INFRASTRUCTURE ON A MISSION

LAWRENCE LIVERMORE NATIONAL LABORATORY

DEEP DIVE INFRASTRUCTURE HIGHLIGHTS

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AREA PLANS, PORTFOLIOS, AND UNDERLYING SUPPORT FUNCTIONS ENABLE EACH STEP IN THE LIFECYCLE OF SCIENTIFIC AND TECHNICAL INNOVATION

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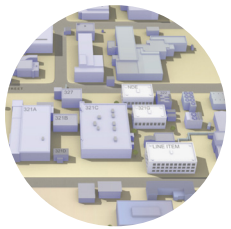

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INFRASTRUCTURE ON A MISSION

LAWRENCE Livermore National Laboratory's (LLNL's) national security and science and technology missions rely on cutting-edge facilities, with an articulated infrastructure vision and long-term plan. LLNL's plans for improvements in its facilities, equipment, and critical skills are currently supported by substantial funding that is arriving in larger amounts than in the past decade.

These resources are revitalizing the aging infrastructure and modernizing the facilities to support National Nuclear Security Administration (NNSA) capabilities while improving the look and feel of the site for attracting and retaining employees.

Over the next 10 years, LLNL and NNSA plan to spend more than $2 billion in infrastructure projects and maintenance alone. This will fund almost 300 new projects, including laboratory and office construction, renovations, upgrades, and demolitions. Over the next 25 years, LLNL anticipates initiating up to 600 major and minor projects.

In this booklet, you will find major elements of the Laboratory's long-range plan, including descriptions of LLNL's key area plans, project portfolios, modeling and projection tools, and project execution processes.

» **Area plans** enable a specific LLNL capability, and are centered around development or redevelopment of a consolidated location onsite. Area plans comprise a set of projects and planned migrations to sustain and enhance the LLNL capability area. The full planning scope includes facilities, equipment, and workforce.
» In turn, **portfolios of projects** are related by the type of work needed, such as utilities, office space, or seismic retrofits, rather than the LLNL capability or location. Portfolios more broadly support many LLNL capabilities, or the entire institution.
» LLNL develops and applies innovative **computerized modeling and projection tools** to better understand its infrastructure data and to project investment needs. These tools produce data-driven, transparent, and repeatable results to support LLNL's infrastructure planning efforts.
» Lastly, the institution has reinvigorated its **project execution methodologies**. A new Project Management Office (PMO) has established a One-Team, collaborative approach for infrastructure. The embodiment of this team approach is the Integrated Project Team (IPT), which aligns NNSA and LLNL capabilities with area plans and portfolios.

Together, LLNL's area plans, project portfolios, modeling and projection tools, and project execution methodologies will ensure LLNL capabilities and associated capacities to deliver the NNSA mission.

LLNL'S INTEGRATED PROJECT LIST

» Designing and building facilities and infrastructure to enable LLNL's mission

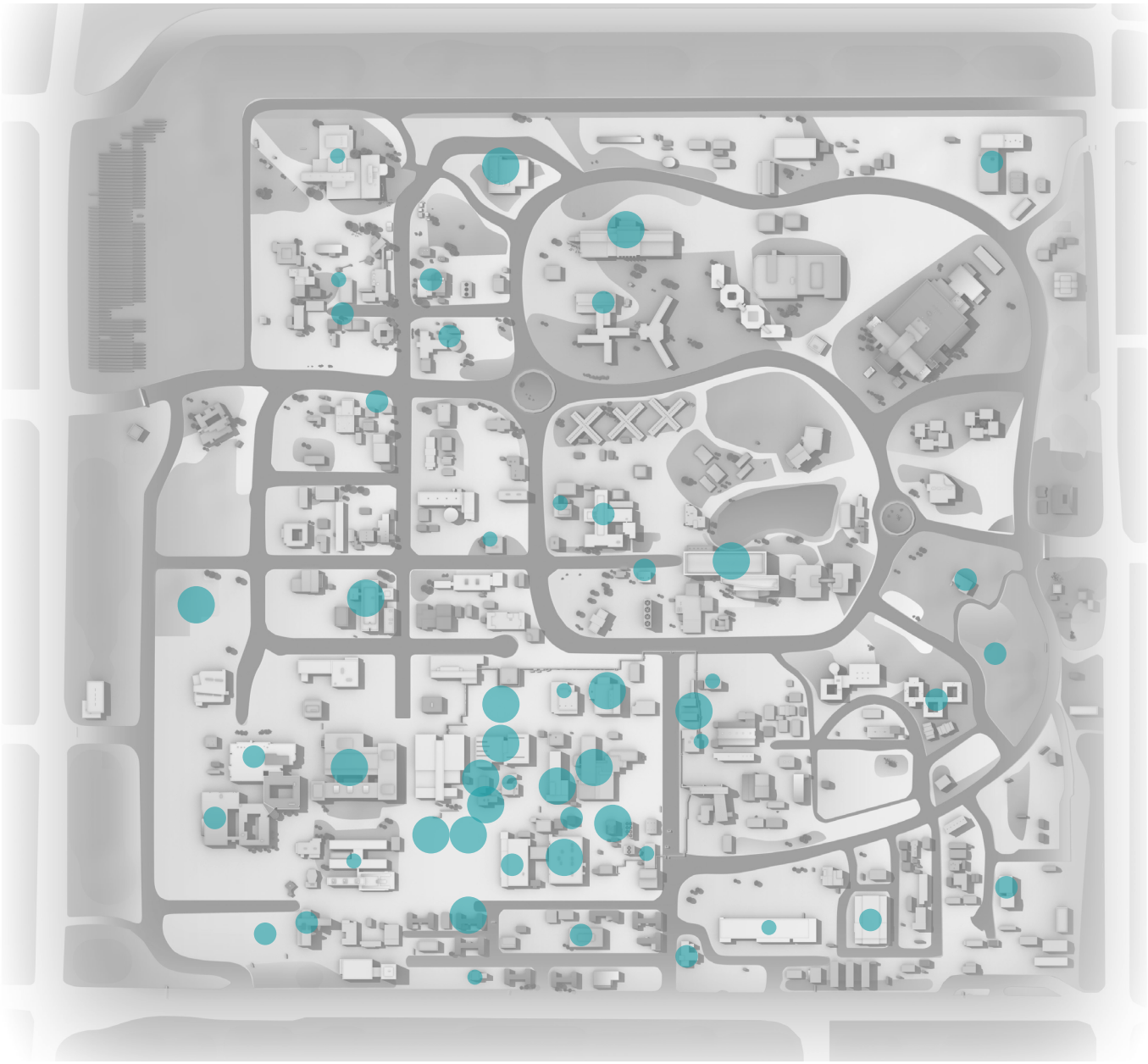
» Executing nearly 200 projects simultaneously

» Managing nearly $250M in construction work

» Averaging less than a 20-month duration per project (reduced from over 30 months)

LEGEND

- $5–$200K
- $200K–$2M
- $2M–$90M



Data as of March 2019

KEY INFRASTRUCTURE HIGHLIGHTS

APPLIED MATERIALS AND ENGINEERING (AME)

» The Applied Materials and Engineering (AME) area plan will modernize material engineering laboratories to support NNSA mission delivery

» Build three new facilities to vacate substandard space (seismically hazardous, beryllium-contaminated), accommodate personnel growth, create flexibility for future mission development, and relocate capabilities out of B231

» Refurbish three enduring buildings and relocate capabilities into them: mechanical testing capabilities into B341, radiological and material characterization laboratories into B321A, and material management capabilities into B233

» Disposition B231 and remaining equipment to mitigate risk

The AME area plan will modernize and consolidate material engineering laboratories by a combination of construction, repurposing, and demolition of facilities. It also involves sustainment of 1,500 pieces of scientific and engineering equipment.

