Fermilab

Closeout Presentation

Director's CD-1 Review of PIP-II

October 10-12, 2017

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1.0 Executive Summary

2.0 Introduction

A Director's CD-1 Review of the Proton Improvement Plan II Project (PIP-II) was held on October 10-12, 2017 at Fermilab. The focus of this review is the readiness of the project to proceed to the DOE CD-1 review planned in December 2017.

PIP-II is a high intensity proton facility being developed to support a world leading neutrino program at Fermilab. PIP-II will upgrade the Fermilab accelerator complex to provide beam power in excess of 1 MW on target at the initiation of the Long Baseline Neutrino Facility operations, and is part of a long term plan to achieve multi-MW capabilities at Fermilab. PIP-II received CD-0 approval in November 2015.

2.0 Technical

2.1 Conventional Facilities

Subcommittee: Brad Bull, Russ Alber

Charge Questions:

- Does the conceptual design satisfy the performance requirements?

  Yes

- Does the conceptual design support the stated cost range and duration?

  Yes, but does depend work being performed by the Lab

Findings

- Resource Loaded Schedule is technically limited – CD-4 Early Q2FY26
- A/E team was selected in February 2017
- CF work was split into work packages by building systems and plan on a design-bid-build approach for construction packages
- Cost estimate was performed by A/E in May 2017 and had contractor on board
- Recycler and Main Injector Improvements will be added to the current scope
- Conventional Facilities KPP's – Threshold: Tunnel enclosures and service buildings ready to support 700 MeV SRF linac and transfer line to the Booster (met in base design) – Objective: Tunnel enclosures to support 1 GeV SRF linac and transfer line to the Booster. Service Buildings to support 800 MeV SRF Linac and transfer line to the Booster.
- DOE pre-validated Alternate Analysis – HEP has selected a CW SRF linac as the preferred option
- Teamcenter is used to document approvals and any documents requiring signoff. DocDB is used to store data. Local network is used for working documents.
- CF has identified $19.6M in EDIA costs with $103.1M in construction costs resulting in a soft/hard cost ratio of 19% which is in line with DOE Estimating Guideline range of 15%-25% which is normal for DOE projects.
- 3D model – buildings in Revit
- Preliminary Life Safety Analysis has been completed.
- Plans to meet High Performance Sustainability Plan is in place – initial checklist is in place and principles are adequately incorporated in this level of conceptual design – approved by project.
- Booster Tower East demolition is included in scope PIP2 Fermilab Interface Document.
- Project Defection Rating Index Analysis (PDRI) is complete at CD-1 and CF team will perform again at CD-2.
- Commissioning agent on board CD-1 thru the general A/E.
- FRS has 4 items are specific to CF - all items addressed.

Comments

- The inclusion of a contractor on the A/E team to provide estimating support is commendable
- CF should re-evaluate the wetland mitigation costs being carried in the estimate which shows a anticipated cost of ~$1M but based on recent experience the actual cost may be two to three times higher
- Electrical design assumes looped feeders originating from one source, Master Substation, with backup Feeder 46A from Kautz Road for house power only. The Project should consider a design configuration that would include redundant feeders from both substations that would handle the full load and conforms to FESS design standards for safety and maintenance.
- Should include Lab contributions and matrixed staffing needs in the PIP2 Fermilab Interface Agreement (MOU) between the project and the Laboratory. The agreement should also capture any facility/scope work assumed in the base design, i.e. eliminating shield blocks, redundant electrical feeds, etc.
- Consider adding at least a level 3 staff member to the CF group as close to CD 1 as possible
- Strongly consider including the 3D model for technical systems into the model produced by CF to have a fully integrated model. This will prove extremely valuable to avoid conflicts and to more effectively and efficiently construct both CF and technical scopes of work
- Cryo Plant Cooling – baseline includes direct flow of ICW with a phased approach for adding capacity in the future but is currently only sized for the baseline (pulsed mode) cooling needs. This approach and the requirements should be signed off on by the cryo group
- Project team should consider additional radiation concerns associated with the increased Booster beam energy and consider if any additional shielding measures are needed around the Booster
- Consider if the Central Utility Building (CUB) Addition's space for future use can be used to take the place of the proposed Utility Building sited at PIP2 and list it as a possible value engineering or "opportunity" risk. This would help to create scope contingency
- Plans are in place for the One-For-One Replacement Strategy and for showing compliance with the 2017 Real Property Related to Operations, but the project should secure concurrence and signoff for space offset plan from DOE prior to CD-1 review
- Verify that all building/facility names are consistent across all CD-1 documents including CDR drawings, cost estimates and presentations

Recommendations

1. Secure signoff of the PIP2 Fermilab Interface Document with the Laboratory by the CD-1 review

2. Secure signoff of current Technical Requirements Specifications (TRS) and Functional Requirements Specification (FRS) documents in process by the CD-1 OPA Review

2.2 Cryo Systems

Subcommittee: Camille Ginsburg, Olivier Napoly

Charge Questions:

- Does the conceptual design satisfy the performance requirements?

  Yes, to within the planned R&D.

- Does the conceptual design support the stated cost range and duration?

  Yes, with some assumptions for in-kind contributions.

