Enterprise Blueprint

ESSENTIAL INFRASTRUCTURE FOR MISSION DELIVERY. ON TIME. AT SCALE.

NNSA
National Nuclear Security Administration

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NNSA 2050

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Sandia's new Limited Area Multi-Program (LAMP) High Bay

The Nuclear Security Enterprise (NSE) has served the United States remarkably well through the Manhattan Project, Cold War, and post-Cold War periods even when significant change occurred, including the end of nuclear explosive testing and strategic arms reductions. Today, rapid geopolitical and technological change impact the strategic environment and place new demands on the NSE to increase capability and capacity and respond more quickly. The United States can no longer rely on decades-old production facilities and science and technology infrastructure to meet deterrence needs. The NSE must re-establish eliminated capabilities; replace buildings that are failing; and meet modern safety, security, and environmental standards. The enterprise needs adaptable infrastructure for a global security landscape influenced by science and technology prowess alongside evolving deterrence strategies.

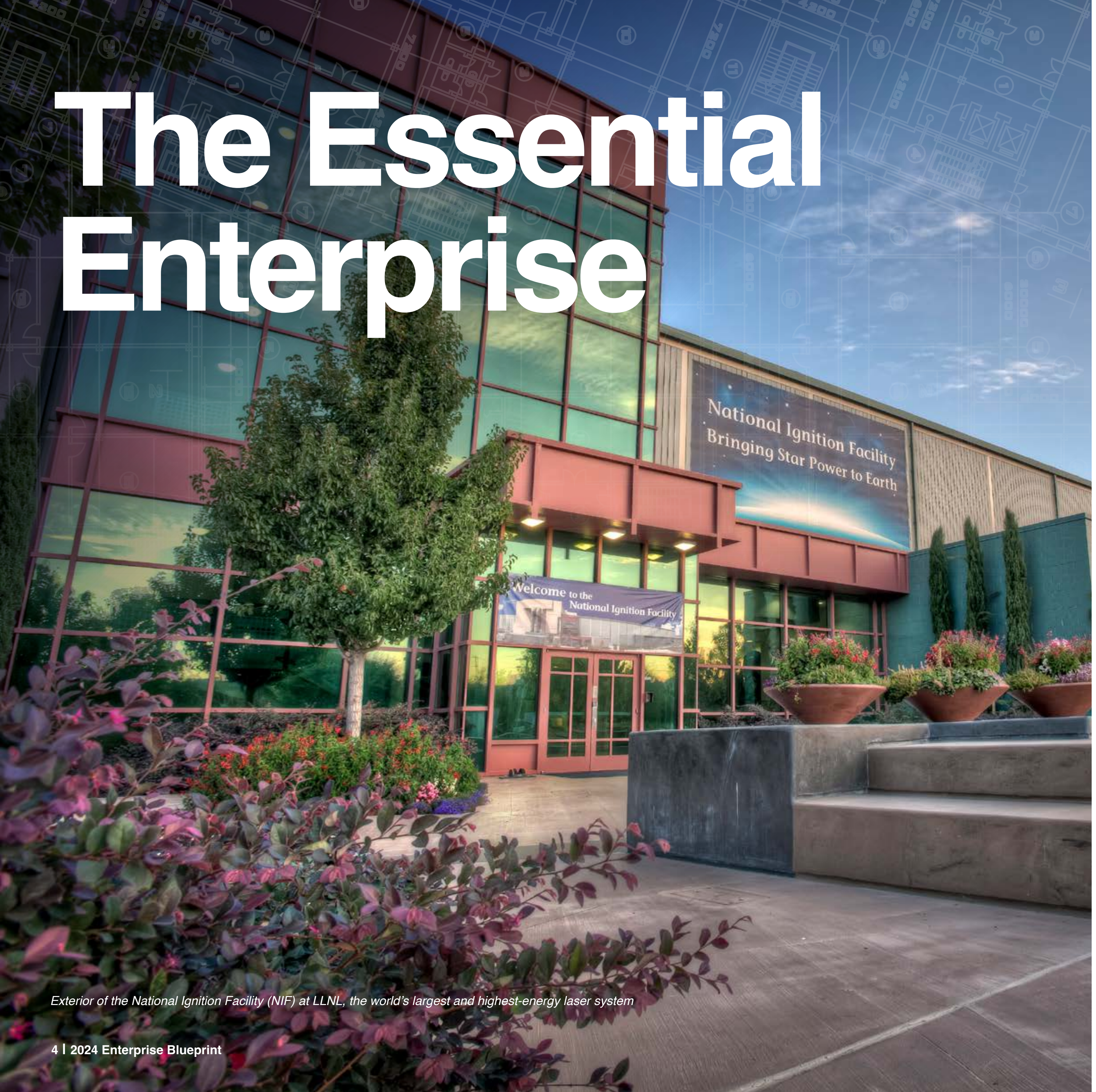
The Enterprise Blueprint outlines a 25-year plan to align the delivery of specialized infrastructure with demands across the nuclear stockpile, global security, and naval nuclear propulsion missions. This Blueprint prioritizes capabilities for mission delivery and takes a practical approach to becoming a more balanced, responsive, and resilient enterprise. Under the Blueprint, the NSE continuously invests in both the production and science infrastructure that support weapons design, certification, and assessment. Initially, the investments are weighted toward restoring production capabilities for modernizing weapons and the critical investments to sustain the current stockpile. As production and stockpile sustainment capabilities are restored, investments increase to revitalize the scientific base to achieve the necessary balance needed in a dynamic environment. Further out in time, important investments in global security and naval nuclear propulsion require higher priority. Together, these investments will modernize NSE facilities and technologies and provide the capacity the mission needs in a timely manner.

This Blueprint incorporates the NSE's best thinking on how to meet mission requirements; balance investments for production, stockpile sustainment, and science; and set the foundation for what the enterprise can deliver for decades to come. In a dynamic global environment, effective, efficient, and safe delivery on mission mandates is vital to American and international security.

Why the Blueprint?

Aging Infrastructure	Mission Demands	Advanced Technologies
Over half of facilities are in poor condition and many date back to the Manhattan Project.	The NSE must deliver the program of record and adapt to shifting demands and geopolitical conditions.	New opportunities from modern technologies must be seized to improve efficiency, safety, and security.

The Essential Enterprise



Exterior of the National Ignition Facility (NIF) at LLNL, the world's largest and highest-energy laser system

A Dynamic National Security Environment

The world has evolved dramatically since the end of the Cold War, when easing tensions opened the door for significant reductions in nuclear stockpiles and ushered in a moratorium on nuclear explosive testing. U.S. leaders reconfigured the NSE to adapt to a more benign environment, shifting the focus to sustaining a shrinking stockpile and improving the science-based understanding of weapon performance. The design and development of new weapons systems was limited to extending lifetimes. Certain facilities were permanently shuttered, other production and manufacturing operations were mothballed, and the NSE embraced the maximum re-use of materials and components. There was no immediate need to manufacture plutonium pits, increase tritium gas production, or manufacture radiation cases at scale, and the related capabilities were neglected. In short, a smaller, less active NSE was envisioned that would be sized to produce sequential life extensions of existing weapons systems, one at a time.

The new approach led to major advances in how science is leveraged to better understand the nuclear stockpile, but the geopolitical stability undergirding it proved short-lived. Today, Russia and China are moving forward on new weapons programs and showing little interest in arms control or strategic stability measures. As a result, the NSE must prepare to deter two nuclear-armed major powers for the first time in history. In addition, North Korea continues to pursue dangerous capabilities, and Iran continues to take steps that could lead to the possession of nuclear weapons.

Meanwhile, interest is surging around the world in nuclear power as a clean energy source. New technical solutions are needed from the NSE to maintain global security norms and guard against proliferation and terrorism threats. The U.S. is strengthening partnerships to address the changing world order, such as the announced AUKUS partnership between the United States, the United Kingdom, and Australia to share conventionally-armed, nuclear-powered submarines.

In parallel, once unimaginable breakthroughs in technology are rapidly transforming science, industry, economics, and national security. Innovations in artificial intelligence, advanced computing, and other technologies are driving new opportunities for research and development (R&D) and production while simultaneously creating new threats. Significant changes in global supply chains and extreme weather events from climate change, such as wildfires, are threatening infrastructure at higher rates.

All these changes are impacting national security, and the NSE is being called upon to create and implement responses. To meet the moment and anticipate future requirements, NSE infrastructure must be capable of supporting enduring missions. This Blueprint lays out a path to get there.

Advancing U.S. Nuclear Policy

Consecutive National Defense Strategies and Nuclear Posture Reviews have acknowledged the need to recapitalize the United States' aging nuclear infrastructure. The Enterprise Blueprint advances the longstanding U.S. policy of building a more responsive and resilient nuclear enterprise to support the deterrent. The investments outlined in this Blueprint will provide NNSA with the specialized infrastructure needed to build and maintain modern nuclear weapons and sustain enduring technical advantages.

A Responsive and Vital Enterprise

The NSE encompasses a workforce of about 65,000 people operating in government-owned facilities with 40 million square feet of floor space on 2,000 square miles of land. It is a decentralized network of research and design, special experimentation, technology and manufacturing, and naval reactors sites. Yet the NSE often relies on decades-old facilities, equipment, and processes to perform critical science and production work. These facilities have served U.S. deterrence needs remarkably well but are now past their design life, rely on outdated technologies, and in some cases suffer from contamination after years of use. As a responsible nuclear-weapon state, the United States must match the scale of its investment with the needs of its mission.

