TECHNIQUES FOR SUCCESSFUL PROJECT MANAGEMENT LESSONS LEARNED FROM THE SPALLATION NEUTRON SOURCE

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Abstract

There are many planned or nascent particle-accelerator-based projects world-wide. Often these are large and complex projects that can benefit from strong project management. Following the premise that it is better to learn from the community's successes rather than its mistakes, this paper will draw on successful experiences from the Oak Ridge Spallation Neutron Source (SNS) project in elaborating strategies and techniques for successful project management.

INTRODUCTION

The Spallation Neutron Source (SNS) is an extraordinarily successful example of how different sectors (government, national laboratories, and industry) can be woven together, with each bringing their respective strengths to satisfy scientific and technological advances. The SNS, located at the U.S. Department of Energy's (DOE) Oak Ridge National Laboratory (ORNL) at Oak Ridge Tennessee, is a state-of-the-art, global leading, $1.4 billion accelerator-based neutron research facility for studies of the structure and dynamics of materials. The SNS project consisted of research and development of physics concepts; design, fabrication, installation, and commissioning of first-of-its-kind accelerator and target hardware, and unique world-class research instruments. After clearing 80 acres of forest, fourteen separate buildings to support all SNS systems were constructed. Consistent outstanding performance was achieved over the seven-year construction period, and the project was successfully completed one month ahead of schedule and $6.5 million under budget, with technical performance that exceeded the initial technical baseline. At its peak, over 600 designers and engineers were employed and the construction workforce exceeded 600 persons on site daily. More than 4-million hours of construction work were completed without a lost workday injury. This record was far better than both government and industry standards at the time.

In a project with so many unique challenges and technical complexities, it is difficult to isolate all the various ingredients that contributed to its technical, budget and schedule success; however, this paper will attempt to elaborate some of the key strategies and techniques in project management that were used in the successful venture.

LEADERSHIP AND STAFF SELECTION

One critical success factor for the SNS was the establishment of a strong project management team. Project management teams must be selected early, be highly credible, and have relevant experience. Early establishment of effective project leadership will establish a clear vision and will help to attract well-qualified staff. It is imperative that the project management team have a project (vs. program) mentality. Although some managers may have success in building a project's mission need or in leading R&D activities, these experiences do not necessarily ensure success in construction. Key traits of successful project managers include: experienced professionals with diverse backgrounds in engineering, industrial management and science, a team building mentality, excellence in communications, the ability to make timely decisions, a strong dedication to the end goal, and probably the most important factor – a keen awareness of and focus on the schedule. The SNS project management team knew that taking every opportunity to stay ahead of the project schedule was essential for keeping costs to the minimum. They rapidly produced an integrated schedule early in the project. Aggressive completion dates for key milestones were established, tracked, and measured. Additionally, a high degree of concurrency in the schedule existed– R&D, design, civil construction, installation, and commissioning were at times going on simultaneously. For example, the Target building foundation was being built while the structural steel design for the building was being changed in response to evolving seismic requirements, and R&D was also in full swing to decide between a solid or liquid metal. Though often cited as excessively risky, fast-tracking such activities (performing work in parallel) avoided the cost and schedule impacts of waiting. It was estimated that it would have taken ~2 years and ~$300 million if the SNS schedule had not had parallel activities but instead all were in series.

Lesson Learned: Build a strong, effective project management leadership team early.

Along with a strong leadership team, it is imperative to have a high quality, capable project staff. It was recognized early on that the significant breadth of technical knowledge, skills and abilities required to design/construct this large accelerator differed from the extensive but aging reactor-based experience in residence at ORNL. The accelerator skills and experience within other DOE national laboratories and institutions needed to be employed and leveraged to extend the range of expertise and achieve a better product. In addition, an industrial contractor that was experienced in large-scale technical civil construction was a necessity. Hence SNS was formed as a partnership among six U.S. national laboratories and a major industrial partner. To ensure

effectiveness at SNS, important management roles at the partner laboratories were filled by staff with proven project management as well as appropriate technical experience. To ensure a constant focus on project deliverables, the SNS management organized the project as if it were being performed by a single institution at a single site where project resources are dedicated and decision-making authority is clearly defined. This objective was accomplished through the implementation of a simple, uniform Memorandum of Agreement (MOA) among the participating laboratory directors. This MOA permitted the SNS project management to deal directly with SNS-assigned management staff within each participating lab, including selection of and input to the their annual performance evaluations, plus establishment of formal SNS performance criteria within each laboratory's operating contract with DOE that could affect each laboratory's annual management award fee. Perhaps for the first time in a U.S. domestic collaboration, each partner was responsible for major portions of technical scope and significant budget, which added to the project's risk. Failure of any one partner could have brought the project to a halt! The success of this collaboration project was largely due to the following:

• *Strong coordination by the SNS central project management team*. This was necessary to establish and enforce workable rules for collaborating, monitoring, and encouraging progress with all the partners and for arriving at management decisions that equally respected the needs of the overall project and each of the partners.

