Project Execution Plan

for the 2018-2021

NP Lattice QCD Computing Project

at the

Thomas Jefferson National Accelerator Facility
Newport News, Virginia

For the U.S. Department of Energy
Office of Science
Office of Nuclear Physics

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1 INTRODUCTION

This Project Execution Plan (PEP) describes the technical scope, schedule, cost, management organization, and control processes for a proposed NP Lattice Quantum ChromoDynamics (LQCD) Computing Project at the Thomas Jefferson National Accelerator Facility (Jefferson Lab), a project to deploy and operate a significant dedicated computing resource for LQCD calculations. This resource will play an important role in expanding our understanding of the fundamental forces of nature and the basic building blocks of matter.

The computing hardware will be housed at Jefferson Lab, and will be available to lattice gauge theorists at national laboratories and universities throughout the United States. The project is proposed to start January 1, 2018 to run through the end of FY 2021, and includes two hardware procurements and four years of operations. The total project cost is $4 million, with 50% budgeted for hardware procurements (compute + storage).

The major performance goals for the project are (1) to deploy new resources capable of an aggregate of at 180 Teraflops of performance in the clover LQCD solver, and over 400 Teraflops in batch zgemm for Spectrum graph contractions, and (2) to operate existing and future resources to deliver, over 4 years, over 0.6 Petaflops-years of integrated performance on these kernals. As a point of comparison, this would imply an aggregate Linpack performance across the two new systems of more than 1 Petaflops on Linpack.

While the clover inverter is used in this draft document, the intent is to move to using a multi-grid solver as the project performance benchmark within the first quarter of this project's execution. Multi-grid will deliver at least a factor of 2 better time to solution, and possibly as much as a factor of 5, and so will become uniformly the production solver in NP LQCD. It is already the production solver on GPUs, and will soon become so on Xeon Phi.

Over the past six years members of the United States lattice gauge theory community have worked together to plan the computational infrastructure needed for the study of QCD. Virtually all members of the community have been involved in this effort. With support from the Department of Energy (DOE) Offices of High Energy Physics (HEP), Nuclear Physics (NP), and Advanced Scientific Computing Research (ASCR) with its Scientific Discovery through Advanced Computing (SciDAC) program, prototype systems, both custom hardware and customized commodity, have been deployed, and the software needed to exploit them has been developed.

Historically, by taking advantage of simplifying features of lattice QCD calculations, it has been possible to build computers for this field that have significantly better price/performance than typical high end supercomputers or even high end clusters. The guiding principle has been to build or purchase whatever hardware best advances the science. To support the selection of hardware, software research and development on specialized systems and evaluation of commercial computers has been done under the lattice gauge theory SciDAC grant. Further ongoing development of software and algorithms under the SciDAC-4 grant will provide additional support for this project.

In the remainder of this Project Execution Plan (PEP) the relevance of the project to the DOE mission is described, and the project's technical scope, management organization, schedule, cost scope, and change control are set out.

2 MISSION NEED

The NP LQCD Computing Project directly supports the mission of the DOE's Nuclear Physics Program "to foster fundamental research in nuclear physics that will provide new insights and advance our knowledge on the nature of matter and energy...". The Project also supports the Scientific Strategic Goal within the DOE Strategic Plan to "Provide world-class scientific research capacity needed to: advance the frontiers of knowledge in physical sciences...[and] provide world-class research facilities for the Nation's science enterprise."

The Standard Model consists of two quantum field theories: the Weinberg-Salam Theory of the electromagnetic and weak interactions, and Quantum ChromoDynamics (QCD), the theory of the strong interactions. The Standard Model has been enormously successful; however, our knowledge of it is incomplete because it has been difficult to extract many of the most interesting predictions of QCD. To do so requires large-scale numerical simulations within the framework of lattice gauge theory.

The objectives of these simulations are to fully understand the physical phenomena encompassed by QCD, to make precise calculations of the theory's predictions, and to test the range of validity of the Standard Model. Lattice simulations are necessary to solve fundamental problems in high energy and nuclear physics that are at the heart of the DOE's large experimental efforts in these fields.

Major goals of the experimental programs in high energy and nuclear physics on which lattice QCD simulations will have an important impact are to: 1) verify the Standard Model or discover its limits, 2) understand the internal structure of nucleons and other strongly interacting particles, and 3) determine the properties of strongly interacting matter under extreme conditions, such as those that existed immediately after the "big bang" and are produced today in relativistic heavy ion experiments. Lattice QCD calculations are essential to the research in all of these areas.

