

Panel Report for the NSF Review of ATLAS

August 18, 2021

Executive Summary

Overall the project is well managed and likely to meet its goals. Progress tracking, and risk management and mitigation are done particularly well. The project organization is clear and well integrated into the larger ATLAS collaboration

We commend the ATLAS team for making significant progress in spite of the general disruption of the COVID pandemic. The project leadership has done an excellent job coping with the COVID pandemic and mitigating the impact of the pandemic on cost and schedule.

Based on the experience to date and on the project's detailed approach to this problem, the project plans for FY2022 are well formulated and realistic, assuming the COVID impact does not increase in the future.

Some of the key underlying assumptions needed for a rebaseline appear to be fluid at this time and may evolve over the next 6 to 12 months. These include assumptions about the overall direction of COVID and its effect on the ATLAS supply base and associated lead times. In addition, a delay in CERN's schedule may create an opportunity to replan activities affected by COVID in order to take advantage of additional float. We recommend that these factors be weighted together with the time-phased need for possible additional funding due to COVID in GFY22 and beyond before proceeding with a rebaseline exercise.

Response to the Review Charge

1. Completion of the Final Design

- a. *Review FDR panel recommendations and comment to NSF on whether they have been satisfactorily addressed*

Findings:

There were three major recommendations to the project at FDR: (i) clarify and document the requirements for LVPS radiation tolerance, (ii) establish verification and compliance matrices for QA/QC, and (iii) verify suppliers' capability to enable the expected high volume purchases. The project presented statements and documentation on closing these recommendations.

Comments:

All of the FDR recommendations were properly addressed by the project and are proposed to be closed.

Additional recommendations were provided by the NSF EVMS Verification Review. These are also included in the current project report as done and also proposed to be closed.

Recommendations:

None

- b. *Have pre-construction technical activities that were separately funded by NSF through the ATLAS operations program been satisfactorily completed?*

Findings:

Pre-construction activities for the **LAr upgrade (WBS 6.4)** were delayed due to unavailability of radiation testing facility, but have been satisfactorily completed by December 2020.

The remaining FDR recommendation for the **Tile Calorimeter (WBS 6.5)** is to complete radiation certification of the LV Power Supplies 6.5.4. While limited access to radiation testing facilities due to Covid did delay completion, all but one of the components have been certified since the FDR and the final test campaign will be started in early September 2021.

Pre-construction technical activities for the **muon upgrade (WBS 6.6)** have been completed.

Pre-construction activities funded through the operations program on the **ATLAS trigger (WBS 6.8)** have been satisfactorily completed. In particular

- HTT hardware - TFM, RTM demonstrator boards individually tested; TP demonstrator board completed and individually tested
- HTT firmware - first version of a common framework was prepared (US and international contributions integrated)
- Global firmware - completed initial studies for trigger framework and algorithms.

Comments:

None

Recommendations:

None

2. Project Management

- a. *Implementation of the Project Execution Plan, project controls and financial reporting, including subawardee oversight. Examine the current version of the Project Execution Plan, representative change control actions, and recent Earned Value Management Reports and advise NSF on their use as effective management tools.*

Findings:

Together with other essential documents, the panel was provided with the 8 August 2021 Project Execution Plan, a representative sample of change control actions and EVM reports for April through June 2021.

Comments:

ATLAS is effectively managing a well-developed project execution plan using a classic set of tools and systems which include an adequate change control mechanism, established subaward and contract management systems, a necessary invoice approval system and an adequate earned value management system for the tracking, statusing and reporting of progress, cost incurred and variances.

Recommendations:

None

- b. *Financial tracking of COVID and non-COVID costs & cumulative COVID costs-to-date*

Findings:

ATLAS presented its system for collecting and accounting for the actual costs incurred to date for both COVID and non-COVID related activities

Comments:

ATLAS appears to be appropriately collecting and reporting the actual costs of internal work performed and is generally receiving current actual costs from its subawardees which are also included in its cost reports. The appropriate inclusion of accruals is required in some cases and a necessary system for reconciling accruals with actuals is in place. An EVMS surveillance review being conducted this week by the Large Facilities Office will verify data integrity and reporting.

