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OPTIMIZING PROCUREMENT STRATEGIES FOR LCLS-II*

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Abstract

The SLAC National Accelerator Laboratory (SLAC) is currently constructing a major upgrade to its accelerator, the Linac Coherent Light Source II (LCLS-II). Several Department of Energy national laboratories, including the Thomas Jefferson National Accelerator Facility (JLab), are participating in this project.

JLab is responsible for procuring a number of critical components. Over the course of this project, JLab has evolved various procurement strategies to minimize risk and improve performance while working within the constraints of budget and schedule. This paper discusses the impact of procurement choices on project technical success.

BACKGROUND

To support construction of the cryomodules for LCLS-II, SLAC chose to partner with JLab and the Fermi National Accelerator Facility (Fermilab). The cryomodule design is based on XFEL, with some design modifications to support the different requirements of the LCLS-II accelerator. The decision to borrow the XFEL design to the extent possible was made to reduce schedule risk and cost. FNAL completed the design of the cryomodules and interconnect sections, including producing all drawings needed for procurement.

The baseline project consisted of 35 1.3 GHz cryomodules, each containing 8 elliptical cavities (Fig. 1). Another 5 cryomodules were added later for redundancy. JLab and FNAL will each construct approximately 50% of the 40 1.3-GHz cryomodules.

Although construction facilities at the two labs differ, efforts were made to use identical or equivalent tooling and equipment to ensure the final products are comparable.

Procurements of components needed to complete this section of the accelerator are split between the two labs (except for FPCs, whose responsibility remains with SLAC). Each lab is responsible for procurement of the total required quantity of approximately half of the components, with deliveries then split between the two labs. Figure 2 shows procurement responsibilities for the labs.

The schedule for the project is rigorous. Due to the large number of employees at both JLab and FNAL working on this project, the cost of a standing army in case of significant production delays could be well over a million dollars per month, thus underscoring the need to avoid any delays in deliveries.

JLab therefore developed strategies for procurements to ensure a robust delivery schedule and minimize technical risk.

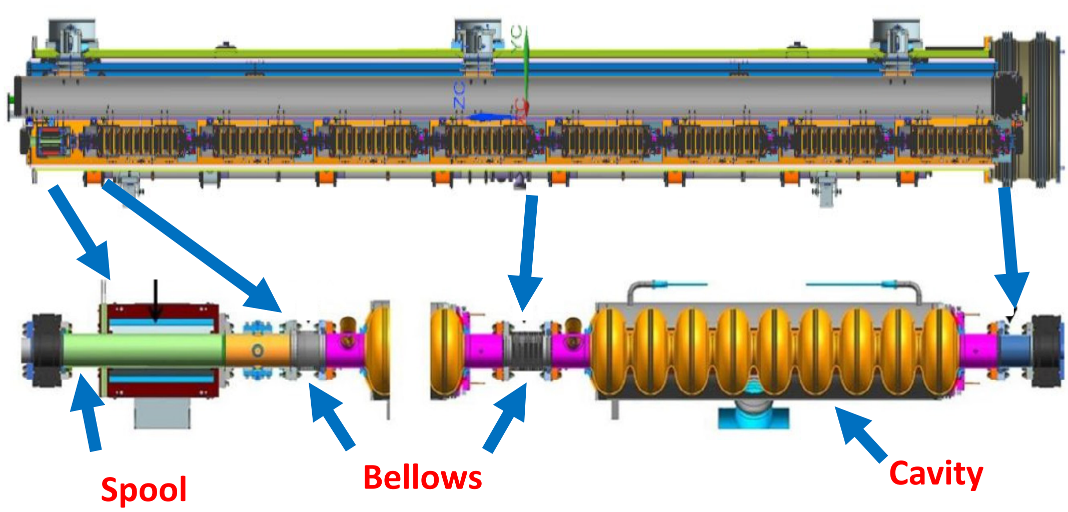

Figure 1: Composition of an LCLS-II Cryomodule.