3 FUNCTIONAL REQUIREMENTS

3.1 Computational Requirements

Two classes of computing are done for lattice QCD. In the first class, a simulation of the QCD vacuum is carried out, and a time series of configurations, which are representative samples of the vacuum, are generated and archived. Multiple ensembles with varying lattice spacing and quark masses are generated, and sets of ensembles are generated using several different numerical approaches. This class of computing requires machines capable of sustaining hundreds of Tflops for days or weeks at a time.

The second class of jobs, the analysis phase, uses thousands of archived configurations from each ensemble to calculate quantities of physical interest. A wide variety of different quantities can be calculated from each ensemble. These analysis computations also require large floating-point capabilities; however, the calculations performed on individual configurations are independent of each other. Thus, analysis computing can rely on multiple machines or partitions each capable of sustaining 1% of the performance of the largest jobs (i.e. hundreds of Gflops to a few Teraflops), with a total aggregate computing capacity of tens to hundreds of Tflops.

In summary, to meet the requirements of 180 Tflops, it is sufficient to have (for example) of order 100 machine partitions, each with of order 1800 Gflops performance. It is the purpose of this project to address this second class of jobs, with typical jobs using 1-8 nodes within a medium size cluster.

3.2 I/O and Data Storage Requirements

During vacuum configuration generation, data files specifying each representative configuration must be written to storage. These files are of order 1 to 10 Gbytes in size, with a new file produced every few hours. During the analysis stage, propagation of quarks must be calculated on each configuration. This requires the numerical determination of multiple columns of a large sparse matrix. The resulting "propagators" are combined to obtain the target measurements. Propagator files for Clover quarks are 16 times larger than the corresponding gauge configuration. Eight or more propagators are calculated for each gauge configuration in an ensemble. Because of the large computational resources needed to generate them, they are often written to external storage for later reuse. Because many independent analysis streams can run on a given lattice QCD machine, substantial aggregate I/O rates (GBytes/sec) are required during the loading of configurations and the storage of results in order to sustain 180 Tflops. The current Jlab system has the needed bandwidth, and anticipated replacements should provide a modest amount of additional headroom.

3.3 Network Requirements

Configuration files will be generated at supercomputing centers, and transferred to Jefferson Lab. This represents a very modest network bandwidth requirement, less than 1 Gbit/s on average today, growing to perhaps 5 Gbps on average. The larger propagator files will typically be generated and consumed at the same site (Jefferson Lab in this case) and so do not represent a large wide area network bandwidth requirement. Jefferson Lab’s current 10g WAN connection is more than adequate today, and will grow to 40g as the LQCD requirements grow towards 5g.

4 TECHNICAL SCOPE

The proposed NP LQCD Computing Project consists of the purchase of two medium scale high performance computing resources, plus 4 years of operations. The first resource will be across the FY2018-FY2019 fiscal boundary (i.e. in calendar 2018), and the second across the FY2020-FY2021 boundary (deployed in calendar 2020).

4.1 Computing Systems - Nodes and Networks

USQCD computing resources have evolved to include a mix of resources, including conventional x86 cluster, GPU clusters, and most recently a Xeon Phi (KNL) cluster at Jefferson Lab. NP applications have done particularly well on the advanced GPU and KNL architectures, and going forward those applications will drive the procurement choices.

As the software evolves and the hardware landscape changes (including costs), the most cost effective architecture will also change. All solutions for the mid-range resources over the last decade, however, have remained cluster solutions, where the software uses MPI to span a small number of nodes to reach the desired memory footprints and performance per job.

In the time period of this project, cluster solutions are expected to remain optimal, and the project will evaluate both Infiniband and Omnipath network fabrics, as well as a number of alternative node configurations, including conventional (e.g. SkyLake Xeon processors), Xeon Phi, and GPU accelerated nodes, where lower cost gaming cards or other specialized accelerators could also be evaluated to augment the high performance of modern CPUs.

4.2 Operations

The operation of the lattice QCD systems will involve physical facilities (buildings, power, cooling), system administration, hardware and software maintenance, configuration management, cyber security, data storage, and data movement.

The computers will be installed in the recently upgraded Data Center at Jefferson Lab, which has adequate space, cooling and power today for the proposed resources.