In addition, ATLAS uses a reasonable approach for estimating the amount of the actual cost incurred due to the effects of COVID and segregates that amount in its ETC. BCPs are examined within the project and discussed with NSF staff to assure costs are properly recorded.

Recommendations:

None

- c. *Risk management process, including completeness of current projections of risk and potential mitigation costs and the adequacy of the contingency budget and schedule to mitigate future non-COVID risks. Advise NSF on the completeness of the risk register in identifying currently foreseen non-COVID related threats and opportunities with appropriate probabilities and estimated cost and schedule*

Findings:

The risk register was reviewed by the panel. There are 108 total active or partially active risks:

- 5 active NSF global risks.
- 22 active or partially realized NSF risks in the WBS 6.4 liquid argon system.
- 19 active NSF risks in the WBS 6.5 Tile system.
- 26 active or partially realized NSF risks for WBS 6.6 Muon System
- 36 active or partially realized NSF risks for WBS 6.8 Trigger

The Risk Manager carries out quarterly risk reviews and any actions are included in the monthly report to the NSF.

Monte Carlo simulation is used to estimate the cost and schedule contingency needed for each subproject independently based on uncertainties and risks. It was stated that the Monte Carlo simulation was run once per year.

The currently available contingency (\$18.6M or 37.5% of the \$49.5M cost-to-go) corresponds to 83% confidence level.

The schedule contingency needed at 90% confidence level ranges from 132 to 387 working days for different subprojects

At this time, due to COVID, both the needed schedule contingency and the “needed at CERN” dates were said to be highly uncertain.

Comments:

Overall, the risk process and register is generally complete and well thought out. The Monte Carlo modeling and resulting predictions are impressive and appear complete. The risks at the L2 level are well described and understood. Some minor improvements (see further comments) are suggested.

The NSF global risks do not include delays associated with continuing resolutions, which is unusual.

The total number of risks is appropriate for the scale of this project.

A plot of risks retired vs time would be useful.

There is also a risk of not properly estimating the cost and schedule impact of COVID, which should be taken into account during the re-baselining.

Some delays associated with non-COVID BCPs have been up to 9 months, which is significant this early in the Project.

The available contingency (\$18.6M) is \$2.3M less than the 90% CL cost contingency needed according to the Monte Carlo calculation. No plan was presented to bring available contingency back to the healthier value corresponding to 90% CL.

Recommendations:

Running the Monte Carlo simulation to estimate cost and schedule contingency should be done more often than once per year. The Project should aim for at least quarterly or whatever frequency at which risks are updated.

It would be prudent to wait for CERN to decide about the start date for Long Shutdown 3 and then update cost, schedule, risks and needed contingencies (both non-COVID and COVID related).

- d. Adherence to the QA/QC processes presented at FDR. Advise NSF on whether it is being implemented as intended*

Findings:

The QA/QC documentation is captured in the DocDB archive. The Quality Assurance Plan for the upgrade project outlines the framework for executing QA/QC. The documentation includes QA/QC narratives for each WBS deliverable item, as well as the corresponding Verification Matrices. For each requirement, the matrix specifies the verification method and the location of the verification (responsible institute). Preliminary QC acceptance criteria will be approved at the (international) FDR, and final criteria at the (international) Production Readiness Review (PRR).

Comments:

The QA/QC documentation represents a satisfactory implementation of QA/QC concepts and practice.

While the Verification Matrices properly frame the verification process and point to the necessary details, expected compliance estimates are not included.

