Panel Report for 2019 Director's Review of SoLID

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Response to Charge questions

1. Are the scientific and technical requirements clearly identified? Is the SoLID conceptual design sound, achievable and sufficiently defined to meet those requirements?

   Yes, for this stage.

2. Have all significant technical risks been identified, and are there appropriate plans in place to mitigate these risks?

   No.

3. Are the cost and schedule estimates appropriately developed for this stage of pre-project planning? Is the basis of the contingency estimate well-founded, and is there appropriate cost and schedule contingency included to address the identified risks?

   Cost methods are good; the details could be more robust.

   Schedule: mixed bag. Some of the schedules, particularly for the detectors, seemed well thought out. Integration needs improvement.

   Contingency: methodology is sound. The risk/judgement items need further evaluation. Overall cost+contingency level is in the right ballpark but likely somewhat low.

4. Are ES&H aspects properly considered in the design, fabrication, and testing plans?

   Mostly. Team is encouraged to continue evaluation and improvement.

5. Has all off-project scope that is required for the successful operation of SoLID been identified? Are credible plans in place to secure completion of that scope?

   Mostly yes. A substantial list of items was presented. The boundary should be crisper.

   The JLab strategy for supporting this off-project work was unclear. It will be important to get this more concrete.

6. Has the project team responded appropriately to recommendations from prior Director's Reviews?

   The panel was unable to assess this.

Recommendations

- Make a pre-R&D plan, including a notional schedule, that resolves all significant technical questions if implemented. Include static/warm tests of the magnet.
- Put in place a strategy for transition to a 413.3-quality documentation package. Insure sufficient resources of appropriate types are assigned. Include a training plan for candidates for critical roles.
- Complete resolving the recommendations from the previous review.
- Carefully re-examine the experiment's implementation to determine if any new or enhanced hazards, ie. beyond "normal" for JLab, have been incorporated. Adjust the implementation as necessary.
- Review the scope/designs for opportunities to reduce costs while meeting the technical requirements. Incorporate the changes into the plan.
- Update the pCDR to incorporate the improvements identified in the other recommendations.
  - Make the links between "physics" requirements and equipment requirements more crisp.
  - Expand the details of engineering integration.

Comments/suggestions

General

- Review talks were well planned and allowed for ample time for discussion. This was very much appreciated.
- An overview of the collaboration and the organization of the collaboration early in the presentations and identifying the role of each person in the project would've been helpful.
- The POL He3 SIDIS experiment is an excellent choice for the first experiment for SOLID.
- Preliminary ideas on KPPs will help focus the later stages of the project.
- A functional requirement document (table) should be developed. This document/table should include a list of parameters and experimental parameters that define operations and performance requirements of the detectors, including its boundaries. This table can serve as basis for the conceptional design choices described in the CDR and reviewed at CD-1.
- Clarify the division of responsibilities between operations, project installation, integrated testing, and detector commissioning – what are the assumption for the installation BOE, what are the interfaces between operations (off project) and installation (on project).
- Clearer delineation of the on-project and off-project scope and goals as they relate to the SoLID project more clearly in the presentations. Consider an assumption document in the pre-brief.
- The pre-R&D plan would benefit from consideration of when/where (parasitic) beam tests can be done.
- The previous review panel had made 36 recommendations. We requested a few lines of explanation to support the closure of certain recommendations. In the end, the supporting information that closed each recommendation was still missing. A few lines of supporting evidence is needed for each recommendation that is considered closed.

Project mechanics

- The cost documentation provided (*SoLID_Cost_Estimate_Worksheets.xlsm* and the various *cost_basis* and *BOE_justification* files) represent a tremendous effort by the SoLID team. Be aware that a CD-1 OPA-style review committee, for example, will want to be able to drill-down and find data that substantiates each element of the cost estimate in greater detail. This is not possible with the material provided as pre-brief. The SoLID team should transition their documentation to a more standard format.
- The LGC and HGC Cost Basis documents contain good high-level descriptions of the contents of each WBS subsection along with comments about how each cost estimate was developed. The descriptive text is an example of what should be written in the WBS dictionary to communicate the scope of each element. Some of the cost estimates will

probably need to be reconsidered, revised, and supported by vendor quotes or expert analyses as the plan is developed. Nevertheless, the existence of static text that provides a complete snapshot of the planner's vision for each project element, taken at the time the project plan is developed and estimated, will be invaluable during both the advanced planning and execution stages of the project.