• *Focus by the SNS central project management team on requirements definition, interface definition, configuration and document control and integrating activities such as installation.* An early concept for installation of SNS hardware envisioned the partners would deliver their specifically defined hardware to SNS at ORNL and be solely responsible for its assembly and test. This approach was quickly discarded with the realization that such an approach did not realistically account for the inevitable problems that would occur at all the interfaces and that the transfer to ORNL of the knowledge essential for SNS operations would not occur. Instead, the SNS management staff developed a hierarchy of interface documentation that governed the equipment interfaces, implemented a central document management system, coordinated design reviews, exercised management oversight of the many procurements awarded by the partners, defined equipment acceptance criteria, documented equipment and supporting documentation turnover plans, and implemented a "lead-mentor-consult" approach to installation. Installation, testing, and commissioning were performed with a changing mix of the participating laboratory experts and ORNL staff hires. This approach proved very successful in transferring operational knowledge to the ORNL staff, while also allowing a slower, deliberate ORNL staff ramp-up for operations.

• *Excellent communications between all partners with frequent and well-organized meetings, using state-of-the-art media technology*. Weekly project videoconferences were held with a focus on raising/discussing key issues. These helped to break down communication and institutional barriers among the partners. Teamwork is imperative in a project, and to have that, there must be trust at all levels, open communications, as well as a willingness to give and receive constructive criticism.

• *Strong institutional commitment by each partner organization in accepting ownership and accountability, allocating adequate support, and helping to achieve project goals*. SNS work at each partner laboratory was managed as a project within an SNS-dedicated division; to ensure cost effectiveness, full-time dedicated resources with a minimum number of small-fraction contributors were requested and assigned wherever possible. Each partner adopted a mutually supportive approach with the other institutions and often assisted the others in developing risk mitigation approaches.

• *Reliance on the technical and procurement specialists within each collaborating lab to manage their hardware procurements with industry*. The general approach by SNS to all procurements was to accomplish these with industry (as opposed to building in-house) in order to maximize competition and gain the best value. SNS central management developed and put in place procurement and quality assurance procedures to encourage effective competition from industry and also developed a centrally managed procurement information database that provided the visibility, communications and control needed to manage procurements within project cost and schedule baselines.

• *Development of performance incentives for construction contractors.* Civil construction was managed by SNS/ORNL through a contract with a commercial Architect Engineer/Construction Manager joint venture. Contract performance incentives were applied on annual and end-of-project bases that were oriented to achieve safety, schedule and cost objectives. These incentives proved extremely successful and resulted in the completion of over 4 million construction man-hours performed with no lost time incidents, facilities schedules that met all technical systems installation plans, and with workman's compensation insurance costs for SNS less than 10% of the regional average.

Lesson Learned: Multi-laboratory and industrial partnerships with clear responsibilities can be successfully used for unique, big-scale projects.

RECRUITMENT AND RETENTION OF STAFF

During the early years of the SNS project, there were difficulties in recruiting candidates and securing rapid acceptance and relocation. Candidates perceived that the project in its early stages could be subject to cancellation and were unwilling to leave stable employment and/or to lose compensation including pay and/or benefits. The DOE chartered a team to develop a proposal for assisting SNS in recruiting. The team was composed of

representatives from the DOE and their contractors with expertise in project management, compensation, variable pay plans, benefits, retirement plans, and recruiting. As a result, the DOE approved implementation of the SNS Project's Human Resources (HR) team's recommendations which became known as the SNS HR toolkit. The toolkit included variable pay options, service-based benefits, and nonqualified tax-deferred retirement plan. SNS was then able to experience good success in rapidly recruiting and retaining highly skilled staff; over 300 positions were filled with an acceptance/offer rate of approximately 85% and a turnover rate of about 4%. The SNS HR toolkit contributed to this success and effectively minimized issues associated with attracting highly-qualified individuals to fill key positions. The toolkit use mitigated the perceived differences in vacation and retirement benefits and eliminated the need to grant exceptions, base pay increases, and other actions that often result in inequities between staff members recruited from different sources who may be performing similar work. The cost impact of using this tool was negligible and in some cases recurring costs were avoided.