APPLIED Materials and Engineering (AME) capabilities are vital to the certification, design, and testing of stockpile systems under the life extension programs (LEPs) and other modernization programs. These capabilities are at-risk due to being housed in B231, a 1950s-era facility that is riddled with obsolescence-based infrastructure failures, seismic deficiencies, process contamination, and a high level of deferred maintenance. B231 is too old, large, contaminated, and costly to modernize.

AME

To ensure long-term support for nuclear stockpile stewardship and LEPs, LLNL and NNSA have developed a multi-year area plan that will replace the existing failing facility, increase operational efficiency, and reduce the area's footprint by 40 percent.

The area plan includes the following strategies:

- Construct sustainable facilities and relocate programmatic equipment to meet mission requirements
- Optimize workflows by consolidating, replacing, and disposing of unreliable and obsolete equipment
- Reduce the overall footprint by 52,000 gross square feet (GSF) by repurposing 38,000 GSF of existing space, building 50,000 GSF of new space, and dispositioning 140,000 GSF in B231

LLNL has developed a comprehensive modernization plan for the area and its equipment through a multi-stakeholder planning process. The LLNL planning team has also analyzed workflows and programmatic equipment needs that resulted in consolidating 2,400 pieces of equipment down to 1,500 pieces, as well as establishing a plan for equipment replacements and relocations.

To prepare the site, LLNL invested in land remediation and began upgrading utilities—including electrical, water, and gas—in enduring facilities and on the now-vacant lot that will eventually be developed. In addition, the mechanical test and video/radio laboratories that currently exist in B231 will be relocated to B341. Therefore, B341 is undergoing infrastructure renovations to prepare for the relocation of these capabilities. The AME area plan will make material design and test capabilities available to the stockpile.

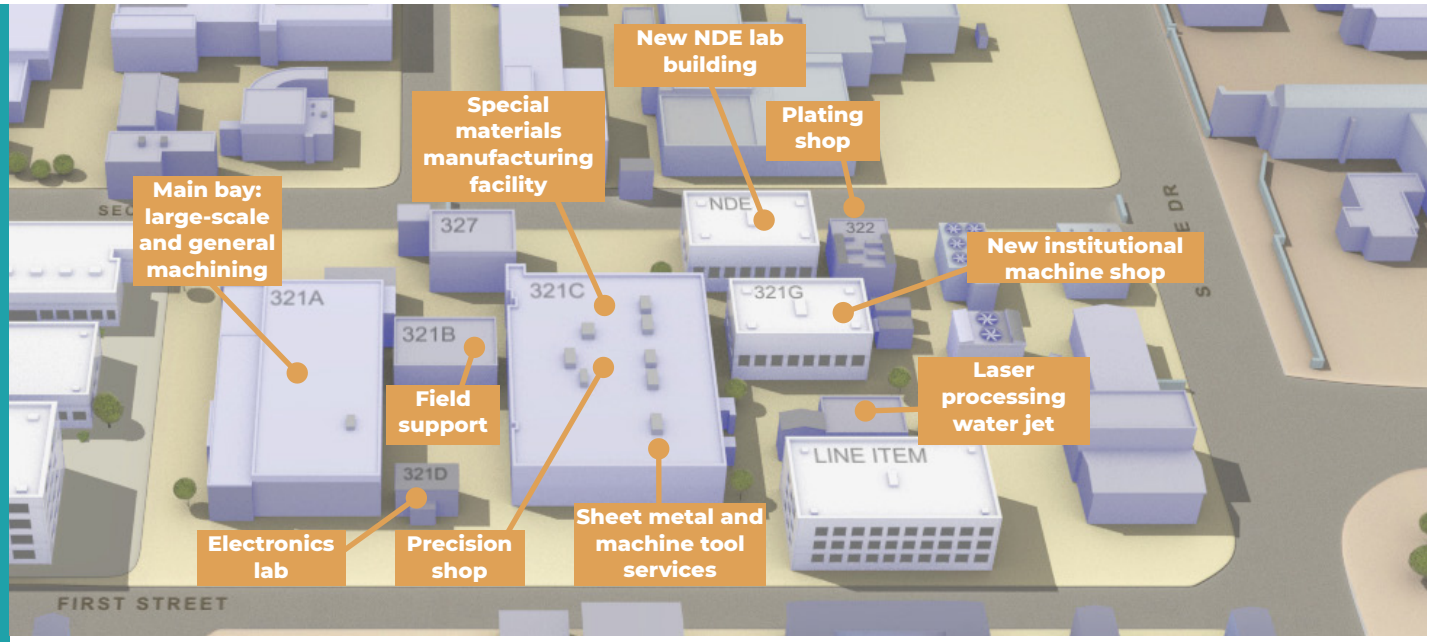
The AME conceptual area plan with the new B224 Office Building (left) and the B223 Polymer Facility (right), with space allocated for a future building, B225 (center).

PRODUCT REALIZATION INFRASTRUCTURE FOR MANUFACTURING AND ENGINEERING (PRIME)

» LLNL and NNSA partnered to establish a comprehensive 3200 Block area plan, the Product Realization Infrastructure for Manufacturing and Engineering (PRIME), to enable delivery of the W80-4 LEP and the W87-1 Modification Program

» This area plan will meet broad program and institutional needs for an increase in manufacturing capacity and scientific program research and development capabilities

» Among many projects, the PRIME area plan will sustain and recapitalize existing facilities, erect two new facilities, and one future line-item building



The Product Realization Infrastructure for Manufacturing and Engineering (PRIME) area plan includes recapitalization of existing facilities (such as B321A, B321C, and B322) and standing up two new facilities (B321G and non-destructive evaluation [NDE] light-lab space), and one future line-item building.

BLOCK 3200 contains LLNL's central manufacturing capabilities that underpin all current and future experimental hardware delivery. With unique facilities that can handle hazardous materials and classified operations, these shops provide manufacturing precision, along with research and development flexibility, that commercial sources cannot fulfill. The end products are fabricated, inspected, and characterized precision parts needed by interdisciplinary and multi-programmatic customers.

Block 3200 facilities and infrastructure continue to age with new challenges that are stressing the manufacturing complex. New manufacturing technologies are emerging and customer demands for hardware capacity are increasing. Long-range planning focuses on addressing these new demands while sustaining critical building systems, utilities, and specialized programmatic equipment. An area plan has been developed to strategically recapitalize the infrastructure to ensure fabrication, inspection, and characterization capability delivery for all LLNL customers.

PRIME

The Product Realization Infrastructure for Manufacturing and Engineering (PRIME) area plan represents a significant step forward in addressing manufacturing capability risks.

