Report of the Director's Review for the DOE/SC IPR

December 16, 2021

COMMITTEE MEMBERS

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Management

Answer to charge points:

1. Is progress on development of the proposed technical design adequate to meet the project's milestone for completion by the proposed CD-2/3 timeframe? Is it likely to meet the performance requirements?

Yes. Design is complete except for DAQ which is, on purpose, the last to finish. It is expected that all systems will be ready for CD-2/3 towards the end of FY22.

2. Is the project making adequate progress on the resource-loaded schedule, risk assessment and contingency estimate to meet the project's milestone for CD-2/3?

Mostly Yes. While there are large uncertainties due to the world-wide COVID-19 situation as well as to the US funding scenarios, the project is doing a good job of making best estimates and plans. (See Cost Schedule and Process control section and also comments and recommendations below)

3. Does the project team have adequate management experience, design skills, and laboratory support to produce a credible technical, cost, and schedule baseline?

Yes. The team is very experienced and has a long history for ATLAS projects. A careful eye needs to be kept on attrition of talent and adequate replacements as this is a long-term project.

4. Does the project team understand the dependencies on outside resources such as participation by researchers with other funding sources and funding from other agencies or international collaborators?

Yes. NSF part of the project is well understood and NSF and DOE scopes are well integrated. The International dependencies are coordinated through international ATLAS.

5. Does the project use the human and technical resources available to it at the participating national labs and universities when they are the most efficient choice? Are qualified vendors being sought out where they are the most cost-effective option?

Yes. The team has a long history in ATLAS and the project management uses their knowledge of capabilities at labs and universities to inform their choices for resources to be used. The lab and universities discuss with the project management in case of issues for their internal resources. Many of the vendors are specialized for the project needs. Where appropriate, wider search is made for the most cost-effective option.

6. Are the long-lead procurements being managed successfully?

Mostly Yes. CD-3a procurements are moving at a satisfactory pace. Overall contingency needs to be monitored carefully. [see specific subsystems]

7. Are the ES&H aspects being addressed properly and is the planning sufficient for this stage of the project?

Yes. The project relies on local ES&H organization for overseeing activities taking place in different labs and universities, with Project ES&H being used mainly for consultation. (This is similar in QA/QC). While this is a valid model, the project might consider more information exchange. [see comments below]

8. Has the project responded satisfactorily to the recommendations from previous independent project reviews?

Mostly yes. An updating of the recommendation tracking document is recommended.

9. Are there any other significant issues that require management attention?

No, but see recommendation on discussions with DOE about funding.

Comments

Observations

1. The US ATLAS HL-LHC project suffers from the uncertainties of the international HL-LHC schedule that will be hopefully updated at the Chamonix meeting in January 2022. As a consequence, the US ATLAS HL-LHC continues to have “need-by-dates” for the delivery of components to CERN that are probably set up to 18 months too early.
2. The US ATLAS HL-LHC schedule is still based on the current (old) HL-LHC schedule and has, in places, little (or negative) float between the date when the US deliverables arrive at CERN and the ATLAS “need-by-date”. The US ATLAS HL-LHC project team thinks that they will be able to implement the new HL-LHC schedule quickly after it

becomes official in parallel to the development of the international ATLAS schedule. While the latter will be approved only at the time of the P2UG review in May no changes are expected.

Presentation of Material

3. The breakout session talk materials (including discussion) could not fit in the allocated time slots. It would have been useful to provide some advance guidance to the Committee on how to use the breakout material. E.g., is it up to the Committee to select what to be presented or there are some items in particular where the Project wants to provide more detailed information?
4. Some committee members were confused by the presentation of the technical readiness review of various systems and not fully aware of the DOE requirements for CD-3, which are spelled out in terms of Technical Readiness Level (TRL) in the DOE G 413.3-4A Chg 1 (Admin Chg), Technology Readiness Assessment Guide. The language used by ATLAS (with specification reviews, preliminary and final design reviews, production readiness reviews) can be misinterpreted by review committees. It is much better to stick to the TRL language (and say that it corresponds to what in ATLAS are considered FDRs) as the requirement for CD-3. It would be good practice to give crisp definitions of readiness for CD-2/3 (both generally and specifically for the sub systems) for the reviewers to aid their evaluation.
5. Similarly, the project team should present separately the status of the hardware and firmware/software for the trigger components. The emphasis should be on the status of the hardware, which is already at the level of PDR/FDR and not on the status of the firmware which may be only at the level of specifications. The only thing that matters in this respect is that the FPGAs have been sized appropriately in terms of available logic and high-speed links to meet any possible requirement coming from physics and the implementation of these requirements in firmware.
6. So far, the project has had cost increases of ~$16M, half of which are estimated to be caused by the COVID-19 pandemic. The remaining ~$8M include ~$2M of savings including a reduction of the workforce in the project office, and therefore the actual cost increase is ~$10M. In order to understand the overall cost-increase the committee needs to look at all the L2 presentations and possibly also at the presentations from the detector parallel session. This cost increase is not unexpected given the current stage of the project, but the review committee would have appreciated it if the information was concentrated in a single presentation. It would have helped to reassure the committee that this cost increase was well understood and under control.
7. While all the information for the cost increases is documented in the BCP, the reviewers have to start navigating through the L2 presentations and the Contingency Tracking spreadsheet, and then through the presentations at the Change Control Board and the documentation of the BCP to get a full understanding of the areas where there have been significant changes. The project should consider having a set of backup slides that document the major cost changes in a way that is easy to navigate for the reviewers.
8. The DocDB document (HL-LHC-doc-457) with the answers to recommendations from previous reviews is confusing and should contain only one spreadsheet with all the recommendations from previous reviews. Duplicate entries should be marked as such and only the most recent one should be kept open. Recommendations that are no longer relevant or that have been addressed should be declared closed.