Findings

- Microphonics and Lorentz force detuning are designated the most important technical risks for cryomodules.
- The HWR cryomodule (qty 1) is at an advanced stage, with couplers being the last major concern. This cryomodule is expected to be delivered to FNAL PIP2IT about a year in advance of its test, and shall be kept under vacuum during that time (except no pumping during transportation).
- SSR1 cryomodule (qty 2) production is well advanced with qualified bare cavities, STC tests of dressed cavities underway and disclosing a potential coupler cleanliness problem.
- SSR2 cryomodules (qty 7) production is on the critical path of the project.
- There is a sharing of responsibilities and commitments between DAE and FNAL regarding the production of the SSR2 cavities, from the design to the fabrication of the prototype cavities. This is introducing some dependencies with a strong impact on the upfront development plan and the schedule for the first prototype cryomodule production and test over a period of 5 years. The remaining 17 months are devoted to the cavity fabrication (20 in India and 20 at FNAL) and assembly and installation of the 6 remaining SSR2 cryomodules, including RF qualification test for 3 cryomodules.
- In-kind partners are responsible for the entire LB650 cryomodules, other than oversight.
- In-kind partners are responsible for the entire LB650 cryomodules (qty 11), other than oversight. These cryomodules are in a very preliminary state.

- The HB650 cryomodules (qty 4) are in a preliminary state, with four pre-prototype cavities (at beta=0.90 instead of 0.92) having been fabricated and tested, which will be dressed and be installed in the first cryomodule, to meet schedule. Some HB650 activities currently in FNAL (DOE) scope are expected to be transferred to in-kind contributions.

- Most cryomodules will be tested at FNAL: Both SSR1's, 4 of 7 SSR2's, 6 of 11 LB650's, and 3 of 4 HB650's.

- The cryoplant procurement takes advantage of an existing ESS design, which is adequate for the 2K heat load, and will be augmented by another smaller cryoplant which can be procured on a longer timescale.

Comments

- With at least one exception of the cryoplant, procurements by in-kind partners are not overseen by FNAL. FNAL provides specifications and requirements, only. Experience from other projects indicates that many technically challenging procurements cannot be reasonably ensured for success solely by supplying documentation up front, and must be actively managed by technical oversight throughout the procurement. In addition, the common FNAL procurement technique of limiting bids to "qualified" vendors is not universally used by in-kind partners, which would increase the amount of necessary vendor oversight.

- The design cryoplant capacity for dynamic heatload at 2K is 1594.9 W plus a 10% safety margin, making assumptions on cavity Q0 for which there are no physical cavities yet (SSR2, LB650 and HB650). If the actual Q0 for LB650 (worst case) with respect to the assumption were 25% low, the safety margin would be exhausted. While the initial tests with nitrogen doping on the pre-prototype 650 MHz cavities are promising, only three of the four cavities met the assumed Q0 spec.

- The tasks and milestones along the SSR2 cryomodules production project are not sufficiently clarified.

- The milestones for LB650 and HB650 are currently defined by project needs, and once they are fleshed out with actual plans with in-kind partners, they may be on the critical path.

- The prototype SSR1 cryomodule will undergo a global qualification system test together with the HWR cryomodule at PIP2IT with RF and beam, to be completed in 2020. This should allow a full system test including in-phase beam acceleration and measurement of dark current.

Recommendations

3. CD-1 presentations should give plausibility arguments or data demonstrating that the Q0 spec is reasonably achievable within a 10% cryoplant safety margin on dynamic 2K heat load. Where substantial uncertainty exists and substantial impact could be observed, embark on a limited development program to confirm or re-assess the Q0 spec, to be completed prior to CD3a.

4. Expand the schedule of SSR2 production project at FNAL to a higher level of detail, and indicate the dependencies with the parallel developments at DAE, prior to the CD-1 review.

5. Since the test plan and test infrastructure are key components of cryo design verification, for the CD-1 review, include a talk on cavity, dressed cavity, and cryomodule testing in the cryo breakout.

6. In the CD-1 plenary talks, describe how test plans address the key technical risks. In the CD-1 breakouts, clearly explain specifically how R&D and/or test plans retire the most significant technical risks. This is in addition to showing the risk registry elements.

7. The importance and impact of HWR and SSR1 integrated tests at PIP2IT with RF and beam should be highlighted in CD-1 presentations.

8. In the CD-1 review, clarify the cost, schedule and technical risk of not testing some cryomodules, especially those at lower beta, and the associated risk mitigation.

2.3 Accelerator Support Systems

Subcommittee: Mike Syphers, John Byrd, Rob Connatser

Charge Questions:

- Does the conceptual design satisfy the performance requirements?

  Yes

- Does the conceptual design support the stated cost range and duration?

  Yes. For accelerator support systems, much of the front-end exists and will be demonstrated over the next few years. This substantially reduces the uncertainty on the cost estimation for these systems. The PIP-II team has extremely strong expertise in these systems, also supporting the presented cost range and duration. The only remaining estimate that may need refinement is the manpower during peak installation periods.

