**Los Alamos National Laboratory**
Los Alamos, New Mexico 87545
Readiness in Technical Base and Facilities

# LANSCE Refurbishment Project

## Mission Need Statement
## Non-Major System Acquisition Project
### Line Item Project Number: LANL- TBD

LAUR-05-4040
June 1, 2005

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## EXECUTIVE SUMMARY

The Los Alamos Neutron Science (LANSCE) is a multidisciplinary research facility located at Los Alamos National Laboratory (LANL). LANSCE provides extraordinary research capabilities in basic and applied science for national security, defense, and civilian applications. Central to the LANSCE facility is a versatile 800 MeV proton linear accelerator (Linac) that drives four major facilities with unique national research capabilities: the Proton Radiography (pRad) Facility that supports Defense Program missions, the Lujan Neutron Scattering Center that supports DP and Office of Science (SC) missions, the Weapons Neutron Research Facility (WNR) that supports DP missions, and the Isotope Production Facility (IPF) that supports Office of Nuclear Energy, Science, and Technology (NE) missions.

> LANSCE-R Project Summary
>
> - LANSCE-R will refurbish critical systems and components to ensure program reliability past 2020.
> - LANSCE provides pRad, nuclear science, and material science capabilities to meet stockpile stewardship deliverables.
> - Supports DP, SC, and NE missions.
> - LANSCE reliability is rapidly declining (frequent program interruptions).
> - Continuity of near-term operations at high risk.
>
> Quick Facts
>
> - $165-238 M; 8-yr schedule
> - Line-item funded
> - Low technical risk equipment replacement

The highest-priority National Nuclear Security Administration (NNSA) driver for LANSCE refurbishment (LANSCE-R) is the unique capability of proton radiography. The Proton Radiography Facility at LANSCE, which uses the pulsed $H^-$ beam from the 800 MeV Linac, is unique in the world and provides time-sequenced radiographs of dynamic phenomena with billionths-of-a-second time resolution. Proton radiography is critical for ongoing certification and model development as described in detail in the classified addendum. It is anticipated that the data from 800 MeV pRad will continue to be of tremendous importance to Stockpile Stewardship for a least the next 15 to 20 years. Ensuring Linac beam operations for proton radiography beyond 2020 will benefit all LANSCE programs.

All three Department of Energy (DOE) offices and DP, NE, and SC that support research at LANSCE have affirmed the importance of having LANSCE operational as a reliable facility for the next decade and beyond. Although all these offices use LANSCE, the Office of the Secretary of Energy has assigned NNSA DP with responsibility and accountability for reliable accelerator operations in support of the overall DOE mission. LANSCE continues to be the major LANL experimental-science facility and therefore is a critical feature of LANL's science-based mission. There is no foreseeable substitute for this capability. Historically, LANSCE and its predecessor, the Los Alamos Meson Physics Facility, have been essential in bringing exceptional talent to the entire Laboratory. Keeping LANSCE viable will continue this process.

LANSCE's reliability has significantly declined over the past 3 years. Major components have become obsolete, demonstrated failure, are years beyond their expected service lives, and could cause a 1-year shutdown while replacements are custom fabricated. Without reinvestment now the facility will continue to decline and will be unable to meet the requirements of its stakeholders and milestones for the Stockpile Stewardship Program.

The LANSCE-R project is designed to sustain reliable facility operations past 2020 for defense research and applications with a focus on dependable beam delivery for proton radiography experiments. LANSCE-R is proposed as a line item capital improvement project with an estimated total project cost ranging from $165 to $238M. The mission need justification for LANSCE-R is to (1) preserve dependable operation of the Linac and (2) increase the cost effectiveness of operations because many of the existing facility systems are beyond their expected end-of-life, and have failures for which spare parts are no longer available. LANSCE-R will allow the facility to avoid single-point failure of aging critical equipment; ensure that the facility will comply with current environment, safety, and health and national code requirements; and improve proton radiography data quality in a straightforward and cost-effective way. Requirements can be met for overall beam intensity, availability, and reliability with long-term sustainability and minimal disruption to scheduled user programs.

This project was identified in the FY05 LANL Ten-Year Comprehensive Site Plan (TYSCP). The TYSCP constitutes the physical master plan for LANL for all areas. One of its major elements is to upgrade, modernize, or replace infrastructure and programmatic facilities to ensure sufficient capacity to support ongoing and new missions. The LANSCE-R Project specifically addresses this need for the Stockpile Stewardship Program.

## Contents

## Acronyms and Abbreviations

| | |
|---|---|
| AGS | Alternating-Gradient Synchrotron |
| APT | accelerator production of tritium |
| ASC | advanced simulation and computing |
| BES | Office of Basic Energy Sciences |
| BNL | Brookhaven National Laboratory |
| C1 | Primary Assessment Technology Subprogram of the Science Campaigns |
| C2 | Dynamic Materials Properties Subprogram of the Science Campaigns |
| C3 | Advanced Radiography subprogram of the Science Campaigns |
| C4 | Secondary Assessment and Technology Subprogram of the Science Campaigns |
| C8 | Enhanced Surveillance Subprogram of the Science Campaigns |
| CDR | Conceptual Design Report |
| DOE | Department of Energy |
| DP | defense program |
| DTL | drift tube Linac |
| EOS | equation of state |
| FNAL | Fermi National Laboratory |
| HE | high explosive |
| HFIR | High Flux Isotope Reactor, Oak Ridge National Laboratory |
| HIPPO | High Pressure Preferred Orientation Neutron Diffractometer |
| HE | insensitive high explosive |
| IPF | Isotope Production Facility |
| IPNS | Intense Pulsed Neutron Source at Argonne National Laboratory |
| LAMPF | Los Alamos Meson Physics Facility |
| LANL | Los Alamos National Laboratory |
| LANSCE | Los Alamos Neutron Science Center |
| LANSCE-R | LANSCE refurbishment |
| Linac | linear accelerator |
| LIR | Laboratory implementation requirement |
| LLNL | Lawrence Livermore National Laboratory |

| | |
|---|---|
| LPSS | long-pulse spallation source |
| Lujan | Manuel Lujan Jr. Neutron Scattering Center |
| MTS | Material Tests Station |
| NCNR | National Institute of Standards Institute for Neutron Research |
| NE | Office of Nuclear Energy, Science, and Technology |
| NEPA | National Environmental Policy Act |
| NNSA | National Nuclear Security Administration |
| ORELA | Oak Ridge Electron Linear Accelerator |
| OU | Ohio University Tandem Accelerator |
| PADNWP | Principal Associate Director for Nuclear Weapons Programs |
| PED | project engineering and design |
| pRad | proton radiography |
| R&D | research and development |
| RRW | reliable replacement warhead |
| SANS | small-angle neutron scattering |
| SC | Office of Science |
| SCL | side-coupled Linac |
| SFI | significant finding investigation |
| SMARTS | Spectrometer for Materials Research under Temperature and Strain |
| SNS | Spallation Neutron Source at Oak Ridge National Laboratory |
| SSP | Stockpile Stewardship Program |
| TUNL | Triangle Universities Nuclear Laboratory |
| TYSCP | Ten-Year Comprehensive Site Plan |
| UCN | ultracold neutron |
| WNR | Weapons Neutron Research Facility |
| WSMR | White Sands Missile Range |

# 1. STATEMENT OF MISSION NEED

The mission need of the LANSCE-R project is to sustain the Los Alamos Neutron Science Center's (LANSCE's) ability to meet Department of Energy (DOE) drivers out to the year 2020 by preserving dependable operation of the linear accelerator (Linac) and increase the cost effectiveness of LANSCE operations.