Further Comments

9. The project presented an analysis of the funding needs where the contingency of 40.4% is applied evenly through the remainder of the project. This was done because the

analysis of the risk MC which is required to correctly allocate the contingency as a function of time was not completed in time for this review. For the future CD-2/3 IPR it would be preferable to present the updated information already at the director's review. This may require running the risk MC analysis a little bit earlier in the review preparation process or at least using the same time profile of a previous review.

10. The committee understands that DOE wants an analysis of the supply chain for this project and the project should coordinate with its international partners to provide this information in a timely fashion and include it in its plans and in the resource loaded schedule. The coordination with international partners is necessary since there are major procurements that are done centrally at CERN by the experiment.
11. The US ATLAS HL-LHC schedule is still based on the current (old) HL-LHC schedule and has, in places, little (or negative) float between the date when the US deliverables arrive at CERN and the ATLAS "need-by-date". The committee agrees with the approach taken by the US ATLAS HL-LHC project office to use the additional 18 months to increase the float available to account for any future delays that could be caused either by the pandemic or further disruptions of the supply chain.
12. The US ATLAS HL-LHC project suffers from continued uncertainties in the funding profiles for fiscal year 2022, but seems to be able to address some (but not all) low funding scenarios, mostly by delaying payments to CERN for common expenses or contracts placed through CERN. Only in some of the most drastic reduction scenarios the project would need to delay work, which would then eat up some of the additional float in the schedule that resulted from the delay and extension of LS3. It should be noted that any delay of activities will result in cost increases for the project at later dates due to escalation. FY2023 appears to be a critical year where the US ATLAS plan relies on a large carry-over from FY2022 which would not be there if the budget for FY2022 is smaller than predicted. In the current plan there is already a shortage of funding for FY2024 and FY2025.
13. The US ATLAS HL-LHC project is proactive in their discussions with DOE about the problems with the funding profile and is investigating possible mitigation actions. Delayed payments to CERN are the main handle that the project has available. US ATLAS should continue to coordinate its actions with the US CMS project and with the Accelerator Upgrade Project to ensure that there are no further delays to the HL-LHC upgrade due to funding constraints.
14. Both on ES&H and QC process the US ATLAS HL-LHC project has a decentralized approach where there is little direct oversight of the ES&H procedures at the collaborating institutions and little direct oversight of the QC processes in the individual work areas (pixel, strips, ….) from the project office. This is unlike the approach that other DOE projects are following where the project office is heavily involved in validating the ES&H procedures followed at all US institutions and in validating the QC process of each work area. While this committee agrees with the validity of the current approach of US ATLAS HL-LHC, we believe it would be useful for the project office to somewhat enhance the coordination in the ES&H area by having a list of ES&H liaisons at the various US collaborating institutions and establishing contacts with them; also continuing with remote ES&H site-visits for the various collaborating U.S. Institutions, taking into account the restrictions imposed by the pandemic, would be valuable. Also, a somewhat stronger coordination between the Project Office and the Institutions and L2 managers on QC matters will help to reinforce the QC processes already in place, and help forestall criticisms of the decentralized approach.
15. The presentation of the status of the CD-3a part of the project was relatively light on details, but it is clear that in the coming months the project should discuss with DOE whether some mechanism for additional funding is necessary since the contingency is

currently only at 25% of the cost-to-go. Cost increases are to be expected for some of the ASIC production and possibly also for the bus tape.

16. The project has some scope contingency handles that are available to achieve the overall budget. Some of the decisions related to scope reductions need to be taken in the relatively near future to keep the possibility open of having an impact on costs. The project presented a table of scope contingencies from the 2019 CD-3a review as a response to a question during the plenary session but a somewhat different list in the Q&A session. It would have been preferable to have consistent information included in one of the presentations in the plenary session. At this point, all the parties involved in the project (the US ATLAS HL-LHC project team, the ATLAS collaboration, DOE, or CERN) agree that it is premature to discuss scope reduction and the committee agrees with the current approach. At the same time the committee thinks that in about one year from now, depending on the funding and the overall progress in the next 12 months, ATLAS will have to start the discussion about descoping. We also note that the CD-3a list and the updated scope contingency list were significantly different in the dollar value for the same items. This was subsequently clarified.
17. The Project should continue to closely monitor escalation assumptions versus reality when you compare with FY2019 rates. The up to 4% difference observed in the labor rates so far apparently was based on a few isolated changes implemented. The reason for the difficulty in having more frequent updates was not clear.
18. Currently COVID-19 effects are considered through December 2022. Taking into account the current situation with respect to COVID-19, the Project needs to consider COVID-19 related effects and risks beyond CY22.
19. While it should be possible to obtain an updated schedule of the HL-LHC in time for a director's review and later an IPR for CD-2/3 in Summer 2022, it may be challenging to have stable EVMS metrics for 3 full months before the Director's review.
20. Given that where I&C scope will reside in the future (project or operations) is somewhat uncertain, the management should make plans so that there are no discontinuities in the needed resources and key personnel.