Findings

- Initial PIP-II injector (PIP2IT) beam tests have been performed. Fast chopping with arbitrary 162.6 MHz bunch patterns have been demonstrated using 200 Ohm chopper.
- PIP2IT has delivered 2.1 MeV beam at 20 Hz, with 2 mA average current.
- As part of PIP-II, the Booster will be upgraded to run at 20 Hz, from 15 Hz, and to facilitate 800 MeV injection. This system will require a new injection foil system, a new beam dump, a new magnet power supply system, and two new injection girder combined-function magnets to make room for the new injection system.
- For the project, the Recycler RF system will require three new 53 MHz RF cavities to provide higher voltage with requisite increased RF power. A mock-up of this cavity has been produced and the design validated by measurements of the cavity Q.
- PIP-II beam intensities will require that the Main Injector RF system be upgraded. The 20 RF cavities in the MI will be outfitted with either a second Power Amplifier (option 1, preferred), which can fit on the existing cavity, or with a new higher-power Power Amplifier (option 2).

- The warm front end for PIP-II will be the PIP2IT system being installed and commissioned at the Cryomodule Test Facility.
- The MEBT used in PIP-II requires a short extension from the MEBT used in PIP2IT, on the scale of three typical focusing units.
- The Engineering Process Data Management system, a FNAL system, is in place and is being exercised regularly by the team.
- The Booster team has already been through a 7.5 Hz to 15 Hz upgrade (PIP) and the complex has had successful running at 14 Hz (15 Hz has not been requested by the physics program) for more than six consecutive months.
- The Booster injection girder design requires two new magnets to "make space" in the straight section for new equipment. The two defocusing gradient magnets will each be 15% shorter than normal.
- The PIP2IT RFQ has been operated at full RF power, with 98% transmission at 2.11 MeV +/- 0.5%, meeting its system specifications.
- General Support Services is working closely with the technical teams and Conventional Facilities to ensure appropriate technical requirements and space allocation are provided. The planned use of fixed price contracts for installation is appropriate.
- Installation and Integration planning is at the appropriate level for CD-1.
- Except for PIP2IT/WFE, very little was presented on the commissioning work and planning.
- A full suite of instrumentation is planned for the frontend and linac ranging from monitors of beam current, loss, beam position, beam profiles. A large part of the instrumentation is being provided by IIFC. Many of the systems will be tested at PIP2IT.

Comments

- **While the use of interface control documents to identify the outgoing technical interfaces with other technical groups is useful, Installation, Integration and Commissioning will be mediating those technical interfaces during the installation process.**
- **An overview of the technical situation and relationships with other projects, such as PIP2IT, would have been useful in the Plenary Session and could have forestalled some of the technical questions that arose during the breakout session.**
- **The sheer number of talks available to this subcommittee was not managed well, with the expectation that the subcommittee pick and choose which talks to hear. In the Accelerator Systems break-out sessions, 10 talks were scheduled and only 7 were able to be completed. The last three talks, regarding vacuum system, magnets and beam position monitors, power supply**

systems for the project, and the entire beam transport/delivery system were not presented due to poor time management.

- **Detailed requirements of the two D-magnets for the injection girder region were not shown. These can have impact on the optics design, tunes, and overall path length in the Booster and should be addressed and presented at the DOE Review.**

- The uniformity of the structure of the talks did help the presenters and ensured that the key information was presented in each talk.

- **Presenters were sharply restricted to their own WBS elements; however, presenters should be prepared to answer questions about technical scope and plans outside of their WBS areas, especially as they impact their own cost, schedule, or technical risk.**

- Block diagrams would be useful to visualize the interfaces between technical systems.

- For General Support Services, which includes water/fluids systems and electrical systems, the scope of the fluids systems is fairly mature and well understood. Conceptual design for electrical infrastructure is less mature, though "volume envelopes" are in place and being further developed.

- PIP2IT safety system is in place and functional, utilizing many or most of the functions required for PIP-II. Safety team is knowledgeable with many years of experience in system design and operation.

- Compared to PIP2IT, PIP-II safety system will require further enclosure access and radiation scanning stations, as well as MUX stations for readout of monitoring information for historical records.

- General Support Services should consider working with Conventional Facilities in order to use the building contractor for their fixed price contracts.

- Installation activities performed during beneficial occupancy will be less efficient than those performed once the construction contractor is completed. This will likely require regular (perhaps daily) communication and coordination. This additional effort should be accounted for.

Recommendations

9. An overview of the smaller and more mature systems should be presented at the CD-1 review by a higher level manager, with the technical experts available in the audience to answer specific questions.

10. For CD-1 breakouts, presenters should be prepared to speak to technical scope and plans outside of their WBS areas, especially as they impact their own cost, schedule, or technical risk. This is in addition to showing an interface matrix.

11. Show and acknowledge the interfaces between Installation, Integration and Commissioning and the various technical groups by the CD-1 review.

12. Generate the design requirements of the two replacement gradient magnets for the Booster injection girder region and present at the CD-1 review.

2.4 RF Systems

Subcommittee: Alex Ratti, Tom Russo

Charge Questions:

- Does the conceptual design satisfy the performance requirements?

  Yes - the team has shown a good understanding of the problems and issues and presented a design that will meet the required performance.

- Does the conceptual design support the stated cost range and duration?

  Probably - the information presented at a high level is consistent with other similar projects. The level of maturity of the presented resource planning and spending profiles were not sufficient to evaluate this further.