Archival storage of physics data will utilize the existing Jefferson Lab tape library, an additional contribution by the laboratory. This project will cover the cost of tape media and slots but not the maintenance of the library itself, and the tape cost is counted in the storage budget.

On a periodic basis, currently twelve months, US collaboration members will be allocated computing time by the USQCD Scientific Program Committee. This committee allocates time in an integrated fashion for the supercomputers (including DOE Incite awards), the HEP LQCD (Institutional Cluster) Project facilities, and this new NP LQCD Computing Facility.

It is proposed that this project will take over the operation of the existing USQCD resources at Jefferson Lab, including (1) the 2016 260 node KNL cluster, (2) the 2012 256 node Xeon cluster, (3) the 2012 45 node quad Kepler GPU cluster, and (4) the 1 PB Lustre file system (half of a 2 PB system shared with experimental nuclear physics). The 2012 clusters will be retired as the first 2018 machine is installed.

4.3 Deliverables

The major deliverable for the project are (1) a new compute resource each two years, and (2) annual operations of the resources for science. Performance metrics are currently quoted as clover bicg solver performance. These will later be replaced with clover multi-grid performance numbers as the code matures sufficiently (by March, 2018).

Each year the NP LQCD Computing Project will have a deliverable of integrated running time measured in Teraflops-years, corresponding to running the resources from the target date of production running with an uptime of 90%. Operations funded by this project will continue through the end of FY2021, or approximately 3.75 years. Over the life of the project, this will be 580 Tflops-years of integrated performance.

The two new resources will be procured in two steps across the fiscal year boundaries of FY2018-FY2019 and FY2020-FY2021. The first phase hardware will be installed by the end of October with production running by Dec 1, and the second phase by the end of November with production running by the following Jan 1. Thus performance increases occur in the 2nd quarter of the deployment fiscal years.

In the first 9 months of the project, there is a deliverable on the existing resources of 112*3/4=84 teraflops-years of integrated running. By the end of the calendar year, 46 TFlops is replaced by 76 with no time lost yielding 112 + 30*3/4 = 134 Tflops in year 2, becoming 142 TFlops in year 3.

Two years later, an additional resource of 104 Tflops yields a FY2020 increase of 78, so 220 Tflops for that year. At the end of the project, 16p might turned off (66 TFlops), leaving the new 180 Tflops for ongoing use.

	FY 2018 (9 mo.)	FY 2019	FY 2020	FY 2021
Delivered integrated performance goal, Tflops-yr	84	134	142	220

Table 1 – Annual Integrated Sustained Performance

Basis of estimates: Intel KNL nodes will be at least 10% less expensive than the 16p procurement based upon the current market. NVIDIA P100 GPU nodes have fallen 2x since the time of the 16p procurement, and so a mixed GPU:conventional solution might deliver even better performance than a KNL solution for the FY18-FY19 purchase. Two years later the market should provide solutions at least 50% better, and in fact might be closer to 80% better, so the later purchase and integrals are conservative. Assumptions include spending 6% of the FY18-FY19 funds on file servers (where more compute capacity than disk capacity is being retired), and 8% of the FY20-FY21 hardware funds on file servers (compute capacity is all new, nothing retired).

MANAGEMENT ORGANIZATION

This section presents the management organization for the LQCD ARRA Computing Project. The management plan also facilitates the involvement of the scientific community that will be the ultimate users of the infrastructure. The figure below shows the management structure.