Recommendations:

None

3. Plans for FY 2022

- a. *Examine and comment to NSF on COVID impact modelling and assessment by the project of forecast COVID-related cost and schedule impacts. Advise NSF on the realism of assumptions and the credibility of the models used, and the completeness (based on current understanding) of additional schedule and budget needs. Advise NSF on the timing for when additional NSF funds to offset pandemic impacts are likely to be needed within the project*

Findings:

ATLAS presented its approach for assessing the potential cost and schedule effects due to the current COVID delay, reduced future efficiency and COVID dependent risks.

Comments:

In its model, ATLAS appropriately includes currently foreseeable risk and uncertainty assumptions related to COVID. Its modelling approach is reasonable and produces a credible range of potential cost and schedule adjustments for consideration.

At this time, the model does not assess the effects of a potential schedule delay by CERN. It appears that if such a delay does occur it will extend the installation schedule by not less than one year.

While increased vaccination rates are encouraging, all of the long term worldwide lasting effects of COVID and its variants are currently unknowable.

Recommendations:

Some of the key underlying assumptions needed for a rebaseline appear to be fluid at this time and may evolve over the next 6 to 12 months. These include assumptions about the overall direction of COVID and its effect on the ATLAS supply base and associated lead times. In addition, a delay in CERN's schedule may create an opportunity to replan activities affected by COVID in order to take advantage of additional float.

We recommend that these factors be weighted together with the time-phased need for possible additional funding due to COVID in GFY22 and beyond before proceeding with a rebaseline exercise. It would be prudent for the project to wait for CERN to decide about possible delays to the start of Long Shutdown 3 (and its duration) before undertaking a major update to the estimate to complete and the associated schedule - rebaselining.

- b. *Examine and comment to NSF on the realism of plans for the coming project year (10/1/21 – 9/30/22) based on current understanding of COVID pandemic impacts and mitigation strategies, and lessons learned from the first year of construction*

Comments:

The project leadership has done an excellent job coping with the COVID pandemic and mitigating the impact of the pandemic on cost and schedule.

The project has carefully gathered data on the impact of COVID and has thought carefully about what this effect will be in the coming year. The division of impact between lab and office work is a good practice

Based on the experience to date and on the project's detailed approach to this problem, the project plans for FY2022 are well formulated and realistic, assuming the COVID impact does not increase in the future. However, as noted in presentations to the panel, the evolution of the COVID pandemic is fundamentally uncertain at this time.

Recommendations:

None

- c. *Examine the forecast risk-adjusted expenditure and obligation profile (including pandemic-related risks) for the coming fiscal year and advise NSF on the adequacy of its substantiation. Make recommendations for modification, if appropriate.*

Findings:

The project is finishing GFY21 with an estimated carryover (excluding NSF-held contingency) of about \$7.5M

Comments:

Based on the project's expected spending in GFY22 (including the estimated GFY22 cost effect of COVID), it is currently forecasting a carryover of about \$3.3M by the end the next fiscal year. Coupled with the pool of unreleased contingency, these amounts appear adequate for ATLAS to confidently execute its plan through GFY22.

Recommendations:

None

- d. *Do the materials presented by the project provide adequate substantiation for re-baselining within the next 6-12 months? If not, what criteria must be satisfied as a precondition for conducting a re-baselining review that would confidently bound estimates for additional schedule and budget based on current understanding?*

Findings:

The project presented that the total impact of COVID cannot be realistically evaluated at this time and it's unlikely that adequate substantiation for re-baselining within the next 6-12 months is feasible.

Comments:

The project has developed the means and tools necessary to rapidly re-baseline. Hence it would be feasible to complete a preliminary re-baseline proposal to the NSF after CERN decides about the start date and duration of Long Shutdown 3. This decision is expected by the end of CY2021.

If the COVID circumstances are under control in early CY22, then the project could be ready to re-baseline, and the NSF could ask for additional funding for FY2024. However, if the COVID circumstances are not under control or remain uncertain by early CY2022, then funding change due to re-baselining is likely to be delayed until FY2025 or later.