Recommendations

1. Review and update the document with the answers to recommendations from previous reviews.
2. Continue working closely with DOE on the funding issue and investigate all possibilities to alleviate the funding shortage in FY2024 and FY2025, without resorting to delaying activities that could also result in further cost increases to the project and without resorting to scope reductions.
3. During the preparation for the CD-2/3 review in Summer 2022 consider completing the risk MC analysis and having the correct time profile for the contingency needs already at the director's review.
4. Consider incorporating lessons learned from the analysis of the supply chain in the resource loaded schedule prior to the CD-2/3 review.
5. Extend your risk analysis to consider COVID-19 effects beyond CY2022.
6. The project should continue to monitor carefully the evolution of the CD-3a part of the project, including COVID-19 impacts, and the available contingency, and discuss with DOE whether some mechanism for additional funding may be necessary.
7. Consider updating more frequently labor rates for the project.

Cost, Schedule & Project Controls.

Answer to charge points:

1. Is progress on development of the proposed technical design adequate to meet the project's milestone for completion by the proposed CD-2/3 timeframe? Is it likely to meet the performance requirements?

Not applicable for Cost & Schedule

2. Is the project making adequate progress on the resource-loaded schedule, risk assessment and contingency estimate to meet the project's milestone for CD-2/3?

Yes, for the most part (see comments and recommendations).

The time-phased contingency needs for the project need to be determined and project must ensure that obligations plus contingency need is within the funding profile

The project team has a plan to get to the Director's review prior to CD-2; complete this work and respond to the recommendations below prior to this review.

3. Does the project team have adequate management experience, design skills, and laboratory support to produce a credible technical, cost, and schedule baseline?

Yes. The team has the experience, skill and support necessary to produce a credible baseline, which should be completed prior to the Director's CD-2/3 review.

4. Does the project team understand the dependencies on outside resources such as participation by researchers with other funding sources and funding from other agencies or international collaborators?

Yes.

5. Does the project use the human and technical resources available to it at the participating national labs and universities when they are the most efficient choice? Are qualified vendors being sought out where they are the most cost-effective option?

Yes.

6. Are the long-lead procurements being managed successfully?

Yes (from reporting perspective)

7. Are the ES&H aspects being addressed properly and is the planning sufficient for this stage of the project?

N/A; the use of boilerplate language for ES&H is less persuasive than it could be.

8. Has the project responded satisfactorily to the recommendations from previous independent project reviews?

Yes. The project has completed or is making adequate progress on prior recommendations.

9. Are there any other significant issues that require management attention?
No.

Comments:

Observations

1. The cost profile plus the linearly spread contingency against the funding profile was presented. FY2024 and FY2025 budget and contingency exceeds funding.
2. Use of “PED” funding term creates confusion on an MIE project.
3. A tailored EVMS is being practiced, though typically not expected at this stage of the project. The project plans to establish a real practice EVMS baseline before the CD-2/3 Directors review.
4. The published RAM is a time-phased budget, not a matrix.
5. Draft WADs are not available for review.
6. The Contingency/BCP log does not separately track CD-3a contingency.
7. The project has experienced large EVMS variances in this practice EVMS period.
8. Each plenary presentation included that ES&H was the “first priority,” but included this late in the presentation.
9. The project has advised that significant changes in the CERN need-by dates are forthcoming.
10. The project has separate P6 and Cobra databases from other BNL projects. (DL comment.)

Further Comments

1. The present approach to manage COVID-19 impacts is based on current-period incremental BCPs that allow for historical edits and what-if scenarios simulation to estimate future impacts. This approach has worked well in the early stages of the pandemic and allowed US ATLAS to effectively manage COVID-19 impacts during this stage of high uncertainty. However, as mitigating safe-working practices have been adopted (including the federal vaccine mandate) the present approach of managing COVID-19 should be reassessed and a plan to evolve this approach towards full EVMS compliance and a more standard risk-assessment process should be considered.
2. The TPC is $181M including $10M for I&C. In few cases, TPC was shown as $171M which may cause confusion. I&C activities ($10M budget) are high-level planning packages.
3. The base year for the current baseline estimate is FY2019. Not updating university labor resource rates exposes the project to potential cost variances when the actual labor rates are not in line with the escalation assumptions.
4. The laboratory labor rates along with burden rates may need to be updated based on the latest guidance available.
5. The Contingency log (BCP log) is not well-formatted, with what may be circular formulas.
6. The project has performed history-modifying BCPs as part of COVID-19 impact BCPs. This is not best practice within an EVMS practice period. Current period revisions may be used to replan activities.
7. Good traceability between the BOE and baseline exists, CAMs may benefit from a drilldown training.
8. The timeline to CD-2/3 reviews is tight. A February SPA allows a Director’s review no earlier than June (assuming February, March and April data are available in mid-May).