The NSE has been asked to take on more work than at any time since the Cold War, and none is optional. NNSA is undertaking the simultaneous sustainment, surveillance, modernization, design, and development of multiple weapons and components that have not been produced in decades; cannot be obtained from commercial markets; and need modern approaches to be efficient, safer for workers, and environmentally responsible.

NNSA must maintain the capacities and expertise to sustain, develop, and produce systems for an effective, reliable nuclear deterrent. In an era with greater barriers to cooperative on-site inspections, the NSE must be able to evaluate emerging technologies, remotely detect and monitor global proliferation, and secure sensitive materials at home and around the world. In addition, the NNSA must support U.S. naval nuclear reactor technology development efforts and manage and examine spent fuel.

Modernized infrastructure is foundational to face and embrace the challenges and opportunities ahead. All the needs are real. However, because of the size of this undertaking, NNSA is making informed decisions to renew, replace, or retire facilities based on the delivery demands and the ability to execute.

Strategic Collaborations

NNSA needs robust internal and external collaborations to save costs and respond quickly. Many NNSA efforts, especially in the global security programs, depend heavily on unique infrastructure and capabilities at other Department of Energy (DOE) laboratories. NNSA relies on strategic investments at non-NNSA labs to sustain mission delivery and is strongly committed to supporting collaboration across the Department's labs.

Within the NSE, collaboration spaces are being strategically created to support virtual and physical co-location. Bringing together experts from multiple locations, these spaces focus on supporting specialized capabilities, such as high explosives, advanced manufacturing, and artificial intelligence. There are two types:

- Enclaves for rapid deployment using design and production agency resources
- Collaboration centers with NSE, academic, commercial, and federal partners

Enclaves are hosted by a lead site and can be part of an "open campus" environment where the NSE workforce can more easily work with external partners.

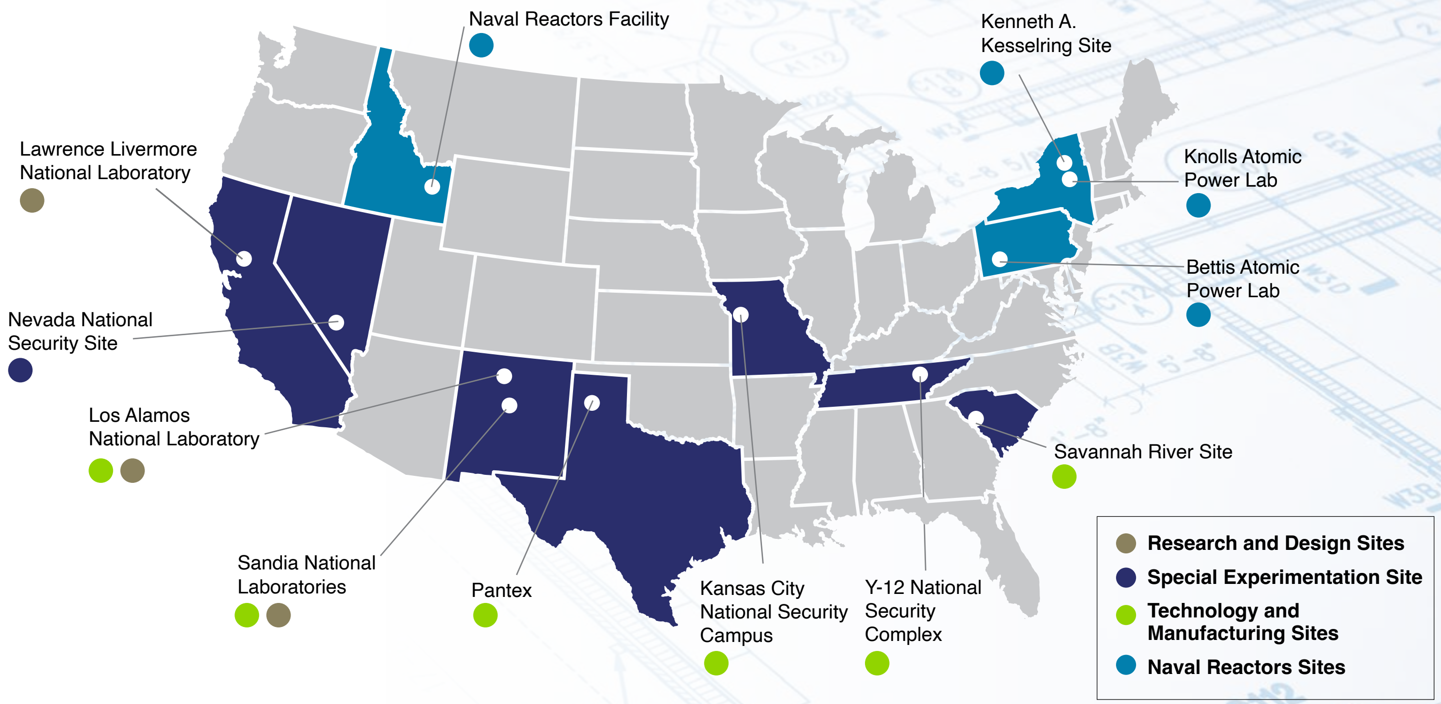
Elements of the Enterprise

▶ RESEARCH AND DESIGN SITES
Offer specialized research, design, certification, assessment, simulation, and engineering capabilities for the nuclear stockpile, nuclear nonproliferation, and counterterrorism.

▶ SPECIAL EXPERIMENTATION SITE
Hosts one-of-kind subcritical testing and a broad suite of unique experimental capabilities for the NNSA mission, including the safe handling of special nuclear and other hazardous materials.

▶ TECHNOLOGY AND MANUFACTURING SITES
Provide unique production, processing, manufacturing, assembly/disassembly, integration, technology development, and staging and storage capabilities for nuclear weapons and materials.

▶ NAVAL REACTORS SITES
Responsible for design and engineering for the U.S. Navy's nuclear-powered aircraft carriers and submarines, and management and examination of naval spent fuel.



Investment Principles and Objectives for a Modern Enterprise

The enterprise must deliver on the program of record and adapt to shifting demands, recognizing that security on the global stage will be influenced by science and technology prowess alongside evolving nuclear deterrence strategy. The NSE's ability to be a more responsive, balanced, resilient, innovative, and flexible enterprise is tempered by today's infrastructure. This Enterprise Blueprint is a long-term specialized infrastructure roadmap for the next 25 years.

Under this Blueprint's investment principles, the enterprise will deliver specialized infrastructure at the scale needed in the timeframe required to meet mission demands — accepting failure is not an option. The investments will be cost-sensitive with an aim to create a more responsive and balanced enterprise that utilizes the existing sites. Resiliency will be improved with a purposeful reduction of single-point failures. Innovation will be strengthened through greater investment in manufacturing and certification R&D. To the extent possible while retaining cost-effectiveness, flexibility will be considered in facility designs.

▶ **RESPONSIVE**
Timely, cost-effective infrastructure to meet needs without operating facilities to failure. As investments are made, safer and more sustainable, waste-reducing, and operationally efficient processes, practices, and materials will be incorporated.

▶ **BALANCED**
Advance the legacy of the enterprise by ensuring that R&D, experimental, manufacturing, and naval reactors sites are healthy and utilized fully and appropriately. The enterprise is collaboratively applying the best people to the right challenges at the best location.

▶ **RESILIENT**
Mitigate single-point failures by building in strategic redundancies and backup capacity. Modern infrastructure provides faster recovery from unexpected conditions.

▶ **INNOVATIVE**
Create one-of-a-kind solutions needed for the NSE mission and adopt commercial best practices whenever possible. Put technology to work faster for the unique mission needs.

▶ **FLEXIBLE**
Scale capabilities and capacities up and down as mission demands shift. Maintain "flex" spaces when possible for rapid responses to emerging challenges and threats. Make agile, data-driven, and risk informed decisions.

Sites and Capabilities

Under this Blueprint, the missions of individual sites are defined to optimize efficiencies and establish necessary strategic resiliency. Time-phased investments in critical capabilities will deliver essential infrastructure for mission delivery, on time and at scale. This focused approach will provide the NSE with the capacity needed for the mission; improve worker safety; modernize technology; and advance scientific understanding. Major outcomes include:

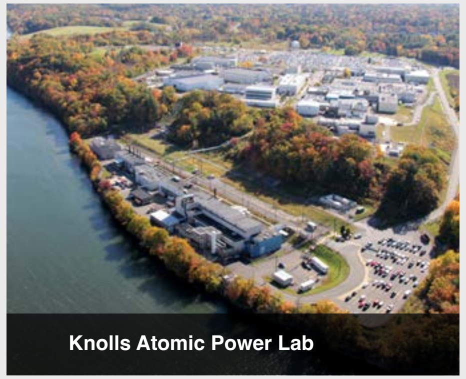
- Pit manufacturing will be re-established at the Los Alamos National Laboratory (LANL) and Savannah River Site (SRS) to replace the capability lost when Rocky Flats was closed.
- Uranium and lithium processing capabilities will be modernized at Y-12 National Security Complex (Y-12) to provide modern equipment and safer environments.
- Subcritical test diagnostics will be improved at the Nevada National Security Site (NNSS) to better understand aging performance to certify the stockpile without nuclear explosive testing and collect data on nuclear materials and newly manufactured components.
- Insensitive high explosive synthesis and formulation capability will be established at the Pantex Plant (PX) to meet capacity requirements and resilience goals.
- Combined radiation environmental test capability will be established at Sandia National Laboratories (SNL) to replace an aged reactor, address current threat environments, and operate safely and predictably.
- Manufacturing research and development capabilities will be established at the Lawrence Livermore National Laboratory (LLNL), Kansas City National Security Campus (KCNSC), Y-12, and SNL to address the fast pace of technological change and collaborate across the enterprise.
- Spent nuclear fuel handling and examination capabilities will be recapitalized at the Naval Reactors Facility (NRF), and key laboratory capabilities consolidated at Bettis Atomic Power Laboratory (Bettis) and Knolls Atomic Power Laboratory (KAPL).

