SYSTEMS ENGINEERING ASPECTS TO INSTALLATION OF THE PHASED MULTI-YEAR LANSCE-REFURBISHMENT PROJECT

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Abstract

The LANSCE Refurbishment Project (LANSCE-R) is a phased, multiyear project. The project is scheduled to start refurbishment in the 2nd quarter of fiscal year 2011. Closeout will occur during the 4th quarter of FY2016. During the LANSCE-R project, installation of project components must be scheduled during six annual 6-month maintenance-outages and not conflict with annual LANSCE operational commitments to its user facilities.

The project and operations schedules must be synchronized carefully. Therefore, the scheduled maintenance outages, functional testing (with beam off, by primarily project personnel) and commissioning (with beam on, by primarily Accelerator Operation Technology (AOT) personnel) must be managed to accommodate operation. Active and effective coordination and communication between the project and AOT personnel must be encouraged to identify, as early as possible, any operational issues. This paper will report on the systems engineering approach to the integration and control of engineering activities.

BACKGROUND

At the core of the LANSCE accelerator lies an 800-MeV proton linac that drives user facilities for isotope production, proton radiography, ultra-cold neutrons, weapons neutron research and for various sciences using neutron scattering. LANSCE is in the planning phase of a refurbishment project that will sustain reliable facility operations well into the next decade [1]. The general goals for LANSCE-R are to replace obsolete and end-of-life components, to maintain acceptable reliability of the 800-MeV proton linear accelerator, and restore 120Hz operation while operating the beam for 3000 hours/year. The "Mission Need" technical scope for LANSCE-R is a direct result of the National Nuclear Security Administration's "*Predictive Capability Framework" (PCF)* which is the roadmap that describes advances in predictive capability needed to enable the Stockpile Stewardship Program. It articulates two deliverables for LANSCE: Proton radiography and Nuclear Cross-Section Measurements. Both depend upon beam from the linac. From the PCF, performance, operation, and life requirements can be derived for the linac which has led to the following scope selection:

Accelerator Systems:

- Drift Tubes Spares,
- Vacuum System Components,
- DTL Water Systems,
- DICW Water Temperature Control System

High- and Low-Power Radio Frequency Systems

- 201 MHz RF System
- 805 MHz RF System
- High Voltage Power Supplies
- RF Control System (LLRF)

Instrumentation & Controls Systems:

- Controls Hardware Replacement
- Timing System Replacement
- Controls Infrastructure
- Diagnostic Systems

The above work focuses on the refurbishment of programmatic equipment — components and equipment directly related to the acceleration of the particle beam. The scope of work ranges from integration of commercial-off-the-shelf components to complete substitution of obsolete and non-maintainable systems and equipment. The project will be self-performed by AOT. After the project is completed LANSCE will enable 4500 hours per year of scheduled linac operation, which is roughly a 1500h increase per year from the current beam availability.

INTRODUCTION

Within the Los Alamos National Laboratory organizational structure, the LANSCE User Facility Director (LUFD) has the overall responsibility for the facility; the Facility Operations Director (FOD) manages the facility, the Experimental Facilities Division Leader oversees the science, while Accelerator Operations Technology (AOT) manages the programmatic equipment. To execute the above scope of work, while maintaining 3000h/year beam operation, the overall implementation strategy is to integrate the execution of the LANSCE-R project with the ongoing LANSCE User Facility operation. The LANSCE User Facility operates cyclically. The accelerator typically runs for several months a year to meet commitments to programmatic customers. Run cycles are interspersed with intra-cycle maintenance breaks of a few days to a week for the purpose of recycling ion sources and conducting emergent or time-sensitive maintenance. Run cycles are followed by months-long outages, during which scheduled and more extensive maintenance is conducted. A typical LANSCE operating schedule is shown in Figure 1. It is recommended by the LANSCE Scheduling Committee and approved by the LUFD. Each of the 12 columns in Figure 1 represents a month (Jan.–Dec.). Each row is a day in the month. A day is divided up into three 8 hour blocks.