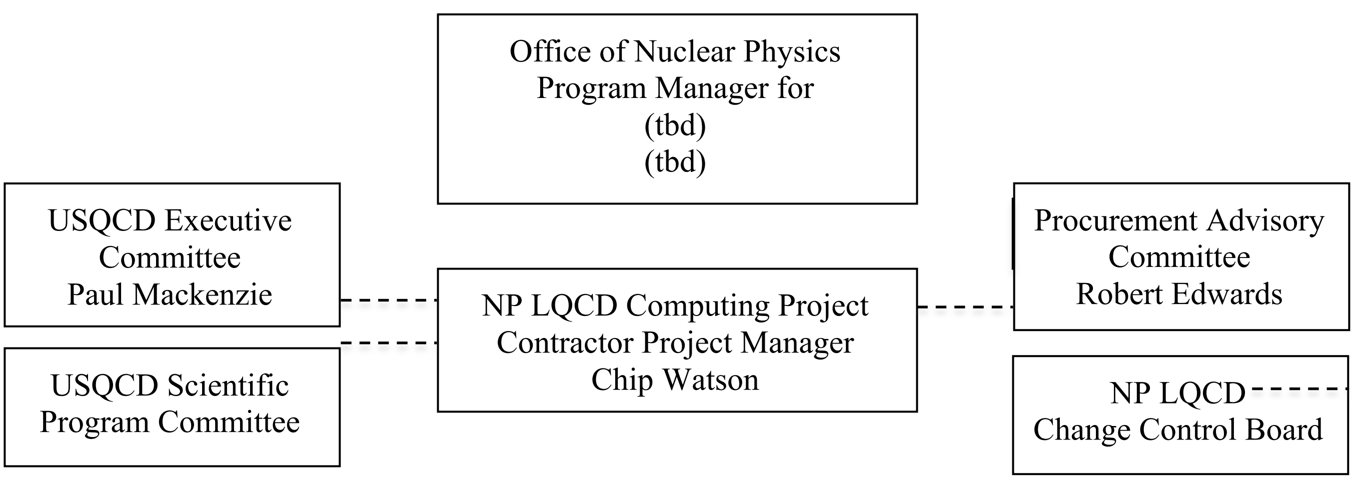

Figure 1. Management Organization Chart for the NP LQCD Computing Project. Vertical lines indicate reporting relationships. Horizontal lines indicate advisory relationships.

4.4 Department of Energy Program Manager

Within DOE's Office of Science (SC), the Office of Nuclear Physics (NP) has overall DOE responsibility for the NP LQCD Computing Project. (TBD: NP program manager)

The DOE Program Manager responsibilities include:

- Provide programmatic direction for the NP LQCD Project
- Function as DOE headquarters point of contact for NP LQCD Project matters
- Oversee NP LQCD Computing Project progress and help organize reviews as necessary
- Budget funds for the NP LQCD Project
- Control changes to the NP LQCD Project baselines in accordance with the PEP

4.5 Contractor Project Manager

The Contractor Project Manager, responsible for the overall management of the project, manages project execution. This person is responsible for insuring that the project is well defined (via a work breakdown structure, WBS) and tracked (via milestones), and is the key interface to the Department of Energy for financial matters, reporting, and reviews of the project. As the manager of the project, the Contractor Project Manager has significant budgetary control, and is in the approval chain for all major project commitments and procurements. The Contractor Project Manager will be Chip Watson. This person will be referred as CPM in all project documents.

Responsibilities

- prepares detailed planning documents for the project, including a work breakdown structure (hierarchical list of tasks, with each task defined at a level that can be externally reviewed, and with individuals responsible for those tasks well identified, and a set of project milestones to rigorously track progress
- prepares and approves proposed budgets consistent with the detailed planning documents
- provides final approval for the project of all major (> $50K) procurements
- prepares quarterly and/or annual project status / progress reports
- provides internal project oversight and review, ensuring that funds are being expended according to the project plan, and identifying weaknesses in the execution of the project plan which need to be addressed
- establishes and manages a project change control mechanism

Interactions

- reports to the DOE Program Manager
- serves as a point of contact with DOE on matters related to budget and schedule of all funded activities

4.6 USQCD Committees

The charter of the USQCD **Executive Committee** is to provide leadership in developing the computational infrastructure needed by the United States lattice gauge theory community to study quantum chromodynamics (QCD). This responsibility spans the current project and other QCD computing projects and computing allocations. The Executive Committee has responsibility for setting scientific goals, determining the computational needs to achieve these goals, developing plans for creating the infrastructure, obtaining funds to carry out these plans, and overseeing the implementation.

Current members of the Executive Committee are expected to serve for the duration of the project. If a vacancy occurs, it will be filled by a vote of the remaining members of the committee. The current chair is Paul Mackenzie of FNAL.

Responsibilities

- sets the scientific goals and determines the computational needs to achieve them
- establishes procedures for the equitable use of the infrastructure by the national lattice gauge theory community
- arranges for oversight of progress in meeting the scientific goals
- arranges regular meetings of the national lattice gauge theory community to describe progress, and to obtain input
- appoints the members of the Scientific Program Committee

The charter of the **Scientific Program Committee** is to assist the Executive Committee in providing scientific leadership for the Lattice QCD Infrastructure Effort. The Program Committee monitors the scientific progress of the effort, and provides leadership in setting new directions.