- Future review committees will find it easier to assess the collaboration's responses to prior-review recommendations if a succinct but complete (equivalent of one slide in a presentation) report on the activities, resulting data or accomplishments, analyses, or conclusions is provided for each recommendation.
- A top level channel count should be shown at the beginning of each of these detector talks to give the audience a top level view of the scope and scale of the detector. Plus it would be easy to reference at a later time. No show stopping issues.
- An overall DAQ system schematic and detector channel table will be required for a CD-1 review. The detailed 'channel description table' should be made to this end. It should clearly couple the DAQ procurement costs.
- It would be beneficial if the costs were presented in a consistent "as spent" format. This would establish the cost range more reliably and permit reviewers to better understand the size of the project.

Staffing

- The SOLID project even at this stage, could benefit greatly from some enhanced engineering and design support work. This will be even more true as the project moves forward.
- JLab management in encouraged to provide additional support to the SoLID team at the earliest possible time to help them prepare for the next director's or independent review and CD-1. This support should include: 1) A project manager with experience in earned-value-management and O413.3B project management processes, and 2) A systems/integration engineer with experience in integration and mechanical engineering design. For effective management of a project of this scale, these individuals should have minimal…or no…other duties. They must have access to support such as project controls, risk analysis, EH&S, designers, Hall A lead engineer etc. as required.
- The LGC team needs mechanical engineering support to move to the next level of design, e.g. mirror tilt mechanism, access paths for in situ servicing PMTs and electronics etc.

Technical

- It was stated that a magnet force analysis was done by the collaboration, the endcaps were optimized to control the end fields and also balance the forces. Consider augmenting this analysis with a JLab-led superconducting magnet engineering analysis to verify the force distribution, the structural calculations and to identify possible value engineering opportunities.
- The scientific requirements were clear and the equipment performance was clear. The tie between the two needs improvement.

- The neutron (and other) radiation heat load to the coil should be evaluated carefully for Deuterium PVDIS to determine the heat load in watts added to the coil for reasonable worst case conditions. Typically superconductors cannot tolerate more than 0.1 milliwatts per cm^3 due to the very small specific heat of most metals at low temperature. Risk of quench is the result.

- Determine the alignment and mechanical stability requirements for the SOLID lead spoked collimator. The engineering and science requirements-based analysis should include the lead spokes, support, alignment incorporation of the neutron shielding and installation. This is a critical component for the SOLID Experiments and the items presented on this topic were notional.

- The Phase II SC magnet's limited cold test should be re-planned to be merged with the Phase I Solenoid rehab plan (which is supported from JLAB operations funds). The schedule for this expanded Phase I scope should be consistent with the completion of approved SOLID pre construction R&D so that the important SOLID SC magnet system is confirmed ready as soon as possible, preferably when SOLID gets CD-0.

- The event reconstruction was presented as having as much as 20% "false" events coming from the tracking in the GEMs. For high-precision parity-violation experiments, this would be highly detrimental. Increased attention should be given to the tracking to identify a method (software and/or hardware) for greatly reducing the bogus tracks.

- The SOLID PVDIS downstream beamline design should be optimized to minimize all impacts on the resolution and asymmetry measurements. Considerations might include using a PVDIS target exit window that is approximately perpendicular to particle trajectories rather than the shallow angle trajectories thru the downstream beam pipe that has been presented.