Future NSE Infrastructure

Naval Reactors Sites

Naval Reactors Facility

Bettis Atomic Power Lab



Knolls Atomic Power Lab

Kenneth A. Kesselring Site

- Dedicated research and engineering facilities for naval nuclear propulsion that provide advanced technology and technical support for safe, reliable operations
- Prototype nuclear propulsion plant for the operational testing of new designs and promising new technologies
- Manage and examine naval spent nuclear fuel and irradiated test specimens for new technology development and improved cost-effectiveness of existing designs

Nuclear Stockpile | Naval Nuclear Propulsion | Global Security & Stability | Emerging Challenges

Special Experimentation Site

Nevada National Security Site

- Unique facilities and diagnostics for underground subcritical experiments for plutonium performance physics and global security applications
- Operation of specialized test beds for experimentation of high explosives and special nuclear materials
- Plutonium operations and staging capabilities
- Detection of nuclear and radiological materials supporting national security, law enforcement agencies, and consequence assessments

Research and Design Sites

Lawrence Livermore National Laboratory

- Design and qualification of nuclear explosive packages and high explosives (strategic resiliency with LANL)
- Center for laser fusion R&D
- Host for high explosive and non-nuclear manufacturing technology development enclaves, and NNSA's first exascale computing infrastructure
- Partner with SLAC for studies of material microstructures and aging (strategic resiliency with LANL-ANL)
- Space domain security R&D

Technology and Manufacturing Sites

Los Alamos National Laboratory

- Production of plutonium pits (strategic resiliency with SRS)
- Design and qualification of nuclear explosive packages and high explosives (strategic resiliency with LLNL)
- Center for primary (fission) dynamic imaging capabilities
- Partner with ANL for studies of material microstructures and aging (strategic resiliency with LLNL-SLAC)
- Space domain instrumentation R&D

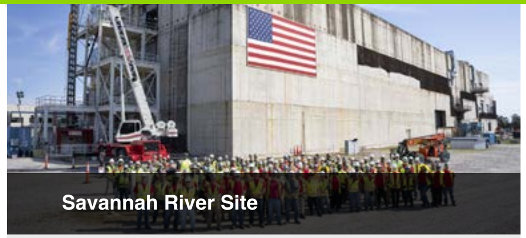
Sandia National Laboratories

- R&D and qualification center for non-nuclear components with substantial environmental test capabilities
- Warhead systems engineering and integration
- Production of specialized non-nuclear weapons components and trusted radiation-hardened microelectronics
- Collaboration center host for advanced manufacturing, material science, and technology exploration and maturation
- Space domain rapid prototyping of advanced sensors, algorithms, and ground stations

Technology and Manufacturing Sites

Y-12

- Production of assembled secondaries for the nuclear stockpile and manufacture of secondary stage materials and components, including provider of enriched and depleted uranium and uranium alloys, lithium, and radiation cases
- Application of special nuclear materials and security expertise and operation of uranium conversion, separation, and component fabrication evaluations for the global security mission
- Supply the U.S. Navy feedstock material to fuel nuclear-powered submarines and aircraft carriers



Savannah River Site

- Robust large-scale production of plutonium pits (strategic resiliency with LANL)
- Center for tritium supply, separation, and gas transfer system loading for nuclear weapons
- Plutonium downblending operations and integrator of the nation's cross-complex plutonium disposition mission

Pantex

- Weapons assembly and disassembly facilities and interim pit storage; safe and secure against weather, accidents, and adversarial threats
- Full-scale synthesis, formulation, production, and testing of main charge high explosives
- Strategic location for detonator production
- Operation of treaty monitoring and verification test facilities

Kansas City National Security Campus

- Modern, multi-faceted, scalable non-nuclear component production capabilities
- Center for strategic supply chain management and optimized vendor sourcing
- Incubator for classified environment digital technology advancements
- Advanced electrical, mechanical, and material capabilities for prototyping and manufacturing

Mission Capabilities

Crews at SRS install a temporary HVAC system for the Savannah River Plutonium Processing Facility (SRPPF)

Specialized Infrastructure

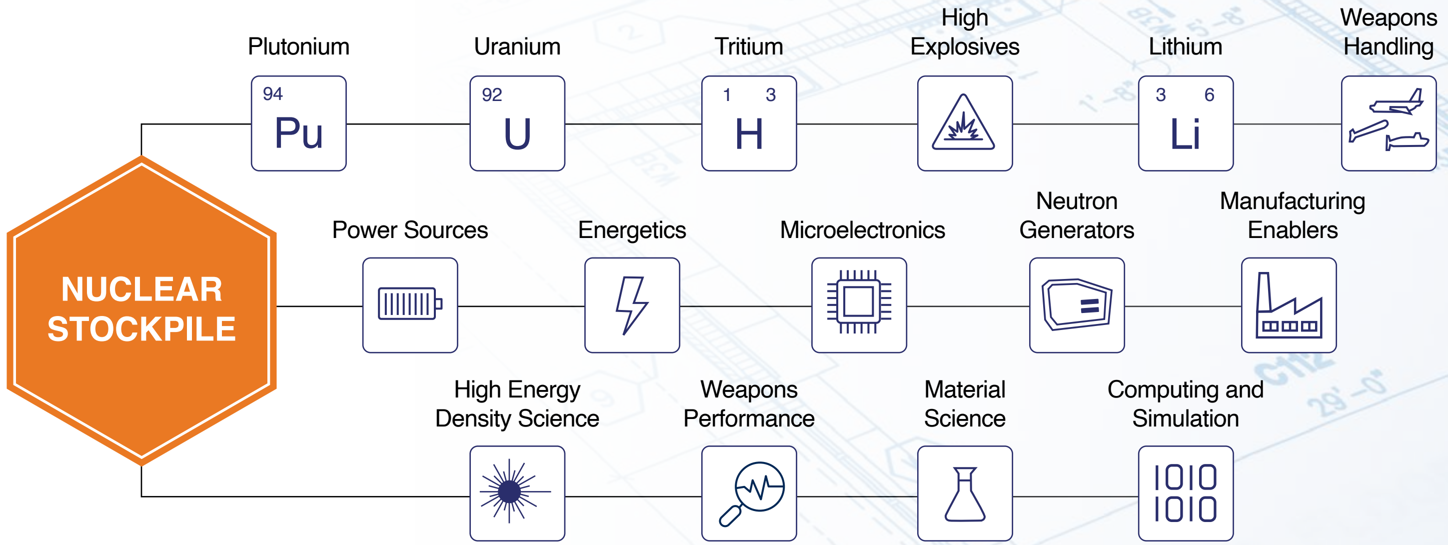
This first Enterprise Blueprint focuses on the highest impact, specialized infrastructure needed. It extends beyond basic infrastructure needs (e.g., office space, utilities, security, communications) to showcase what makes the NSE unique and highlights the capabilities that will be the bedrock of production and science abilities for decades to come. Its new facilities, refurbishments, and acquisitions are categorized by capability areas that support the nuclear stockpile, global security, and naval nuclear propulsion missions. Within each capability area, infrastructure needs are contextualized by a strategy and linked to the activity sets planned to meet the needs.

Nuclear Stockpile

The nuclear stockpile mission requires capabilities to handle and process special nuclear materials; radioactive, hazardous, and specialized materials; non-nuclear unique components; and assembled nuclear weapons. The special nuclear materials include plutonium and uranium of various specifications. Radioactive, hazardous, and specialized materials include tritium, high explosives, and lithium. Non-nuclear components include power sources, energetics, microelectronics, and neutron generators. Additionally, the mission requires handling nuclear weapons themselves and requires some manufacturing enabling technologies. Together, these capabilities allow the design and production of safe, secure, reliable, and effective nuclear weapons. The Blueprint time-phases investment based on mission needs, but all are must-have capabilities unique to the NSE.

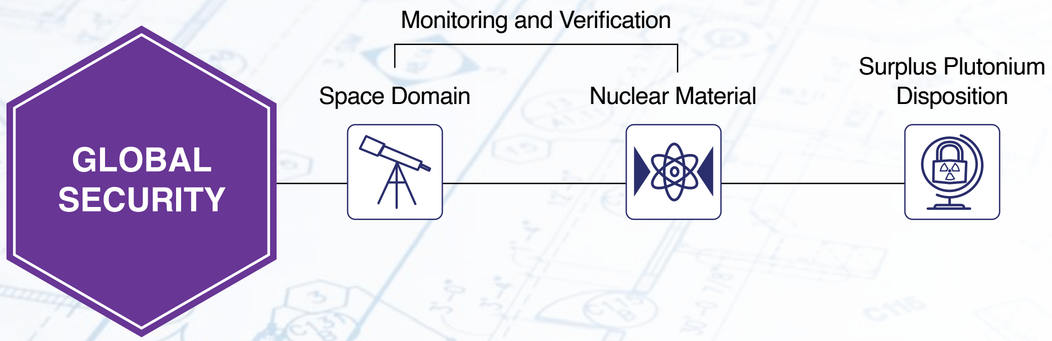
Research, Design, Certification, and Assessment capabilities involve world-class evaluation and problem-solving tools associated with the nuclear stockpile, including high energy density (HED) science, weapons performance, material science, and computing and simulation. Continued investment in these capabilities is critical for sustaining and certifying the stockpile without nuclear explosive testing. They also provide a deterrence value by staying at the forefront of advanced sciences and technologies.