Recommendations:

None

4. Technical Progress

- a. *Comment on the adequacy of progress and planning across all Level 3 Work Breakdown Structure (WBS) elements, considering COVID-19 uncertainties. Identify non-COVID-related impediments to technical progress and comment on the adequacy of plans and efforts exerted by ATLAS to mitigate their impacts.*

Findings:

LAr Calorimeter system (WBS 6.4) has made significant technical progress despite difficulties related to COVID. Several technical downselects have been made since the FDR such as ADC and preamp/shaper designs. The radiation testing of the ADC suffered significant delay, but the team managed to conduct the tests, complete the ADC PDR, and provide feedback to the prototype design.

Tile Calorimeter (WBS 6.5) scope has made considerable progress despite the challenges of the Covid era. Continued excellent performance of Module-0 in-situ on the detector and parallel test-beam activity builds confidence. The team was proactive in ordering Commercial Off the Shelf (COTS) Integrated Circuit (IC) components at the onset of Covid which substantially reduces the risk exposure of IC availability.

The FDR noted possible radiation dose vulnerability LVPS ICs. The expected dose in the LVPS region has been re-evaluated more completely which resulted in a significant reduction of the expected dose. Working with the CERN radiation task force, the team has developed a program to validate the radiation hardness of each IC production batch and will carry an associated risk (RN-06-05-04-13) through the duration of production.

The ***muon upgrade project (WBS 6.6)*** made significant progress. The project risks are closely monitored and, at this point, all subprojects have sufficient floats

The SMDT production started in Dec 2020, by now more than 25% of 24,000 tubes have been produced and 7 out of 49 chambers have been completed. The achieved daily tube production rate is significantly higher than required by the schedule, remaining risks are dominated by the COVID-related ones.

FDR for TDC module took place in early Aug 2021, v2 of the module passed all functionality tests, radiation tests to be completed before the PRR.

All ten prototype boards for SCM passed the functionality requirements, preliminary results of neutron irradiation indicate high robustness wrt SEU's, TID tests to be done before the PRR.

Change in the LOMDT module design delayed completion of the preliminary design by about one year, Substantial progress on the firmware development has been reported.

The design of the *ATLAS trigger (WBS 6.8)* is being significantly changed. L0 will be the only hardware layer of the trigger. There are still multiple options for the new trigger design that were not resolved at the time of the review

The fiber optic plant is being built by the group that did the same thing for the phase 1 upgrade. Work is not scheduled to begin upon this until November this year

Significant progress on the hardware for the hardware track trigger was shown. The full hardware demonstrators for the NSF components have been completed. Hardware development and integration tasks were significantly impacted by Covid related delays. However the HTT is impacted by the L0 only decision and the future path for the project is being evaluated. Three paths have been considered

- “custom hardware” (redesign compared to HTT baseline)
- “heterogeneous commodity hardware”(based on commercial FPGA accelerators)
- CPU-based tracking performed in software only.

The recommendation to the collaboration is that TDAQ should commit to a commodity based solution for EF tracking at HL-LHC, but this decision needs to be endorsed by the collaboration board.

The status of the early work on the global trigger firmware was shown. There was a decrease in the efficiency of the work due to Covid impacts. The global trigger plans are not significantly impacted by the hardware track trigger decision.

Comments:

LAr Calorimeter system (WBS 6.4) team has done an excellent job dealing with COVID related impediments. However, ASIC and PCB production delays, availability of commercial parts, as well as radiation testing will continue to pose significant risks for cost and schedule. The team should adjust the plan as more information on COVID impacts become available.

Non-Covid related impediments can come from external dependencies such as preamp/shaper (DOE scope), lpGBT ASIC (CERN deliverables), and voltage regulators (technical downselect not finalized). They are not on the critical path, but their progress should be tracked and monitored by the team.