Lesson Learned: Innovative HR programs are key for successful recruiting and retention of staff.

PROJECT MANAGEMENT PROCESSES

Underpinning the success achieved by the SNS collaboration was the recognition by the SNS management that constant, unrelenting control of costs and schedules using disciplined project management systems was a must. Useful, robust project management systems were developed and implemented and accountability placed with the project line managers. Such management systems should not be overly complicated, but must be designed to be effectively used by the working engineer. Top level oversight of SNS work was accomplished by demanding the needed analysis, staying on top of the details, believing the indicators, anticipating problems, and forcing early resolution of issues before becoming significant. Other useful techniques included:

• *Monthly evaluations of performance indicators from all areas of the project (e.g., safety, quality assurance, cost, schedule, staffing…).* Only by analyzing and integrating all data, can the true health of the project be understood and a credible assessment of project performance be provided to the project stakeholders.

• *Obtaining regular candid advice.* Although ad hoc reviews of the project were held for specific problems, routine, disciplined peer review processes on all aspects of the project were put in place to provide timely and constructive criticism to the project team. Fifteen such reviews were held during the seven years of the project. The intent was non-confrontational, value-added peer input. (After all, peer pressure is a strong motivator!) By sharing this knowledge and expertise, lessons learned from other projects could be incorporated. It was an excellent tool for understanding and managing risks and vulnerabilities and benefits were accrued just from preparing for the reviews.

• *Planning for known risks plus potential impacts of unknowns.* The SNS project leadership assessed project cost, schedule, and technical risks monthly and developed /tracked mitigation plans. Higher risk technical innovations (mercury target, superconducting linear accelerator) received management attention early. Although the risks in low-tech areas were never dismissed as issues, they did eventually arise in those areas (e.g., plumbing, welding quality).

• *Centrally managing the project cost and schedule contingencies.* Given the complexity involved with designing and constructing over many years a scientific facility as complex as SNS, it was essential to include reasonable cost and schedule contingency for the inevitable unknowns. In a collaboration, each partner naturally tends to embed cost and schedule contingency in their plans. When all the partners' plans are rolled up, these contingencies can result in a total project cost and schedule that is greater than necessary. The SNS management team reviewed their partners' cost and schedule estimates and, working with each partner, removed the contingencies from these lower-level plans. Based on a risk-based analysis, the contingencies needed for the total project were developed and held centrally. Additional funds and/or extension of schedules for the partners were provided through formal change control processes.

Lesson Learned: Many project management tools and processes are needed to manage project performance, although processes alone are not sufficient to effectively manage project performance.

COMMITMENT TO SAFETY

An emphasis on a rigorous safety culture was instilled from the beginning of the SNS project. No matter how great a project is performing on cost and schedule, a serious safety incident can cause the project to come to a complete halt, with the possibility of never being resumed. The project's safety program must be "Workforce Friendly." SNS's approach to this included an on-site nurse's station for quick attention to work-related injuries which was also made available for non-work related injuries. This approach helped maintain an environment that encouraged event reporting. Frequent "celebrations" were used to recognize workers with good safety performance. In addition, crafts participated in hazards analyses and work process development. The safety program must also be "Management Driven." A commitment from the project management, the Construction Manager, and the subcontractors that safety is #1 priority is a must. Other actions by SNS that led to its excellent safety record included:

• Only subcontractors with good safety records could bid on construction tasks.

•"White Hat" oversight was utilized. Weekly safety walks were conducted by 5-6 craft employees (often from

different trades), subcontractor superintendents, engineers and safety personnel from the Construction Manager, ORNL safety, and DOE safety personnel. Each observation was openly discussed with the group as to why the task being performed was either correctly or not correctly being performed. No punitive actions were taken for deficiencies found. All deficiencies were either corrected immediately or closely tracked until closure was achieved.

•Safety inspections were made by the Construction Manager's corporate and insurance company.

•Precursor events were tracked and trended allowing appropriate corrective actions to be developed sooner as well as tailored to specific issues.

Lesson Learned: Safety requires the unrelenting attention and commitment of management and the workforce.

In conclusion, instituting successful project management requires early selection, recruitment, and retention of strong project leadership and staff; selection and implementation of useful project management processes; and unrelenting attention and commitment to safety. As a result of the project management techniques and processes that were utilized at SNS, the project met all its technical, cost, and schedule objectives, and these strategies have become a model for other large science projects. Perhaps more importantly, the project participants can now look back with pride on a successful achievement of a very important and challenging goal.