Since the Manhattan Project, computational science capabilities have been and will remain a long-term focus for the NSE. No other government agency has comparable in-depth expertise in large-scale, multi-domain scientific computation. Understanding that the computing landscape will evolve rapidly beyond exascale, NNSA is committed to supporting regular investments in hardware, software, algorithms, data analytics, artificial intelligence/machine learning, and the underlying data and computing infrastructure. Investments in this area are ongoing under the Advanced Simulation and Computing program, and to a lesser extent in other programs, and are therefore not included as part of the Blueprint.



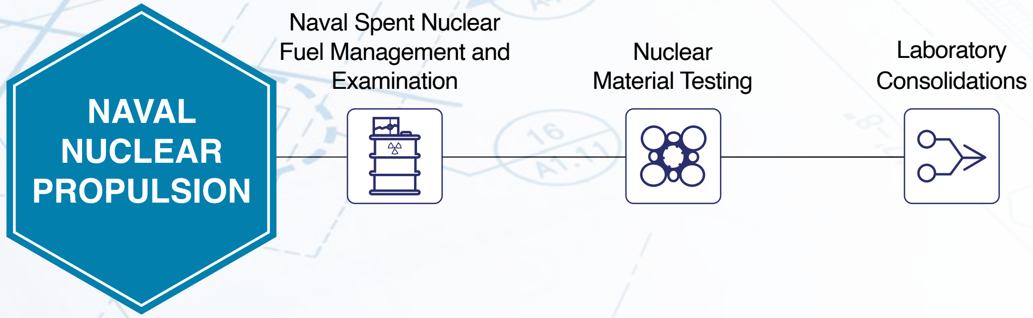
Global Security

The Global Security mission often relies on the NSE nuclear stockpile and other DOE facilities. However, dedicated facilities are needed for some unique mission work. Global conditions and U.S. commitments necessitate investment in specialized facilities for space-based detection systems development and manufacturing, test beds and realistic processing environments for advanced nonproliferation detection and security activities, and long-term surplus plutonium disposition.



Naval Nuclear Propulsion

Specialized infrastructure for naval spent fuel management, nuclear material testing and examination, and key functional nuclear laboratory consolidation are the top infrastructure priorities for Naval Nuclear Propulsion. Recapitalized spent nuclear fuel handling and storage support Navy refueling and defueling schedules; next generation spent fuel examination is essential to naval readiness; and laboratory consolidation will centralize capabilities in modern, flexible facilities to improve efficiency, effectiveness, safety, and product innovation at reduced cost. Providing nuclear reactors that support maintaining naval superiority requires robust research, development, and design efforts.



94
Pu

Plutonium

NUCLEAR STOCKPILE

Resilient, at-scale pit production and greater understanding of material behaviors

Strategy

Resilient, at-scale plutonium pit production and unique experimental capabilities to study plutonium properties are vital to the nuclear stockpile. NNSA will manufacture plutonium pits at the quantities needed to support military requirements using a two-site strategy. SRS will have the capability to produce at least 50 pits per year, and LANL will have the capability to produce 30 pits per year. LANL also will have the tools and capabilities to conduct plutonium research and explore new pit designs to improve warhead safety and tailor performance. SRS will have the capabilities to improve production approaches at-scale. These capabilities will be used to produce test materials and articles for single- and multi-physics experimental capabilities to enhance understanding of fundamental plutonium properties and aging affects as described in the Weapons Performance section.

Targeted Needs

- Sustained plutonium pit production capacity of 30 pits per year at LANL
- Sustained plutonium pit production capacity of at least 50 pits per year at SRPPF
- Using the Scorpius test bed for Principal Underground Laboratory for Subcritical Experimentation at NNSS*

Timeline

2025-2030	2031-2040	2041-2050

LANL: Los Alamos Plutonium Pit Production (PF4)

SRS: Savannah River Plutonium Processing Facility (SRPPF)

**The Scorpius test bed is captured in Weapons Performance on page 27.*

The Plutonium Facility (PF4) at LANL

92
U

Uranium Processing

NUCLEAR STOCKPILE | GLOBAL SECURITY | NAVAL NUCLEAR PROPULSION

Efficient and safe processing of materials and components essential for the NSE

Strategy

Y-12 hosts the nation's primary uranium processing capabilities, largely within facilities that are well beyond their intended design lives, often in poor and contaminated conditions that decrease efficiencies. NNSA must invest in uranium processing capabilities that are scalable, safer, and more efficient with robust supply chains. The long-term strategy will involve completely rebuilding, in a stepwise fashion, the capabilities to process uranium, replace the analytic chemistry laboratory, manufacture components with depleted uranium and alloys, manufacture components with HEU, and assemble and disassemble secondaries. These activities will take place from now through the 2050s to provide the capabilities needed for the stockpile, global security, and naval nuclear programs.

Targeted Needs

- HEU casting, machining, and recovery
- Full rate, modernized processing of uranium alloy and component manufacturing
- Modern and resilient analytical chemistry capabilities and increased capacity to meet mission needs

Timeline

2025-2030	2031-2040	2041-2050

Y-12: Uranium Processing Facility (UPF)

Y-12: Analytical Chemistry Laboratory

Y-12: Agile Radiation Case Capability

Y-12: Enriched Uranium Manufacturing Center

Y-12: Secondary Stage Assembly/Disassembly Capability

Construction of the Uranium Processing Facility (UPF) at Y-12

92
U

Uranium Enrichment

NUCLEAR STOCKPILE | GLOBAL SECURITY | NAVAL NUCLEAR PROPULSION

Delivering enriched uranium for the NSE on time in the needed quantities and enrichment levels

Strategy

Sustained enriched uranium supplies are needed to meet defense and nuclear nonproliferation needs. Uranium is enriched to different levels depending on its intended use, such as weapons science, naval nuclear reactors, power reactors to produce tritium, and commercial facilities to produce research and medical isotopes. NNSA has secured enough unencumbered and unobligated low enriched uranium (LEU) to support tritium production through the early 2040s but needs a long-term source. Similarly, a long-term domestic source for highly enriched uranium (HEU) is required for naval nuclear propulsion fuel by the early 2050s. High-assay low enriched uranium (HALEU), which may be obtained in the commercial market, also will be needed by the 2040s to support foreign research reactor conversion and isotope production facilities. Small-scale, LEU production using both the AC100 enrichment technology and the Domestic Uranium Enrichment Centrifuge Experiment (DUECE) is being evaluated, with some LEU production operations beginning in the early- to mid-2030s. This will serve as a dual-track effort to advance enrichment technologies and sustain and grow U.S. expertise in the field and will enable full scale-enrichment of LEU for tritium and HEU production for naval nuclear propulsion at a location to be determined.

Targeted Needs

- New LEU supplies for tritium production beginning in the early 2040s
- New HEU sources for naval nuclear propulsion by the early 2050s
- Short- and long-term HALEU availability for reactor conversion and medical isotope production

Timeline

2025-2030	2031-2040	2041-2050

TBD: Uranium Enrichment

Tritium

NUCLEAR STOCKPILE

NAVAL NUCLEAR PROPULSION

Resilient and efficient tritium processing and gas transfer systems

Strategy

Resilient and efficient tritium processing and the loading of gas transfer systems (GTS) are needed to sustain the stockpile. Tritium is a radioactive gas in nuclear weapons that creates fusion yield and is vital to maintaining required nuclear weapon performance characteristics. Unlike other strategic materials, it decays relatively quickly and must be continually produced and regularly replaced in deployed weapons. SRS hosts tritium extraction, isotope separation, and storage, in addition to GTS loading and finishing capabilities. Its new facility will replace key capabilities for GTS surveillance, packaging, and shipping. NNSA's tritium capabilities also rely on other entities outside of the NSE, including Pacific Northwest National Laboratory as the tritium-producing burnable absorber rod (TPBAR) design authority, Idaho National Laboratory for TPBAR testing, Columbia Fuel Fabrication for TPBAR assembly, and the Tennessee Valley Authority's Watts Bar reactors for tritium production. Within NNSA, LANL and SNL are the GTS design agencies, Y-12 provides lithium and near-term uranium for tritium production, and long-term LEU availability will rely on NNSA's domestic uranium enrichment solution. As this complex array of entities demonstrates, robust supply chains, increased processing efficiency, and mitigation of single-point failures are critical for the tritium mission.

Targeted Needs

- Advanced processing and modernized handing storage capabilities

Timeline

2025-2030 | 2031-2040 | 2041-2050

SRS: Tritium Finishing Facility

Savannah River Tritium Enterprise

High Explosives

NUCLEAR STOCKPILE

Responsive, resilient pathways to development, qualification, and readiness

Strategy

High explosives (HE) drive the implosion of the weapons' fissile cores and other weapon functions. The NSE must procure or produce a range of high quality HE in sufficient quantities to meet demands. LANL and LLNL play a critical role in transitioning materials and technologies from research and development to production, with each lab focusing on a variety of processes and materials for resiliency and retention of the design expertise. PX will provide a centralized capability to produce main charges, boosters, and detonators and assemble weapons into full systems. NNSA will rely on industrial vendors for materials that benefit from stable external demand signals and continue to leverage its partnerships with the Department of Defense for production resiliency of high demand HE types. This strategy offers resilient, rapid development and deployment capabilities that are scaled to need and employ advanced manufacturing techniques. It also mitigates supply chain and single-point failures and provides the well-coordinated approach required for innovation and responsiveness to changing needs.