The PRIME area plan focuses a multi-year infrastructure investment scope into LLNL's manufacturing capabilities. Three primary infrastructure thrusts include:

- » Introduction of new manufacturing technologies relevant to national security
- » Capability sustainment activities on critical building systems, utilities, and specialized programmatic equipment
- » Augmentation of manufacturing capacity to support the increased demand for precision parts

The PRIME area plan features a combination of new construction, facility and equipment recapitalization, and consolidation, as well as transition and disposition of assets at the end of their lifecycle.

To meet these challenges in a timely manner, the PRIME area plan building construction will be complete by FY22. Among several projects, the PRIME area plan will recapitalize existing facilities (such as B321A, B321C, and B322) and erect two new facilities (B321G and non-destructive evaluation [NDE] light-lab space).

B321G, a new manufacturing building, will house institutional Hi-bay machining and characterization space. The building will have an expanded Vault Type Room shop capacity. This higher security posture provides the Block 3200 complex the greatest flexibility to address demands for all types of precision parts (classified or unclassified), with the exception of radiological components. B321G will support all interdisciplinary and multi-programmatic customers. The new building will be sited adjacent to the existing B321 complex to gain a more efficient workflow.

The current B327 is the primary research and development facility for NDE capabilities at LLNL. This capability is required to meet Nuclear Security Enterprise missions, such as certification of the stockpile, collaboration with other NNSA partners, inspections for high-energy-density and inertial confinement fusion work, and other nuclear security missions. To meet milestones for these missions, the infrastructure must be upgraded and expanded to sustain this capability. The new B328 will expand NDE capabilities to enable higher throughput. PRIME will enable LLNL to serve as a manufacturing innovation engine for NNSA.

The manufacturing capabilities that the PRIME area plan will ensure that LLNL can meet capacity challenges, remain agile for ever-changing challenges and solutions, and guarantee U.S. stockpile responsiveness.

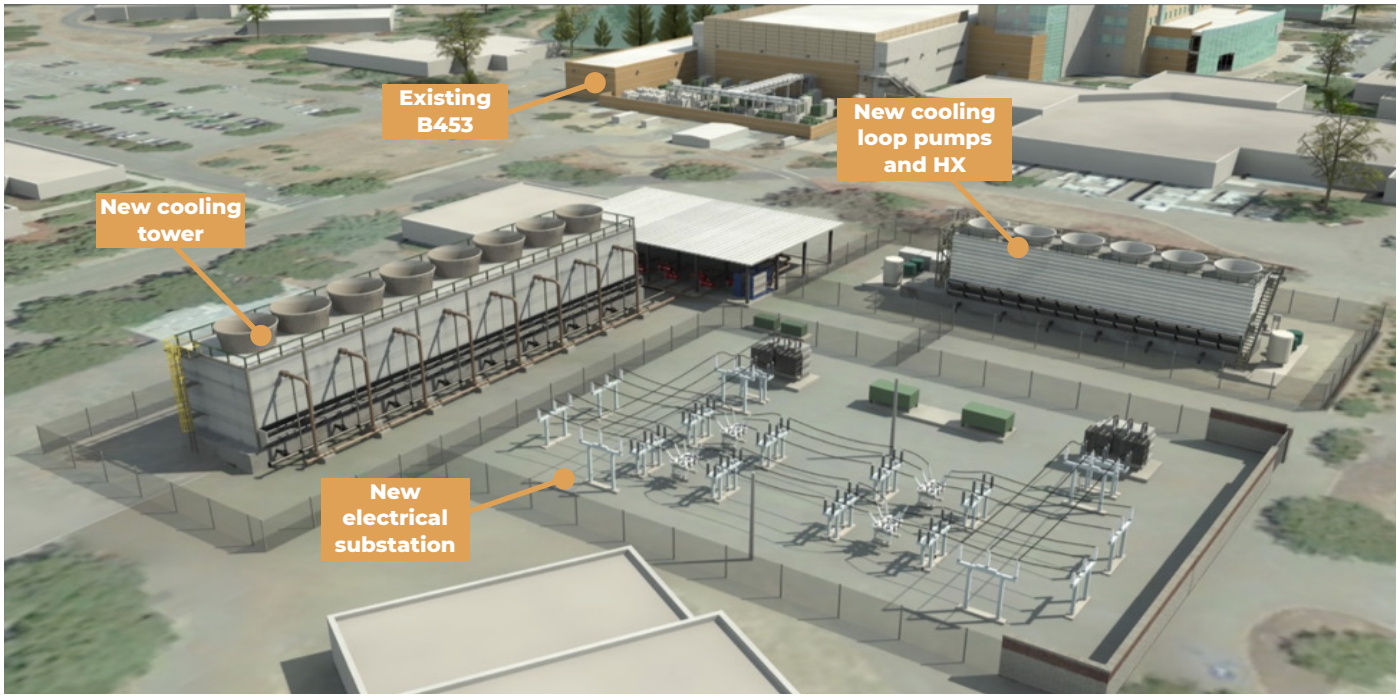
LIVERMORE COMPUTING—EXASCALE MODERNIZATION

» High-performance computing (HPC) empowers LLNL's scientific discovery and technology development, all in support of LLNL's vital missions for the nation

» HPC has become increasingly important as LLNL executes two concurrent stockpile programs, the W80-4 LEP and the W87-1 Modification Program

» Livermore Computing developed a facility master plan for infrastructure to consider growth in programmatic data-intensive computing facility requirements

» To achieve exascale computing, a line-item project will renovate an existing computing facility to scale-up its power and cooling capacity



To achieve exascale computing and meet programmatic missions at LLNL, the existing B453 will need infrastructure investments to scale-up the building's power and cooling capacity. A line-item, the Exascale Computing Facility Modernization project, will address these needs.

LIVERMORE'S world-class high-performance computing (HPC) ecosystem—the hardware, software, facility infrastructure, and computer support staff—empowers scientific discovery and technology development on classified and unclassified fronts in support of LLNL's vital missions for the nation. Livermore's most powerful computers are used primarily for stockpile stewardship efforts, which are ramping up as LLNL leads two concurrent programs, the W80-4 LEP and the W87-1 Modification Program. As the nation's weapons age long past the point at which the designers assumed they would be replaced, it is important for LLNL to simulate their behavior and performance with the highest possible level of confidence. Oftentimes, this means running many iterations of complex simulations of weapons performance and behavior.

LIVERMORE COMPUTING—EXASCALE MODERNIZATION

The current Livermore Computing (LC) Complex is spread across LLNL's main site. Several facilities have been repurposed or closed due to aging infrastructure that cannot accommodate HPC resources. LC has reduced its overall footprint by nearly 10,000 GSF over the past decade and will focus on the following facilities for long-term HPC activities: Classified Computing–B453, Unclassified Computing–B654, High-Side Computing–B439, and Test Bed Computing–B451.

To continue to push the state-of-the-art in HPC, infrastructure investments are needed. LC developed a long-range facility master plan for infrastructure to consider growth in programmatic data-intensive computing facility requirements. The plan assesses facilities while considering interim and long-range goals for HPC at LLNL by identifying deficiencies and addressing opportunities for improvement and modernization.

Based on an analysis of existing infrastructure, considerations have been made relative to reuse, refurbishment, and replacement of facilities. The master plan includes the following:

- Integrates sustainability and energy efficiencies as an integral part of facilities
- Evaluates existing facilities and site-wide infrastructure
- Incorporates current and future plans that influence the strategic vision
- Evaluates future trends for required computing needs
- Recommends buildings for demolition and decommissioning, renovation, and/or reuse of existing facilities, and identifies needs for potential future facilities

A gap analysis was performed to evaluate existing infrastructure for current and future capabilities for HPC applications. A process was developed to assess the probability of siting future extreme-scale systems to meet mission in facilities. To meet future mission needs, LLNL spent the past several years focusing on sustainability in HPC and identified core competencies needed to improve operational efficiencies and ultimately achieve extreme scale computing.