## 1.1 DOE Mission Drivers

DOE's overarching mission is to advance the national, economic, and energy security of the United States; to promote scientific and technological innovation in support of that mission; and to ensure the environmental cleanup of the national nuclear weapons complex. The two DOE strategic goals most relevant to are the

- **Defense Strategic Goal:** To protect our national security by applying advanced science and nuclear technology to the nation's defense.
- **Science Strategic Goal:** To protect our national and economic security by providing world-class scientific research capacity.

LANSCE supports DOE missions in National Nuclear Security Administration (NNSA) Defense Programs (DP), Basic Energy Sciences (BES) of the Office of Science (SC), and Office of Nuclear Energy, Science, and Technology (NE) missions.

### *NNSA/Defense Programs*

The 2004 National Nuclear Security Administration (NNSA) strategic plan affirms that the nuclear weapons program continues to be NNSA's foremost national security responsibility and that the nuclear weapons complex fosters the scientific and technical expertise needed to pursue excellence in all NNSA national security program interests with its Nuclear Weapons Stewardship Goal.

The NNSA DP mission is to strengthen and support United States security through nuclear deterrence by ensuring the capability to

- maintain a safe, secure, and reliable nuclear weapons stockpile to sustain the security of the United States and its allies, deter aggression, and support international stability.
- maintain a flexible, responsive, robust nuclear weapons complex infrastructure to address new challenges.
- execute test and research and development (R&D) activities to support United States leadership in science and technology.

The DP vision is to sustain an integrated nuclear security enterprise—consisting of R&D, testing, and production facilities—that operates a responsive, efficient, secure, and safe nuclear weapons complex and that is recognized as preeminent in personnel, technical leadership, planning, and program management.

Eleven program-related capability elements have been defined that are critical to the DP mission. The elements most relevant for LANSCE are the following:

- Conduct surveillance of the stockpile to assess the safety, security, and reliability of warheads including disassembly and inspections of warheads, conducting flight and laboratory tests, developing enhanced surveillance techniques, and supporting annual assessment of certification. Seek to eliminate the surveillance backlog and demonstrate more rapid closure of significant finding investigations (SFIs).
- Sustain long-term leadership and vitality in science and engineering to support national security. Develop and apply comprehensive methodologies, plans, and tools for

qualification, assessment, and certification including hydrodynamic testing, simulation, engineering, material science, and high-energy-density physics experiments.

- Continue to renew the work force by attracting, training, and retaining the next generation of excellent personnel to serve the nation's nuclear security needs. Plan assignments of current personnel with nuclear weapons design, development, and test experience so that the program gains maximum benefit from their experience before their retirement.

In addition, NNSA recognizes in the 2004 strategic plan the necessity to create and leverage enhanced relationships with other scientific organizations and institutions to ensure scientific and technical excellence in the NNSA work force and foster long-term, synergistic ventures.

### *Office of Science BES Scientific User Facilities*

The mission of the Basic Energy Sciences (BES) Program—a multipurpose, scientific research effort—is to foster and support fundamental research to expand the scientific foundations for new and improved energy technologies and for understanding and mitigating the environmental impacts of energy use. The program supports work in the natural sciences, emphasizing fundamental research in materials sciences, chemistry, geosciences, and the biosciences. As part of its mission, the Office of Basic Energy Sciences plans, constructs and operates major scientific user facilities to serve researchers from universities, national laboratories, and industry.

### *Office of Nuclear Energy, Science, and Technology Isotope Program*

DOE's Office of Nuclear Energy, Science, and Technology Isotope Program's mission is to ensure the availability of an adequate supply of medical and research isotopes, which is essential to the nation's health care system.

## 1.2 How LANSCE-R Meets the Mission Need

### *Background*

Central to the LANSCE facility is a versatile 800-MeV Linac that drives four major facilities with unique national research capabilities:

- Proton Radiography (pRad) Facility for high-resolution, time-dependent, high-speed proton imaging—a critical capability to interrogate the hydrodynamics phase of a nuclear weapon supporting DP missions,
- Manuel Lujan Neutron Scattering Center for condensed matter and nuclear physics research using the brightest pulsed beams of moderated cold, thermal, and epithermal neutrons in the world supporting DP and Office of Science (SC) missions,
- Weapons Neutron Research facility (WNR) for nuclear science research using the world's most intense high-energy neutron source across the entire nuclear weapons spectrum supporting DP missions, and the
- Isotope Production Facility (IPF) for production of proton-rich isotopes for biomedical research and medical applications supporting NE missions.

Figure 1 is a schematic of the present LANSCE 800-MeV Linac. Ion sources, placed in Cockroft-Walton generators, produce $H^+$ and $H^-$ beams. Injection of the beam into a four-tank 201-MHz drift tube Linac (DTL) and acceleration to 100 MeV follows. The 100-MeV $H^+$ beam is presently shunted to the IPF. The 100-MeV $H^-$ beam is matched transversely to an 805-MHz side-coupled Linac (SCL) by elements in a transition region. The SCL then accelerates the beam to 800 MeV. The beam is directed by switchyard and kicker magnets to the experimental areas, including pRad, UCN, WNR, and the Lujan Center.