Targeted Needs

- Dual design agency and high explosive lab- and pilot-scale binder and main charge synthesis and formulation research, development, testing, and evaluation
- PX-based insensitive high explosive production

Timeline

2025-2030 | 2031-2040 | 2041-2050

PX: High Explosive Science and Engineering

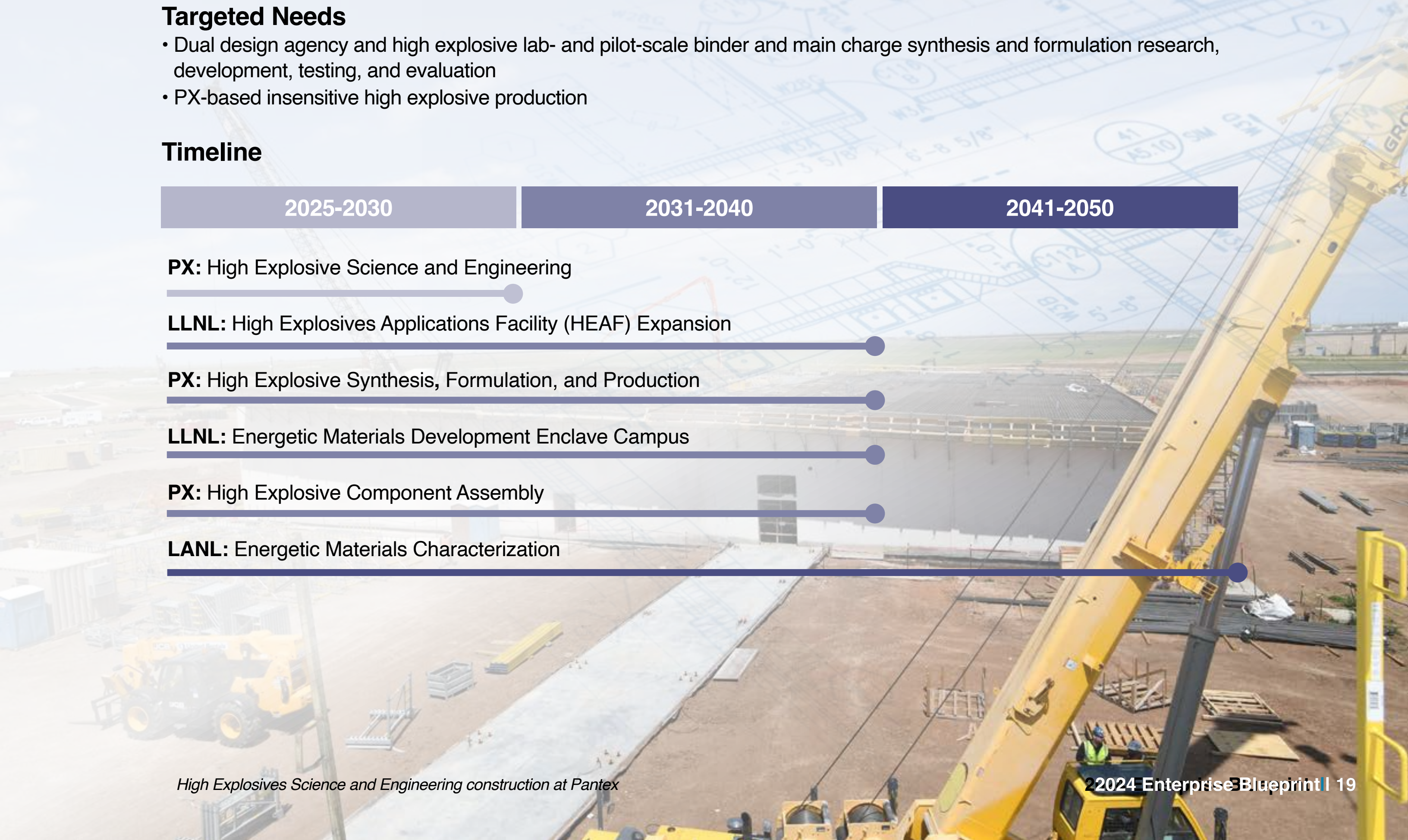
LLNL: High Explosives Applications Facility (HEAF) Expansion

PX: High Explosive Synthesis, Formulation, and Production

LLNL: Energetic Materials Development Enclave Campus

PX: High Explosive Component Assembly

LANL: Energetic Materials Characterization



High Explosives Science and Engineering construction at Pantex

Blueprint Roadmap

Mission-driven infrastructure investments – on time, at scale

NUCLEAR STOCKPILE ●
GLOBAL SECURITY ●
NAVAL NUCLEAR PROPULSION ●

FY25

W80-4 FPU

- 30 **plutonium pits** per year production capacity
- Increased **manufacturing** and R&D **capacities**

B61-13 FPU

- Safer, more efficient **uranium** processing
- Restored **lithium** processing
- In-house **high explosive** production

Near-term (2025-2030)

W87-1 FPU

W93 FPU

- **Laser** and **accelerator** upgrades
- ≥ 80 **plutonium pits** per year production capacity
- Next-generation **radiation cases**

SLCM-N IOC

Mid-term (2031-2040)

- Expanded **radiation-hardened microelectronics** capabilities
- Modernized capabilities for **survivability testing**
- **Uranium** and **secondary** processing modernization
- Next-generation **high energy density** science
- Full-scale domestic **uranium enrichment**
- Full-scale surplus **plutonium disposition**
- Next-generation **thermal test reactor** capabilities

FY50

- Modernized **weapons operational** areas

Long-term (2041-2050)

- - - - - = Underway
FPU = First Production Unit
IOC = Initial Operating Capability
SLCM-N = Sea-Launched Cruise Missile – Nuclear

3 6
Li

Lithium

NUCLEAR STOCKPILE

Safer, more reliable, right-sized processing

Strategy

A safer worker environment with modernized, scalable technologies and processing operations is needed to restore and safeguard NNSA's lithium capabilities which support the nuclear stockpile (e.g., warheads and joint test assemblies) and global security (e.g., radiation detection equipment and isotope production). Y-12 hosts NNSA's lithium operations in an oversized, degraded facility from the Manhattan Project era that presents a high risk to workers and lacks certain processing capabilities. NNSA uses enriched lithium-6 that is very different than the lithium material used in many industrial applications, including batteries. The lithium-6 inventory is sufficient but finite because NNSA stopped enriching lithium in 1963. NNSA now recycles lithium from existing lithium-6 stores and retired weapons dismantlement feedstock. Legacy lithium processing is hazardous and corrosive to infrastructure, so NNSA is investing in technology maturation and process improvement efforts to make operations safer and more efficient. A new Y-12 facility will replace legacy facilities and host advanced processing technologies.

Targeted Needs

- Lithium-6 handling, packaging, and advanced processing techniques
- Modern space for scalable technology development

Timeline

2025-2030	2031-2040	2041-2050

Y-12: Lithium Processing Facility

Building 9204-2 (Beta-2), current home of Y-12 lithium operations

Weapons Handling

NUCLEAR STOCKPILE

Safe, secure, flexible nuclear weapons staging, assembly, and disassembly operations

Strategy

Safer, secure, and flexible weapon and material staging solutions are needed to replace aged, over-subscribed facilities at PX. PX hosts the nation's only facilities authorized for full assembly and disassembly of nuclear weapons which enables the assembly of new weapons and test systems; replacement of parts and components in aging weapons; and collection of data to support evaluation, surveillance, and certification of the stockpile. New weapons and special nuclear materials staging and operational facilities will provide PX with the capabilities, expanded capacity, and more efficient process workflows required to meet future mission demands. A phased, modularized approach will be taken to refurbish and enhance out-of-date bay and cell technologies and end-of-life assembly/disassembly facilities.

Targeted Needs

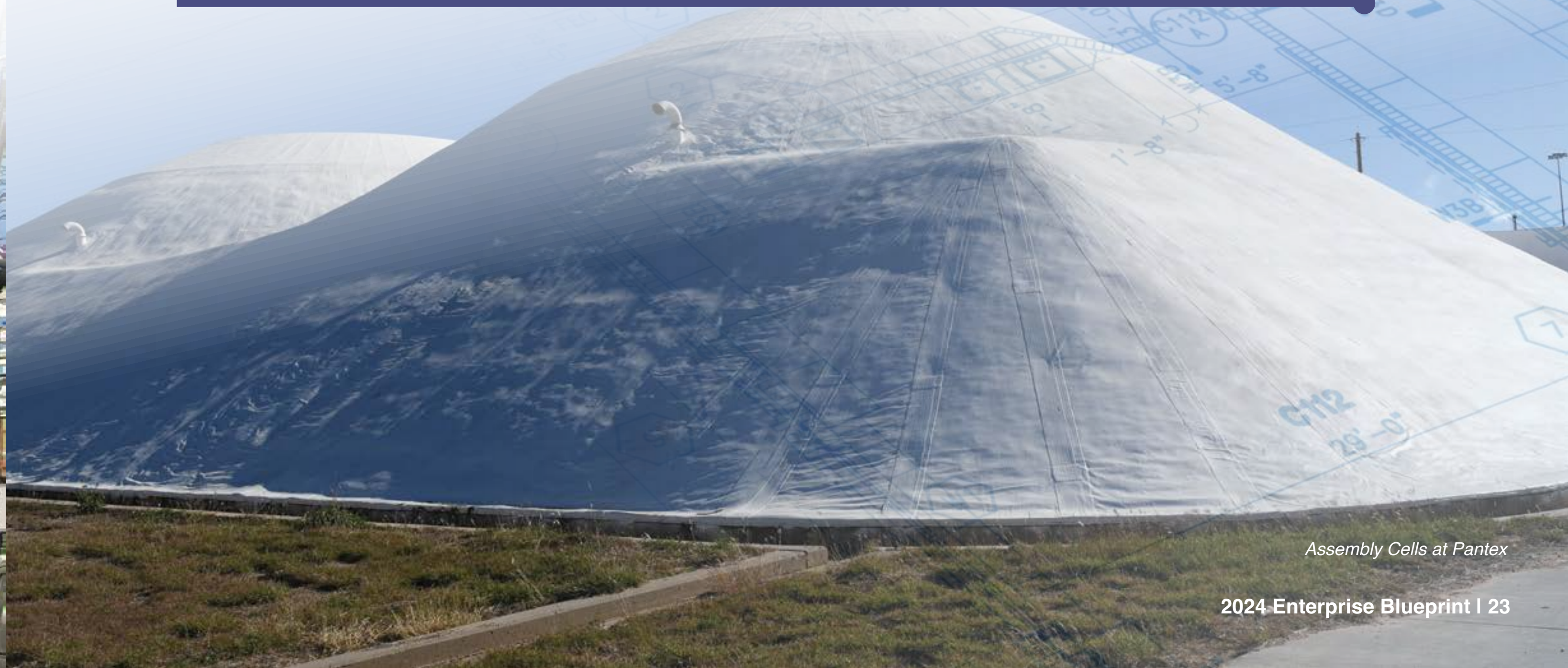
- Modernized, expanded material handling and staging options
- Future approaches for today's bay and cell operations assembly and disassembly facilities