B654, constructed in 2016, used the modular solutions approach based on the HPC technology that was installed in 2017. B654 will be expanded in the future to handle growing unclassified systems across the LC Complex, study is underway and detailed design will take place in 2020.

B453 will scale to 85 megawatts and 28,000 tons of cooling through the Exascale Computing Facility Modernization (ECFM) line item project. Design is nearly complete and construction will begin in December 2019.

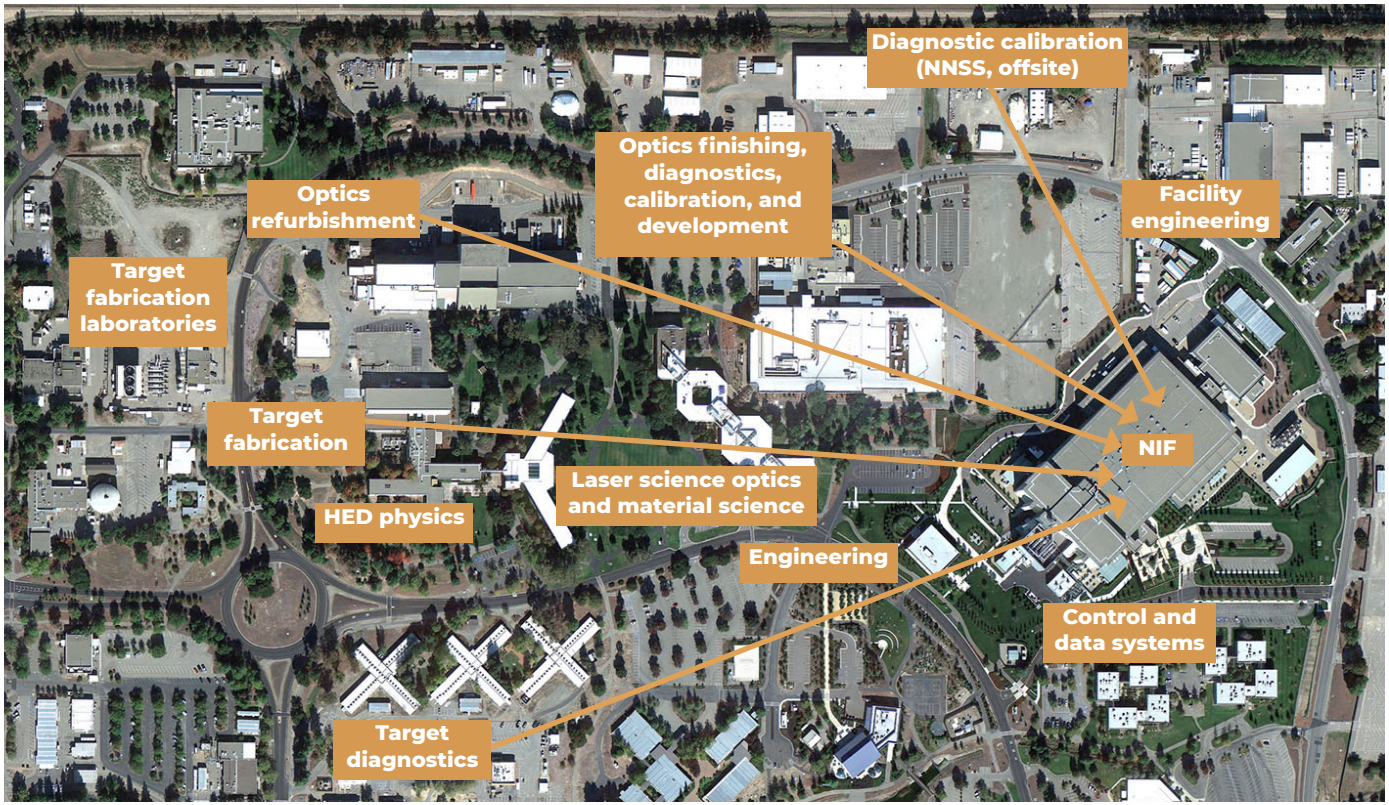
HIGH-ENERGY-DENSITY (HED) CAMPUS

» Experimental data from the National Ignition Facility (NIF) plays an essential role in maintaining our nuclear deterrent without further underground testing

» NIF experiments are enabling design options for the W80-4 LEP and the W87-1 Modification Program, supporting annual assessment, and making possible the training of stockpile stewards

» As NIF and its supporting infrastructure ages, maintenance investments will be required to meet mission needs

» Investments in consolidating target diagnostics will improve efficiency and performance, and create new opportunities for intersite collaboration



National Ignition Facility (NIF) experiments rely upon many disparate facilities (see map above) and a variety of expertise to be successful.

NATIONAL Ignition Facility (NIF) experiments support the W80-4 LEP and W87-1 Modification Program, as well as other stockpile stewardship program (SSP) missions. These experiments rely upon a flow of consumables, including onsite production facilities and diverse expertise. These enable NIF to contribute to the SSP design options by improving LLNL's science and workforce.

To continue to support the SSP, NIF facilities and infrastructure will require refreshment and improved efficiency. Annual sustained investments will address critical high-energy-density (HED) infrastructure and maintenance needs and ensure LLNL will maintain NNSA's $5 billion investment in NIF so it can deliver for the SSP. LLNL has been working

on a HED campus area plan, focusing on three primary parts: target fabrication consolidation, target diagnostics consolidation, and a laser upgrade. The target fabrication consolidation effort is underway. Future plans include an area plan for target diagnostics consolidation and a laser upgrade.

Diagnostic consolidation will improve efficiency and performance, as well as create new opportunities for joint collaborations. Mission Support and Test Services (MSTS) will relocate NIF calibration support from offsite Livermore offices. NIF will consolidate the following laboratories: diagnostic development labs, assembly and test labs, characterization labs, and office and storage labs.

The target diagnostics area plan is centered around the NIF Engineering and Diagnostics Laboratory, B490. This building houses critical NIF support capabilities, including the development of improved optics manufacturing techniques and assembly and refurbishment of cryogenic target systems and computer control systems. This building is the proposed site of a consolidated target diagnostics capability to improve the efficiency of developing, testing, calibrating, and maintaining HED diagnostic systems.

Also integral to the target diagnostics area plan is the NIF Optics and Diagnostics Labs in B391, which are home to the tooling and clean room facilities to enable optics manufacturing, optics processing, and optics mitigation. This building contains laboratory space for diagnostics development and processing.

These activities can be summed up in the following list of projects:

- B298 HED Physics Precision Target Micro Machining Refurbishment
- B490 Diagnostic Support Laboratories

Pictured above is B490, the NIF Engineering Optics and Diagnostics Laboratory, which is the focal point of the target diagnostics area plan.