Findings

- Presentations covered most electrical systems, from control systems, to RF to beam instrumentation.
- None of these items are on the critical path
- SSA RF amplifiers are due to come from India - tech transfer is in progress in support setting up production in India.
- RF systems include all RF power sources and distribution system for all complex. Systems operate at 162.5, 325 and 650MHz.
- All RF power sources have a minimum of 20% margin over the power necessary for beam power and cavity bandwidth.
- Beam instrumentation consists of BCMs (toroids, dccts, and wcms), profile monitors, loss monitors (pmts and neutron detectors), and Allison scanners.
- Development is underway for an improved laser wire based profile monitor and emittance scanner, to provide non intercepting beam diagnostics.
- A laser based system profile monitor system similar to that uses at SNS will be developed.
- LLRF leverages the experience from the collaboration on the LCLS-II LLRF system and takes a similar approach, with a SSSA configuration with one rack controlling four cavities (two racks per cryomodule).

- The injector up to the MEBT is fully built and beam testing is underway.

Comments

- Only a few of these systems require development or need to perform at a level that could push the state of the art, yet several systems (LLRF, MPS..) are critical to the success of the facility.
- There are substantial differences in operating the linac in pulsed or CW mode. This dual mode of operation puts significant additional constraints to the system requirements, in particular for the LLRF, instrumentation and timing control systems.
- Interfaces with Conventional Facilities, for example the electrical systems was not discussed - needs: space, cable trays, AC power, water, HVAC. The mechanism to sign off approved requirements to CFID, verify the requirement has been achieved, and manage change should be shown.
- The equipment in PIP2IT provides a convincing demonstration of the injector (for now) all the way up to the MEBT. This is a key element of the proposed facility and the team should emphasize and leverage this experience. For example, the implementation of the MPS for this system provides the basis for the MPS in the full facility.
- The presentations shown did not fully show the level of hardware design and implementation that has been completed. The project team should show more detail that reflects that fact that although this is a CD-1 review, there has been significant hardware built and tested.
- Significant relevant experience exists at FNAL in RF, power supplies, diagnostics, and controls. The PIP-II project should ensure availability of key staff for the project and minimize disruption from operations or other projects. This team has all the necessary experience to manage the selection of critical components in light of the lifecycle of parts.
- It order to minimize risk, the team should develop a plan for close coordination of the large RF systems in kind contributions. The plan should ensure that PIP-II staff have full access to all materials/vendor inspections and are part of any testing as FNAL deems necessary.
- This task would benefit from having a CAM dedicated to the planning of this part of the project.

Recommendations

13. Analyze all electronics systems and identify areas where development is needed to reduce performance or schedule risk, or provide cost reductions. By the end of the year, develop and prioritize a plan to carry this out in a timeframe consistent with the project's milestones.

3.0 Project Management

3.1 Cost and Schedule

Subcommittee: Elmie Peoples-Evans, Bill Freeman, Bob O'Sullivan

Charge Questions:

- In establishing the cost range for the DOE scope, has the project clearly identified all scope for which the DOE will be responsible?

  Yes, however recent scope changes are planned to be incorporated prior to the DOE CD-1 Review.

- Are the estimated cost and schedule ranges credible and realistic for this stage of the project?

  Partially. Supporting documentation for the M&S estimates and in-kind contribution schedule milestone dates were not provided and there are discrepancies in some of the resource assignments used in P6.

- Is adequate scope, cost, and schedule contingency included?

  Yes.

Findings

- The project presented a cost range of $586M - $771M, with a point estimate of $648M which includes $157M of cost contingency. Actuals through FY17 are $32M.
- The contingency includes $104M of estimate uncertainty, $53M of identified risks, and standing army costs for 1.5 years of risk based schedule contingency.
- Estimate uncertainty was applied externally, based on info in BOEs. In cases where it exists in P6, most of the uncertainty factors are in the range of 20-30%.
- The project accepted 131 of the 150+ originally identified risks in the risk registry for the project to manage. The highest ranked risk is an overhead change to major procurements that has an estimated cost impact of over $4M.
- The top 15 risks make up $13M of the risk based cost contingency, fourteen of which are technical based risks.
- The bases of estimates (BOEs) are summarized at level 5 of the WBS. Backup information for M&S estimates were not provided during the review. The committee found instances where the BOE trace revealed some inconsistencies.

- A resource loaded schedule (RLS) has been developed and includes 30 months of float to the CD-4 date in the 1st quarter of FY29.
- The RLS has 5,137 activities with 6,957 logic links. 95 activities are constrained, 6 are missing a predecessor, 709 activities without successors and 1 invalid logic relationship.
- Approximately 73% (3,744) of the activities have one or more years of float and 66% (3,409) have two or more years of float.
- The project assumes CD-2/3a approval in FY19 to procure the following long lead items: niobium, initial superconducting cavity orders, and conventional facilities site preparation. CD-3 approval is planned for FY20.
- The following discrepancies were found in the P6 schedule: missing obligation activities, resource assignments for CF scope that have lower escalation rates than provided in the assumptions document, and labor resources with reduced overhead rates that should be used after CD-3 used before CD-3.
- Approximately $200M of project scope will be provided by international institutions as in-kind contributions.
- Scope for additional ring upgrades (Main Injector and Recycler) and the newly announced UK contribution are not included in the current point estimate. Amounts pledged by UK use “European” accounting, i.e. labor not included.
- Control account managers (CAMs) have not be officially assigned so L3 managers were identified to serve in the CAM role for the purposes of the review. The committee performed drilldowns on four L3 managers.
- The project presented an organization chart showing a project controls manager position that has yet to be filled.
- The assumptions document states the following regarding spares: “Operations funds for special process spares will be available to support the fabrication of an initial complement of spare components.”, The PIP-II project will fabricate an adequate complement of spare components to complete all threshold KPPs and supporting objective KPPs...spares will be included in project costs.”, and “In consultation with the Acceleration Division, the project will identify and fabricate an initial complement of spare components adequate to sustain operations. Such spares...will be transferred to, and reimbursed from, the Fermilab special process spares account prior to CD-4.”
- One of the L3 managers commented that “yield” spares are included in the in-kind contributions.