Timeline

2025-2030	2031-2040	2041-2050

PX: Material Staging Capability

PX: PX Weapons Assembly/Disassembly Replacement Capability



Assembly Cells at Pantex

Non-Nuclear Components

NUCLEAR STOCKPILE | GLOBAL SECURITY

Complex systems requiring extreme precision and ultra-high quality manufacturing at scale with specialized materials

Strategy

Non-nuclear components weaponize the nuclear explosive package into a reliable, safe, and secure military capability. Safer, more efficient processes and enduring, trusted suppliers are required across a range of non-nuclear capabilities. NNSA will optimize its make-versus-buy practices to create more robust supply lines with timely deliveries and flexible capacity that is aligned to changing needs. At KCNSC, SNL, and LLNL, new advanced manufacturing techniques and expanded partnerships for accelerated production development and deployment will be employed. KCNSC's major, long-term expansion will accommodate a significant increase in the number of weapons systems that must be simultaneously maintained, modernized, and developed. At SNL, which is the nation's only supplier of strategic radiation-hardened microelectronics that meet weapon system requirements, upgraded replacement facilities will be built for power sources, microelectronics, and neutron generators. Collaborative centers at LLNL and KCNSC will significantly advance NNSA's advanced manufacturing abilities through robust design and production agency engagement.

Within NNSA's wide array of non-nuclear components capabilities (e.g., weaponization, fuzing and firing, nuclear safety, unauthorized use prevention, handling and transportation, ground and flight tests, reliability and survivability, and counterterrorism and counterproliferation), this Blueprint focuses on major needs in five areas:

Power Sources

Increased capacity for meeting unique size, weight, active life, and performance requirements for specialized pulse and long-life batteries and radioisotope thermoelectric generators

Energetics

Energetic material science, component design, development, and production for the array of ignitors, actuators, valves, and squibs needed for multiple weapons features to function

Microelectronics

Reliable facilities and responsive technology advancement to produce radiation-hardened microelectronics capable of functioning in extremely hostile environments on time and at scale

Neutron Generators

Secure and efficient operations and scalable spaces for testing and installing new technologies to support systems that produce neutrons at precise rates and times

Manufacturing Enablers

Relief from capacity shortages, resources for rapid prototyping, and incubators for production technology development and deployment

Targeted Needs

Power Sources

- Additional capacity and configuration flexibility for power source production and testing

Energetics

- Increased capabilities and capacities for in-house component development, prototyping, and production

Microelectronics

- Resilient, trusted supply of microelectronics and microsystems with additional cleanroom space

Neutron Generators

- More efficient workflows by consolidating material movement and product staging operations

Manufacturing Enablers

- Increases in manufacturing space and collaboration centers for accelerated production development and deployment

Timeline

2025-2030 | 2031-2040 | 2041-2050

KC: Kansas City Short-Term Expansion Plan (KC STEP)

LLNL: Product Realization Infrastructure for Stockpile Modernization

SNL: Power Sources Capability

SNL: Microelectronics Component Capability

SNL: Energetics Components Capability Sustainment

SNL: Neutron Generator Enterprise Consolidation

KC: Kansas City Non-Nuclear Component Expansion Transformation (KC NExT)

The MESA Complex at SNL produces robust, integrated microsystems

High Energy Density Science

NUCLEAR STOCKPILE | GLOBAL SECURITY

Probing material performance and aging in weapons-relevant environments

Strategy

High energy density (HED) science replicates extreme and hostile fusion environments that weapons must withstand to optimize designs, provides stewardship protocols for nuclear explosive packages, and facilitates confidence in the existing stockpile without nuclear explosive testing. To remain a global leader in HED environments, NNSA will pursue new high-yield capabilities to access never-before-reached regimes of weapons-like conditions. This will result in an unprecedented ability to inform manufacturing and production decisions, qualify a broader range of capabilities, and answer critical stockpile science questions. A significant increase in LLNL's National Ignition Facility (NIF) fusion outputs will provide greater access to weapons-relevant physics regimes to validate computer simulations and produce cutting-edge fusion energy innovations. In the 2040s, a new high-yield capability will be built that leverages the body of knowledge being generated today across a range of platforms.

Targeted Needs

- More robust performance and enhanced yield of 5-10x fusion output by increasing laser operating energies
- Future high-yield platforms

Timeline

2025-2030 | 2031-2040 | 2041-2050

LLNL: Enhanced Yield Capability for NIF

TBD: Future High Energy Density Capability

Target positioner being inserted in the NIF target chamber

Weapons Performance

NUCLEAR STOCKPILE | GLOBAL SECURITY

Essential activities for stockpile confidence without nuclear explosive testing

Strategy

Critical path, single-point failures must be mitigated and modern safety standards met for targeted weapons certification and qualification activities. This requires replicating the environments weapons must withstand to advance understanding of material performance under hostile gamma and x-ray radiation, neutron, thermal, and mechanical conditions. SNL, LANL, NNSS, and LLNL host the hydrodynamic, radiography, and accelerator tests needed for weapons design, assessment, and qualification which must be modernized and refreshed to validate advanced simulations of aging, next generation systems, and nuclear threats. As part of Enhanced Capabilities for Subcritical Experiments at NNSS, the first use of dense plasma focus instruments with plutonium and an x-ray-based test bed will bring new insights about aging and manufacturing effects. At SNL, major upgraded replacements will support radiation and reactor-based performance qualifications of materials, components, and systems. At LANL, technologically-dated and high-risk accelerator systems in the Los Alamos Neutron Science Center (LANSCE) will be replaced and new capabilities added to extend this one-of-a-kind accelerator's availability and reliability. In the 2040s, next-generation radiography capabilities will build on the work done at LLNL's Site 300 Contained Firing Facility (CFF) and LANL's Dual-Axis Radiographic Hydrodynamic Test (DARHT) complex, and additional capabilities will be modernized at LANL and SNL.

Targeted Needs

- Enhanced multi-pulse x-ray imagery and neutron pulse fission capabilities for subcritical special nuclear materials experiments
- Integrated reactor, accelerator, and mechanical shock testing conditions
- Component and system performance evaluations in gamma and x-ray environments at needed levels of assembly and throughputs
- Extended availability and reliability for LANSCE proton and neutron sources
- High-resolution implosion imaging leveraging the experiences of CFF (large field of view) and DARHT (dual-axis, multi-frame)
- Modernized assembly and disassembly capabilities for experimental devices containing HE and other materials

Timeline

2025-2030 | 2031-2040 | 2041-2050

NNSS: Z-Pinch Experimental Underground System (ZEUS)

NNSS: Advanced Sources and Detectors (ASD)/Scorpius

LANL: LANSCE Modernization

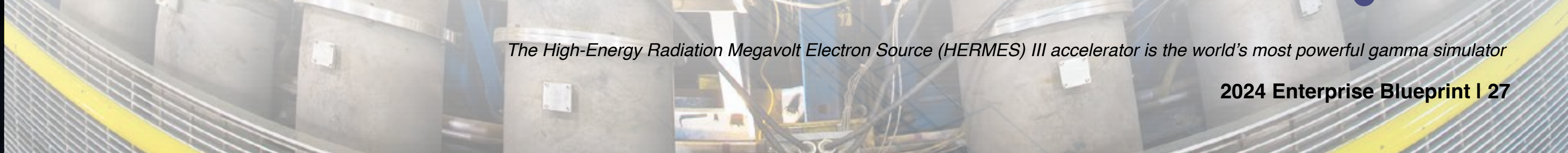
SNL: Combined Radiation Environments for Survivability Testing

TBD: Future Dynamic Radiography Capability

LANL: LANSCE Enhancements

LANL: Test Element Assembly Capability

SNL: Future Saturn/HERMES Replacement Capability



The High-Energy Radiation Megavolt Electron Source (HERMES) III accelerator is the world's most powerful gamma simulator

Material Science

NUCLEAR STOCKPILE

Complex and high-hazard capabilities to explore, develop, and process specialized materials

Strategy

Material science enables the assessment and qualification of stockpile materials by providing an understanding of how they behave in weapons-relevant environments. This requires expanded knowledge of material behavior in mesoscale regimes and sustained R&D and manufacturing capabilities for special materials essential to weapons programs and global security. In partnership with the DOE Stanford Linear Accelerator Center (SLAC) and Argonne National Laboratory (ANL), LLNL and LANL will reduce today's mesoscale knowledge gaps to provide high-confidence performance modeling and simulation capabilities and support safer, more resilient, and right-sized R&D and production capabilities. At LANL in the 2040s, manufacturing sciences for special materials will be enhanced by an upgraded replacement of the aged Sigma Complex to support innovative weapons manufacturing processes.

