	128.93
NE2_HEX2	Electrical Designer	80.64	99.32	106.32
NE3_HEX2	Electrical Technician	72.17	88.89	95.15
NE4_HEX2	Controls Engineer	97.78	120.43	128.93
NO1_HEX2	Mechanical Engineer	94.78	116.74	124.97
NO2_HEX2	Mechanical Designer	76.68	94.44	101.10
NO3_HEX2	Mechanical Technician	72.90	89.79	96.13
NO4_HEX2	Facilities Technician	55.10	67.87	72.65
NO6_HEX2	ME - D&I Engineer	94.78	116.74	124.97
NO7_HEX2	ME - D&I Technician	72.90	89.79	96.13
NO8_HEX2	ME - Insertion Device Engineer	94.78	116.74	124.97
NO9_HEX2	ME - Insertion Device Technician	72.90	89.79	96.13
NS1_HEX2	Scientist	125.80	154.94	165.87
NS2_HEX2	Assistant/Associate Scientist	89.74	110.53	118.32
NS3_HEX2	Scientific Associate	73.14	90.09	96.44
NS4_HEX2	Post Doc/ Research Associate	47.54	58.55	62.68
NSU_HEX2	Building Surveyor	1	1.18	1.31
SE2_HEX2	EL - Survey Technician	72.17	88.89	95.15
SE3_HEX2	EL - Utility Engineer	97.78	120.43	128.93
SE4_HEX2	EL - Utility Technician	72.17	88.89	95.15
SE5_HEX2	EL - Vacuum Engineer	97.78	120.43	128.93
SE6_HEX2	EL - Vacuum Technician	72.17	88.89	95.15
TE1_HEX2	EL - D&I Engineer	97.78	120.43	128.93
TE2_HEX2	EL - D&I Technician	72.17	88.89	95.15
TE4_HEX2	EL - Insertion Device Engineer	97.78	120.43	128.93
TE5_HEX2	EL - Insertion Device Technician	72.17	88.89	95.15
MPO	MPO All Resources	147.93	174.18	189.19
ELC_HEX2	Electrical Power	1	1.02	1.05
NCT_Fixed_HEX2	Purchased Professionl Labor (Fixed Rate)	1	1.23	1.28
NCT_HEX2	Purchased Professionl Labor	1	1.23	1.31
NEQ_Fixed_HEX2	Capital Equipment (Fixed Rate)	1	1.12	1.12

NEQ_HEX2	Capital Equipment	1	1.12	1.15
NLP_Fixed_HEX2	Large Procurment (>$2M) (Fixed Rate)	1	1.02	1.02
NLP_HEX2	Large Procurment (>$2M)	1	1.02	1.05
NMA_Fixed_HEX2	Material (Purchase <$25k) (Fixed Rate)	1	1.32	1.12
NMA_HEX2	Material (Purchase <$25k)	1	1.32	1.14
NSM_Fixed_HEX2	Material (Purchase >$25k<$2M) (Fixed Rate)	1	1.17	1.12
NSM_HEX2	Material (Purchase >$25k<$2M)	1	1.17	1.14
NTR_HEX2	Travel Cost	1	1.32	1.14
SPC_HEX2	Space	1	1.23	1.31
CHV_Fixed_HEX2	Construction HV (Fixed Rate)	1.00	1.17	1.12
CHV_HEX2	Construction HV	1.00	1.17	1.14
CLV_Fixed_HEX2	Construction LV (Fixed Rate)	1.00	1.17	1.12

2.2 Contracting Assumptions

The beamline contracting approach will utilize one of the following procurement strategies based on the complexity and risk of the item or system being procured:

- Request for Quote (RFQ):
  - Definable requirements
  - Commercial off the shelf equipment
  - Award criterion: Lowest price
- Request for Proposal “Best Value” (RFP) Method:
  - Specifications are supported by functional requirements
  - Schedule and supplier’s past performance are an integral part of the proposal evaluation criteria
  - Evaluation criteria are developed through Souce Selection Board members
  - Performance and technical specifications are detailed
  - Suppliers’ proposals are evaluated based on overall compliance with technical requirements
  - Award criteria include: Best Value: best combination of technical evaluation results and price

2.3 Space and Electric Power

Not applicable to this project (to be confirmed).