- The project team should put a modest additional effort into re-evaluating alternative approaches. These could include trade-offs such as 1) reducing the cost and complexity of the forward iron return and use of MCPPMTs on the LGC and HGC, 2) instrumenting all GEM sensors with VMM chips or on-board fADC chips vs re-use of APV 25, 3) use of W-Cu alloy (using near-net shape fabrication rather than machining) or additive manufacturing of W (e.g. laser sintering) versus lead for the baffle system, 4) use of lower environmental and safety impact target material for the polarized proton target, 5) splitting the detector system so that it is not exposed to the "sheet of flame" region rather than masking channels 6) optimization for reconfiguration of the detector to reduce down-time in operations, 7) additional robustness (and physics?) using multi-anode readout of the MAPMTs on the Cherenkov detectors versus summed readout.

- It is essential that a careful magnetic analysis be performed of the SOLID Solenoid cold low current test configuration in the Test Lab and the 50 gauss and 5 gauss field boundaries clearly identified. It may be possible to optimize the SOLID Solenoid test location within the Test Lab to minimize magnetic effects on adjacent magnetically sensitive equipment and occupied areas. The magnetic field boundaries must be measured during the SOLID Solenoid low current testing and the 50 gauss boundary, 5 gauss boundary and maybe even a lower magnetic boundary measured and posted.

- Develop the magnetic magnet measurement specification (resolution, precision…) – so the testing activity can be adequately planned for and costed. Resolve inconsistency between costed magnet measurement set-up (50k) and number stated in the pre-CDR (200k).
- Progress in event simulation and reconstruction since the last Director's review has been impressive.
- The LH2 target cell for the J/Psi configuration appeared to be closer to the front of the magnet than the existing scattering chamber and target plumbing may permit. This should be checked.
- Regarding the sharing of the Hall B gas handling system for recycling/polishing the C4F8 in the Hall A HGC:

  There remains the potential issue of liquification at expansion points in the return lines to the Hall B system (C4F8 liquification temperatures are about 10C at the HGC operating pressure 1.7atm and -6C at 1atm). This is not a show-stopper nor a cost-driver for SOLID, but is an example of a sub-subsystem that needs more study before it can be costed.
- The GEM team should update the pCDR to reflect 3 discrete chamber sizes used throughout both detector configurations.
- The alternate GEM readout integrated circuit will have to be prototyped and tested at JLAB to integrate into the CODA DAQ framework for testing with the overall experiment software.
- The project should re-evaluate the GEM readout decisions that have been made with specific consideration of 1) the costs of developing and supporting multiple readouts, 2) the technical advantages of improved time resolution, specifically ability to resolve individual beam bunch times, and 3) obsolescence of the APV25. There may be additional R&D required.
- The GEM readout system is large ~100K channels instrumented with APV25 ASIC. The overall DAQ rate was listed at 100 kHz but this is a limitation from the APV25. The 30 sector proposal for the DAQ is complex, and will need significant development time. Considerations for a new ASIC [VMM3] to readout the GEM detectors were presented and these are promising. There is clear need for further R&D before final designs can be put into production.
- The APV25 chips are already obsolete and obsolescence will become an increasingly difficult problem over the lifecycle of this project and the subsequent ~5 years of operations.
- The VMM chip has on-board digitization which would eliminate the need for fADCs in the DAQ system. Capital vs long-term costs of this solution should be folded together in a best-value analysis. (operational expense to support fADC vs potential on-project cost of implementing the VMM for all GEM channels).
- The VMM chips have a rate limit that is marginal for the current GEM layout (strip lengths and pitch).

- The VMM chip is intended for use in the ATLAS experiment in a region with expected dose of 1700 Gy (170 krad) which is within a factor of ~2 of the SoLID requirement.
- SoLID should carefully evaluate of committing to using up to date solid state devices thus anticipating the obsolescence of current JLAB standard devices.
- The LGC team should consider laminating both sides of carbon fiber with Lexan to make a symmetric structure to avoid warping from differential coefficient of moisture (and thermal) expansion. Materials will have significant water content at assembly (likely 30%) and will dry over time in inert gas atmosphere.
- The LGC and HGC are sharing many technical design elements such as mirror fabrication method and PMTs. This is a good approach as it is beneficial to both efforts.
- A complete pre-conceptual design of the detectors, their supports and installation including assembly and installation tooling would help the SoLID project with the cost and schedule analysis to develop a pre-conceptual cost.