Targeted Needs

- Exploration of structural deformation, strength, transport, and other behaviors in mesoscale regimes with:
  - Dynamic compression in partnership with SLAC
  - High-Z capable platforms in partnership with ANL
- Next-generation systems for process development for depleted uranium, beryllium, and other specialized materials required in small batches

Timeline

2025-2030	2031-2040	2041-2050

LLNL: Dynamic Materials Property Laser at SLAC

LANL: Defense Materials Science Sector at ANL

LANL: Manufacturing Sciences for Nuclear Explosive Package Components

The Linac Coherent Light Source (LCLS) II at SLAC represents a significant next step in the ongoing revolution in x-ray lasers

Computing and Simulation

NUCLEAR STOCKPILE

GLOBAL SECURITY

NAVAL NUCLEAR PROPULSION

Pace-setting development and timely deployment of high-performance platforms and tools

Strategy

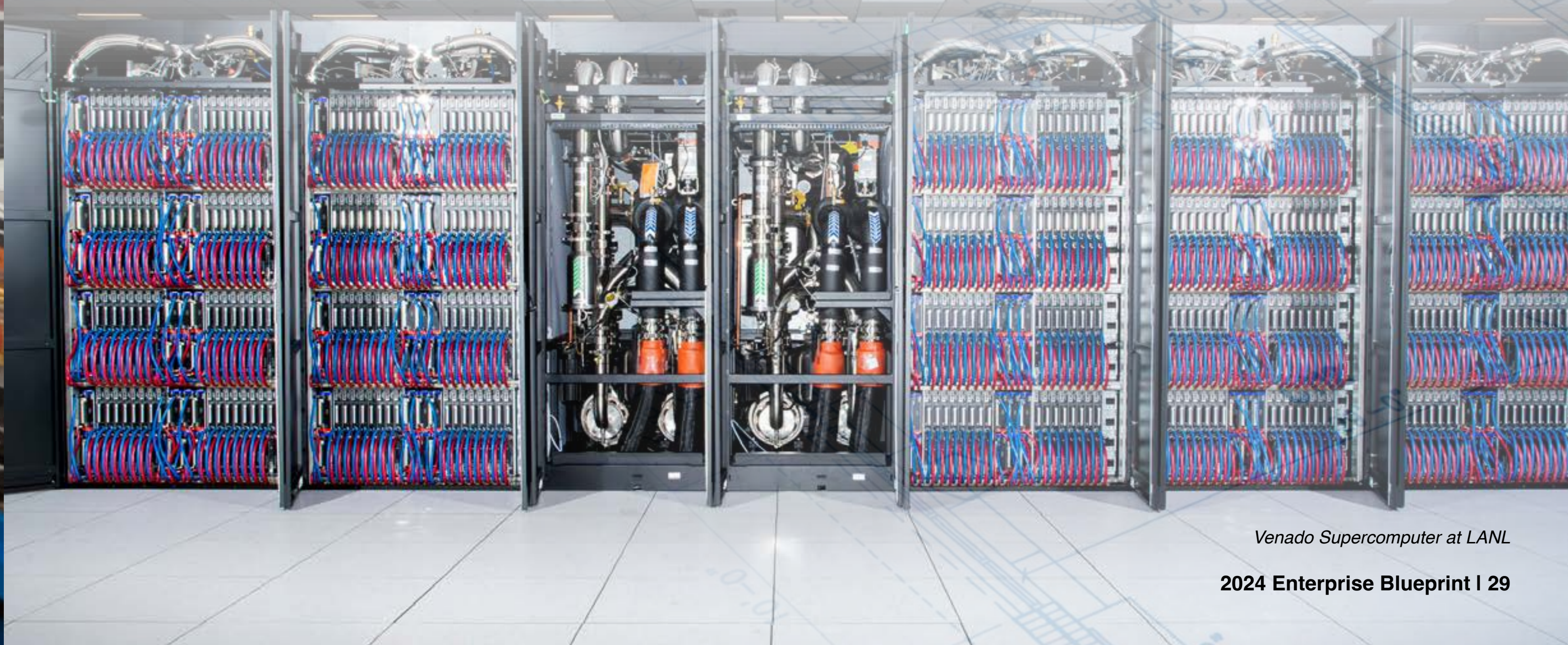
Computational resources that model and simulate the complex processes of weapons physics swiftly and with high fidelity are vital to NNSA's national security missions. Under the Advanced Simulation and Computing (ACS) program, LLNL, LANL, and SNL historically have driven hardware and technology developments that transformed the high-performance computing industry, achieving a series of global firsts and helping to maintain a fundamental U.S. industrial advantage over competitors. LLNL is hosting NNSA's first exascale computing machine, El Capitan. Cadenced investment rhythms in computing and simulations capabilities will enable NNSA to match the pace of technology improvements by industry and address changing threats and opportunities. Modernized simulation portfolios will be strengthened by the increased use of AI/ML and benefit from expanded internal and external partnerships.

Targeted Needs

- Heterogeneous computing, high-speed networking, and related technologies to address the memory wall
- Computing technology energy efficiency and high-performance computing data centers
- Infrastructure to enable the integration of technologies across the enterprise, including experimental resources
- Advancing high performance computing platforms that enable unique, sensitive work performed by global security programs

Timeline

Activities are primarily funded and executed under the ASC Platform Acquisition Plan. They occur in coordination with, but outside of, the boundaries of this Enterprise Blueprint.



Venado Supercomputer at LANL

Space Domain Monitoring and Verification

Expanded tool set to respond to global threats

GLOBAL SECURITY

Strategy

NNSA must be positioned to respond quickly and effectively to national needs in the space domain. Space monitoring and verification is part of an integrated deterrence strategy that involves enduring capabilities to meet evolving nuclear explosion monitoring mission needs and innovative responses to rapidly evolving space-based threats. NNSA develops and builds the United States' space-based remote sensors that enable integrated approaches to modeling, simulation, and data analytics that support of a range of treaty monitoring and military applications. All three labs are contributing to this sensitive and dynamic mission area with LANL leading on advanced, reconfigurable space instrumentation; SNL leading power source prototyping and testing; and LLNL leading on space security R&D capabilities.

Targeted Needs

- Workspaces with flexible classification levels for:
  - Reconfigurable instrumentation
  - Rapid prototyping and testing against surrogate mock-up targets
  - Integrated space security

Timeline

2025-2030 | 2031-2040 | 2041-2050

LANL: Space Systems Integration Building

SNL: Space Rapid Prototyping and Test Facility

LLNL: Space, Sources, and Sensing Facility

The LANL test lead applies temperature monitors to a Hard Radiation Sensor test unit in preparation for thermal vacuum testing

Nuclear Material Monitoring and Verification

Realistic environments for advancing nuclear nonproliferation technologies

GLOBAL SECURITY

Strategy

NNSA must provide unsurpassed expertise to stay on top of proliferation threats across the nuclear fuel and weapons cycle. Weapons-related test beds provide realistic operations of material processing, manufacturing, and monitoring and verification technologies in support of global security and stockpile missions. Pilot-scale test beds at Y-12 and PX will leverage the activities and knowledge bases at the sites to evaluate state-of-the-art nuclear nonproliferation technologies. The Y-12 test bed will focus on uranium conversion, separation, component fabrication, and weaponization. The PX test bed will test and demonstrate radiation measurements on nuclear explosive configurations, pits, canned sub-assemblies, high explosives, and containers. Efforts at both sites support the next generation of experts in chemical conversions, separations, component fabrications, and arms control.