Comments

- The team is commended on their efforts to prepare for the review.
- Consider the time allowance when preparing presentations. A good rule of thumb is 2 minutes per slide.
- Project should consider including the technical impact of a risk in the calculation used to rank the risk in terms of severity in addition to cost and schedule impacts. This will help ensure the project is focused on mitigating the risks that impact the project the most from all perspectives.
- The team is encouraged to revisit the risks related to not testing cryomodules given the lack of full spares if a problem occurs. Explain the testing that will be done on the cryomodules, if applicable, such that the review committee understands the low impact assigned to these risks. Vacuum leak checks, but not cold testing for example.
- The labor BOEs are well written. Include the benchmark information used to create the estimates to add more confidence in the numbers provided. Some of the labor BOEs did not match P6, such as the cryoplant design effort covered by the project.
- The team is strongly encouraged to do a thorough check on all project documentation to ensure consistency. BOEs should match P6 exactly. Assumptions should be consistent with the actual process used for the information provided at the review (i.e. using/not using Cobra, at least one month of float for all activities not on the critical path, and matching the LBNF shutdown schedule).
- The team did not provide the M&S backup needed to truly validate the estimates. This information is needed to fully determine the credibility of the entire cost estimate.
- The project is encouraged to update the critical path (SSR2) and summary schedule charts used in the presentations. The critical path chart shows cavity and cryomodule production tasks occurring sequentially, but the tasks are actually in parallel with staggered starts. Thus, the longest path is through the 1st CM and ends with the rest of the CMs. The summary schedule includes lots of information that may be better presented with rolled up summary bars and a focus on just the critical and near critical paths.
- Durations for major procurements should be reviewed by the Procurement Manager to validate alignment with the durations included in the assumptions document.
- Consider adding intermediate milestones to monitor progress of international partners. Perhaps add schedule visibility tasks for partners to better demonstrate how the delivery dates were determined.
- The planned CD-2/CD-3a review date seems optimistic. Counting backwards from the planned September 2018 DOE Review date, the project needs to provide three months of EVM data (August excluded), this gets us to May 2018. CAMs require training, estimates require updating and the schedule needs to be cleaned up to be ready for a baseline by May (at the latest) to get the appropriate data. This leaves five months to accomplish this given the DOE CD-1 review in

December. This also includes preparing for a Director's Review in July 2018, causing more complication.

- The schedule assumptions state that "deliverable schedules for international in-kind contributions to the construction phase will be formalized by the time of CD-3". This timing seems too late and the deliverable schedules should be formalized by the time of CD-2, unless it is known that a given contribution is well off of the project's critical path.

- Addressing the following schedule and cost issues would greatly improve the quality and credibility of the estimates:

    - Assign appropriate funding types throughout the whole schedule to minimize confusion.

    - Link CD-3a and CD3 milestones as predecessors appropriately to properly time phase procurements and work scope that follows.

    - Include an obligation activity for all major procurements.

    - Consider using a phase code to show stages of the project.

    - Ensure Funding Type activity code complements the resource type selected to each activity to allow proper application of Lab indirect rates.

    - Include estimate uncertainty factors to all resource assignments and estimate type codes that are consistent with those factors.

    - Calculate estimate uncertainty using those factors * base units to facilitate rollup of time-phased and total contingency from P6.

    - Ensure each activity has a proper link (missing predecessors and successors) to ensure proper time phasing of costs and to mitigate some the excessive float.

    - Perform a fuse analysis if time permits to address other schedule quality issues such as % of FF and SS logic used, or the use of SF relationships.

- Consider showing some analysis that validates the statement made that the costs from P6 are within < .1% from the Cobra costs to ensure credibility in the approach used for the CD-1 review.

- The project would benefit from more project controls support, in addition to the PCM position identified in the org chart. Help is needed to further develop the project schedule and cost estimates, prepare for critical decision reviews, prepare review documentation (detailed costbook, milestone and WBS dictionary, BOEs, etc.) and provide guidance on review expectations. For example, providing a RAM or something similar to help the committee understand scope responsibilities and to help instill ownership of said scope within the team, and putting CAMs through drilldown training so they understand the line of questioning and the appropriate responses. This will be huge for the independent cost review and the CD-2/3a review planned in FY18.

- Clearly state the plan for spares in the plenary talk(s). A chart showing which items will have spares, including special process and "yield" spares and the responsible party for covering the costs would help clarify the approach taken by the project.

Recommendations

14. Promptly secure additional Project Controls support to prepare for the DOE CD-1 review and begin the hiring process for a Project Controls Manager.

15. Update the schedule to coincide with the new DOE funding profile, the UK contribution and the MI and Recycler upgrades. Validate and document the schedule assumptions used for the in-kind contributions work prior to CD-1 review.