The Scientific Program Committee is charged with allocating time on all of the hardware that will be operated under the project, as well as other resources shared by the USQCD Collaboration. The Committee has instituted the following allocation process. Once a year it solicits proposals for use of the computational resources that will be available to the user community during the allocation period. The Committee reviews the proposals, and makes preliminary allocations based on its reviews. It then organizes an open meeting of the user community to discuss the proposals and the preliminary allocations. The Committee makes final allocations following this meeting. The objective of this process is to achieve the greatest scientific benefit from the resources through broad input from the community. The Committee is also charged with organizing an annual meeting of the user community to review progress in the development of the infrastructure and scientific progress achieved with the infrastructure, and to obtain input on future directions.

Members of the Scientific Program Committee are appointed by the Executive Committee. The current members are expected to serve for the duration of the project. If a vacancy occurs, it will be filled by the Executive Committee.

Responsibilities

- organizes annual meeting of the users community
- solicits proposals for using LQCD computational resources
- allocates computing resources

4.7 Procurement Advisory Committee

The Procurement Advisory Committee provides additional input to the project on the hardware alternatives under consideration for each of the even year procurements. The advice includes input on the software maturity and software developments planned within the NP LQCD SciDAC-4 project. The committee is chaired by Robert Edwards, who is also the P.I. of that project.

4.8 Change Control Board

The Change Control Board (CCB) is composed of the Contractor Project Manager (representing the project), the Chairman of the Procurement Advisory Committee (representing software development), a member appointed by the USQCD Executive Committee (representing users) and the Jefferson Lab Chief Information Officer (representing the host institution). The purpose of this committee is to assure that changes to the project are managed with the primary focus on the advancement of the scientific goals of the project. The CCB acts on change requests according to the procedures described in section 7 below.

Responsibilities

- evaluates feasibility, cost, and impact of proposed changes to the project which result in more than a minimal cost or schedule change

Interactions

- gathers input from the project participants and the user community about project scope changes

4.9 Interaction of Host Laboratory Management and the Project

Management of the host laboratory, Jefferson Lab, provides oversight and supplemental support to the project including all line management duties such as staffing, safety, etc. Management authorities for DOE and senior upper management of the host laboratory are shown in Figure 2.

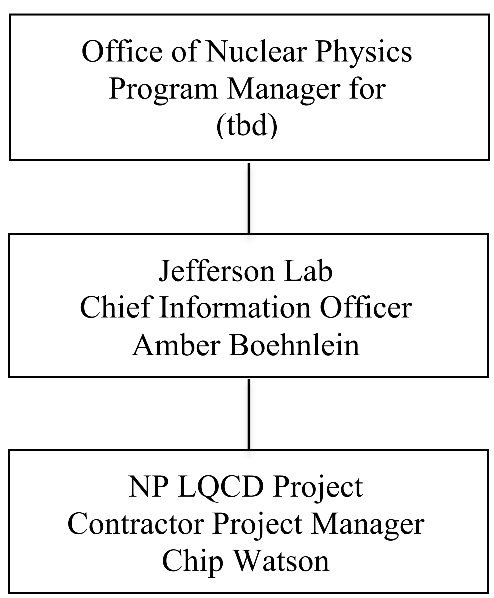

Figure 2. Management Authorities Chart for the LQCD Computing Project.

5 SCHEDULE AND COST

The project is organized into a WBS for purposes of planning, managing and reporting project activities. Work elements are defined to be consistent with discrete increments of project work and the planned method of project control. LQCD has three major WBS Level 1 components:

Planning: Includes all project management activities
Deployment: Includes all site preparation, acquisition and deployment of the LQCD ARRA resources in two phases.
Operations: Includes operation of the facility to serve the LQCD researchers for the four years of the project.

5.1 Project Milestones

The Level 1 project milestones defined in the project WBS are shown in Table 2. Any significant changes to milestone schedules will be processed according to the change control procedure.

Milestones	Date
Project Start	1/18
Issue Request for Proposal (RFP) for first disk and compute cluster	7/18
Place order for first phase of first disk and compute cluster	9/18
Place order for second phase of first disk and compute cluster	10/18
Begin early use on first cluster	12/18
Production running on first cluster	1/19
Complete Annual Peer Review of NP LQCD Project (June of each year)	6/19
Complete Annual Peer Review of NP LQCD Project and plans for 2nd procurement	6/20
Issue Request for Proposal (RFP) for second disk and compute cluster	7/20
Place order for first phase of second disk and compute cluster	9/20
Place order for second phase of second disk and compute cluster	10/20
Begin early use on second cluster	12/20
Production running on second cluster	1/21
Complete Annual Peer Review of NP LQCD Project	6/21

5.2 Budget

The total project cost for the NP LQCD Computing Project is $4 million ($1M/year). Equipment costs include system acquisitions (computers, networks) and storage (disk and tape). Labor costs include system administration, engineering and technical labor, and project management. Indirect costs will be applied according to Jefferson Lab standards. All labor estimates have been inflated using escalation rates of 3%.