Targeted Needs

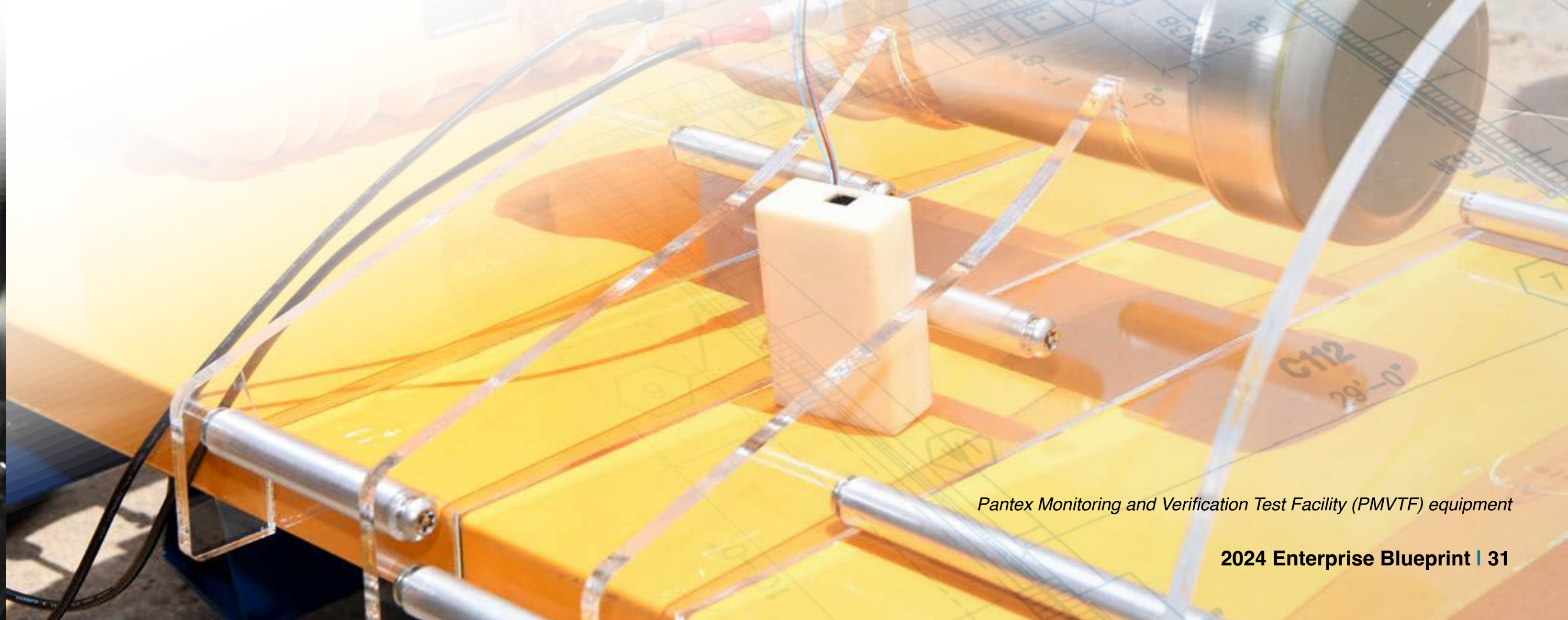
- Consolidated uranium processing evaluations
- Radiation measurements on nuclear components of significance

Timeline

2025-2030 | 2031-2040 | 2041-2050

Y-12: Uranium Production and Weaponization Test Bed

PX: Pantex Monitoring and Verification Test Facility (PMVTF)



Pantex Monitoring and Verification Test Facility (PMVTF) equipment

Surplus Plutonium Disposition

GLOBAL SECURITY

Fulfilling U.S. commitments with safe and effective long-term solutions

Strategy

NNSA permanently reduces inventories of plutonium declared excess to the national security program to reduce global nuclear threats and meet international commitments and U.S. nonproliferation policy objectives. NNSA will significantly expand its capacity for dispositioning large amounts of surplus plutonium to enable the disposition of up to 34 metric tons of excess plutonium and removal of excess plutonium inventories from SRS. It also will facilitate third party verification of disposition activities in accordance with international obligations and as a demonstration of the United States' global leadership in stockpile reductions and nonproliferation principles.

Targeted Needs

- Near-term expanded surplus plutonium downblending capacity at SRS K-Area
- Long-term at-scale solution set for 34 metric tons of surplus plutonium pit and non-pit plutonium disposition

Timeline

2025-2030	2031-2040	2041-2050

SRS: Surplus Plutonium Disposition K-Area

TBD: Pit Disassembly and Processing

Aerial view of the K-Area Complex at SRS

Naval Spent Nuclear Fuel Management and Examination

NAVAL NUCLEAR PROPULSION

Critical spent fuel handling and characterization for Naval reactors

Strategy

Once nuclear fuel has been used to power naval propulsion systems, it becomes spent fuel that must be handled and maintained using safe, environmentally sound practices. Efficient workflows for spent nuclear fuel handling (e.g., receipt, preparation, packaging) and recapitalized abilities to collect and analyze data are needed to support the current and future U.S. nuclear-powered naval fleet (e.g., submarines and aircraft carriers). Examination of spent fuel is the best way to validate that in-service Navy nuclear reactors are performing as expected and provide data for modeling reactor designs and spent fuel safety analyses. At the Naval Reactors Facility (NRF) on the Idaho National Laboratory (INL) site, a new naval spent fuel handling facility is under construction, and a new examination laboratory is being designed. Together these facilities will recapitalize key spent fuel management and examination functions and eliminate the need for contingency systems to handle spent fuel from aircraft carriers that is too large for existing facilities.

Targeted Needs

- Recapitalized spent fuel handling capabilities
- Recapitalized expended core examination capabilities

Timeline

2025-2030	2031-2040	2041-2050

NRF: Spent Fuel Handling Recapitalization Project

NRF: Naval Examination Acquisition Project

M-290 shipping container for naval spent nuclear fuel

Nuclear Material Testing and Examination

Sustained ability to evaluate reactor fuel and material performance

NAVAL NUCLEAR PROPULSION

Strategy

The complex supporting the world's premier Advanced Test Reactor (ATR) must be recapitalized to support the development, qualification, and deployment of new and improved nuclear fuels and materials. Thermal neutron irradiation testing and examination of nuclear material test specimens at the needed cadence and capacity will improve operational performance, enhance safety, and lower costs for existing and new defense and commercial nuclear reactor systems, including advanced reactors. Computational models are no substitute for the physical testing done at ATR, as they cannot predict the complex atomic-level effects of irradiation that drive material behavior. To support this project, a detailed Analysis of Alternatives led by the DOE Office of Nuclear Energy will be used to inform the optimal solution to maintain a thermal neutron irradiation testing and specimen examination capability on the INL site. The largest decision point is whether it is cost-effective to extend the life of the existing reactor or if building a replacement is the optimal path.

Targeted Needs

- Sustained availability of thermal neutron irradiation testing and specimen examination capability

Timeline

2025-2030	2031-2040	2041-2050

INL: Thermal Test Reactor Capability (TTRC)

Naval Nuclear Laboratory Consolidations

Optimized laboratory functions for risk reduction and efficiency

NAVAL NUCLEAR PROPULSION

Strategy

Bettis and KAPL provide design, testing, and support of the U.S. Navy's nuclear-powered fleet and the Naval Nuclear Propulsion Program. These formerly independent laboratories are now fully integrated into the Naval Nuclear Laboratory (NNL) system. As part of this integration, the Naval Nuclear Propulsion Program is recapitalizing key laboratory capabilities at the Bettis and KAPL sites to improve efficiency, reduce radiological and environmental risks and liabilities, and recapitalize key research and development capabilities. Thermal hydraulics capabilities are planned to be consolidated at Bettis, and nuclear fuel research capabilities are planned to be consolidated at KAPL.

Targeted Needs

- Consolidated functionality for thermal hydraulics
- Consolidated functionality for nuclear fuel research

Timeline

2025-2030	2031-2040	2041-2050

Bettis: Thermal Hydraulics Testing Consolidation

KAPL: Nuclear Fuel Laboratory Consolidation

From Vision to Reality

The Polymer Enclave facility was developed as part of a NNSA collaboration between KCNSC and LLNL and has been expanded to include LANL and the U.K. Atomic Weapons Establishment (AWE)

Timely Investments

The Enterprise Blueprint provides a roadmap to meet the mission during the next 25 years. It provides an integrated and sequenced view of the specialized infrastructure needed to meet program needs. With this roadmap, resource allocation and programmatic risks can be better understood and informed trade-offs made.

The Blueprint signals that infrastructure investments will require significant attention and resourcing to meet mission demands. The Blueprint informs established planning, programming, budgeting, and evaluation processes. It provides a holistic, time-phased enterprise view of specialized infrastructure that accounts for mission deliverables and deconflicts executability issues. It is a living document that will be updated as needed to account for uncertainty and keep stakeholders informed.

Companion Efforts

Companion efforts to this Blueprint will more fully articulate long-term strategies for other infrastructure needs such as office space, operations and maintenance, and computing. NNSA has a multi-billion-dollar deferred maintenance backlog that Blueprint investments will only partially address. Alongside new infrastructure investments, the Blueprint recognizes the need to appropriately resource operations and maintenance. Given the number of new specialized facilities coming online, sustainment funding will be necessary to avoid degradation of new facilities. NNSA will exercise a disciplined process to prioritize investment opportunities that maximize mission effectiveness. Complementary investments that are vital to robust capabilities and a productive workforce are needed in operations, maintenance, and recapitalization (e.g., offices, light laboratories, utilities, communications, emergency services, transportation systems).

Modern Office Space and Light Labs

Modernized office space and light laboratories are vital to recruiting and retaining a world-class workforce. Construction of new office space has not kept pace with growth. Instead, the NSE has relied on costly offsite leases and smaller, standardized designs. NNSA must invest in office and light laboratory spaces that are on-site and on-scale with NSE growth. The mix of classified and unclassified facilities will be more land-efficient, support site culture, and provide collaboration space to tap into the creativity, productivity, and innovation of the workforce.

Reconfigured collaboration space at LANL

High Explosives pressing operations at Pantex

Meeting the Moment

The NSE has served this country remarkably well, but new investments are needed to deliver on today's mission demands and navigate the future. The United States can no longer rely on decades-old production facilities and science and technology infrastructure. Current facilities have been driven long and hard, and the operational risks are unacceptably high.

The Enterprise Blueprint serves as a roadmap, incorporating the best thinking from across the NSE on how to achieve an appropriate balance among production, stockpile sustainment, and science investments. Given the dynamic global environment, mission priorities are likely to shift over time. This first Blueprint focuses on specialized infrastructure that is unique to the mission. NNSA will update the Blueprint as needed and develop companion efforts that provide a fuller picture of the NSE's long-term infrastructure needs. NNSA has already made significant progress on infrastructure and with the right investment, at the right time, and in partnership with stakeholders, NNSA will deliver security for the American people.

Shift change going downhole at U1a at NNSS


LANL Main Campus

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