Electron-Ion Collider CD-3A Lessons Learned
CD-3A Long Lead Procurement Review
EIC Project

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Purpose of this Lessons Learned Document:

The purpose of this document is to capture the results of a lessons learned review that was conducted by the Electron-Ion Collider (EIC) Project regarding execution of CD-3A Long Lead Procurements (LLPs). Project staff were charged to analyze relevant information and identify what happened compared to the expectations, what could be improved, and what lessons were learned.

EIC CD-3A Lessons Learned Background: In March 2024, the EIC Project Teams located at Brookhaven National Laboratory (BNL) and Jefferson Lab (JLab) received approval by the Department of Energy (DOE) to begin executing the CD-3A long lead procurements. The CD-3A procurement package contained 14 items totaling ~$90M. In September of 2024, an EIC CD-3A Lessons Learned Review was initiated for several of these procurements after delays in several contract award dates. The outputs of that review are documented below. These findings will be utilized to improve the project's execution of the CD-3B and future procurements.

Scope:

Please note this exercise did not analyze every CD-3A procurement. Items which presented the largest learning opportunities were selected. Also, while there is strong interlock and synergy between the JLab and BNL procurement teams, each lab does operate under their home organization procurement processes. For example, JLab does not have a Procurement Liaison Engineer role. The comments documented in the report below are often addressed as general statements that focus on project level improvement. Findings and recommendations could be pertinent to BNL, JLab, or both laboratories. For a comprehensive overview of both laboratory procurement processes, please reference the EIC Procurement Plan.

CD-3A Long Lead Procurement Scope Analyzed:

- Hadron Storage Ring (HSR) Beam Position Monitor (BPM) Cables and Buttons
- Actively Cooled Beam Screens
- 591 MHz Single Cell (multiple procurements)
- Superconducting Strands
- Scintillating Fibers for forward and Barrel Electromagnetic Calorimeters
- Forward Hadron Calorimeter Absorber Steel Plates and housing
- IR10 Cryogenic plant

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Section 1 - Common Themes Identified Across CD-3A

1. What was supposed to happen?
    a. Final requirements (Technical Specification and Statement of Work (SOW)) should have matched what was presented and accepted at the CD-3A Review.
    b. Official quotes received via RFQs/RFPs should have aligned with the information obtained in market research.
    c. Procurement package reviews should have been approved on time and the contract awards should have been executed to the original schedule target milestones.

2. What was the reality? / What did not go well?
    a. Several CD-3A procurement packages have not met their original award target dates.
    b. Official quotes received during the RFQ/RFP process in some cases depicted significantly higher pricing, exceptions to requirements not previously communicated, and some suppliers chose not to participate in the proposal process.
    c. Several Technical Specification and SOW documents required multiple iterations to reflect the final requirements. Some changes were needed as late as after official RFQs/RFPs were received.
    d. The production of fully aligned Technical Documents (Technical Specifications, SOWs, Requirements Docs and QA/Test Plans) requires a tight interlock between the technical teams, Systems Engineering and Quality Assurance; but ultimately the CAM and L2 are responsible for timely coordination and comprehensive review. In an effort to recover original schedule targets and expedite the release of these documents many misalignments occurred.
    e. Review cycles between the project and the DOE took longer than expected for the larger procurements. It became apparent that an effort is required to improve this process and streamline communication pathways.
    f. It is not uncommon for suppliers to request additional time to respond to solicitations, often for valid reasons. Usually this is in the projects best interest to accommodate the request.
    g. While the pandemic is over, several impacts on various supply chains still linger:
        i. Many vendors are still dealing with personnel issues affecting their capacity and throughput capabilities.

ii. Material availability also remains a challenge in certain industries, causing unforeseen delays and requiring additional time to find suitable alternatives.
iii. The cost of inflation is still driving material premiums.
iv. These realities are causing many suppliers to make difficult prioritization choices, in turn narrowing the field of bidders.

3. What went well?

a. Ultimately, review processes caught critical issues prior to awarding these high priority/high visibility subcontracts.
b. The JLab Technical Package Readiness Review provided detailed review and approval of all technical documents going into procurement packages to confirm accuracy and completeness. In addition, the Procurement Readiness Review added an additional review to the overall process to ensure the technical and business packages were ready to go.
c. In addition, JLab utilized the interview process during the clarifications of proposals with vendors to better understand their proposal. The interviews consisted of the vendors doing a presentation of their proposal with questions afterwards.
d. Recurring procurement task force meetings provided a forum for issues to be shared with other procurement leads to mitigate some recurring issues.
e. RFIs were issued and did help identify some critical issues prior to RFQ/RFP solicitation issuance.
f. Implementation of a new Procurement Dashboard tool at BNL highlighted key issues and allowed escalation for intervention and recovery. JLab is in the process of implementing a similar tool.
g. The newly created Procurement Liaison Engineer (PLE) role for BNL has expedited technical document formation and coordination. They are also driving synergy between documents.
h. Many EIC technical staff now have a better understanding of the procurement process and can utilize lessons learned further upstream in the engineering design process and for CD-3B long lead procurements.