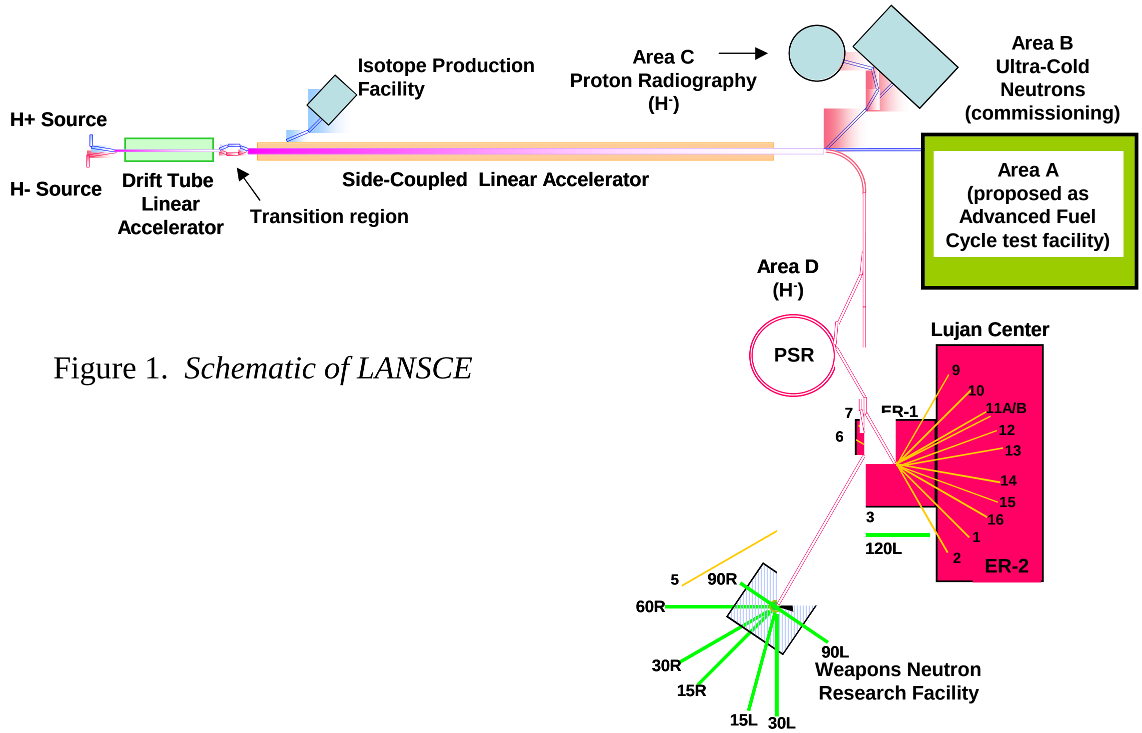


Figure 1. *Schematic of LANSCE*

The LANSCE-R project is designed to sustain reliable facility operations past 2020 for defense research and applications with a focus on dependable beam delivery for pRad experiments. LANSCE refurbishment (LANSCE-R) mission need is to preserve dependable operation of the Linac and to increase the cost-effectiveness of operations because many of the existing facility systems are beyond their expected end-of-life and have experienced failures which require spare parts that are no longer available.

## *Meeting NNSA Mission Needs*

The Proton Radiography Facility at LANSCE, which uses the pulsed $H^-$ beam from the 800 MeV Linac, is unique in the world and provides time-sequenced radiographs of dynamic phenomena with billionths-of-a-second time resolution. Proton radiography is arguably the most valuable single tool that is available to interrogate the hydrodynamic phase of a weapon. Whereas many diagnostic tools have been developed for hydrodynamic behavior, most rely on surface measurements and are unable to interrogate the critical state variables and stress-strain response in the interior of the hydro components.

Detailed modeling depends on accurately capturing the time evolution of the hydrodynamics on a microsecond time scale. Proton radiography with its ability to penetrate and accurately imagine the interior of highly compressed components as well as its highly flexible and precisely recordable pulse format is uniquely suited to providing the necessary data for our weapon certification codes and models without nuclear testing. The 800-MeV pRad work is critical to ongoing and future certification. See the classified addendum for details. We anticipate that the data from 800-MeV pRad will continue to be of tremendous importance to stockpile stewardship for at least the next 15 to 20 years. The $H^-$ source intensity can be increased a factor of two in a cost-effective, straightforward manner. A factor of two in H- intensity would provide a factor of two improvement in image statistics and a commensurate improvement in quantitative density resolution for the scaled hydro-like experiments that are needed for current and future certification methodology experiments. The pRad facility contributes uniquely to the above program-related capability elements that are critical to the DP mission. LANSCE-R is required to sustain the nation's pRad capability beyond 2020 and to provide future improvements to meet Stockpile Stewardship Program (SSP) requirements.

Lawrence Livermore National Laboratory (LLNL) and LANL are in the final stages of publishing the classified Primary Certification Capability Plan on behalf of NNSA. This draft primary certification capability plan looks to the stockpile assessments and mission needs of 2020 and beyond. As outlined in the plan, improved data sets are required from pRad for insensitive high explosive (IHE), dynamic material response, and experiments relating to understanding boost to support a reliable replacement warhead (RRW). The plan noted that experimental facilities like proton radiography are essential through the indefinite future for validating new advanced simulation and computing (ASC) models.

In addition, the investment in LANSCE-R benefits the WNR and the Manuel Lujan Center by sustaining the reliability of the Linac that feeds beam to these facilities. The three facilities together support NNSA's nuclear weapons stewardship goal by addressing a broad suite of scientific and technical issues. NNSA's FY2006–2010 Stockpile Stewardship Plan, Vol. II, Report on Criteria for Stockpile Stewardship Tools, details the criteria for judging whether the science-based tools (for which pRad, WNR, and Lujan) are being used by the DOE for determining the safety and reliability of the nuclear weapons stockpile, are performing in a manner that will provide an adequate degree of certainty that the stockpile is safe and reliable. Those criteria can be translated into requirements for facility and experimental capabilities and experiments that need to be performed. Near, mid-term, and long-term strategic approaches to meeting the experimental data requirements are detailed in Volume 1 of the FY2006–2010 Stockpile Stewardship Plan by Science Campaign subprograms. Table 1 gives representative experimental efforts and their corresponding program drivers.

LANSCE is LANL's most significant portal to the outside scientific community and a necessary component of remaining a world-class laboratory. It is an important recruiting and retention tool. The user programs at WNR and Lujan Center attract a large number of students, faculty, and postdoctoral fellows. During the 2003–2004 operating period, there were over 1100 user visits and nearly 400 separate experiments were performed, roughly half of which supported Los Alamos programs. During this period 96 students used LANSCE facilities for their advanced-degree thesis research. The investment in LANSCE-R will sustain LANSCE and continue to renew the work force by attracting, training, and retaining the next generation of outstanding scientists and engineers needed to serve the nation's nuclear security needs. LANSCE's ongoing leveraged relationships with NE and SC can continue to ensure scientific and technical excellence in the LANL component of the NNSA work force.

This project was identified in the FY05 LANL Ten Year Comprehensive Site Plan (TYSCP). The TYSCP constitutes the physical master plan for LANL for all areas. The TYCSP focuses on physical assets that support LANL's missions and operations. It is the capstone of LANL strategic planning execution that includes NNSA and LANL requirements and takes input from other plans to define the facilities and infrastructure needed to accomplish LANL's mission. Several major project elements are targeted in the TYCSP. One of these major elements is to upgrade, modernize, or replace infrastructure and programmatic facilities to ensure sufficient capacity to support ongoing and new missions. The LANSCE-R Project specifically addresses this need for SSP.