WBS	Name	Total Cost K$
1.	Project Planning and Management	110
2.	Deployment	
2.01	2018 Phase 1 deployment incl. $64K procurement labor	550
2.02	2018 Phase 2 deployment	500

2.03	2020 Phase 1 deployment incl. $72K procurement labor	500
2.04	2020 Phase 2 deployment	490
3.	Operations	
3.01	Year 1 (9 months)	350
3.02	Year 2	485
3.03	Year 3	500
3.04	Year 4	515
	Total Project Cost	**4,000**

Table 3 – Cost Summary by WBS with contingency

5.3 Procurement Strategy

The overall strategy for the computational resource is the same strategy as has been used by the ARRA LQCD Computing Project, and the LQCD Computing Project for the last 10 years: always procure the system which provides the best performance for the anticipated workload, under the constraints of what the software is capable of supporting.

As described above, the project has been divided into two procurements, with two types of components planned for the computational system: cluster nodes, file storage nodes.

The target job performance is set at about 1% of the performance now being achieved on leadership class machines doing configuration generation, as described in section 3.1 above.

The first procurement will likely include some amount of conventional resource for very unoptimized applications and ad-hoc use (best match). The remaining funds could either go into expanding the 16p cluster (leveraging its existing routers but otherwise separate), or into GPU accelerated nodes.

The split between a standard nodes and advanced KNL nodes or GPU enabled nodes will be driven by software maturity. The fraction going into advanced architectures is expected to be higher in the second procurement since the need for conventional (to replace 12s) will have been addressed in the 2018 procurements.

The relative merits of different hardware choices will be evaluated by the hardware selection committee, and expressed as benchmark applications for the best value procurement, where the selected benchmarks in June of 2018 and June 2020 reflect anticipated running for the coming 2 years, and take into account the existing USQCD hardware portfolio, with a view towards optimizing aggregate performance for science across all systems.

Disk server capacity and performance requirements are projected based upon a roughly 2x increase from 112 Tflops sustained to 220 Tflops sustained at Jefferson Lab. Budget was set assuming an average over 3 years of $80 / Terabyte at the bandwidth needed.

All procurements will be best value with a firm fixed price award, acquiring as much performance or capacity as can be obtained within budget (build to cost).

6 CHANGE CONTROL

Changes to the technical, cost and schedule baselines will be controlled using the thresholds described in Table 4, below.

All changes that include or exceed Level 2 approval thresholds are to be documented by the Contractor Project Manager. For changes exceeding Level 2, the Contractor Project Manager will document the change using a Change Request (CR) form and transmit the CR to the Change Control Board (CCB, section 5.4 above) with recommendations. If the request exceeds the Level 1 threshold, the CCB will submit the CR to the DOE Program Manager for approval or rejection of the request.

The CCB must approve all changes resulting in a shift of more than $200K (10%) between equipment and labor budgets, or any one month or greater delay of a level 1 WBS milestone. The Contract Project Manager will present such changes to CCB for approval before executing any changes. All changes approved by CCB will be reported to DOE. Changes that might result in any increase in the total project cost or a 3-month or greater delay in a level 1 WBS milestone or a change that could adversely affect project performance specifications must in addition be approved by DOE prior to executing the change.

If a change is approved, a copy of the approved CR, together with any qualifications or further analysis or documentation generated in considering the request is to be kept by the Contractor Project Manager as part of the project documentation. If approval is denied, a copy of the CR, together with the reasons for denial, is to be filed.

Level	**Cost**	**Schedule**	**Technical Scope**
DOE Program Manager (Level 0)		> 3-month delay of a Level 1 milestone date	Change of any WBS element that could adversely affect project performance specifications
CCB (Level 1)	A cumulative increase of more than $200K in WBS Level 2	> 1-month delay of a Level 1 milestone date	Any deviation from technical deliverables that does not affect expected project performance specifications.
Contractor Project Manager (Level 2)	Any increase of > $50K in the WBS Level 2	> 1-month delay of a Level 2 milestone date	Technical design changes that do not impact technical deliverables.