This makes little time available for the DOE review and ESAAB authorization within FY22.

Recommendations

1. Prior to the DOE IPR in January 2022, consider developing a plan to evolve the present approach to manage COVID-19 impacts towards full EVMS compliance and a more standard risk-assessment approach. This plan should be discussed with DOE and considered for implementation prior to the CD-2/3 review in late FY22.
2. The time-phased contingency estimate needs to be determined. This needs to be used to compare obligation profile with contingency vs funding profile before the DOE IPR in Jan-22
3. Perform a final EVMS-practice S=P=A baseline adjustment, which will incorporate existing carryover into the future budget profile, and begin comprehensive System Description-compliant EVMS implementation a minimum of three months, and preferably more, prior to the Director's CD-2/3 review. After establishing a final practice EVMS baseline, this compliance should include no further revisions to history.
4. After establishing the final EVMS-practice baseline, include analysis of actual costs and open obligations vs. funding in funding/budget/obligation presentations.
5. Use funding type terminology consistent with an MIE project, i.e., OPC and TEC.
6. Hold practice drill-down sessions with CAMs before the CD-2/3 Director's review.
7. Update the baseline RLS after CERN's need-by dates are updated.
8. The Contingency (BCP) log should track CD-3a contingency values separately from the remainder of project contingency. The log should rely on very few formulas, so as to engender confidence in the results.

LAr

Answer to charge points:

1. Is progress on development of the proposed technical design adequate to meet the project's milestone for completion by the proposed CD-2/3 timeframe? Is it likely to meet the performance requirements?

The project is likely to meet the requirements for CD-2/3

2. Is the project making adequate progress on the resource-loaded schedule, risk assessment and contingency estimate to meet the project's milestone for CD-2/3?

Yes

3. Does the project team have adequate management experience, design skills, and laboratory support to produce a credible technical, cost, and schedule baseline?

Yes

4. Does the project team understand the dependencies on outside resources such as participation by researchers with other funding sources and funding from other agencies or international collaborators?

Yes

5. Does the project use the human and technical resources available to it at the participating national labs and universities when they are the most efficient choice? Are qualified vendors being sought out where they are the most cost-effective option?

Not enough time to evaluate

6. Are the long-lead procurements being managed successfully?

Yes

7. Are the ES&H aspects being addressed properly and is the planning sufficient for this stage of the project?

Not enough time to evaluate

8. Has the project responded satisfactorily to the recommendations from previous independent project reviews?

Two recommendations from CD-1 reviews still open, progress is being made and expected to be closed before CD-2.

9. Are there any other significant issues that require management attention?

None

Comments

Overall comments:

1. The team is highly experienced and has worked together successfully for many years delivering key components for the original detector and for the Phase 1 Upgrade. The progress on this project made has been very impressive. In particular, the collaborative selection of the preamp/shaper and the results from testing the ALFE2 ASIC are to be commended.
2. We note that the system being developed for Phase 2 is much more challenging than the Phase 1 system as the data throughput between the frontend to the backend is increased by a factor of 200.

6.4.5 Preamp/shaper

1. The preamp/shaper design (ALFE2) has made good progress, with the collaboration settling on a BNL ASIC design. The ALFE2 prototype chips are currently undergoing tests and initial results look promising. Several critical tests remain to be completed, in particular a test with protons at FNAL for SEU effects that is scheduled for early 2022.

To fully qualify the design, the ALFE2 ASIC needs to be tested with ADC chips on a full-size front-end board (FEB2). The FEB2 test is currently scheduled for Fall 2022 after the CD-2/3 review, due to constraints outside of the project's control. The ALFE2 FDR is, however, scheduled for early 2022. The team is confident that the full size FEB2 test is not essential for ALFE2 FDR.

2. We note that in the event that it is found during these qualification tests that the ALFE2 ASIC does need another revision, then a new ASIC designer would be needed to work on the design, as the original key designer has left the group. This risk is captured in the Risk Register.
3. The plan is for the US group to test 40k ALFE chips in production using a robotic testing setup, that is being developed by a French group. The group plans to have a detailed plan for the testing and the tooling in place by mid-summer for CD2.