**Table 1. Experimental Efforts and Program Drivers**

| Experimental Activity | Technical Driver | Program Driver | LANSCE Facility | Comment |
|---|---|---|---|---|
| Conduct quantitative time-resolved study of HE burn | Develop models to assess weapons performance | Primary Assessment Technology Subprogram (C1)<br>Dynamic Materials Properties Subprogram (C2) | pRad | Dynamic experiments with up to 10 lb HE drive. Resolves up to 60 gm/cm$^2$ areal density with 30 µm resolution at up to 30 images (50-ns resolution limit). Able to investigate HE, DU, and other stockpile surrogates for mission-critical research. Recently commissioned powder gun. |
| Conduct dynamic material properties such as equation of state (EOS), spall, and metal fracture | | | | |
| Conduct hydrodynamics experiments | | | | |
| Conduct high-(<5%) accuracy measurements of neutron cross sections | To interpret archival underground nuclear tests and validate weapons performance predictions (yield actinide inventories) based on ASC codes; reduce uncertainty associated with predictive capability | Secondary Assessment Technology Subprogram (C4)<br>C2 | WNR and Lujan | The combination of the WNR and Lujan Center is the world's most intense source for neutron-induced nuclear reactions across the entire spectrum of a nuclear weapon (0.0001 to 100 MeV). Capabilities exist to produce and measure short-lived, high-activity isotopes for capture, (n,2n), (n,xn), and fission cross sections. |
| High-(<5%) accuracy measurements of principal fission; fusion cross sections of nuclear fuels required | To accurately predict weapon performance | C1<br>C2 | | |
| Determine the constitutive properties of weapons materials (e.g., plutonium,)under extreme conditions | Develop models and physical data bases for to assess weapons performance, safety, and reliability w/o nuclear testing | C2 | Lujan | The High Pressure Preferred Orientation Neutron Diffractometer (HIPPO) provides data as a function of pressure. |
| Assess effects of aging on stockpile materials and performance | Evaluate structural stability of polymers, foams, HE, CSA/case materials and other metallic components | C2<br>Enhanced Surveillance Subprogram (C8) | Lujan | Spectrometer for Materials Research under Temperature and Strain (SMARTS) allows studies of phase stability as a function of temperature and stress. Small-angle neutron scattering (SANS) gives unique structural characterization of stockpile relevant polymeric materials |

| Table 1. Experimental Efforts and Program Drivers | | | | |
|---|---|---|---|---|
| **Experimental Activity** | **Technical Driver** | **Program Driver** | **LANSCE Facility** | **Comment** |
| Understand the structural properties of HE materials | Development of models for weapons certification | C2<br><br>C8 | Lujan | SANS studies to elucidate the structure |
| Measure texture of stockpile metals | To address texture characteristics during deformation of key stockpile metals | C2<br><br>Lifetime Extension Programs (LEPs) | Lujan | SMARTS provides texture measurement capability as a function of temperature and stress. |
| Serve as a national user facility | To address stockpile issues in weapons science and Directed Stockpile Work; and for basic neutron science as related to the structure of materials and fundamental nuclear physics of weapons. | DP | pRad, WNR, Lujan | MOU among DOE DP, SC,NE, and Office of facilities and Operations, and LANL |

The LANSCE-R project preserves dependable operation that allows LANL to satisfy current and future programmatic work safely and cost-effectively. LANSCE is an integral part of the nuclear and nonnuclear complex at the Laboratory. Because of this integral role for the weapons program, there could be serious consequences for national security if the life extension actions are not completed as proposed by this project. Further, this project enables NNSA and LANL to more easily and cost effectively complies with regulatory requirements, particularly with respect to worker safety and environmental protection.

### *Meeting Basic Energy Sciences Scientific User Facilities Mission Needs*

The Manuel Lujan Jr. Neutron Scattering Center (Lujan Center) at Los Alamos National Laboratory is a BES user facility that provides an intense pulsed source of neutrons to a variety of spectrometers for neutron scattering studies to support the BES mission. The Lujan Center features instruments for measurement of high-pressure and high-temperature samples, strain measurement, liquid studies, and texture measurement. The facility has a long history and extensive experience in handling actinide samples, as well as nuclear weapons components for use in classified experiments. With 20-Hz operation and an optimized target-moderator for cold neutron production, the Lujan Center will remain a premier facility for long-wave (>4 Angstrom) neutron scattering even after the spallation neutron source (SNS) achieves full capability. Flight paths at the Lujan Center also support fundamental physics measurements and research that synergistically provides unique insight into astrophysical phenomena and nuclear weapons performance. The LANSCE-R project sustains the Linac reliability enabling this capability.

### *Meeting NE Isotope Program Mission Needs*

The IPF at LANL produces radioisotopes by using a fraction of the LANSCE primary proton beam to support the DOE NE Isotope Program's mission. The unique characteristics of the LANSCE accelerator include a high-energy, high-beam current that allows production of higher-quality radioisotopes as well as radioisotopes that cannot be produced in other facilities. Many of the isotopes produced at IPF provide for the future advancement of nuclear medicine applications and the continuation of human clinical studies. The LANSCE-R project sustains the Linac reliability enabling this capability.

### *Meeting Possible Future Mission Needs*

The LANSCE-R project will sustain the capabilities that exist today and will preserve options for future capabilities that the program may need in the future. In January 2005, Los Alamos held a workshop on "LANSCE Futures." Five possible future scenarios were examined that would be enabled by enhancing LANSCE beyond LANSCE-R to provide expanded capability for DP, SC, and NE missions. These five scenarios are summarized in an appendix to this document.

## 1.3 Functional Capability Needed

To meet NNSA program deliverables, the primary functional capability associated with LANSCE-R is to enable the facility to deliver 6 to 8 months (approximately 4000–5000 hours, depending on operating funds) of beam and no single-point failures that would result in a complete loss of operating capability for proton radiography for more than 30 days during a run cycle, and a factor of two improvement in the H- intensity. The threshold for 30 days' downtime was based on the ability to meet SSP deliverables in a run cycle. Six to eight months is a BES requirement and provides enough beam for 20 to 30 pRad experiments a year. The beam requirement for 20 to 30 pRad experiments is based on outyear program planning, past experience in performing the work load required, and the schedule that experiments need to deliver data by to meet model validation and certification milestones.

## 2. ANALYSIS TO SUPPORT MISSION NEED

### 2.1 Assessment of Capability Shortfall

In 2001, a LANL independent team led by Klaus Berkner (retired) from Lawrence Berkeley National Laboratory evaluated the annual operations funding and the refurbishment investment necessary to keep LANSCE viable. This data and review form the basis for LANSCE-R (LANSCE User Facility Cost Estimate Review Committee, August 1-3, 2001).