Cost

- The SOLID cost estimate should be revisited with attention to assigning contingency more realistically.
- A comprehensive magnetic environment optimization study of the SOLID extended iron magnet should be performed in order to support the basis for what is the highest cost item in the magnet WBS. There may be opportunities to improve the magnetic performance, cost, manufacturability, assembly, detector access, detector performance, mechanical support and installation. This next level analysis should be performed in an engineering environment with all the quality considerations necessary included.
- For this stage in the project the point cost estimate is credible, but it appears to be on the low end of the range for the identified scope given the early stages of the engineering design. Given that the engineering integration and design is in the very early stages and the assumption for the cost estimate are not defined, the point cost estimate presents a lower threshold – for CD-1 a more realistic cost estimate will be needed (especially for integration). Contingency should be revisited as not all risks and functional requirements seem to have been identified.
- Establishing a defendable cost range in addition to the current point estimate would be valuable. Risk analysis and scope adjustments could be incorporate into development of a preliminary cost range
- Costs for project management effort should be added into WBS 1.1.
- Develop an assumption document that defines the boundary conditions of the BOE.
- The labor estimates and schedule for the GEMs are reasonable but only if the right experts to guide the workers.
- Labor resources should be included for the subsystems or components that will require SME evaluation or analysis for compliance with JLab EHS&Q regulations. It would be prudent to get the qualified JLab staff involved early.

- The non-project efforts (OPC scope in full-scale projects) should get cost estimates and a schedule so the needs can be folded into JLab's overall plans clearly and so the SoLID team has reliable schedule ties.

Schedule

- It would be beneficial to include in the next version of the schedule an assembly/reconfiguration process development period (dry run) so that the integration with the target and the various detector configurations can be tested.
- It is suggested that the SOLID team do a complete dry run detector installation and assembly within the iron end cap at another location other than Hall A to facilitate debugging and optimization of this critical step. The JLAB Test Lab or another location with crane capability on site is suggested.
- Integration between the various detectors, the magnet, the target, and the hall infrastructure is in a very early stage of the design. It would be beneficial to assigned focused engineering manpower to the project team so that engineering design can achieve a conceptual design level and a realistic cost estimate can be made.
- Develop and vet a detailed installation plan which incorporates best engineering practices. This installation plan would optimally include step-by-step CAD models of sufficient detail that a future review panel can clearly see that the steps are included and all major required SOLID items are covered. This is very valuable to support the cost and schedule planning required to establish a pre-construction cost range that can be reviewed.
- The engineering team of hall A has extensive experience in mounting and reconfiguring experiments. The presented manpower for the engineering design for integration and installation seems reasonable (on a high level) and can be traced back to previous experience. However, without documented assumptions and further detail, effort planning this estimate cannot be validated.
- Develop a notional schedule that integrates the JLAB operations, the MOLLER experiment schedule, the planned installation time spans, and the first reconfiguration after the initial first experimental run. Add this notional plan to the installation section in the CDR
- Develop a written skeleton installation plan including draft acceptance criteria lists that defines the hand-off points between installation, integration and testing. As presented the engineering design and planning seems to be still be handled in an isolated way. This should be an extended section in the CDR.
- Details of the installation plan should be included in the next review.
- Combined between the LGC and HGC, 700 PMT's are needed. The team should check production time required at HPK and plan accordingly.

ES&H

- Add installation safety and material handling (rigging) to your list of safety considerations.