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Times when the linac sees no beam are marked as:

- Red (maintenance outage) and
- Dark Blue (scheduled maintenance)
- Pink (ion source recycle),

Times when the linac transports beam partially or in full are marked as:

- Orange (beam turn-on/beam tuning after outage),
- and all other remaining colors

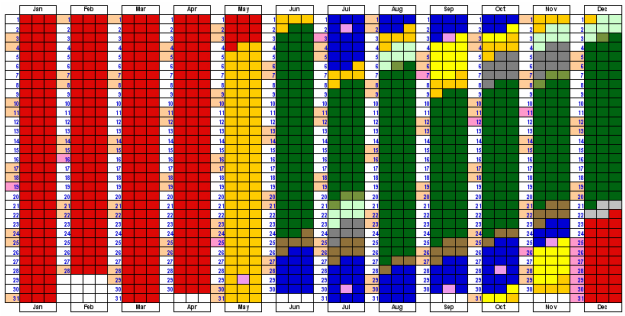

Figure 1: LANSCE annual operating schedule.

The operational schedule suggests that most of the work needs to be executed during the maintenance outage period (red). Shorter activities or activities that could not be completed during the outage period may be executed during the scheduled maintenance periods (dark blue). This, of course, assumes that theses activities did not and will not interfere with beam production. While this may answer the question on when the work may be executed, a more important question is: What is the governing framework for LANSCE-R to execute the work scope?

OPERATIONS MANAGEMENT PLAN

The governing documents that authorize operations for the Facility are the "Safety Assessment Document for the Los Alamos Neutron Science Center User Facility" and the "Accelerator Safety Envelope".

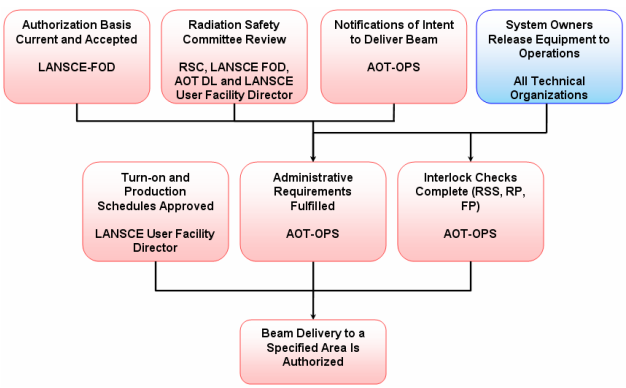

Figure 2: LANSCE beam delivery duthorization process.

Within these umbrella documents an integrated Operations Management Plan was developed. This Plan provides an overall framework for coordination and management of operations at LANSCE.

BEAM DELIVERY AUTHORIZATION

Operating requirements specify a standard process (shown in Figure 2) for authorizing accelerator operations and beam delivery to specific areas. This hierarchical (top to bottom) process orchestrates the steps that need to be taken, authorized, and documented before beam can be delivered. For LANSCE-R the right upper process box (System Owner Releases Equipment to Operations) plays a key role. This step will be enhanced to accommodate the needs of LANSCE-R within the framework of an existing operating facility. LANSCE-R will "bolt-on" to existing plans and manuals which are already in place:

- Accelerator Operations Manual,
- Outage Management Plan, and others

These specific implementation documents are enhancements to the Operations Management Plan.

ACCELERATOR OPERATIONS MANUAL

The Accelerator Operations Manual establishes a robust framework within which turn-on (Equipment Readiness Checks, Post Maintenance Tests, Transfer of Equipment to Operations) is conducted. The tasks in the blue boxes in Figure 3 will accommodate integration of LANSCE-R execution.

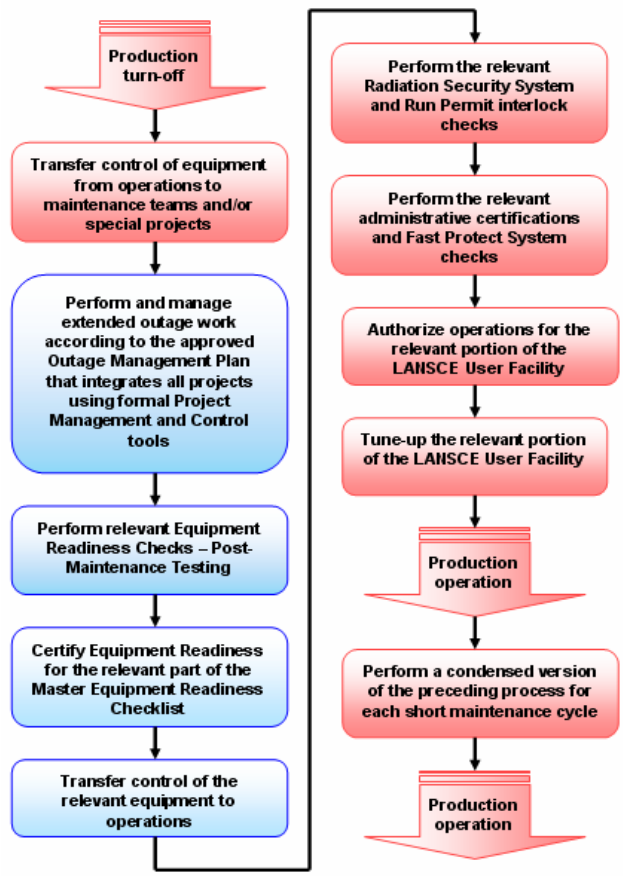

Figure 3: Framework for maintenance and turn-on.