### 2.2 Range of Alternatives Considered

A list of other facilities that could be possible alternatives for portions of the mission need has been identified by capability type. The technical capabilities for evaluation were pRad, fast-burst neutron sources, neutron irradiation of weapons components, fast-neutron nuclear science, low-energy neutron nuclear science, and neutron scattering in support of weapons materials science. No one alternative facility was identified that could fulfill the entire mission space of LANSCE and no combination of facilities was identified that could complete the required missions without a new investment several times the cost of LANSCE-R. During the conceptual design, value-based considerations will be applied to evaluate the technical risk and cost of alternatives at other facilities. Those will include cost effectiveness, timeliness, and ability to deliver a similar range of capabilities such as the ability to work with actinides and to perform experiments using classified weapons components. Potential facilities, in addition to LANSCE, are the Alternating-Gradient Synchrotron (AGS) at Brookhaven National Laboratory (BNL), the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory (ORNL), Fermi National Laboratory (FNAL), the Sandia Pulse Reactor (SPR), the White Sands Missile Range Fast Burst Reactor (WSMR), the Oak Ridge Electron Linear Accelerator (ORELA), Triangle Universities Nuclear Laboratory (TUNL), and the Ohio University Tandem Accelerator (OU), the University of California at Davis Cyclotron, the Intense Pulsed Neutron Source at Argonne National Laboratory (IPNS), ORNL's High Flux Isotope Reactor (HIFR), and the National Institute of Standards Institute for Neutron Research (NCNR). A high-level matrix that cross walks the technical capability presently available without additional investment of the same or greater magnitude as LANSCE-R is given in Table 2.

## 3. IMPACT IF NOT APPROVED

Not approving or delaying LANSCE-R would force the facility to continue to rely on obsolete equipment that is prone to failure, continue inefficiencies in operations, continue accumulating deferred maintenance, and eventually result in the closure of the LANSCE facility—leaving the nation without unique critical capabilities required to provide the necessary data for the Stockpile Stewardship Program. Finally, without LANSCE, the scientific vitality of Los Alamos would be severely impaired and the ability of NNSA to attract new talent into the Nuclear Weapons Program would be greatly reduced.

| **Table 2. Crosswalk of Current LANSCE Technical Capabilities** | | | | | |
|---|---|---|---|---|---|
| | **Potential Applicable Capabilities to be Evaluated** | | | | |
| Alternative | pRad | Fast-burn neutron irradiation of weapons components | Fast-neutron nuclear science | Low-energy neutron Nuclear science | Neutron scattering for weapons materials science |
| LANSCE | F | P | F | F | F |
| AGS | F | | | | |
| SNS | | | | F | F |
| FNAL | P | | | | |
| SPR | | F* | | | |
| WSMR | | P | | | |
| ORELA | | | P | P | |
| TUNL, OU | | | P | | |
| UC Davis Cyclotron | | | P | | |
| IPNS | | | | | P |
| HIFR | | | | | P |
| NNCNR | | | | P | P |

F=fully capable, P=partially capable.

*SPR will be closed permanently in 2007.

# *4. CONSTRAINTS AND ASSUMPTIONS*

## 4.1 Functional, Technical, Operational Assumptions

The following are a summary of the key constraints and assumptions:

- Upgrades, renovation, repair, retrofit, and related activities should be implemented in the existing LANSCE, rather than build a replacement facility.
- The revitalization effort, when complete should be sufficient to extend the service life of affected special equipment systems by up to 10 years.
- LANSCE safety and operating procedures are satisfactory as is and are not in need of fundamental change.
- A significant level of planning and management support will be needed for the life of this project, well above that needed for a conventional facility, due to the need to integrate

with planned operations and experiments via outages (so as not to disrupt or delay experiments) and due to the unique nature of the facility.

- Planned outages will be required to execute the work. Delays or cancellation of outages to accommodate operations or experiments will result in significant cost and schedule impacts.
- An extended outage in the 2010-2012 time frame may be required; otherwise during planned, annual beam outages, the LANSCE beam delivery program is expected to be fully operational and supporting user programs. It is assumed that the LANSCE-R activities will be coordinated so that outages are planned and announced in advance so that DOE DP, SC, NE and LANL stakeholders and users may plan accordingly.
- Project funding will be provided in a stable and predictable manner for the entire life of the project.
- It is assumed that routine maintenance is covered by a sustained operating budget concurrent with LANSCE-R.
- Project will be afforded flexibility in defining, implementing, and sequencing work.
- Technology to replace existing special equipment and components can be primarily procured commercially; limited development of new technology is required for those items not commercially available.

## 4.2 Environment, Safety, and Health Requirements

The LANSCE accelerator facility has been safely operated by LANL for over 30 years and is governed by the requirements of DOE O 420.2B, *Safety of Accelerator Facilities*. The safety analysis for the accelerator is documented in the *Interim Safety Assessment Document for the LANSCE User Facility*, LANL TA-53-ISAD-007, approved by DOE in April 2002. A final safety assessment document was submitted to DOE on January 19, 2005.

## 4.3 NEPA Compliance

National Environmental Policy Act (NEPA) compliance will be managed by the NNSA Los Alamos Site Office, with assistance from the NNSA Office of Environment, Safety, and Health Operations Support (NA-53). The refurbishment of existing accelerator components and supporting infrastructure is anticipated to fall within the bounding limitations of the existing site-wide environmental impact statement. A review of project activities, conducted in the form of a NEPA cultural and biological screening, will be conducted to ensure that NEPA requirements are satisfactorily met. The results will be forwarded to DOE for review and DOE will determine the need for further information and documentation. No environmental issues are anticipated.

## 4.4 Safeguards and Security Considerations

There are no safeguards and security issues that would preclude the project. Physical property protection already in place for the LANSCE accelerator facility is in accordance with DOE Policy 470.1, *Integrated Safeguards and Security Management*

*(ISSM) Policy*, 5/8/01 as implemented by Laboratory Implementation Requirement (LIR) 406-00-01, *General Security*, and the *FMU 4 Safeguards and Security Plan* for Technical Area 53. Access to the facility is controlled and limited to LANL or DOE badge holders and authorized visitors. Visits by foreign nationals are subject to the requirements of LANL LIR 406-00-01 Attachment 5, *Foreign Visits and Assignments*. Limited-access, secure satellite areas for classified activities are occasionally approved and set up in the LANSCE experimental areas and are not affected by the scope of this project. We foresee neither changes to security planning nor a need for security assessment funding.

## 4.5 Legal or Regulatory Constraints

There are no existing or foreseeable legal or regulatory constraints that would preclude the project.

## 4.6 Standardization and Standards Requirements

Standardization and standards requirements will be developed in depth in the conceptual design process as required in DOE M 413.3-1, Sections 5.2.1 Requirements Analysis, and 5.2.4, Conceptual Design Report (CDR). At the national level, most of the DOE Orders, standards, manuals, and guides apply for the areas.

At the national level, most of the DOE Orders, standards, manuals, and guides are applicable for the areas that they cover. Industry standards will also be applied in areas that they cover. At the New Mexico state level, there are a number of governing documents. New Mexico is an agreement state with the EPA; agreement states tend to focus on environmental concerns.

At the LANL site level, the DOE-UC contract is the defining document. It calls out which DOE rules apply and at what revision levels, for example, 6430.1A Division 13 only. The LANL LIRs, Laboratory implementation guidance, and policies apply and may interpret the DOE level rules to the site conditions.