6400 BLOCK (OPEN CAMPUS)

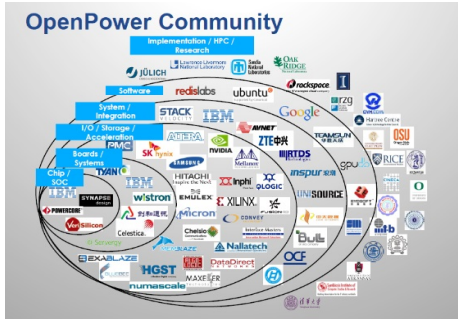
» The Block 6400 area helps NNSA and LLNL address the security challenges presented by the evolving science and technology landscape

» The Block 6400 area plan will establish an innovation hub where collaborations can take place between experts from LLNL and beyond

» The area plan includes the Advanced Manufacturing Laboratory, revitalizing the Hertz Hall complex, and construction of future office and lab buildings

MISSION

PARTNERSHIPS



WORKFORCE

The Block 6400 area plan helps NNSA and LLNL address the security challenges presented by the evolving security and technology landscape by providing space in the general access area.

NNSA and its laboratories are faced with multiple challenges in the context of today's security environment:

- Maintaining a competitive edge against increasing global science and technology investments
- Improving our technology maturation timescales to match and counter those of our adversaries
- Providing an environment that attracts, retains, accesses, and stimulates the best and brightest

To ensure that the national laboratories have the resources required to address the spectrum of national security needs, LLNL has developed the Block 6400 area plan to invigorate an innovative general access area (GAA, or open campus) that will aid LLNL's collaboration with outside industry, partners, and academia. Also, as one of the last buildable areas of land on the main site, the open campus will relieve office space pressure for LLNL staff.

The Block 6400 area is an unclassified research and development campus that houses laboratory, office, and collaboration amenities on the east side of LLNL's site in a general access area. The newest Block 6400 area facility is the Advanced Manufacturing Laboratory (AML). A number of earlier completed projects, including utilities extensions and fence realignment, have paved the way for an effective area plan to continue to develop the Block 6400 area. The comprehensive area plan comprises many projects extending to FY28. Upcoming projects include a new office

building (B642), revitalization of the existing Hertz Hall complex, and a new office andcollaboration building.

The three-building Hertz Hall complex is managed by the University of California Office of the President (UCOP); UCOP is planning to recapitalize the complex. The updated facilities would include office, light lab, meeting, and collaboration spaces.

This area plan will allow LLNL to partner strategically with academia, industry, and national laboratories on evolving science and technology landscape advancements, such as advanced manufacturing (AM) technologies, HPC advances, energy and environmental security, biosecurity, cybersecurity, and nonproliferation, while building deep expertise and contributing to national security missions and U.S. competitiveness. AM and HPC offer the potential to significantly reduce the cost, space, and time needed to manufacture key components for the nuclear security enterprise.

The Block 6400 area enables partnership agreements that offer expanded opportunities for LLNL to engage with external entities, maintain second-to-none science, technology, and engineering capabilities, and attract and retain the workforce needed for national security missions. Investments in the Block 6400 area are necessary to support LLNL's missions.

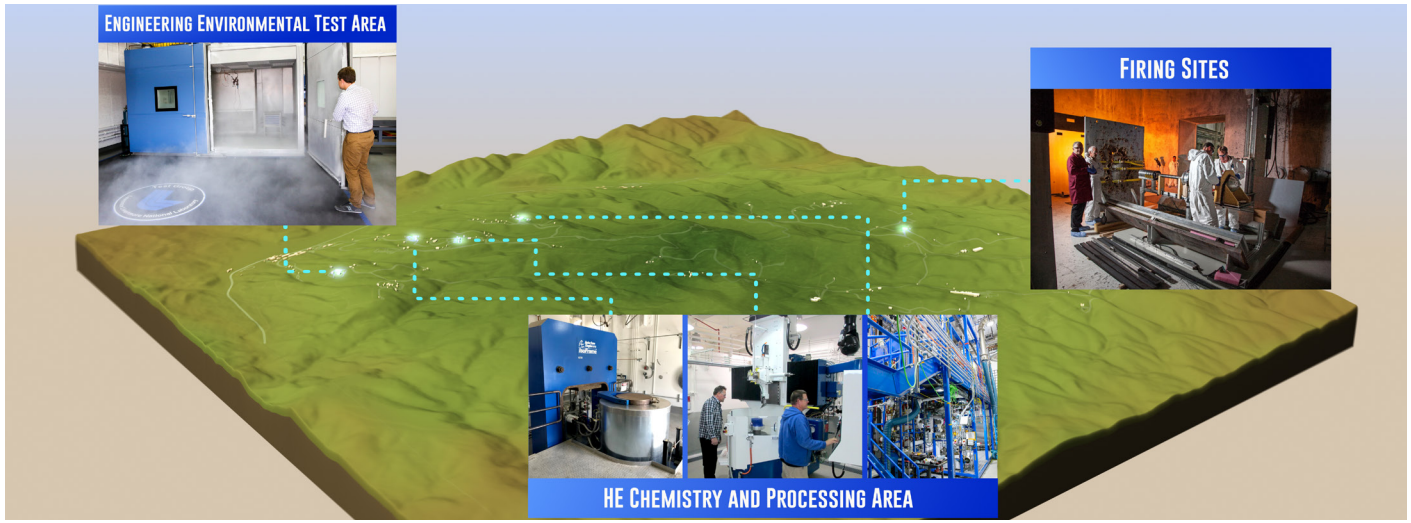
The Block 6400 area plan includes 1) the Advanced Manufacturing Laboratory, 2) a future office building (B642), 3) the Hertz Hall complex, 4) a future lab building, 5) a future office/collaboration building, and 6) a potential new build-out site.

SITE 300—TEST AND EVALUATION

» Site 300, LLNL's remote experimental test site, houses a diverse set of advanced capabilities that support the production and characterization of explosive materials

» Work at Site 300 is increasing due to two concurrent nuclear stockpile programs, the W80-4 LEP and the W87-1 Modification Program

» Increased work requires sustained infrastructure investments in key mission facilities



Site 300 is home to diverse capabilities spread across the 7,000 acre remote test site. Three areas are the primary focus of upcoming infrastructure investments (as noted above).

LLNL'S Experimental Test Site, known as Site 300, provides one-of-a-kind testing opportunities, which allow our researchers to safely assess the function of non-nuclear weapons components and assemblies through physics and engineering testing in support of our national security programs. Site 300 is home to a diverse set of advanced capabilities that result in the device-scale synthesis and characterization of explosive materials.

Activities utilizing these capabilities are ramping up to support two concurrent nuclear stockpile programs, the W80-4 LEP and the W87-1 Modification Program. Infrastructure investments at Site 300 are necessary to meet the requirements needed by these two stockpile modernization programs, as well as nonproliferation, nuclear counterterrorism, and other security programs.

Future-years nuclear security program (FYNSP) investments will focus on three primary areas:

» High explosives chemistry and processing area (B825, B826, B827, B806, B809, B817, B810 and B855)
» Engineering environmental test area (B834 and B836)
» Firing sites (B801 and B851)

Future planning for Site 300 will examine how to maintain the site's unique capabilities, and as such, the best path forward for lifecycle sustainment.