This, however, lacks specific details for coordination with other one-time projects like LANSCE-R.

OUTAGE MANAGEMENT PLAN

The Annual Outage Management Plan integrates scheduled preventive, predictive, and corrective maintenance with other one-time projects like LANSCE-R that affect accelerator operations.

- Outages are scheduled using standard project management and control processes that allow project schedules to be integrated with the facility schedule
- Outage Manager directs and coordinates all outage work
- User Facility Director and line management establish task priorities
- Integrated schedule permits resource leveling, conflict resolution and re-planning based on emergent work

LANSCE-R INTEGRATION

Both the Accelerator Operations Manual and the Outage Management Plan create the foundation for the proposed process for executing the scope for LANSCE-R within an operating facility. The process is outlined in Figure 4 and will be explained in the paragraph below.

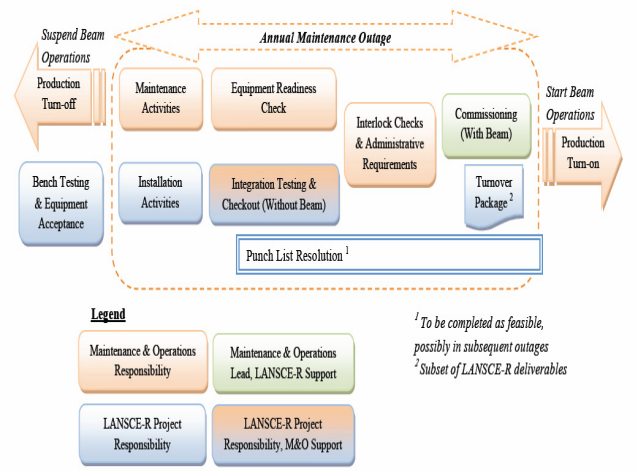

Figure 4: Annual maintenance outage.

To facilitate a project operating within the existing management structure, the model above has been adopted where the role of the project is that of an outside contractor requested to come on-site to perform work by the LANSCE User Facility Director. In addition the project as a contractor does not have the expertise or the authority to operate the linac, and therefore cannot conduct final testing or commissioning of the equipment. This is true even though many members of the project team are also members of AOT and thus have dual roles and responsibilities but it is important to distinguish between the roles and responsibility of the project and AOT division [2].

The responsibility of the project is to install, integrate, and check out (with the beam off) the refurbished equipment. The integration and checkout process will be done jointly between the project, LFO, and AOT Maintenance and Operations group (AOT-OPS) to ensure all testing, designing, fabricating, and installation requirements have been met.

AOT will then perform equipment readiness checks, interlock checks, and administrative requirements. When these are complete, transfer to AOT of ownership of refurbished equipment occurs: the liability of the project for future corrective action (excluding punch list actions) is removed.

Before commissioning can be completed, the refurbished equipment requires additional testing with the linac turned on. LANSCE-R as a contractor does not conduct final testing or commissioning of the equipment. AOT performs all linac operations, including the resumption of operations following regularly scheduled-maintenance outages. Therefore, AOT, with assistance from project staff, will be responsible for final testing and commissioning of refurbished equipment after the linac is turned back on, but prior to the start of operations.

This project management process is illustrated in Figure 4. LANSCE-R is a phased project; the installation of refurbished components will take place during regularly scheduled maintenance outages (nominally once per year), the linac is turned back on at very low power levels, and the refurbished equipment is commissioned with beam prior to resumption of full power operations [3].

CONCLUSION

LANSCE has a robust established organizational and maintenance and operations paradigm with demonstrated success in integration of major projects in an operating framework. Established framework provides a sound foundation for successful execution of LANSCE-R.

REFERENCES

[1] K.W. Jones, F. R. Gallegos, J. L. Erickson, “The LANSCE Refurbishment (LANSCE-R) Project”, Proceedings of PAC07, Albuquerque, New Mexico, USA (July 2007)

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