16. Update the schedule to include proper critical decision approval links to the procurements (linking CD-3 and CD-3a such that things don't start before they are approved), and use the appropriate resource assignments based on the dates after the logic links are incorporated. Complete this work before the CD-1 review.

17. Update Basis of Estimate documentation with additional supporting documentation, including vendor quotes for M&S purchases over $100k. Complete this work before the CD-1 review.

18. Include the technical impact as part of the formula used to derive risk severity rankings prior to the CD-2 review.

3.2 ESH&Q

Subcommittee: Mike Bonkalski

Charge Questions:

- Is ESH&Q being appropriately addressed for this stage of the project?

  Yes

Findings

- All presentations commented that ESH&Q was integrated into the work to be performed and that it was a high priority to the project.
- Project team is incorporating Lessons Learned from other projects into work activities.
- Required CD-1 documents have been created, but the QA plan is still in draft form.
- NEPA determination has been completed and EA is planned. RFP has been prepared and it is estimated to cost $250k and take 6-8 months to complete.
- Project stated that ES&H/QA requirements will be communicated to outside entities via International Agreements, MOU, and SOW.
- Current ES&H/QA language in international agreement with India is very high level and lack specifics. Other current production agreements include detailed design specifications in an attempt to ensure compliance with Fermilab requirements
- ESH&Q risks have been appropriately identified in the PHAR and mitigation strategies are detailed.
- CF Construction ES&H support will come from the ESH&Q section.
- QA Plan lacks formal process to communicate ESH&Q requirements to partners/vendors.
- No discussion regarding participation on production readiness reviews for partners/institutions and on internal design reviews.
- Storage constraints for equipment received prior to installation has not been considered by the project.

Comments

- ESH&Q is well integrated into the Project. Presentations consistently showed that ESH&Q was being implemented throughout the project. The CD-1 IPR presentations should speak to specific examples of how this is being done.

- All required CD-1 ESH&Q documentation is in place, however;
    - PHAR should be reviewed to ensure accuracy with regard to referencing Lab's current implementation of ISO 14001 / OHSAS 18001.
    - QA plan is still currently in draft form.

- ESH&Q support is adequate for this stage of the Project, but will need to increase as the Project matures to address QA requirements and CF construction oversight.

- Associate Project Manager/ESH&Q should participate in Design Reviews and Production Readiness Reviews to assure ESH&Q requirements are being met.

- Reach out to other projects to assure the EA cost and schedule estimate are reasonable. Present process for developing estimated cost and completion schedule in CD-1 IPR break-out presentation.

- CD-1 IPR break-out presentation of QA plan should include examples of PIP-II QA elements currently in use.

- As new international partners join the project, guidance should be sought to assure any potential code compliance issues are addressed.

- Project should determine if off-site storage of deliverables will be required and assess potential impacts to the Preliminary Security and Vulnerability Report.

Recommendations

19. Prior to DOE CD-1 IPR, Project needs to finalize the QA plan which shall includes elements to assure ESH&Q requirements are communicated to partners

3.3 Management

Subcommittee: Elaine McCluskey, Rich Stanek, Greg Bock

Charge Questions:

- Does the acquisition strategy document a carefully considered analysis of alternatives that supports the preferred alternative?

Yes - we were told this process was completed separately.

- Is the project being appropriately managed?

Yes. The project has been appropriately managed through the R&D/conceptual design phase and is now moving into the design and construction phase. This will require a much different approach to managing the work and tracking progress. The flexibility shown in responding to varying funding scenarios over the last few years is a good indication that the management is prepared for this task. There are plans to adjust the WBS and organizational structure to meet the challenges ahead.

- Does the proposed project team and staffing plan offer adequate management experience, technical expertise, and Laboratory support to produce a credible technical, cost and schedule baseline required for CD-2?

The project team is experienced in accelerator and SRF technology and in project management. The complexity of the various international agreements and deliverables puts additional burden on the team to control the work and meet the project objectives. It is clear that there are lessons learned from other projects that will help prepare for this task.

The Project Management Control Systems team (PMCS) needs strengthening in order to meet the CD-2 time table, this is in their plans. The project needs to examine roles and staffing levels across the team (QA, Procurement are examples). There is a change in senior leadership planned in the near future which needs to be resolved soon.

- Is the required DOE Order 413.3b documentation on track to be complete for CD-1?

Yes. The list of DOE Order 413.3b documentation was presented along with the current status. All documentation is either approved or in draft form. The project should be able to complete the required documentation and be ready for the CD-1 Review.

Findings

- The project configuration was selected by HEP through a rigorous selection process in which HEP specified 4 alternatives & 10 evaluation criteria. The PIP-II project did an evaluation and prepared a report. A DOE review committee was charged to validate the report. The HEP Associate Director selected the preferred alternative.

- The project anticipates receiving new DOE funding guidance on 16 October 2017 and will be required to revise the resource-loaded schedule to match the guidance before the planned CD-1 DOE IPR in December 2017.

- With only a technically-limited schedule, the critical path is through cavities/cryomodules and commissioning. Some of the activity durations (for example - Installation) are set by available time and not work durations.

- Partner contributions are outlined in the Assumptions Document, although presently this is only for India (IIFC).