» The high explosives chemistry and processing area is where the lab-scale development work done at Site 200's High Explosives Applications Facility is scaled up for testing and evaluation. Investments have been made in this area, but additional programmatic equipment procurements and facility upgrades are needed to support insensitive high explosive (IHE) qualification requirements for the W87-1. Additionally, Site 300 has a unique Nuclear Security Enterprise capability to melt-cast and mold large quantities of explosives that can be machined and assembled for unique program requirements.
» The engineering environmental test area allows LLNL to simulate the harsh environmental conditions that a given weapon could experience in its lifetime. This type of testing is essential to ensure the durability of the nation's nuclear stockpile. This area will need investment to increase its testing capacity with new shaker tables, a refurbished thermal environmental chamber, as well as establish new test environments to meet specific military characteristics of the W87-1. Recently, a new thermal aging capability was built to artificially age explosive materials. This capability assures weapon designers that the weapon materials will age as expected far into the future.
» Non-nuclear, "hydrodynamic" experiments conducted at the Contained Firing Facility allow our scientists to assess material behaviors during the "implosion" stage of a nuclear weapon, which is when the high-explosive detonation compresses metals into a denser form and ultimately affects the weapon's performance. Data from these hydrodynamic experiments are essential for LLNL to refine the computational models used to simulate nuclear weapon performance. These models are key to helping us ensure the safety, security, and effectiveness of the U.S. nuclear stockpile in the absence of underground nuclear testing.
» The key diagnostic at CFF, the flash x-ray, or FXR, enables scientists to see into the heart of test objects at different implosion stages. FXR is the only penetrating radiographic machine in the nuclear weapons complex that provides wide field-of-view images—up to 140 centimeters by 140 centimeters—which are most suitable to examine interactions of an exploding object with exterior components. The ability to produce images of this magnitude is only possible at CFF. FXR allows for the capture the images of very dense, fast-moving objects, essentially freezing the dynamic motion within 65 billionths of a second. This is essential for W80-4 LEP and W87-1 Modification Program, which require validation that new missile bodies and its warheads will not interfere with each other during operation.

To meet the increasing mission needs, the capabilities of CFF and FXR need to be maintained and sustained with future infrastructure investments. The infrastructure must be modified to become a testbed for advanced diagnostics that support subcritical experiments at U1a and other NA-11 campaigns.

UTILITY DISTRIBUTION SYSTEM (UDS)

» LLNL's missions require reliable utilities that are available 24/7

» The utilities system at LLNL comprises over 21 miles of above-ground high-voltage electrical lines, 45 miles of underground electrical lines, 750,000 feet of mechanical utility piping systems, and over two million gallons of potable and fire-fighting water storage

» LLNL and NNSA have partnered to upgrade LLNL's utilities systems through the Utility Distribution System (UDS) area plan

» The plan comprises a series of prioritized projects spanning all of LLNL's utility systems over the next decade

Aged cooling towers, pumps, and heat exchangers at U291, the Northwest Station, provide building and experimental cooling water site-wide.

LLNL'S utilities infrastructure is a system that must be fully reliable 24/7 to ensure LLNL meets its programmatic mission requirements. LLNL must be prepared, and where possible have redundancies built in, to ensure of inevitable system breakdowns both internal to LLNL and external from utility service providers, such as Pacific Gas and Electric (PG&E) and the Western Area Power Administration (WAPA), among others. These utility systems include electrical power, potable and fire-fighting water, building and experimental cooling system water, programmatic use de-ionized water, compressed air, natural gas, and sewage. Whether in a drought, flood, frozen, or high-heat condition, the utility system must operate day and night.

To get a sense of the breadth of LLNL's utility systems, LLNL has over 21 miles of above-ground high-voltage electrical lines and 45 miles of underground electrical lines. LLNL also has over 750,000 feet of various mechanical utility piping

systems, and over two million gallons of potable and fire-fighting water storage.

Unfortunately, most of LLNL's utility system infrastructure is underground where it cannot be readily seen, monitored for condition degradation, nor preventatively maintained. More often than not, repairs and upgrades are only made after system failures occur. Those system failures impact programmatic missions at orders of magnitude of the cost of the actual utility repair. Many of LLNL's utility systems are the original systems installed when LLNL was an Naval Air Station over 65 years ago and are well beyond useful life.

To better understand the condition of our utility systems, in a recent 18-month period, there was an unprecedented number of water pipe failures (14). In addition, in calendar year 2018, LLNL experienced a water line break in a six-inch main service pipe at Site 300 that resulted in a 72,000 gallon water loss and washed out a section of road. LLNL experienced five power outages at Site 300 and found over 300 mechanical utility valves that do not operate properly. LLNL and NNSA have partnered to upgrade LLNL's utility systems through the UDS portfolio. This plan provides for a series of prioritized projects spanning all of LLNL's utility systems for the next several years. Studies suggest where LLNL needs to focus its limited resources. Some projects, such as replacing over 100 of LLNL's most critical utility system valves, are nearing completion, as well as providing for additional high-voltage distribution capacity for the increasing needs demanded by the ECFM line-item project.

LLNL also has projects underway at both sites to provide filtration and chlorination treatment to the water supplied from the Hetch Hetchy reservoir. In 2020, LLNL has planned projects to replace the aged, defunct air compressors at both sites, as well as to begin planning a new main water distribution pipeline at Site 300. Examples of future projects include a second external high-voltage power line to Site 300 for added redundancy and protection from external shutdowns, further utility valve replacements and refurbishments to the potable water supply system, sewer system upgrades, greater system reliability and redundancy in the high-voltage substations, and increased reliability and capacity in LLNL's building and experimental cooling water systems.

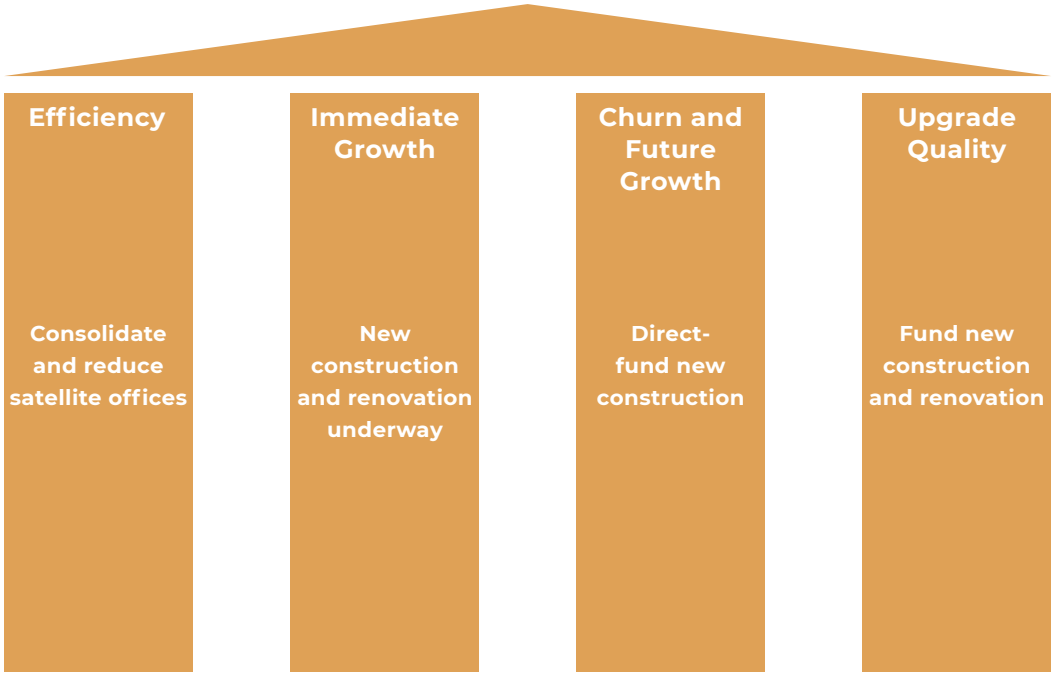
The most vulnerable main site potable water distribution system pipes based on age and condition.