2.4 Basis of HEX Labor Cost Estimate

The initial cost estimate for the HEX beamline was developed by a team of Photon Division Scientists and Engineers who are responsible for the planning and execution of the beamline. This team prepared the initial labor and material cost estimate, based on similar NSLS-II beamlines, which includes the design, procurement, fabrication, assembly and testing of the beamline as well as project management and support, and activities required to complete the accelerator and beamline infrastructure (source, straight, front end, hutches, utilities, EPS, PPS), and the beamline control system. The initial satellite building estimate developed by MPO was incorporated into the base estimates. The MPO team based their labor estimates on previous historical experience with the NSLS-II and NEXT project beamline satellite buildings.

In a second phase of this effort, the Cost Estimating team provided a detailed cost estimate by labor band (Scientist, Assistant Scientist, Mechanical Engineer, Electrical Engineer, Designer, Mechanical Technician, Electrical Technician, Riggers), basing the direct costs on FY17 Labor Band Rates provided by the Project Office. This cost estimating effort provided the basis and starting point for the HEX Project Beamline Managers (Control Account Managers, [CAMs]) to ensure that the detailed cost estimates fit within the approved NYSERDA budget of $25Million, plus a contribution from NSLS-II operating funds of $5M for oversight activities.

The two side branches of the beamline are currently unfunded and are marked in the P6 schedule as potential future project activities. This has now been removed from P6 following advise from POB sub panel meeting in Oct-17.

In the third phase of this effort, the cost estimating team refined the detailed cost estimates. The FY18 base year rates were used along with FY18 TMC burdens and FY19 onwards VAB burdens. The satellite building estimates are now based on the independent cost estimate.

The basis of estimate (BOE) for labor and material cost estimates is defined in the HEX project cost estimate in CEB for each resource estimated. A definition of the BOE categories and backup documentation to satisfy the BOE choice is found in the table below:

Basis of Estimate (BOE) Category	**Definition**	**Required Documentation**
Professional Judgment (PJ)	Cost estimate is based on engineering/ scientific judgment techniques such as rules of thumb from previous experience (taking a percentage of the material or other cost listed in the cost estimate), use of recognized cost estimating standards/ take-offs, etc.	Identify the rule of thumb and its source, actual cost/quantity and its source, the basis for the estimate percentage, the percentage used, the standard or code being used, or other engineering judgment basis as applicable.
Historical Costs (HC)	Cost estimate is based on actual costs or estimates from previous similar projects/ systems/equipment service. More definitive than professional judgment.	Provide PO, list of actual cost, or previous validated cost estimate spreadsheets from previous project experience (e.g., NSLS-II Beamline, Accelerator systems).
Vendor Quote (VQ)	Cost estimate is from an equipment or service supplier (design, consulting, Project Management, testing) or other industrial source of equipment or service. More definitive than historical costs.	Provide PDF, fax, email memo of phone conversation, or other indication of the quote's source. Quote should include description of items and the quoted price to be current within one year of estimate preparation. Include date quote was obtained and vendor name.
Catalog Price (CP)	Cost estimate is based on standard vendor catalog price lists or internet website prices.	Copy of catalog page or website screen shot of equipment or service to be supplied and the associated list price. Include date of quote, and vendor name.
Actual Cost this Project (AC)	Not applicable to this project	Not applicable to this project
Engineering Estimate (EE)	Cost estimate based on Engineering drawings and material take off	Engineering drawings/sketches, material take offs. Cost for line item material have to be established by either PJ/HC/VQ/CP)
Level of Effort (LE)	Project oversight and support activities	Not applicable
Similar Procurement (EP)	Cost estimate based on a similar procurement and is scalable	Means of using the scale to be established quantitatively

3 SCHEDULE ASSUMPTIONS

3.1 Key Schedule Assumptions

The HEX Beamline schedule is similar to the schedules developed for the NSLS-II and NEXT Project Beamlines. After a technically limited schedule is developed, lags/delay had to be introduced to match the project spending plan with funding profile from NYSERDA (see Reference document: NYSERDA Contract for HEX Beamline). The schedule assumptions are as follows:

- The schedule is integrated and used as a management tool by the Portfolio/Project Manager, Level 2 Managers, and Cost Account Managers. The schedule will be used to evaluate the impact of "what-if" scenarios, measure progress, and evaluate the effect of current progress on future work.
- The schedule is resource-loaded with cost estimates prepared by the Control Account Managers.
- To develop the schedule, management has evaluated risk magnitude, absolute cost magnitude, and technical complexity. Analysis of project activities by the management team identifies the following phases of work, as detailed in the project schedule:
  - Phase 1: Design of beamlines
  - Phase 2: Long lead-time procurement packages for beamlines
  - Phase 3: Remaining procurement packages for beamlines
  - Phase 4: Installation and testing of beamline components, ending with integrated testing of all components for each beamline

3.2 Advanced Procurement Plans (APPs)

The beamline APP process will utilize either a Request for Quote (RFQ) or Request for Proposal (RFP) procurement strategy depending on the complexity and risk of the component or system being procured. Based upon guidance from BNL Procurement and Property Management (PPM) shown in Appendix A, the following durations are planned:

- The standard duration for the activity string utilizing an RFP procurement strategy consists of 112 working days.
- The standard duration for the activity string utilizing an RFQ procurement strategy consists of 77 working days.

The standard RFQ and RFP activity strings can be adjusted, as necessary and by mutual agreement between the HEX Project and PPM, for a given procurement, e.g., for DOE approval of large dollar value procurement packages or for approved requests for extension of the due date for offerer proposals.

4 PROCESS FOR COST/SCHEDULE FORMULATION AND RISK ASSESSMENT

4.1 Cost and Schedule Formulation

Not applicable for this version. Will be updated before baselining the schedule.

4.2 Formulation of Resource-Loaded Schedule

The HEX Control Account Managers and the Project Controls Specialist met to decide how labor would be applied (resource-loaded) to activities in the schedule for each beamline. Each labor resource was reviewed based on the activities defined in the WBS for each beamline. The WBS for each beamline is structured similar to the standard NSLSII beamline WBS structure.

4.3 Project Risk Assessment

4.3.1 Risk Assessment and Contingency Analysis

Risks assessment during the estimation phase was initially prepared in Excel. The project cost estimate is transferred into CEB (Cost Estimating Book) for project risk analysis and basis of estimate coding using two different approaches:

- Top down risk analysis by WBS to determine the cost range. Risk at the lowest WBS level are identified by the Core Project Team using factors and multipliers by schedule, cost and technical sources as shown in Appendix B. The sum of the product of these factors results in an overall risk value that can be used to make informed decisions, determine contingency or arrive at a cost range.
- Bottoms up estimate uncertainty is also done concurrently where risks at the resource level are determined based on BOE (Basis of Estimate), (CP, VQ, AC etc). The uncertainty percentatges for the BOE types are determined by the HEX Management team as shown in Appendix C, but the CAMs have the ability to override these percentages with a valid explanation.

The above two methods can be compared directly to help establish contingency value or to determine cost range after management adjustments. The two methods of risk quantification along with Risk register can be compared and we will attempt to match the scope contingency based on the contingency analysis document.

4.3.2 Risk Register

A risk register was prepared by the CAMs in conjunction with Project Manager and Beamline Scientists, based on a review of the scope and cost/effort estimates for all lowest-level WBS elements. Technical, cost, and schedule risks were defined and an assessment of the risk consequences and likelihood of occurrence was performed. This risk assessment resulted in a contingency percentage for all risks identified at that WBS level. These

contingency percentages, weighted by the estimated cost of the WBS element to which they apply, were used as the basis for the overall contingency percentage for the project.

The output from the risk assessment results in a table of high-, medium-, and low-level risks by WBS for the project. This Risk Assessment is the basis for formulating the HEX Project Risk Register; this will be updated quarterly, or more frequently, if needed.