- International agreements will be bilateral between the US and the international partner. The project described them as follows:
    - India agreements are governed by tiered group of agreements between US-India. The current Joint Project Document is only for R&D phase; a construction agreement will be discussed starting right after CD-1 is achieved.
    - INFN: formalizing INFN construction phase contribution on LB650 cavities and cryomodules, last week after high-level discussions.
    - UK: developing plan for $28M on construction phase deliverables.
    - CEA/Saclay: discussing assembly of LB650 cryomodules.

- Partners include 2 national DOE labs (ANL, LBNL) and 4 international partners (India, Italy, UK, & France), with formalized arrangements to be in advance of CD-2. Presently, the agreements are at a variety of completion levels.

- Interfaces between India and Fermilab are managed via subproject coordinator-subproject manager weekly or biweekly meetings. POCs are defined at both FNAL and DAE.

- The Machine Advisory Committee and Accelerator Advisory Committee advise the Fermilab Directorate on the PIP-II technical design.

- The Project expects to revise the project management and work breakdown structure after CD-1. Project Office staffing is planned to grow by 1 FTE PCS and 0.5 FTE finance between FY18 & 19. The project did not hear from all the WBS L2 managers during the review presentations.

- Risk management is based on the Fermilab Risk Management Plan, with tailoring in the area of quantifying risk ranking. 150+ risks are entered in Fermilab risk register, with some risks identified as enterprise risks that are the responsibility of Directorate or DOE.

- Schedule risk is calculated at 15% of total schedule impact days (mean*probability).
- Requirements to upgrade capabilities to 2.4 MW beam power only impact conventional facilities.
- The project presented several metrics for measuring design maturity which showed most of the project is at the preliminary design level, with smaller amounts each at conceptual as well as beyond preliminary design.
- The draft PIP-II Interface Document that was provided addresses interfaces between the project and Fermilab, not the physical interfaces within the project.
- The PIP-II Project Management Plan describes what the Project Office does and what it will take to execute the project. The project is supported by the PIP-II Technical Board and PIP-II Risk Board.
- The Fermilab Director has delegated responsibility for Directorate oversight of PIP-II to the AD Head, and the project organizationally at Fermilab resides under the Accelerator Division.
- From a labor perspective, most of the DOE project labor is from Fermilab, with a 60/40 split between AD and TD. Some labor is not directly costed to the project but rather is included in the overhead charges, including ESH, some fraction of procurement, and all administrative support.
- Project management has budgeted for import duties at 2.6% of estimated value of international deliverables.
- CD-3a is planned simultaneous with CD-2. This was not presented at this review beyond references in the DOE Acquisition Strategy and Assumptions Document and some discussion in the Conventional Facilities breakout.
- The project provided a brief scope contingency list that represents the difference between the objective and threshold KPPs.

Comments

- The project's leadership team has many years of experience in building, upgrading, and operating accelerators and is effectively utilizing it for this project. The project has appropriately recognized that the work breakdown and the organizational structure in the WBS L2 Superconducting Linac needs to be subdivided to be more effectively managed. Subproject leaders will need to be identified for these new WBS L2 systems.
- CD-1 required DOE documentation is at draft if not final completion level. Several documents that are not required, but important to support the CD-1 documentation, should be provided at the DOE IPR. These include the WBS Dictionary, interface matrices/documents, and up-to-date statused responses to recommendations from past reviews (DOE and design).
- The PIP-II Interface Document describes important internal organizational understandings between Fermilab and the project and should be finalized as soon as possible. To avoid possible confusion with similar documents describing physical engineering interfaces or interfaces between scope

elements for partner contributions with 'interface' titles, consider a different title like 'PIP-II - Fermilab Agreement.'

- The project should prepare a talk or document that describes the specific DOE scope contingency elements by WBS, the cost savings, and the trigger date for decisions for the CD-1 DOE IPR.

- The review team provided a good consistency in the review presentations and was generally well-prepared for the talks, although some standard slides, such as those for ESHQ, should be more tailored to the talk being presented.

- Because of the FY17 funding level, a full-year FY18 continuing resolution would have the same impact as funding from the FY18 President's Budget Request. However, the project is capable of utilizing significantly more funding in FY18 than this lower level, per the presented technically-limited schedule.

- The project has been utilizing terminology such as "R&D" and "Construction" as the phases of work with associated types of funding designations in P6. The project should work to evolve their phase of work descriptions and funding types to match that appropriate for a line item construction project. This will assist project leaders to work with DOE in planning when and how much funding is required. This will also make more sense to DOE review committees who will expect this type of language.

- The project doesn't have an organizational chart that includes all partners at a managerial level. Consider developing such a chart to better explain how the project is structured to accomplish all work, not just the DOE scope.

- The project should develop a list of mitigation strategies that can be implemented if/when critical deliveries are delayed or milestones from international partners look to be delayed. Examples could be developing a strategy to send people to India for extended periods of time (6 months or more), creating two cryomodule test stands in the footprint of the PIP2IT cave, investigating alternatives for testing cryomodules in Europe (Saclay, DESY or Daresbury) or running two shifts and multiple crews on installation.

- A risk management system has been adopted and is being used. The project should review the list of top risks to assure that technical risks are adequately prioritized.

- The project has already had several key contributions and deliverables arrive from the international partners. This should be accentuated in the overview presentations.