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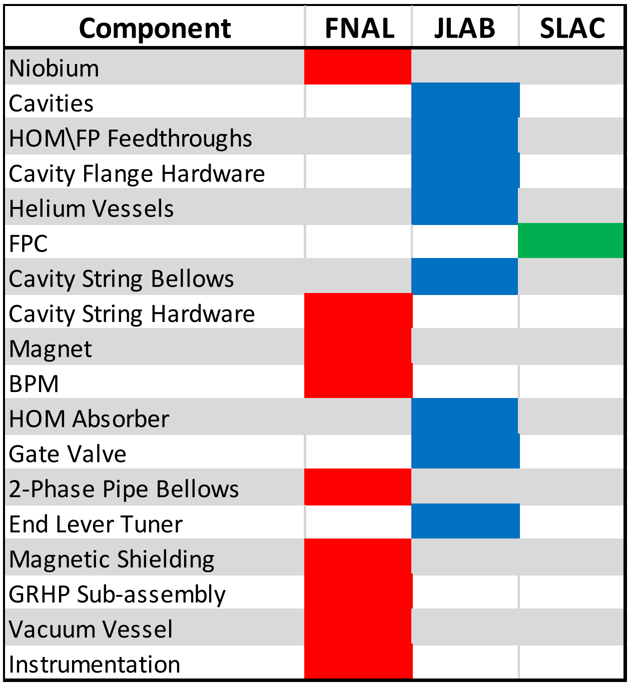

Figure 2: Procurement responsibilities [1].

SPLITTING SUBCONTRACT AWARDS

"Vertical" Split: Parallel Procurements

On some critical requirements, JLab attempted to qualify more than one vendor and split the award between them. This provides clear advantages in terms of redundancy and protects the schedule. Ideally, deliveries should be scheduled so that either vendor alone can continue to support the project construction requirements. This is particularly beneficial for high-risk procurements, which have a greater chance of production delays or technical issues. On LCLS-II, this technique was used by FNAL, JLab, and SLAC with niobium, cavities, and FPCs. It proved valuable to the project in maintaining schedule.

After initial measurements on the material, it was determined that flux expulsion differed significantly between the two niobium vendors [2]. Cavity manufacturing was changed to use the material with better flex expulsion while additional tests were performed on material from the other vendor. Changes in the processing methods allowed satisfactory flux expulsion in the second material. The ability to restructure the manufacturing this way allowed the project to hold schedule while continuing necessary research on the niobium.

Cavity subcontracts were awarded to two vendors [3, 4]. Due to a series of manufacturing issues, as well as the above mentioned material issues, production at one of the cavity vendors was suspended for about six months while procedures were validated, reworked and requalified, ultimately resulting in high-quality cavities [5]. Cavities delivered from the other vendor sustained cryomodule production during this time. The redundancy in the procurement allowed the project to deal with significant technical issues with minimal schedule delay while maintaining two viable sources for the project.

Attempts were made to use the same technique for copper plating on the beamline bellows and spools. We were, however, unable to qualify two vendors in the highly-demanding technical plating requirements. Fortunately, the vendor had no significant issues and the project did not experience delays due to plating.

"Horizontal" Split: Direct Management

Procurements were also broken into separate steps and components to allow JLab more control over the process. In past projects, JLab has awarded procurement of critical cryomodule components to vendors who subcontracted parts of the job to other companies. In some cases, the primary vendor's technical knowledge has been inadequate to the task of managing technically-demanding procurements outside their field of specialty. Since JLab is not allowed to involve itself in a prime-to-subcontractor's contractual arrangement, this has in the past resulted in unsatisfactory results.

On LCLS-II, for two of the cryomodule procurements, the beamline bellows/spools and the tuners, JLab chose to break the acquisition into separate procurements to allow JLab hands-on management of the separate tasks.

The manufacturing and the plating of the bellows and spools were separated. This allowed (1) JLab to receive and QC unplated stainless parts to ensure conformance prior to plating and (2) JLab to directly manage the plating process, resolve technical plating issues, and ensure adherence to requirements. The tuners were likewise split into three separate procurements: the piezo actuators, the stepper motors, and the tuner frames. In addition to the extra control in quality conformance checks, the split allowed JLab and FNAL to directly deal with the motor and piezo actuator manufacturers to implement design changes and resolve issues with defective parts. A single vendor might have made this process needlessly lengthy and fraught with red tape.