4. Opportunities for Improvement

a. Requirement fidelity (Technical and SOW) should be scrutinized more intensely and a more conservative approach to pursing LLP targets should be implemented. This has already been put into place for CD-3B.

b. More emphasis should be placed on market research review during internal preliminary and final design reviews. Pricing and lead times are only a portion of the larger picture.
c. Caution should be used when attempting to breakup multi-step complex manufacturing processes. This can lead to lack of liability, gaps in responsibility and unknown upstream manufacturing requirements.
d. If engineering First Article units are likely to come with typical 'findings' that require re-builds, time for those iterative builds should be captured in the schedule upfront.
e. When looking to source novel proprietary materials, risk should be considered when exploring potential new suppliers. There is a strong likelihood of the new supplier failing to meet deliverable requirements. This was the case while trying to establish an alternative source to a novel stainless-steel composition for the HSR Beam Screens.
f. Earlier engagement with potential new suppliers on our Terms and Conditions to reduce the back and forth with vendors on Terms and Conditions.
g. Creation and utilization of an RFI Best Practices Outline and Checklist (see Section-3 below in document) is recommended.

Section 2 - Supporting Information – Specific Procurement Issues

1. HSR BPM Cables and Buttons

a. The instrumentation and mechanical engineering teams had the challenge of designing BPM cables and buttons that will be installed inside hundreds of existing operational Relativistic Heavy Ion Collider (RHIC) cryostats and will interface to newly designed components. Based on the below outcomes, moving forward, it is recommended that additional time and resources should be planned for extensive evaluation of unknowns and unexpected special envelopes.
    i. A worst-case installation outlier situation, specifically the cryostats with re-coolers, was missed during the initial design process and caught during RFP reviews.
    ii. Lack of accurate 'As-built' configuration drawings were discovered after uncovering an outlier configuration.
b. A post receipt processing risk with the connector pin type affecting both the cables and BPMs was realized late in the procurement process during Source Selection Evaluations post solicitation. BNL plans to bake the BPM buttons after receipt to prepare them for the UHV environment, this baking process

could reduce the elasticity of the SMA connector petals. This risk was addressed by changing the connector specification.

2. Actively Cooled Beam Screens
    a. Budgetary quotes on the raw stainless steel did not account for a higher-than-expected scrap/yield factor later discovered when engaging metal cladder candidates.
    b. A preferred cladder chose not to bid after reviewing our Terms and Conditions.
    c. Breaking up the various manufacturing processes involved with making the beam screens created a sourcing issue.
        i. The future candidate roll-forming vendor would only provide a turn-key solution (cladding + roll forming) this was caught after the procurement process for the 3A scope of cladding only was already well underway.

3. 591 MHz Single Cell
    a. The 591 MHz Single Cell (multiple procurements) listed as one requirement here was broken down into 34 requirements. The cavity was started on in the summer of 2024 along with the Heat Exchanger package which left 32 requirements that were not started due to a redesign effort. The re-design will affect the cavity package and require an amendment already listed in the SOW and discussed with the proposing vendors. There are no issues to report for the Heat Exchanger package.
    b. Vendor responses to negotiated requests took longer than planned delaying the award date.
    c. Design requirements were made known to the team after Final Design Review (FDR). New designs to address the new and existing requirements are being developed.
    d. Risks of all levels can be realized at all times. Here a low-risk item was realized. Complex high-risk systems requiring expert design need time and there is an error band on schedule durations as technical questions are resolved.

4. Superconducting Strands
    a. Engagement of the Magnet Steering committee highlighted additional items of concern and recommendations.

b. Requirement changes invalidated original RFI results:
    i. Size/Diameter changes
    ii. Annealing requirements changed
    iii. The quantity of required material wasn't solidified in time.
c. Exotic materials often come with short Quote Validity periods.