6.4.4 FEB System Integration and Production Testing

1. The US scope is to fully test and qualify 806 FEB2 boards and to perform the full chain vertical slice system integration of the FEB2 boards, the phase 1 trigger boards, the backend electronics and the TDAQ. The production testing for the FEB2 boards and the vertical slice system testing is planned to be done at BNL under the supervision of 1.3 FTE engineers with technical labor employed by the lab.
2. Prototype testing of the FEB2 board is well advanced and results obtained so far have been positive. The first tests of the final version (full size) of the FEB2 board are scheduled to take after the CD-2/3 review.
3. The data throughput between FEB and LASP is two-hundred times greater than the existing system. This data throughput is a challenge in itself, and will likely reveal problems before and during production.
4. So far, a 32-channel prototype has been built and tested, but the real proof of the system design is in the operation of a full-size board with a realistic data flow, which will happen after CD3. The design and testing of the full-size board is further complicated since it will receive data from two new custom-designed ASICS, the ALFE2 and a new 16-bit high-performance ADC. The final verification of the ALFE2 and the ADC will also depend on the successful testing of the full FEB2.
5. The system integration of the FEB2 and the off-detector electronics is complicated by dependencies on several components that are outside of the DOE scope. Some are from French collaborators and some are from the NSF side of the project. The current status of these projects was not presented. Nevertheless, to date the collaboration appears to be going well and to be well managed and progressing well. Delays in this pipeline could delay the completion of 6.4 with concomitant cost increments. It is possible that using board emulators could help to mitigate some of the risks associated with board delays and allow early tests.
6. We note that the engineering effort that will be needed for the FEB2 QA/QC and the system integration is a resource shared with other parts of the project and other projects. While this is useful for management of the resources it does need to be managed well. Additional 1.5 years schedule delay could mean more delays in the delivery of the components for the vertical slice full chain testing.

Recommendations

1. At a future review the status of components from the NSF side of the project and other sources should be included in the presentations and the interface documentation made available to the reviewers.

Pixels

Answer to charge points:

1. Is progress on development of the proposed technical design adequate to meet the project's milestone for completion by the proposed CD-2/3 timeframe? Is it likely to meet the performance requirements?

Mostly Yes. There is good progress on design and prototypes. The schedule is tight to complete the testing underway. See comments and recommendations.

2. Is the project making adequate progress on the resource-loaded schedule, risk assessment and contingency estimate to meet the project's milestone for CD-2/3?

Yes.

3. Does the project team have adequate management experience, design skills, and laboratory support to produce a credible technical, cost, and schedule baseline?

Yes.

4. Does the project team understand the dependencies on outside resources such as participation by researchers with other funding sources and funding from other agencies or international collaborators?

Yes.

5. Does the project use the human and technical resources available to it at the participating national labs and universities when they are the most efficient choice? Are qualified vendors being sought out where they are the most cost-effective option?

Yes.

6. Are the long-lead procurements being managed successfully?

Yes.

7. Are the ES&H aspects being addressed properly and is the planning sufficient for this stage of the project?

Yes.

8. Has the project responded satisfactorily to the recommendations from previous independent project reviews?

Yes. Both were addressed: develop QA/QC and good progress on R&D to prepare for CD-2.

9. Are there any other significant issues that require management attention?

No.

Comments

1. We commend the team for the significant progress made on the design and prototyping of the inner pixel system since the last review. Module assembly sites and the integration lab have been set up, prototypes are in construction, and QA/QC plans are in development for each deliverable.
2. FY22 has important technical design validations and system tests in advance of ATLAS FDRs. It is important to have adequate funding for these activities. US ATLAS HL-LHC upgrade management understands this and is prepared to address needs in this critical year.
3. The March 2022 date for the ATLAS FDR of the pixel module is aggressive given the issues uncovered with failed bump bonds from at least one vendor. While the issue is under investigation and possibly comes from thermal stress and CTE mismatch between the silicon hybrids and copper of the flex, a resolution is needed for the final design
4. Completion of the electrical chain tests with *all* components including module, twinax cable, power cable, GBCR, and opto-box is a crucial step in validation of the design. Attention should be put into understanding of the performance, including operational margin and environmental conditions (temperature, magnetic field, radiation).
5. Attention to grounding and shielding during system tests is required to finalize electrical and mechanical designs. Waiting too long to define the grounding and shielding strategy could require significant redesign and impact cost and schedule.
6. The module assembly workflow has initial testing which is important to catch any issue from hybridization and module assembly. The set of tests should be defined to cover any issue or concern to give quick feedback to upstream work or vendors during production.
7. External deliverables, particularly “bare” sensor-ASIC hybrids for quad modules and assembled triplet modules, continue to constitute a high-risk item for the project. Project management is aware of this and tracks the progress with external milestones attached to the schedule for US scope. Management has identified risks and US personnel are well placed in the international ATLAS project to keep abreast of developments and communicate concerns. The committee recognizes the risk register contains a new risk in 6.1.5 “change in scope” that can mitigate possible schedule delays by adjusting sharing with international ATLAS.
8. Adequate technical and scientific labor (students, postdocs) at labs and university groups is crucial during module assembly, testing, and loading/integration. As the project moves into preproduction, attention should be paid to ensure these resources are made available to the project.

Recommendations

1. Complete the full characterization and testing of the prototype quad modules. Investigate any issues uncovered, including the observed bump bond failures, and revise the design or assembly/testing procedures to address any shortcomings on performance requirements before the CD-2/3 review.
2. Present the plans for grounding and shielding for the next review.

Strips

Answer to charge points:

1. Is progress on development of the proposed technical design adequate to meet the project's milestone for completion by the proposed CD-2/3 timeframe? Is it likely to meet the performance requirements?