OPTIONS/SUBCONTRACT MODIFICATIONS

Another technique that was used on this project is the award of options as part of the initial subcontract award. Typically, a large-scale procurement of accelerator components includes multiple spares. In procurements on the LCLS-II project, costs were reduced by minimizing the number of spares ordered in the initial order. Instead, options for additional parts were built into the initial subcontract. These options could be exercised at a later date, based on perceived need to provide just-in-time delivery of spare parts. Options have the advantage of locking in prices and also reducing duplicated costs for both technical and procurement personnel by eliminating the need for multiple subcontracts.

Options were exercised for a number of the primary cryomodule procurements, including copper-plated beamline bellows, cavities, gate valves, and HOM and field probe feedthroughs. In other cases where options were not available, subcontract modifications were made with the agreement of the vendors, to accomplish the same objective,

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though this method is limited to lower-cost procurements. These methods have the advantage both of avoiding purchase of unnecessary components and also allowing additional purchases to be tailored to need.

A minimal number of spare parts were ordered for both the beamline bellows/spools and the gate valves. No spares were ordered for the cavities. However, a number of options were built into all of these subcontracts, all of which were eventually exercised to some extent. In the case of the gate valves, which typically have a low failure rate, options were exercised well after the delivery of the initial components in order to supply gate valves for the additional cryomodules added to the project later. In the case of both the beamline bellows/spools and the cavities, failure rates were higher than expected, and more parts were also needed for the additional cryomodules.

The benefit of options is not only in avoiding the purchase of unnecessary parts, but also in being able to target the procurements. For example, the initial order of beamline bellows and spools included 10% extra on the quantity of each part. By the time options were exercised, one part had been replaced with an alternate design, and failure rates had been observed to be significantly higher on the spool pieces then on the bellows [6]. JLab was able to avoid buying any more of the discontinued design, and to buy a disproportionate number of the spools to replace failed parts. Similarly, with the cavities, JLab was able to place an order for cavities made only from the better flux-expelling niobium, thus avoiding the cavity performance issues seen earlier in production.

VENDOR COMMUNICATION

The LCLS-II project has provided for a number of visits to the project's vendors. This has proved invaluable in improving the technical quality of the parts. Particularly on a large-scale, international project where vendors may have cultural or language differences, and have different experience and techniques for manufacturing parts, in-person visits have been instrumental in resolving issues early, and assisting with mutual understanding of the project requirements and goals.

JLab's approach has been to hold a kick-off meeting with vendors before the beginning of production, and before any significant changes or additions to the production in order to review requirements and ensure agreement on important issues. In addition, should any significant technical issues arise during production, in-person visits are the preferred method of resolution. Vendor visits have, over the course of the project, produced improved production methods, speedier problem resolution, and cost savings.

Although there are cost and time implications to having subject experts as well as procurement officers and management travel, given the high raw material cost and technical challenges and long lead time of accelerator components, these extra overhead cost are in general a net gain.

In addition, weekly status meetings were scheduled with critical vendors, and project status was monitored through use of tracking tools.

PERFORMANCE INCENTIVES

In order to maintain an aggressive schedule, JLab successfully incentivized some vendors to accelerate delivery. For the cavities, for instance, although the full cost of the cavities would be paid when the cavities were delivered per contractual requirements, which included a reasonable delivery date, the subcontract was modified with vendor agreement to include a bonus payment for each cavity delivered by a more aggressive date. Technical requirements were unchanged. This was successful in accelerating the delivery of most cavities for the project.

Similar techniques were used successfully on some cryogenics components.

CONCLUSIONS

To ensure success on a project with a challenging schedule and cutting-edge technical requirements, JLab has developed innovative procurement strategies to ensure that delays in deliveries do not affect production.

By splitting procurements between vendors, minimizing unnecessary spending through use of options and subcontract modifications to provide just-in-time procurement of spare parts, collaborating with vendors face to face, and motivating vendors with bonus payments to perform their best, JLab hopes to ensure the best possible performance in terms of cost, schedule and performance of LCLS-II cryomodules.

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