OFFICE SPACE

» LLNL's employee population is projected to experience a substantial net increase driving LLNL's need for more office space

» Many of LLNL's current office spaces are located within degraded trailers and buildings and are in need of revitalization

» To meet LLNL's needs, projects for new or refurbished space have been proposed, space analytics have been leveraged to optimize office space use, and LLNL's current population has been surveyed to better understand their needs



A four-pillar approach will be used to increase the supply of enclosed offices of adequate quality or better.

LLNL'S mission growth is driving an increase in institutional employee population. This growth is projected to reach anywhere from 100–500 employees per year over the next five years. Growth this substantial requires additional office and laboratory space to house these new employees.

Not only does LLNL need more office space, but the institution also prefers that space to be pleasant enough to attract and retain new employees.

Many of LLNL's current substandard and inadequate office spaces are located within trailers and buildings that are beyond their useful life. For example, a previously used, rented, 30-year-old life-extended trailer represents the "front door" to LLNL's 6400 Block (Open Campus) collaboration space. In addition, barracks buildings dating back to 1944

are currently being used as institutional cooler space, housing new hires that are awaiting their clearances. These represent just a few of many substandard and inadequate office spaces.

Office spaces like the ones mentioned above pose challenges for LLNL to retain the next generation of employees. In addition, the Laboratory faces a unique challenge with LLNL being near Silicon Valley, a local modern technology hub that offers employees appealing amenities.

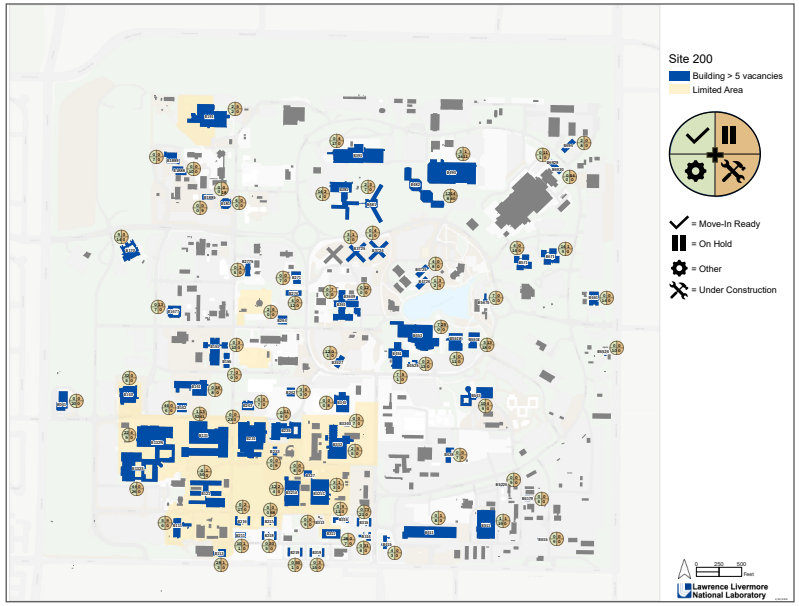
To meet the office space needs at LLNL, a number of actions have been taken:

- Projects have been proposed and planned to erect new generic office buildings and revitalize existing facilities
- Space-use analytics tools have been implemented to optimize the utilization of office space
- Directorates have been surveyed to better understand office and laboratory space needs

Upcoming office space renovation projects include B131, B142, T1884, T1885, and B217; these projects will be completed in the near-term. New office buildings will be constructed, including T2420, B224, and B642; these projects will be completed by FY21. In total, these projects will increase LLNL's office capacity by more than 450 desks for employees.

Space-use analytics tools, such as the Move Management System (MMS), enables LLNL, for the first time, to see real-time office utilization data. This allows for the detailed planning needed to address space requests and improves the way employees are moved onsite.

(*Read more about the MMS tool on page 30.*)



This map is developed from real-time Move Management System data and represents how LLNL's space management quantifies the vacancies of each building at a glance, as well as provides a deeper understanding at the individual building level.

RDT&E LABORATORY SPACE

» RDT&E laboratories are integral to LLNL's scientific discovery and applied research and development, which help LLNL address critical national issues

» LLNL's RDT&E laboratories are aging, and further, do not have the capacity needed to support the increasing volume of work

» Near- and long-term infrastructure plans have been developed to address these issues

» Cornerstone RDT&E laboratories will be revitalized, and smaller, less efficient laboratory buildings will be replaced with new, modern buildings

Renovated laboratory space in B235 supports LLNL's rapidly growing feedstocks capability. High-resolution particle analysis tools are used to develop and analyze feedstocks for additive manufacturing and National Ignition Facility target development.

RESEARCH, development, test, and evaluation (RDT&E) laboratories are breeding grounds for innovation and knowledge acquisition that feed directly to LLNL's nuclear weapons and national security missions. These laboratories are where basic scientific discovery and applied research and development (R&D) intersect to address the critical challenges facing our country.

The experimental physics, materials science, and chemistry laboratories are concentrated along the west side of LLNL and were originally built to support the design and testing of nuclear weapons. Many of these facilities have been repurposed to address new mission requirements such as developing novel materials for the life-extension programs or to improve the accuracy of nuclear data used by high-performance computing simulations that have replaced the role of underground testing.

While these facilities remain highly productive spaces, they are aging. Even the newest buildings with significant laboratory space, buildings 235 and 132, are approximately 35 and 20 years old, respectively. Many are far older—such as Building 151, the hub for radiochemistry experiments at the Laboratory, which was built in the late 1960s. Further, the quantity of laboratory space is not keeping up with the volume of work. Cramped conditions can pose safety risk, adversely affect LLNL's programmatic output, and even provoke staff retention concerns.

Decades of infrastructure deterioration coupled with a growing demand for specialized laboratories necessitate a two-pronged approach to addressing near- and long-term experimental laboratory space needs: revitalize cornerstone laboratory buildings and replace smaller, less efficient laboratory buildings with new, modern laboratory buildings. Only through this combined approach will LLNL be able to safely, efficiently, and effectively deliver on its mission in the coming years, while attracting and retaining world-class scientists.

Recent infrastructure projects include:

- » B151 laboratories #1–4 renovations
- » B155 vault-type room expansion
- » B235 rad-capable feedstocks lab

Current projects include:

- » B151 glove box and dissolver wing renovations
- » B151 laboratories #5–8 renovations
- » B235 synthesis laboratory renovation

Future projects include:

- » Continued renovations of cornerstone laboratory buildings (B151, B194, and B235)
- » New feedstock R&D laboratory building to support the LEP
- » Next-generation nuclear science building

(left) U.S. Atomic Energy Commission chair Glenn Seaborg led a tour of the new Building 151 after its 1967 dedication. In the half-century since, the building's custom-built labs have served an important mission, enabling radiochemists to adapt to an increasingly diversified mission space.