Appendix A - Procurement Activity Strings for RFP and RFQ

The top line in each case shows the activities and the second line shows the durations used in Primavera P6, assuming a 5 day work schedule.

The two lines below show the actual tasks to be accomplished within each P6 activity and their individual duration.

Procurement activity string and its durations for Request for Proposal (RFP).

RFP	P6 RFP Activities	PPM Accepts & pins Req	Prepare and Submit RFP				Receive Proposal	Evaluate Proposals	Negotiate with Offerors	Prepare & Approve Contract package			Contract Award	**Total**
	Working Days	0	27				25	25	10	25			0	**112**
	PPM RFP Activities	Accept Req at PPM	COMP RFQ/RFP	PPM MGT Approval	DOE PKG Approval	Issue RFQ/RFP	Receive Proposal	COMP EVAL	COMP Negotiate	Prep Proc Pkg	PPM MGT Approval	DOE Approval	Contract Award	**Total**
	Working Days	0	15	10	0 (upto 6WKS)	2	25	25	10	10	10	0 (upto 6wks)	5	**112**

Procurement activity string and its durations for Request for Quotation (RFQ).

RFQ	P6 RFQ Activities	PPM Accepts & pins Req	Prepare and Submit RFQ				Receive Proposal	Evaluate Proposals	Negotiate with Offerors	Prepare & Approve Contract package			Contract Award	**Total**
	Working Days	0	17				20	15	5	20			0	**77**
	PPM RFQ Activities	Accept Req at PPM	COMP RFQ/RFP	PPM MGT Approval	DOE PKG Approval	Issue RFQ/RFP	Receive Proposal	COMP EVAL	COMP Negotiate	Prep Proc Pkg	PPM MGT Approval	DOE Approval	Contract Award	**Total**
	Working Days	0	10	5	0 (upto 6WKS)	2	20	15	5	10	5	0 (upto 6WKS)	5	**77**

Appendix B - Factors and Multipliers for Risk Types - Schedule, Cost and Technical

Schedule Risk Factors and Multipliers

Schedule risk based contingency (%)			Schedule risk weight (%)
			1
Schedule Risk Factors	No schedule risk	0	0
	No schedule impact on any other item	2	2
	Delays completion of non-critical-path subsystem item	4	4
	Delays completion of critical-path subsystem item	8	8

Cost Risks Factors and Multipliers

Cost risk based contingency (%)			Cost risk weight (%)	
			Material cost OR Labor	Material cost AND Labor
			1	2
Cost Risk Factors	No cost risk	0	0	0
	Off-the-shelf or catalog item	1	1	2
	Vendor quote from established drawings	2	2	4
	Vendor quote with some design sketches	3	3	6
	In-house estimate based on previous similar experience	4	4	8
	In-house estimate with minimal experience related to existing capabilities	6	6	12
	In-house estimate with minimal experience and minimal in-house capability	8	8	16
	Top down estimate from analogous programs	10	10	20
	Engineering judgment	15	15	30

Technical Risks Factors and Multipliers

Technical risk based contingency (%)			Technical risk weight (%)	
			Design OR Manufacturing	Design AND Manufacturing
			2	**4**
Technical Risk Factors	No technical risk	**0**	0	0
	Existing design and off-the-shelf hardware	**1**	2	4
	Minor modifications to an existing design	**2**	4	8
	Extensive modifications to an existing design	**3**	6	12
	New design, nothing exotic	**4**	8	16
	New design, differs from established designs or existing technology	**6**	12	24
	New design, requires R&D, but does not advance state of the art	**8**	16	32
	New design, develops new technology, advances state of the art	**10**	20	40
	New design, way beyond the current state of the art	**15**	30	60

Appendix C - Cost Uncertainty Percentages Based on BOE Type

BOE Type	BOE Type Description	% Uncertainty
AC	Actual Cost this Project	0%
LOE	Level of Effort	1%
CP	Catalog Price	8%
VQ	Vendor Quote	10%
HC	Historical Costs	12%
EP	Similar Procurement	15%
EE	Engineering Estimate	20%
PJ	Professional Judgment	25%