Yes. The project is essentially ready for CD-2. There are still a number of tasks to complete for CD-3. It is likely that these can be achieved before August 22 but the timescale is tight.

2. Is the project making adequate progress on the resource-loaded schedule, risk assessment and contingency estimate to meet the project's milestone for CD-2/3?

Yes. The project has been actively developing their risk assessment in light of recent cost increases and delays.

3. Does the project team have adequate management experience, design skills, and laboratory support to produce a credible technical, cost, and schedule baseline?

Yes. The team has the required experience and skills.

4. Does the project team understand the dependencies on outside resources such as participation by researchers with other funding sources and funding from other agencies or international collaborators?

Yes. The team clearly highlighted the external dependencies.

5. Does the project use the human and technical resources available to it at the participating national labs and universities when they are the most efficient choice? Are qualified vendors being sought out where they are the most cost-effective option?

Yes, the project appears to have made appropriate choices for in-house vs vendor resource allocation.

6. Are the long-lead procurements being managed successfully?

Yes, the project has procured a large fraction of the long-lead items approved in CD3-a.

7. Are the ES&H aspects being addressed properly and is the planning sufficient for this stage of the project?

Yes. ESH was clearly highlighted and hazards and mitigations outlined. The project is also going through a rigorous and extensive site qualification process. Because of COVID-19 restrictions this is being carried out remotely rather than through site visits.

8. Has the project responded satisfactorily to the recommendations from previous independent project reviews?

Yes.

9. Are there any other significant issues that require management attention?

No

Comments

1. The ATLAS strip group has outstanding expertise and experience.
2. Designs and assembly procedures are now quite mature. Successful fabrication of the PP2 stave exercised the full assembly and test chain. This provides good confidence in the pre-production components and processes.
3. A single vendor was identified as a risk for the bus tape flexible circuit. This vendor was acquired by another company and is no longer a candidate for bus tape production.
    1. This was identified as a single-vendor risk by the project. We note that development of a second vendor was included in the risk mitigation strategy.
    2. The strip project responded aggressively to the loss of the bus tape vendor and there are now two viable producers. The vendors have different costs, constraints and capacities. The project should carefully optimize cost, schedule and risk considerations in placing production contracts.
4. Additional noise has been observed for staves operated at low temperature. This particular problem has been solved, but it may be an indication of noise sensitivity. Noise sensitivity should be monitored and tested throughout the qualification, production, and integration process.
5. The redesign of the HCCStar to mitigate single event effects resulted in a 2-year delay in the availability of the chip. The pre-production chip will be tested soon. Successful testing of this chip in the winter and spring of 2022 is crucial to the project schedule
6. Documentation that clearly identifies the external interfaces of the project and how they are controlled should be made easily available to future reviewers.

Recommendations

1. The strips subproject will require a rapid ramp-up of technician labor (10 new technicians at 4 sites) in the next few years. In the current labor climate, it may be difficult to hire and train well-qualified people. The subproject (and project as a whole) should consider adding personnel recruitment as a risk prior to the CD-2/3 review.
2. All quotes for items that are not part of the CD-3a scope should be refreshed prior to CD-2/3 so that they are not older than one year. An example is the quote for the bus tapes by Altaflex. This quote is from October 2020. A new quote should be obtained for the number of parts beyond the CD-3A scope prior to the CD-2/3 review.

Global Mechanics

Answer to charge points:

1. Is progress on development of the proposed technical design adequate to meet the project's milestone for completion by the proposed CD-2/3 timeframe? Is it likely to meet the performance requirements?

Yes

2. Is the project making adequate progress on the resource-loaded schedule, risk assessment and contingency estimate to meet the project's milestone for CD-2/3?

Yes

3. Does the project team have adequate management experience, design skills, and laboratory support to produce a credible technical, cost, and schedule baseline?

Yes

4. Does the project team understand the dependencies on outside resources such as participation by researchers with other funding sources and funding from other agencies or international collaborators?

Yes

5. Does the project use the human and technical resources available to it at the participating national labs and universities when they are the most efficient choice? Are qualified vendors being sought out where they are the most cost-effective option?