- Include results of the activation simulations as input into the planning for reconfiguring between configurations and maintenance. This should be a section in the CDR.
- Ammonia concentrations in the Hall could become a problem in case of target failure. A hazard evaluation should be done and an appropriate mitigation plan implemented.
- The analysis of potential radiation exposures of personnel should be enhanced. It would be beneficial expand radiation analysis to address potential personal exposures and potential constraints for personnel entering the hall or when changing experiments.
- A re-check of the potential hazards should be done to identify opportunities in the design phase to reduce exposure to hazardous materials, e.g. lead.
- Assign ESH Representative/Safety Manager that will serve throughout the project and re-evaluate projected costed labor for a Safety Manager.
- The SoLID team may improve their safety envelop by application of germane Lessons Learned in the JLab Lessons Learned database. Incorporate lessons learned into design, fabrication, and operation phases.
- The project should continue to work in collaboration with engineering and EH&S staff to evaluate potential risks for the entrance windows for the HGC, including stored energy and personnel and equipment safety in the event of a failure, both during test/assembly and operations.

Risk/contingency

- Develop a more robust risk registry and distinguish between on and off project risk
- To help reviewers, particularly non-specialists, of the Detector Systems, clearly identify risks or extension of state-of-the art (for non-specialists). Walk through each detector is useful, but a crisper presentation with quantifiable risks assessments would be useful.
- The risk cost assigned to installation seems low. Consider revisiting this estimate. If 14 FTE are required for the installation, $100K represents less than 2 weeks delay, which seems rather optimistic. If it is believed to be sufficient; the team should be ready to give a good justification at the next review.
- The contingency plan seems early in its development. Maturation of the plan should contain thoughts on additional scope to utilize any freed contingency in the later stages of the project.
- Establish clear hand-off criteria of detector systems from university to installation, test data documentation, performance criteria from detector level testing that qualifies a detector system as ‘Ready for Installation’ (draft is typically required for CD-1)
- Magnet tests should be given a priority to eliminate this critical risk for the project.
- Add possible magnet modifications/repair/refurbishment as risk to the risk registry

- A risk that should be included in the DAQ is unexpected noise in the detectors (or linear summers) which form the trigger. Perhaps this potential risk could be addressed with a sufficiently flexible trigger mask for the relevant detectors (LGC and ECAL).
- *Risk_Contingency.pdf* contents demonstrate a good start on a list of project cost risks. Descriptions of the risks are provided and the cost contingency thought to be needed for each one is provided. The risk-based contingencies values shown might be reasonable, but the method used to arrive at each one is not presented. A description of the risk evaluation and quantification process is needed. Risk-based schedule contingency will need to be developed in a similar manner.
- The project team is encouraged to develop a prioritized list of contingency scope with associated cost reductions and science impacts. Items to consider could include 1) dropping the outmost ring of ECL modules, dropping the HGC detector, dropping the 6th tracking plane.
- The identified risks for the project are not yet complete and focus on technical risks. Absent are e.g. risks related to Euro-dollar fluctuations, VAT and tariffs (e.g. GEM procurements), risks related to University contributors (domestic and contracted foreign contributions) under-performing, and risk related to off-project labor (i.e. scientist) contributions not being realized, EH&S risks associated to lead handling, hoisting and rigging, etc. It could be useful to engage a risk analyst to elicit project risks to shore up the risk register and risk-based contingency estimation process. This is desirable forthe next director's or independent review and likely necessary at CD-1.
- It is encouraging to see that simulations have been completed to show occupancies and dead-time for DAQ rates, plus the infrastructure data links have been considered for the experiment network all the way to the computer center.
- The main concerns about the Heavy Gas Cerenkov were focused on the large gas windows. It is clear that more testing/studies are needed to be sure they know what will happen if there is a widow failure.

Appendix A: Charge to panel

2019 Director's Review of SoLID

The Solenoidal Large Intensity Device, SoLID, is a multipurpose spectrometer system that has been under development by the SoLID collaboration and Jefferson Lab for the last decade. Five experiments using SoLID have been recommended for Stage I approval by the Jefferson Lab Program Advisory Committee. Following preparation of a draft pre-Conceptual Design Report in 2014, a Director's Review was held to evaluate the status of SoLID in February 2015. The collaboration has devoted considerable effort over the last 4 years to address the many valuable recommendations resulting from that review. In summer 2017, the previous review committee was requested to review (via email) the updated pre-CDR. The committee submitted a favorable report with advice to monitor progress in a few areas of focus. Since that time, the SoLID team has concentrated on pre-project R&D and developing a more thorough cost estimate. In anticipation of the next step in developing this effort into a construction project, we are convening another Director's Review of SoLID focused on technical design, risk assessment, and the cost/schedule of the anticipated project.