At the present time a significant change in the design of the *ATLAS trigger (WBS 6.8)* is underway and those design changes have not been completed. The reviewers were told that the track trigger will use commodity components, which in principle should ease the load on the engineering effort. However without a more detailed description of what the plans are it is difficult to comment further. This is not

intended as a criticism of the project. In fact the project should be commended for being open to moving in a new direction given the rapidly changing capabilities of commercially available components. This should ultimately result in a more robust and cost effective design.

Recommendations:

Given the significance of the changes to the design of the *ATLAS trigger (WBS 6.8)*, it is recommended that NSF conduct a separate review of the trigger upgrade once the design changes are complete, focusing on track triggering. This review should reevaluate the technical design of the project, its cost, and the revised schedule.

b. Comment on the level of engineering and scientific labor that is being applied to support Level 0 Trigger development, as evidenced by satisfactory technical progress in firmware development.

Response to this question is included in the response to 4.a.

Appendix

Panel Members

<i>Name</i>	<i>Expertise</i>	<i>Review area</i>	<i>Affiliation</i>	<i>email</i>
<i>Management</i>				
George Angeli (chair)	Sys Eng	PM	Retired - adviser to GMT	gangeli@gmto.org
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Charge to the Review Panel

1. Completion of Final Design:
 - a. Review FDR panel recommendations and comment to NSF on whether they have been satisfactorily addressed.
 - b. Have pre-construction technical activities that were separately funded by NSF through the ATLAS operations program been satisfactorily completed?

2. Project Management: Examine and comment to NSF on:
 - a. Implementation of the Project Execution Plan, project controls and financial reporting, including subawardee oversight. *Examine the current version of the Project Execution Plan, representative change control actions, and recent Earned Value Management Reports and advise NSF on their use as effective management tools.*
 - b. Financial tracking of COVID and non-COVID costs & cumulative COVID costs-to-date.
 - c. Risk management process, including completeness of current projections of risk and potential mitigation costs and the adequacy of the contingency budget and schedule to mitigate future non-COVID risks. *Advise NSF on the completeness of the risk register in identifying currently foreseen non-COVID related threats and opportunities with appropriate probabilities and estimated cost and schedule.*
 - d. Adherence to the QA/QC processes presented at FDR. *Advise NSF on whether it is being implemented as intended.*

3. Plans for FY 2022
 - a. Examine and comment to NSF on COVID impact modelling and assessment by the project of forecast COVID-related cost and schedule impacts. Advise NSF on the realism of assumptions and the credibility of the models used, and the completeness (based on current understanding) of additional schedule and budget needs. Advise NSF on the timing for when additional NSF funds to offset pandemic impacts are likely to be needed within the project.

- b. Examine and comment to NSF on the realism of plans for the coming project year (10/1/21 – 9/30/22) based on current understanding of COVID pandemic impacts and mitigation strategies, and lessons learned from the first year of construction.
- c. Examine the forecast risk-adjusted expenditure and obligation profile (including pandemic-related risks) for the coming fiscal year and advise NSF on the adequacy of its substantiation. Make recommendations for modification, if appropriate.
- d. Do the materials presented by the project provide adequate substantiation for re-baselining within the next 6-12 months? If not, what criteria must be satisfied as a precondition for conducting a re-baselining review that would confidently bound estimates for additional schedule and budget based on current understanding?

4. Technical Progress

- a. Comment on the adequacy of progress and planning across all Level 3 Work Breakdown Structure (WBS) elements, considering COVID-19 uncertainties. Identify non-COVID-related impediments to technical progress and comment on the adequacy of plans and efforts exerted by ATLAS to mitigate their impacts.
- b. Comment on the level of engineering and scientific labor that is being applied to support Level 0 Trigger development, as evidenced by satisfactory technical progress in firmware development.

Note: Because the EPO plans presented at FDR described how ATLAS would leverage the high luminosity upgrade activities within the context of its existing EPO and Diversity programs, NSF will review the current status of those plans as part of the ATLAS 5-year operations proposal review (July 20-21, 2021).