Yes

6. Are the long-lead procurements being managed successfully?

Yes

7. Are the ES&H aspects being addressed properly and is the planning sufficient for this stage of the project?

Yes

8. Has the project responded satisfactorily to the recommendations from previous independent project reviews?

Yes

9. Are there any other significant issues that require management attention?

No

Comments

1. The Global Mechanics team has made very good progress with CD-3a funding, completing design and fabrication scope associated with key components; the Outer Cylinder, Structural Bulkheads and Strip Barrel Shells.
2. The outer shell failure was identified by the supplier, analyzed and a repair path was chosen in collaboration between the supplier and LBNL. The work instructions were modified to mitigate similar mechanical failures in future parts. This repair also included taking into account that the outer layer of this assembly serves as a RF shield. A patch using the same material, VeeloVEIL carbon mesh, was also applied. The team should remain diligent completing detailed inspections of shells for other types of failures or anomalies that could compromise the structural integrity or RF shielding performance of barrel sections and other load carrying components.
3. The team has done a good job of coordinating and defining internal interfaces and it appears they have coordinated external interfaces also. Developing formal interface documentation for all external interfaces is important, especially for installation tooling that may interface across design authority boundaries. The committee is pleased to see that the main engineers in charge of production will take the lead to guarantee the integration of the different components at CERN.
4. The CD-3a recommendation to procure a third set of components that could be used to fabricate a replacement of the 2 structural bulkheads, in the event of a catastrophic bonding issue, is considered not necessary due to short lead times to procure replacement components. This is an optimistic strategy.
5. Even with a year of float in the overall schedule – based on a delay in the CERN schedule – due next month – long lead time orders for materials must be placed as early as possible and tracked diligently.
6. There is a concern about possible tolerance build-up with the large sections of the outer shell that may need to be compensated in the fabrication of the flanges. This may also apply to the overall assembly of all of the shell structures into a final assembly.
7. The Global Mechanics team seems highly qualified to meet the schedule that has been put forward. This subsystem will be the first to complete the project scope in advance of CD-4, this may cause issues with continuity of key personnel required during integration. The team has also demonstrated excellent communication paths with both vendors, ACSD and collaborating institutions – University of Washington – who will be focused on the IST.
8. The bulkhead is a multifunctional component with several interfaces to hardware outside the GM WBS. These multiple interfaces and functions may require additional tests of the bulkhead prior to installation, beyond the leak tightness certification.
9. While the Global Mechanics structure has significant margin for additional mass that may be added as the design of services matures, the available volume for cooling and cabling is significantly constrained. The ITk services mockup is a best practice and should continue to be used as service routings develop and mature. CAD drawings of cable routings are typically not sufficient to confirm space for bend radii and other hardware related limitations. Additional mock-ups and strict change control should be considered to aid in resolving routing and space issues.
10. Attention from project management is needed to plan for availability of the key engineers for the Integration and Commissioning effort at CERN. There is a gap between current

budget profile and schedule for delivery of Global Mechanics scope and I&C activities.

Recommendations

1. Shipping of large components – shells – needs to be focused as soon as possible due to possible delays in scheduling international shipping – in coordination with customs and collaborating institutions. In addition, how the liability is being handled during shipping for these large, high value, one-off components should be clarified upfront. Present shipping and transportation plans at CD-2/3.
2. Prepare and present Grounding and Shielding design and verification plan/results for Global Mechanics at CD-2/3.

DAQ

Answer to charge points:

1. Is progress on development of the proposed technical design adequate to meet the project's milestone for completion by the proposed CD-2/3 timeframe? Is it likely to meet the performance requirements?

Yes, with additional comments regarding the changes to the plan caused by a recent change to 6.7.4.1

2. Is the project making adequate progress on the resource-loaded schedule, risk assessment and contingency estimate to meet the project's milestone for CD-2/3?

Yes, but the risk register needs to be scrubbed to account for risks that can not be retired before CD-⅔. And those that will be retired before CD-2/3

3. Does the project team have adequate management experience, design skills, and laboratory support to produce a credible technical, cost, and schedule baseline?

Yes, the team is very experienced and has done an excellent job of managing this project.

4. Does the project team understand the dependencies on outside resources such as participation by researchers with other funding sources and funding from other agencies or international collaborators?

Yes, and while risks remain, the team is managing this well.

5. Does the project use the human and technical resources available to it at the participating national labs and universities when they are the most efficient choice? Are qualified vendors being sought out where they are the most cost-effective option?

Yes

6. Are the long-lead procurements being managed successfully?

Yes, the team is doing a good job of tracking supply situation and vendors.

7. Are the ES&H aspects being addressed properly and is the planning sufficient for this stage of the project?

Yes

8. Has the project responded satisfactorily to the recommendations from previous independent project reviews?

There have been no previous recommendations. There were no recommendations in the May 2019 Directors review nor the July 2018 DOE CD-1 Review. So yes.

9. Are there any other significant issues that require management attention?

6.7.4.1 needs to be aligned with the current “EF tracking” approach chosen by the ATLAS collaboration. This will be a recommendation.

Comments

1. The progress made by the DAQ team is adequate to meet the tier 3 and 4 milestones by the proposed CD-2/3 timeframe. As reported, for 6.7.1 (GCM) SPR is due in Jan 2022, for 6.7.3 (FELIX), PDR is planned for Q1 of 2022 and for 6.7.4 (readout interface FW), global trigger SPR is expected in Jan 2022.
2. The project is likely to meet performance requirements and has demonstrated excellent progress in most areas. The only area where technical progress appears to be behind (but this is only appearance) is 6.7.4.1, where a change from custom hardware to commodity-based solution, endorsed by the ATLAS CB in Oct 2021 requires a change in the firmware, but over all, this is a simplification and will not negatively impact the project schedule.
3. The project team has done a good job highlighting the status of hardware vs firmware/software and this is helpful to the reviewers and they should continue to highlight the separate aspects and risks associated with each. They are both relevant for the PDR/FDR and the team is addressing risk and schedule differences.
4. The team has more than adequate management experience, design skills, laboratory and engineering support to produce credible technical, cost and schedule estimates. The team’s presentations were excellent, the answers to reviewers’ questions clear and on point.
5. The project team understands well the dependencies on outside resources and has done an excellent job of managing and mitigating the risk associated with these dependencies. Most of these outside contributions are in the form of engineering labor

and design, and the team works closely with the relevant institutions to manage the work and understand the progress. We commend the decision to bring key resources to BNL to contribute locally, embedded within the US team. Nevertheless, risks remain and will need to continue to be closely managed in the future.