5. Detector Scintillating Fibers

a. The major fraction of the delay (~3 months) relative to the CD-3A baseline is due to the transition to a procurement cycle consistent with >$5M scope.
b. The SOW was revisited to a) get samples for evaluation before contract award, and b) allow a vendor to offer several options. This resulted in some small delay.

6. Detector Steel

a. An engineering First Article unit came with typical 'findings' that are not uncommon and will now be corrected/improved on the manufacturers side in the 2nd build. The original schedule did not capture time for iterative builds.
b. The team received several recommendations from the FDR committee that had to be incorporated:
    i. Eliminate tungsten from design.
    ii. A change in geometry to detector envelope.
c. Value engineering changes were applied by the vendor.
d. We incurred delayed deliveries from the vendor for absorber structure samples.
e. Required safety tests for load and crush tests on updated engineering modules needed to be finalized before approval of Specifications and SOW.

7. IR10 Cryogenic Plant

a. Additional time was required for the DOE's review and approval process of the Acquisition Plan (AP) and RFP by both the JLab site office senior management / DOE, and by the DOE Independent Review Board (IRB). This was in part due to the dollar value of the procurement (included all 3 satellite refrigerator plants) and the complexity of the system being procured.
    i. This approval process is very serial in nature and opened up the process to a "rinse and repeat" cycle as comments were generated by the reviewers and answered by the team.
    ii. Additional guidance from the DOE as to what is expected in an acquisition plan would reduce the subjective nature that exists today. FAR part 7 may be a good starting point but the DOE requires more

detail. Examples would have been helpful. Further, multiple reviewers may lead to inconsistent feedback and guidance during iterations.

iii. A portion of the extra time required to gain approval of the RFP was also due to the IRB misunderstanding the procurement as a site construction type instead of a fabrication build at the vendor. This was successfully resolved by holding a joint meeting between site office, IRB representatives, and the JLab team.

b. An extension of proposal submissions due to the complexity of the system being procured also played a role in the overall timeline extension.

Section 3 – RFI Best Practices and Checklist

1. RFI Best Practices

a. Treat the RFI as a full dry run of the coming RFQ/RFP.
b. In addition to technical accuracy, focus on non-technical aspects often described in the SOW, but also in the RFI cover letter. (Volume/Quantities, MOQs, form factors of material, scrap/yield rates, period of quote validity and manufacturing capacity).
c. Know your market – Issue surveys to obtain information from vendors on their manpower, supply chain support, job priorities etc.
d. Acknowledge and document items that are not yet fully mature and/or have a likelihood of changing prior to the official RFQ/RFP. It is important to revisit these changes and prepare suppliers who've shown interest and plan to participate in the RFQ/RFP.
e. Request pricing for multiple configuration and quantity scenarios to help ensure required data points are available if scope changes prior to official RFQ/RFPs being issued.
f. Early engagement with potential new suppliers on our Terms and Conditions should be a part of the exploration process. Redlines and exceptions aren't uncommon, but a preliminary review with the procurement team and the potential vendors should be conducted to ensure there aren't any showstoppers. On new requirements that come in, utilize previously negotiated terms and conditions to save time if the vendor is the same.
g. Don't fixate on only pricing and lead times. A detailed review of the response packages should be conducted and distributed to the associated disciplines L2 Managers, CAMs, Tech Reps and Subject Matter Experts (SMEs).
h. Information in response to RFIs should be inspected in more detail. A supplier's response to the RFI is only the beginning. Engagement meetings

with the suppliers should be held post RFI to clarify questions and expectations.

2. RFI Checklist – Use as Reference

☐Are expectations of what is planned to be accomplished clearly outlined in the RFI letter?
☐Is a compliance matrix appropriate? If so, specify that request.
☐Ensure we provide clear non-technical requirements:
- ☐Volume & Quantities
- ☐Form factors of material
- ☐Special packaging/shipping instructions
- ☐Inventory and inspection requirements

☐Request non-technical information:
- ☐Minimum Order Quantities (MOQs)
- ☐Scrap/Yield rates
- ☐Manufacturing capacity

☐Ask if a change in quantities of approximately 5-20% would drive significant pricing and lead time changes
☐Ensure the appropriate supplier Quality Assurance requirements are specified, e.g., BNL form BNL-QA-101, *Supplier Quality Assurance Requirements*
☐Request a list of cost drivers
- ☐Design driven
- ☐Material/Component driven

☐Ensure drawings, Technical Specification and SOW have been evaluated for proper Export Control notations and labels
☐Inquire with the potential vendors about manufacturing capability, capacity limitations (for schedule) and possible tooling restrictions.