A more comprehensive listing and applicability analysis of codes and standards will be developed as part of the conceptual design phase and the CDR.

# *5. APPLICABLE CONDITIONS AND INTERFACES*

In addition to DP, all the other principal stakeholders, SC, NE, and LANL, endorse and support the LANSCE-R Project. In support of DOE mission, SC supports a growing program of users conducting neutron-scattering experiments that explore aspects of materials science and technology. LANSCE will remain the nation's most intense neutron source until the Spallation Neutron Source (SNS) becomes operational at its design specifications (approximately 4 to 6 years from now). As identified by the Office of Science and Technology Policy Interagency Working Group on Neutron Science, June 2002, the overall lack of neutron sources in the US and the projected growth of the scientific community using neutrons, makes it critical that LANSCE serve the neutron scattering community for a significant period after SNS becomes fully operational.

Also, NE in support of the DOE mission has recently begun operating the Isotope Production Facility to produce isotopes for the medical community. As the medical community begins to rely on the supply of isotopes from LANSCE there will be increasing pressure to avoid any interruptions in that supply. Although the operating plans for IPF can accommodate normal, scheduled outages of the accelerator complex, NE has indicated that they will not be able to handle prolonged stoppages of the accelerator complex. They are planning for at least a decade of reliable operation of the IPF to justify the capital construction investment.

The LANSCE Refurbishment activities will be coordinated so that outages are planned and announced in advance in order for DOE DP, SC, NE and LANL stakeholders and users to plan accordingly.

# 6. RESOURCE REQUIREMENTS AND SCHEDULE

## 6.1 Scope

Specifically, LANSCE-R Project will enhance cost effectiveness by system refurbishments or improvements that reduce operating costs; and improve decreasing facility reliability by replacing systems that have an impact of 15% or greater on reliability for those systems; increase the $H^-$ intensity (factor of two) for improved proton radiography data. In addition, it will eliminate the following sources of operational inefficiencies that could improve operational effectiveness:

- single-point failures with an estimated time to repair of greater than 30 days,
- equipment that is beyond its predicted end-of-life that could severely impact facility operations,
- obsolete equipment for which no spare parts are available,
- ES&H or code compliance issues necessary to continue safe operation.

Achieving this requires the following activities:

- replacing minimum set of klystrons, transmitters, high voltage power systems, and ancillary hardware with new and modern equivalents to achieve high reliability of 805 MHz RF system ($86M);
- replacing power amplifier, IPA, and ancillary hardware with a modern system to maintain and improve the reliability of the 201 MHz RF system by ($28M);
- replacing antiquated hardware and software in the accelerator controls, data acquisition, and timing systems that have become virtually non-maintainable because of obsolescence($39M);
- refurbishing and replacing the vacuum and cooling systems, and magnet power supplies for the accelerator and beam-transfer lines to substantially reduce the increasing amount of beam downtime due to these systems ($7M),
- refurbishing and improving the beam-diagnostics systems to provide much needed efficient beam-tuning capabilities to maintain reliability($17M),
- replacing injector components to increase the $H^-$ beam intensity by a factor of two ($7M).

This scope has been reviewed by Los Alamos National Laboratory and is considered the minimum required to meet requirements.

## 6.2 Funding Requirements and Sources

The total project cost (TPC) range for LANSCE-R as a line item is $165 M to $238 M. An initial design cost estimate provided a total estimate at completion of approximately $183M for the engineering, design, procurement, and fabrication for the various project segments. Many of the estimates for LANSCE-R are based on recent project experience. In several cases the estimates come from use of nearly identical equipment to that supplied to SNS, or from historical experience associated with replacing parts needed to maintain the LANSCE accelerator. High dollar value material items were updated with current vendor quotes. The point estimate has a contingency of 34% calculated on total cost based on a risk assessment. Los Alamos had an independent panel review the cost estimate for the LANSCE-R project February 22-23, 2005. Recommendations from the panel were incorporated into the point estimate.

The range is based on a pre-conceptual design point estimate believed known to -10% to +30% at this early stage. This is consistent with DOE guidance and parametric techniques, and is consistent with using pre-conceptual technical information used to develop the estimate. The project will be a line item funded project. Funding strategies are being finalized with NNSA. Approach will be to utilize some funds appropriated by Congress and redirection of site allocations. Our approach to conceptual design is explained in the Conceptual Design Execution Plan. Figure 2 shows an estimated funding distribution.

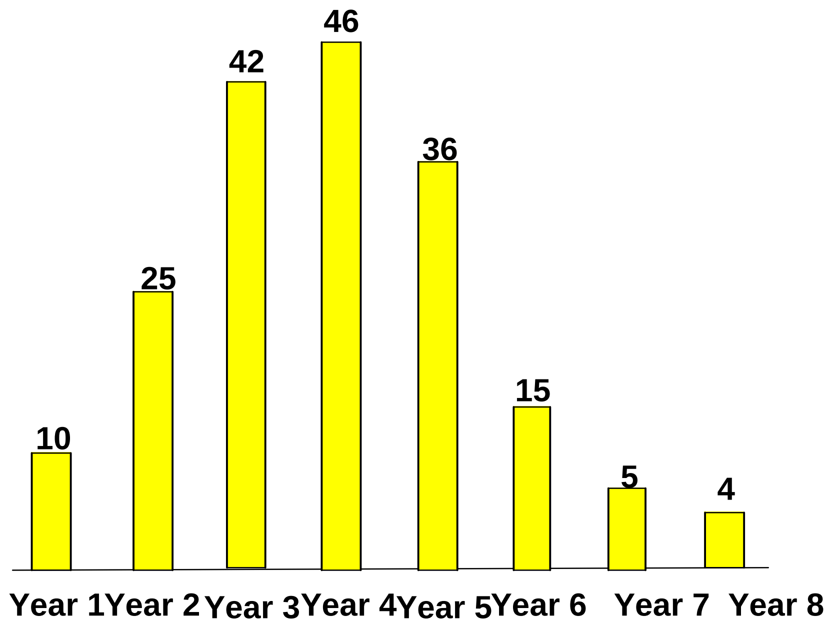


*Figure 2. Estimated Funding Distribution over 8 years in millions of dollars*

By commencing the LANSCE-R Project as soon as possible, the significant capabilities will be available to the program without continued loss in reliability and ever increasing cost. Operational efficiencies will be realized sooner and thus more cost effective.

## 6.3 Personnel and Expertise

The LANSCE-R project will draw in large part from existing operational, technical and scientific expertise at LANL. Contractor labor will be used as needed to draw on industry best practices and to provide critical skills where labor is not available at LANL. LANL has the necessary personnel and expertise to ensure the success of a project of this magnitude and complexity. Many aspects of the LANSCE-R project are similar to those of the APT, Switchyard Kicker, and SNS Accelerator projects, all of which were successful examples of excellent project management.