6. The current COVID-19 induced crisis in the semiconductor industry poses challenges to the DAQ sub-project hardware deliverables in acquisition of FPGAs, optical modules, and even PCBs. The team is doing a good job of managing supply challenges, monitoring the status and keeping in close touch with key vendors. They are identifying, testing and estimating the impact of alternatives to the current baseline components and solutions.
7. The team is doing a good job of understanding and properly addressing the ES&H aspects of the DAQ project. This includes the safety aspects of high-performance electronics such as fire risk and noise as well as accounting for the effects of COVID-19 and working with the national labs to prioritize the work to move the project forward.

Recommendations

1. Ensure that 6.7.4.1is aligned with the current “EF tracking” approach chosen by the ATLAS collaboration before moving to CD-2 / 3 review.

Appendix I

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November 19, 2021

Charge for the HL-LHC US ATLAS Upgrade Project Director's Review

Virtual, December 13-15, 2021

DOE Office of High Energy Physics is planning Independent Project Review (IPR) of the US ATLAS HL-LHC project for second half of January 2022. To evaluate status and readiness of the project for the review, the review committee should provide in depth review of the project concentrating on the areas where the project can improve for the coming DOE review. Pandemic created major challenges with the execution of the project, including impacts on cost and schedule. Your feedback on these impacts and proposed by the project mitigation strategies will be extremely valuable.

As part of assessing the project's progress and plans, the committee should focus on the following questions:

1. Is progress on development of the proposed technical design adequate to meet the project's milestone for completion by the proposed CD-2/3 timeframe? Is it likely to meet the performance requirements?
2. Is the project making adequate progress on the resource-loaded schedule, risk assessment and contingency estimate to meet the project's milestone for CD-2/3?
3. Does the project team have adequate management experience, design skills, and laboratory support to produce a credible technical, cost, and schedule baseline?
4. Does the project team understand the dependencies on outside resources such as participation by researchers with other funding sources and funding from other agencies or international collaborators?
5. Does the project use the human and technical resources available to it at the participating national labs and universities when they are the most efficient choice? Are qualified vendors being sought out where they are the most cost-effective option?
6. Are the long-lead procurements being managed successfully?
7. Are the ES&H aspects being addressed properly and is the planning sufficient for this stage of the project?
8. Has the project responded satisfactorily to the recommendations from previous independent project reviews?
9. Are there any other significant issues that require management attention?

I appreciate the committee time and efforts to help with conducting this review. The review summary will be most effective if delivered by December 17, 2021.

Dmitri Denisov
Deputy Associate Laboratory Director for High Energy Physics

Appendix II

BNL Director's Review for the
January 2022 DOE/SC Independent Project Review (IPR)/CD-3b
U.S. ATLAS High Luminosity LHC (HL-LHC) Upgrade Project
Brookhaven National Laboratory
December 13-15, 2021

Agenda

Monday, December 13, 2021

9:00 am	Full Committee Executive Session ..... Denisov
9:45 am	Welcome ..... Denisov
9:50 am	Project Status and Overview ..... Kotcher
10:25 am	Technical Status, COVID Simulations and I&C ..... Evans
10:55 am	Baseline Costs & Tracking, COVID BCPs, EVMS ..... Novakova
11:25 am	Project Evolution, Maturity & Risk, Monte Carlo ..... Brooijmans
11:55 am	Break
12:10 pm	Pixels ..... Grenier
12:40 pm	Strips ..... Sciolla
1:10 pm	Global Mechanics ..... Anderssen
1:40 pm	Lunch
2:15 pm	Liquid Argon ..... Parsons
2:45 pm	Trigger & Data Acquisition ..... Zhang
3:15 pm	Break
3:30 pm	**Subcommittee Breakout Sessions**

- Pixels —
- Silicon Strips —
- Global Mechanics —
- LAr —
- DAQ —
- Management, Cost & Schedule –

5:00 pm	Full Committee Executive Session
6:00 pm	Adjourn

Tuesday, December 14, 2021

9:00 am	Subcommittee Breakout Sessions — (remote rooms above)
11:00 am	Break
11:15 am	Subcommittee Breakout/Executive Sessions
1:00 pm	Lunch
2:00 pm	Responses to Questions (Full Committee)
3:00 pm	Executive Session/Report Writing
6:00 pm	Adjourn

Wednesday, December 15, 2021

9:00 am	Executive Session/Report Writing
10:00 am	Closeout Dry Run
1:00 pm	Closeout Presentation
2:00 pm	Adjourn