Table 4: Summary of Change Control Thresholds

7 SAFETY AND RISK MANAGEMENT

7.1 Environment, Safety and Health

7.1.1 Integrated Safety Management (ISM) Plan

Environment, safety and health (ES&H) will be integrated into all phases of planning, acquisition and maintenance of the project using appropriate procedures defined by the host laboratory. The Project will follow the five core functions of ISM:

- Define work and identify the potential hazards
- Analyze potential hazards and design the equipment or activities to appropriately mitigate or eliminate those hazards
- Establish controls for hazards that cannot be eliminated through design features
- Perform work in accordance with the procedures
- Review the effectiveness of the hazard analyses and controls and provide feedback for improvement.

The line management of the laboratory retains supervisory authority of their personnel and responsibility for the safety of work at the laboratory. Line management will keep the Contractor Project Manager informed about their laboratory's management and ES&H organization structures. Any safety concerns by Project personnel are to be communicated to the Contractor Project Manager and to the line management where the concern occurs.

The Contractor Project Manager will work with safety officers at the laboratory to ensure that the specific hazards found in the project are documented according to plans and procedures of the laboratory and mitigated appropriately. Information pertaining to these hazards will be documented. Also, laboratory personnel will receive specific training required or recommended for project to perform their job in a safe and proper manner. The Contractor Project Manager is responsible for verifying that the staff members have received appropriate training and that this training is documented.

Applicable electrical, mechanical, etc. codes, standards and practices, will be used to ensure the safety of personnel, environment, equipment and property and will be integrated into the project. Where these codes, standards and practices are in conflict, the most stringent or most appropriate will be selected. Reviews will assess compliance with these codes, standards and practices. All equipment purchased from manufacturers must comply with Underwriters Laboratories Inc. or equivalent requirements, or it will be reviewed for safety. The results and conclusions of these reviews, when applicable, will be documented.

7.1.2 NEPA

There is no direct construction activity associated with the project. From past experience at the three USQCD deployment sites covering a range of research and related activities, it is anticipated that the Project will be determined to be included under Categorical Exclusion.

7.1.3 Quality Assurance

The NP LQCD Project defines Quality as the "fitness of an item or design for its intended use" and Quality Assurance (QA) as "the set of actions taken to avoid known hazards to quality and to detect and correct poor results." NP LQCD will follow established quality control procedures of the host laboratory.

7.2 Risk Assessment

Because of the build-to-cost nature of the project, LQCD has low risk of not completing on cost. The cost estimates are based on the actual cost of labor for deploying and operating the existing facilities. Hardware component cost variances will result in adjustments to the sizes of the computing systems deployed. There is a modest contingency (10%) on labor and deployment costs other than the major procurement purchases. Out year operations are well known to an accuracy smaller than this. If deployment labor costs exceed this contingency, a small adjustment in the Phase 2 procurement could be done to compensate (most deployment costs occur prior to the Phase 2 award).

The performance risks associated with the planned computing and network systems are estimated to be low due to the successful R&D performed during the ongoing SciDAC-4 project, and also due to the use of common off the shelf components whenever possible. The performance milestones are based primarily upon the performance of existing systems and by knowledge of near term new hardware. Contingency is built into the estimates of the performance of the systems that will be acquired during the project through the use of conservative estimates of vendor pricing.

The most important schedule risks are delays in releasing new systems to production after their procurement caused by difficulties in integrating the computer, network, and software subsystems, and delays resulting from slippage in vendor schedules. Integration delay risks are low when new systems are based on components previously used on earlier LQCD clusters, specifically Infiniband clusters and file servers.

7.3 Cyber Security

The Project resources will be installed in the Jefferson Lab Scientific Computing network enclave. This enclave has access control which makes it inaccessible directly from offsite, and has rules governing access from onsite. As described in the enclaves cyber security documentation, the compute nodes are in non-routed subnet(s), and access is only via interactive gateway notes. All nodes except the compute nodes are scanned for vulnerabilities daily, with a deeper scan conducted once a week. The systems are maintained according to Jefferson Lab cyber security policies, and the system will be operated under Jefferson Lab's Authority To Operate. Cyber monitoring of the scientific computing enclave is performed by the cyber security group; this service is an in-kind contribution from the laboratory.