## 6.4 Project Schedule

An initial schedule assessment indicates that all parts of the project can be completed by the end of FY14 assuming an FY07 start. In order to accomplish that goal, project engineering and design (PED) funding must be available and design be completed and procurement of long lead critical components initiated no later than FY07. Figure 3 shows the major activities and anticipated time frames. An extended outage in the 2010-2012 time frame may be required; otherwise during planned, annual beam outages, the LANSCE beam delivery program is expected to be fully operational and supporting user programs. Partial benefits should be realized as components are installed.

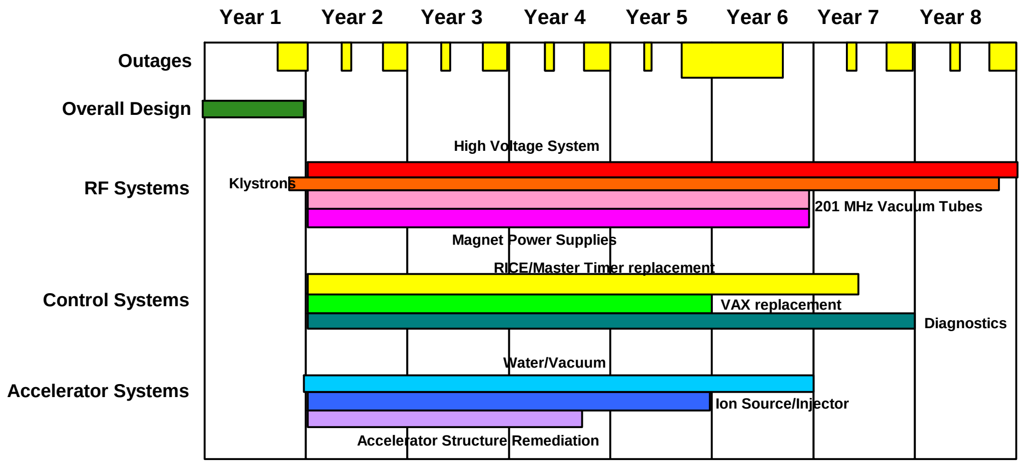


*Figure 3. Estimated schedule*

# 7. DEVELOPMENT PLAN

## 7.1 Project Oversight

The total project cost for LANSCE-R is estimated to be greater than $150M, the Acquisition Executive authority is at the NNSA Administrator, but the intent is to request delegation of the Acquisition Executive functions to the Deputy Administrator for Defense Programs. The cognizant Program Manager for defining program requirements will be the Director of the Office of Defense Science. The Federal Project Director will be appointed. The LANL Project Leader for LANSCE-R will be appointed upon the approval of CD-0 and report to PADNWP Weapons Infrastructure.

## 7.2 Acquisition Strategy

LANL will serve as both the integrator and manager for this project, under the direction of NNSA. The design, procurement, and installation of required equipment will be accomplished using a combination of new and existing contract vehicles, which will have either a firm-fixed-price or cost reimbursable contract format. Decisions to use either a firm-fixed price or cost reimbursable contracting strategy will be based on the level of definition that is possible for contract scope and an assessment of the risk factors associated with each required procurement.

The conceptual design phase of this project will be accomplished using a combination of LANL staff and contractor support personnel. The acquisition and execution approach for the project will be further defined during the conceptual design phase. The majority of the required procurements are expected to be placed in support of design and fabrication efforts for specialized equipment.

There are a very limited number of qualified vendors for many of the critical components that will be required to achieve project objectives. In cases where there is only one vendor for a needed component or required piece of equipment, the project will employ a technical "proof of concept" phase coupled with a "first-article" test prior to the actual initiation of any full production decision. In cases where there are multiple specialty vendors who can deliver a required component (e.g. manufacture of klystrons), a competitive procurement process will be followed. A strategy of splitting equipment orders between two vendors will be evaluated, in cases where overall costs will not significantly differ, to help ensure there is a viable second source available for the project's critical components.

The project's major RF and accelerator system components are known to have long-lead times associated with their delivery. Mitigating the project's overall procurement risk, however, is the fact that several critical components, such as the 805 MHz RF system equipment, have already gone through a rigorous design and checkout phase using specifications written as part of the SNS project. These specifications will be modified to incorporate lessons learned from previous SNS and LANSCE projects that used similar equipment. To further mitigate risk, the project intends to employ a phased CD-1a/2a/3a process. This approach will allow crucial long-lead items that require minimal design efforts to be procured early in the project's schedule. Using this acquisition strategy will help assure that any minor delays in crucial equipment deliveries will not adversely impact the project's overall schedule

## 7.3 Status of Project Development Activities

The overall approach to develop the conceptual design includes the following key activities:

- Formation of an Integrated Project Team (IPT) to manage the project through the period of performance. The LANL project team portion of the IPT is somewhat larger than normal due to the significant planning, scheduling, and control needs of the project.
- Development of a CD-1 Package (including an overall project CDR) through detailed investigation of each subproject, rolled up into the overall CDR.
- Development of a detailed execution plan to manage and control the subprojects. The execution planning will give special attention to areas that have proven most difficult when on other projects at LANSCE and other LANL facilities in the past. These areas include:
  - Requirements definition
  - Quality assurance
  - Safety and AB
  - Integration and coordination with programs and other projects
- Development of a detailed plan for procurement and installation (as part of the acquisition strategy) to account for resource limits (e.g., craft) and the potential need for specialty subcontractors. Given the operational constraints for LANSCE and the safety considerations for subprojects, site access will require a higher level of planning than is normal for typical design and construction projects.

### *Completed Development Activities*

FY01 Klaus Berkner Review of LANSCE Operating and Infrastructure Requirements and Cost Review, August 1–3, 2001

FY05 LANL LANSCE Futures Workshop, January 10–11, 2005

FY05 LANL Independent Review of Scope and Cost for LANSCE-R, February 22–23, 2005

FY05 CD0 presentation to Deputy Administrator for Defense Programs, April 13, 2005

### *Scheduled Development Activities*

June 23, 2005 ESAAB presentation for CD-0

### *Future Project Development Activities*

| | |
|---|---|
| June 2005 | Complete Pre-Conceptual Planning |
| July 2005 | CD-0 and Begin Conceptual Design |
| November 2005 | Deliver first 90% Conceptual Design and CD-1 Package |
| January 2006 | External and Independent Project Reviews complete on first package |
| February 2006 | Complete first Conceptual Design and CD-1 Package |
| February 2006 | ESAAB Presentation for first CD-1 |
| February 2006 | CD-1a (authorization to begin capital funded design) |
| FY2006-2012 | Subprojects Preliminary Design |
| FY2006-2013 | CD-2 (multiple; authorization to begin Detailed Design) |
| FY2006-2013 | Subprojects Detailed Design |
| FY2006-2013 | CD-3 (multiple; establish subprojects performance baseline) |
| FY2008-2014 | Subprojects Construction and Procurement |
| FY2008-2014 | CD-4 (multiple; turnover and closeout by subproject) |