Charge

We would like the review team to evaluate the technical design of SoLID as well as the readiness to proceed with project planning by assessing the preliminary cost and schedule estimate within the context of a project risk assessment.

In particular, we request that the review team address the following charge questions:

1. Are the scientific and technical requirements clearly identified? Is the SoLID conceptual design sound, achievable and sufficiently defined to meet those requirements?

2. Have all significant technical risks been identified, and are there appropriate plans in place to mitigate these risks?

3. Are the cost and schedule estimates appropriately developed for this stage of pre-project planning? Is the basis of the contingency estimate well-founded, and is there appropriate cost and schedule contingency included to address the identified risks?

4. Are ES&H aspects properly considered in the design, fabrication, and testing plans?

5. Has all off-project scope that is required for the successful operation of SoLID been identified? Are credible plans in place to secure completion of that scope?

6. Has the project team responded appropriately to recommendations from prior Director's Reviews?

Appendix B: Panel Members

Paul Brindza	Jefferson Lab
Chris Cuevas	Jefferson Lab
James Fast	Pacific Northwest National Lab
Howard Fenker	Jefferson Lab
Leigh Harwood	Jefferson Lab – Chair
Daniela Leitner	Lawrence Berkeley Lab
Dave Mack	Jefferson Lab
Jennifer Williams	Jefferson Lab

Appendix C Agenda

Monday 09 September 2019 CC F113

Executive Session, Charge	08:30-09:00	MCKEOWN, Robert
Welcome - (09:00-09:10)-		HENDERSON, Stuart
Science and Technical Requirements	09:10-10:00	GAO, Haiyan
Conceptual Design & Technical Risks	10:00-11:10	SOUDER, Paul
BREAK	11:10-11:25	
Overall Cost, Schedule, Contingency	11:25-12:30	CHEN, Jian-ping
Working Lunch	12:30-13:30	
Off-project Scope	13:30-14:30	KEPPEL, Cynthia
Responses to Recommendations from Prior Director's Review	14:30-15:30	MEZIANI, Zein-Eddine
BREAK	15:30-15:45	
Executive Session	15:45-17:00	

Tuesday 10 September 2019

Answer to homework questions - F113	09:00-10:00	
Session 1: F113		
Magnet (WBS 1.1.6 and 1.2.6)	10:00-10:55	SEAY, Whit
BREAK	10:55-11:10	
Radiation study	11:10-12:00	ZANA, Lorenzo
Working Lunch	12:00-13:00	
Support structure, infrastructure & integration (WBS 1.1.7 and 1.2.7)	13:00-14:00	SEAY, Whit
ES&H overview	14:00-14:40	FOLTS, Ed
Oversight and project management (WBS 1.2.9)	14:40-15:20	WOOD, Stephen
BREAK	15:20-15:35	
Executive Session	15:35-17:30	
Session 2: L102		
ECal and SPD Detectors (WBS 1.1.1 and 1.2.1)	10:00-11:00	ZHENG, Xiaochao
BREAK	11:00-11:15)	
GEM Detectors (WBS 1.1.4 and 1.2.4)	11:15-12:00	LIYANAGE, Nilanga
Working Lunch:	12:00-13:00	
Light Gas Cherenkov (WBS 1.1.2 and 1.2.2)	13:00-13:40	PAOLONE, Michael
Heavy Gas Cherenkov (WBS 1.1.3 and 1.2.3)	13:40-14:30)	ZHAO, Zhiwen
DAQ and Electronics (WBS 1.1.5 and 1.2.5)	14:30-15:20)	CAMSONNE, Alexandre
Software and Simulation (WBS 1.2.8)	15:20-16:00)	HANSEN, Ole
BREAK	16:00-16:15	
Executive Session	16:15-17:30	