- The P2MAC is an example of an advisory committee that has provided a valuable service to the project. Their involvement in the review of the CDR was quite successful.

- Long-lead procurements are typically identified at the time of CD-1 to clearly define the need for early procurements as well as the overall critical decision strategy. The project needs to make their intent regarding CD-3a more prominent at the DOE IPR.

- Procurement planning seems reasonable for this stage of the project. A list of major procurements was presented to the committee. The project should present a plan at the DOE IPR for procurement staffing as compared to the project obligation plan for larger procurements, and show that the staffing can be supported from the Fermilab Procurement Department..

- PIP II requires and assumes specific SRF and RF power labor resources and infrastructure will be available in order to meet the proposed schedule. These needs could be in conflict with ongoing and future planned projects and operations. A detailed plan which incorporates all required SRF/RF power related resources and infrastructure (including possible international contributions) should be developed so as to assure that conflicts can be resolved.

- Labor resource profiles as presented were matched to the technically-limited schedule with spikes and valleys, and did not represent the realistic labor planning that will be needed for execution.

Recommendations

20. By the CD-1 DOE IPR, develop a list of strategies to collaborate with international partners to address issues such as schedule, quality assurance, and coordination.

21. Fermilab management should help the project get the resources needed to be successful at the CD-1 DOE IPR and ICR.

22. By CD-2, develop a plan which shows how PIP II coexists with current and future SRF/RF projects planned for the Lab and with operations, focusing on key labor resources and critical infrastructure.

23. Present the specific list of anticipated CD-3a long-lead procurement requests in a plenary presentation at the DOE CD-1 IPR.

24. Proceed to the DOE CD-1 IPR after responding to these recommendations and finalizing all required CD-1 documentation.

4.0 Appendices

A. Charge

B. Agenda

C. Review Committee Contact List and Writing Assignments

Appendix A

Charge

Director's CD-1 Review of PIP II

October 10-12, 2017

Date: August 31, 2017

To: Mike Lindgren, Chief Project Officer

From: Nigel Lockyer, Director

Re: Director's CD-1 Review of the Proton Improvement Plan II (PIP-II) Project

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Message:

Please conduct a Director's Review of the Proton Improvement Plan II (PIP-II) project on October 10-12, 2017 to assess the project's readiness for the DOE CD-1 review and approval process. The Director's Review should assess all aspects of the project's conceptual design and associated plans.

The review committee should respond to the following questions:

1. **Design and Scope.** Does the acquisition strategy document a carefully considered analysis of alternatives that supports the preferred alternative? Does the conceptual design satisfy the performance requirements? Does the conceptual design support the stated cost range and duration?
2. **Cost and Schedule.** In establishing the cost range for the DOE scope, has the project clearly identified all scope for which the DOE will be responsible? Are the estimated cost and schedule ranges credible and realistic for this stage of the project? Is adequate scope, cost, and schedule contingency included?
3. **Management.** Is the project being appropriately managed? Does the proposed project team and staffing plan offer adequate management experience, technical expertise, and Laboratory support to produce a credible technical, cost and schedule baseline required for CD-2? Is the required DOE Order 413.3b documentation on track to be complete for CD-1?
4. **Environment, Safety, Health, and Quality (ESH&Q).** Is ESH&Q being appropriately addressed for this stage of the project?

The committee is asked to present a draft of their report at the review closeout and to issue the final report within two weeks of the review's conclusion.

Nigel S. Lockyer
Director
Fermi National Accelerator
Laboratory

Appendix B

Agenda

Director's CD-1 Review of PIP II

October 10-12, 2017

Appendix C

Review Committee Contact List and Writing Assignments

Director's CD-1 Review of PIP II
October 10-12, 2017

Chairperson		
Greg Bock	bock@fnal.gov	630-840-4302
Project Management		
Elaine McCluskey* FNAL	mccluskey@fnal.gov	630-840-2193
Rich Stanek, FNAL	rstanek@fnal.gov	630-840-3519
Greg Bock	bock@fnal.gov	630-840-4302
Cost and Schedule		
Elmie Peoples-Evans* ANL	epeoplesevans@anl.gov	630-252-2311
Bill Freeman, FNAL	wfree@fnal.gov	630-840-3020
Bob O'Sullivan, FNAL	bobo@fnal.gov	630-840-8094
ESH&Q		
Mike Bonkalski* FNAL	bonkalski@fnal.gov	630-840-8448
Conventional Facilities		
Brad Bull* MSU	Bull@frib.msu.edu	517-908-7751
Russ Alber, FNAL	ralber@fnal.gov	630-840-2501
Cryo Systems		
Camille Ginsburg* FNAL	ginsburg@fnal.gov	630-840-3901
Olivier Napoly, FNAL	napoly@fnal.gov	630-840-4172
Accelerator Support Systems		
Mike Syphers* NIU	syphers@fnal.gov	630-840-8863
Rob Connatser, ANL	rconnatser@anl.gov	630-252-3676
John Byrd, ANL	jbyrd@anl.gov	630-252-5392
RF Systems		
Alex Ratti* SLAC	ratti@slac.stanford.edu	650-926-5257
Tom Russo, MSU	Russo@frib.msu.edu	517-908-7769

*Lead

Observers	
Adam Bihary, DOE/FSO	adam.bihary@science.doe.gov
Henry Patlan, ANL	hpatlan@anl.gov