## References


- Conceptual Design Execution Plan for the LANSE-R Project (June 2005).
- DOE M 413.3-1, Sections 5.2.1, Requirements Analysis, and 5.2.4, Conceptual Design Report.
- DOE NNSA Strategic Plan, DOE /NA-0010 (November 2004).
- DOE Strategic Plan, DOE/ME-0030 (2003).
- LANL and LLNL Bi-Laboratory Draft Primary Certification Capability Plan (May 2005).
- Memorandum of Understanding Among the Office of Defense Programs, NNSA, the Office of Facilities and Operations, NNSA, the Office of Science, DOE, the Office of Nuclear Energy, Science and Technology, DOE and the Los Alamos National Laboratory for the Definition of Governance Roles and Responsibilities for the Los Alamos Neutron Science Center (December 17, 2001).
- NNSA FY2006-2010 Stockpile Stewardship Plan, Vol. I, Stockpile Stewardship Plan (April 2005).
- NNSA FY2006–2010 Stockpile Stewardship Plan, Vol. II, Report on Criteria for Stockpile Stewardship Tools (April 2005).
- Project Management for the Acquisition of Capital Assets, DOE Manual 413.3-1 (March 28, 2003).
- Report of the LANSCE User Facility Cost Estimate Review Committee (August 1–3, 2001).
- Ten-Year Comprehensive Site Plan, FY 2005 to FY 2014, LA-CP-04-0678 (February 11, 2005).
- DOE Order 420.2B, *Safety of Accelerator Facilities*. Interim Safety Assessment Document for the LANSCE User Facility, LANL TA-53-ISAD-007, approved by DOE in April 2002.

# Appendix

**LANSCE FUTURES**

The Los Alamos Neutron Science Center (LANSCE) has served the nation for over 30 years as a premier research facility for national security and fundamental science. LANSCE is a cornerstone research facility at Los Alamos for scientific enterprise—a “destination for scientific excellence”—attracting the very best scientific talent needed to meet Los Alamos National Laboratory missions. LANSCE and subsequently an investment in LANSCE-R enable the possibility of multiple enhancements or futures for the facility to meet additional scientific and programmatic mission requirements. Los Alamos evaluated possible follow-on enhancements and the result of this evaluation is found in the LANSCE Futures document and is summarized here.

Future missions drive the requirements for enhanced LANSCE capabilities across five principal research areas: proton radiography, weapons nuclear science, civilian nuclear science, materials science and bioscience, and fundamental nuclear physics. Enhancements are designed to meet evolving Laboratory missions in national security research, energy security research, and maintaining Los Alamos as a center of scientific excellence.

***Proton Radiography***

Research utilizing 800-MeV proton radiography will remain critical to stockpile certification for the foreseeable future. The evolving SSP mission will require the ability to spatially resolve features with 1mm accuracy in targets of up to 60 $gm/cm^2$ areal density. Additional capabilities that may be required that were identified included the ability to study the hydrodynamics of systems with precisely tailored pressure and shock profiles. Specific facility enhancements to provide these capabilities include high quantum efficiency detectors to improve data fidelity for dynamic experiments, fielding a new implosion driver such as an electromagnetic implosion driver to enable pressure-tailored, convergent hydro and shock experiments, and improving the pRad-firing site to enable dynamic experiments with up to 20 pounds of HE drive.

The LANSCE 800-MeV Linac provides a cost-effective injector for an enhanced energy option. Classified results of static experiments performed at the BNL AGS facility have indicated that 20 GeV class proton radiography could accurately measure the properties of full-scale hydrotests on the largest stockpiled systems.

***Weapons Nuclear Science***

Uncertainties in nuclear data drive uncertainties in code predictions of weapons performance. Over the next decade, improvements in nuclear performance modeling by ASC codes will require a reduction in nuclear data uncertainties. This in turn will likely require cross section data on short-lived isotopes that heretofore have not been possible. Specific facility enhancements to meet these requirements include upgrading flight-path instrumentation at WNR and the Lujan Center, developing the capability to produce and prepare unstable isotopes for measurements, and developing a dedicated flight path for intense neutron burst irradiation of targets and components.

***Civilian Nuclear Science***

**T**o meet the mission of nuclear energy development, a major component of our national energy strategy, the US will require a fast neutron irradiation capability. This new capability, called the Material Test Station (MTS), is planned for the LANSCE facility. The MTS will use the LANSCE 800-MeV Linac to drive a high-power neutron spallation production target. The neutron flux produced by the MTS will provide sufficient intensity to optimize the next generation of materials and fuels necessary to develop advanced fission systems. This irradiation capability can be effectively doubled by fully refurbishing the 805-MHz RF power systems in the LANSCE Linac, providing irradiation intensity equivalent to a 100 MW fast-flux reactor.

### *Condensed Matter Physics, Materials Science, and Bioscience*

Neutron scattering addresses the scientific grand challenge known as “structure-property relationships in materials”. The evolving challenges in condensed matter physics, materials science, and bioscience create the need for large-scale user facilities with greater power and acuity. LANSCE has a unique opportunity to develop next-generation neutron scattering capabilities that anchor the Laboratory’s scientific excellence in materials structure, materials synthesis, nanoscience, and structural biology for decades to come. Fully exploiting the capabilities of the Lujan Center, by enhancing cold neutron production and investing in instrumentation, sample preparation facilities, sample environments, and associated user-support infrastructure, would allow Lujan to remain a premier international neutron scattering facility for the foreseeable future. Prototyping a high-power long pulse spallation source (LPSS) would explore the promise of Generation-3 neutron scattering and anchor 21$^{st}$ century materials research for basic, weapons, and threat reduction research. The LPSS approach is a cost-effective strategy to complement the capability of the spallation neutron source (SNS) presently under construction at the Oak Ridge National Laboratory while providing an innovative path to exceed SNS performance. By fully refurbishing the 801-MHz RF system, the LPSS prototype would operate with 660 kW of spallation power at 20 Hz. For cold neutron experiments most relevant to soft matter, nanomaterials, and bimolecular science, the LPSS would achieve comparable performance to the full power SNS.

### *Fundamental Nuclear Physics*

Fundamental nuclear physics, and the staff it attracts and retains, plays an important role in ensuring that the Laboratory fulfils its missions. Fundamental nuclear physics research at LANSCE spans four major areas: cold neutrons, ultracold neutrons (UCN), neutrinos, and nuclear astrophysics. A range of possible LANSCE enhancements would enable meeting future challenges and opportunities across these areas of investigation. Increasing the production of cold and ultracold neutrons would provide for precision tests of the standard model of the electroweak interaction. In nuclear astrophysics, LANSCE is currently the most advanced facility producing precision neutron capture cross section measurements for understanding S process nucleosynthesis. Enhancements in neutron production, coupled with upgrades to Lujan and WNR flight paths, would significantly increase the scientific impact of this fundamental research. An enhanced neutrino source, driven by a 3-GeV Linac upgrade, would create a productive facility for studying the masses and mixing parameters of neutrinos; providing a unique capability for the United States.