(right) Representatives from the NA-50 Office of Safety, Infrastructure and Operations, and LLNL staff tour the renovated radiochemistry labs in B151 in November 2018. The three-year modernization project encompassed four laboratory spaces, combining two labs into one and updating equipment for nuclear and radiochemistry researchers.

LEGACY FACILITIES

» Established in 1952, LLNL's campus continues to age, and many facilities have met their lifecycle contributions

» Past mission objectives have left LLNL with many process-contaminated, failing, and obsolete facilities

» LLNL has a robust transition and disposition program that helps ensure proper stewardship of these facilities

LLNL'S campus, established in 1952 (with prior Naval history dating back to 1942), is aging, and many of its facilities have met their lifecycle contribution. As LLNL continues to support nuclear security delivery, the institution is compelled to free up real estate to construct new state-of-the-art facilities vital for LLNL to successfully deliver its missions.

Past mission objectives have left LLNL with many process-contaminated, failing, and obsolete facilities. Therefore, LLNL has a robust transition and disposition (T&D) program that works to reduce mission obsolescence; lessen

LLNL's transition and disposition (T&D) footprint comprises $130 million of approved scope over the next 36 months. The buildings highlighted in orange above represent assets in LLNL's current T&D portfolio.

process contamination and structural risk; diminish potential negative impact to mission, employees, the public, and the environment; reduce surveillance and maintenance costs; ensure compliance with environmental and waste management regulations; and unencumber critical site footprint to support building new mission capabilities.

Actions have been taken to ensure that by FY30, all high-risk process-contaminated legacy facilities will be removed from LLNL's sites. These actions include:

- By FY19 close, LLNL will have met requirements for transfer of high-risk process-contaminated legacy facilities for disposition by DOE's Office of Environmental Management (EM)
- Regulatory notifications, reviews, and compliance measures necessary to disposition LLNL's high-risk process-contaminated legacy facilities have been completed
- LLNL has developed NNSA Project Management Plan–compliant, Class 3 estimates
- LLNL is planning to undertake two disposition new starts each year starting in FY20
- The institution continues to monitor and reduce risk while integrating plans into site strategic mission planning

Risk reduction (RR), one key approach that supports the T&D portfolio, focuses on identifying issues, developing response actions and mitigation before the issues promulgate, and ensuring that potential events are moderated before they begin. Legacy facility RR manages both the facility and surrounding areas in the event of a catastrophic occurrence.

As part of the legacy facility portfolio, the following projects are the top T&D priorities for the next five years:

MARS E-BEAM FACILITY, B175

HEAVY ELEMENT FACILITY, B251

LIVERMORE POOL-TYPE REACTOR, B280

ROTATING NEUTRON TARGET SOURCE, B292

SEISMIC RETROFIT

» Some of LLNL's facilities are seismically deficient in terms of meeting the minimum life safety objective

» At Site 200 alone, there are 62 facilities of concern, five of which are category A (the highest risk)

» LLNL and NNSA have made progress in addressing seismic deficiencies: more than 10 retrofits have been completed, more than six partial retrofits have been completed, approximately 10 buildings have been vacated, and some buildings have even been demolished, including (most recently) B326, a category A facility, in 2019

» LLNL is actively working to complete studies on all areas of concern

LLNL's Site 200 (indicated by the black box above) is located in a high-seismic-risk area near two faults (indicated in red), the Greenville fault zone (1.5 miles away) and the Las Positas fault zone (0.6 miles away).

LLNL was established in 1952 on an existing Naval Air Station base. When LLNL was opened, the institution leveraged many existing buildings. These buildings are still standing and in use today, and as such, many are seismically deficient in terms of meeting the minimum life safety objective. For LLNL, this poses a particular concern being located in California, where earthquakes are common—there is a 72% probability that one or more earthquakes, with a magnitude of 6.7 or greater, will occur in the San Francisco Bay region by 2043.

At Site 200 alone, there are 62 facilities of concern: five are category A (the highest risk), 17 are category B, and 40 are category C. To address seismic concerns, LLNL has established a comprehensive, multi-year plan that will reduce the risk.

LLNL has made progress in addressing seismic deficiencies: more than 10 retrofits have been completed, more than six partial retrofits have been completed, approximately 10 buildings have been vacated, and some buildings have even been demolished, including (most recently) B326, a category A facility, in 2019. However, there is still more work to do. LLNL has a planned path forward for its most seismically hazardous buildings identified to date.

LLNL identified these risks through past studies of seismic conditions and is actively working to complete studies on all areas of concern and update the previous studies according to new codes and standards. The order of executing these evaluations was prioritized based on each building's occupancy level, mission dependency index rating, replacement cost, age, and type of structure.

The multi-year plan includes two main approaches: 1) building new facilities and relocating employees and capabilities, and 2) performing seismic retrofits. An example of the build and relocate approach is category A facility B231, which is being replaced through the AME area plan that started in 2017. The seismic risk in B231 is being addressed with the construction of two smaller general plant project–funded laboratories, and an institutional general plant project–funded office building, as well as relocation of capabilities to those new facilities and several other existing underutilized buildings.

Recently, the conceptual design for a seismic retrofit was funded for another category A facility, but the estimates have shown that the repairs needed will exceed the line-item threshold. To that end, LLNL has had a seismic risk mitigation line item on the NNSA line-item Integrated Project List (IPL) since the mid-2000s, which is now scheduled for funding in 2028. The line item will address seismic retrofits at both category A and the highest risk category B facilities.

In addition, line item–funded build and relocate projects are planned for older category A facilities where the cost to retrofit doesn't make sense economically in relationship to the age or overall condition and utilization of the building. For example, constructing a new, smaller, modern, and seismically compliant facility may be a better option for B511, and that project is on the NNSA IPL for 2025. The seismic retrofit of category C facilities will be performed upon major remodeling or modification of the building.

INSITE: INTEGRATION OF G2/BUILDER AND CMMS

» BUILDER is NNSA's infrastructure lifecycle modeling software application for managing assets and other structures and facilities in the DOE complex

» BUILDER allows NNSA and its Management and Operating partners to consistently track more than $54 billion in complex assets

» As a pilot site for BUILDER, LLNL helps guide BUILDER's testing and implementation

» NNSA plans to use BUILDER to support budget requests and prioritization of resources

LLNL's real property data flows from the Enterprise Asset Management (EAM) tool through InSite and into BUILDER.

INVENTORY and condition data for NNSA's buildings and other infrastructure assets is maintained on the G2 BUILDER system, a cutting-edge infrastructure management tool. The BUILDER system, originally developed by the Construction Engineering Research Laboratory (CERL) of the U.S. Army Corps of Engineers, provides greater consistency and transparency in infrastructure lifecycle management.

NNSA relies on BUILDER as an authoritative data source for information related to condition and functionality assessments.

BUILDER is part of an NNSA-wide infrastructure initiative to provide an enterprise-level, risk-informed, decision-making tool. The BUILDER analyses enable evaluation and projection of infrastructure conditions, resource scenarios, and requirements to meet NNSA and site missions. This data informs decision making by NNSA and stakeholders to support budget requests and resource prioritization for a $54 billion portfolio of capital assets.

As a BUILDER Center of Excellence, LLNL helps lead implementation and test of pilot tasks, involving the Computerized Maintenance Management System integration, data validation and verification, and infrastructure analysis.

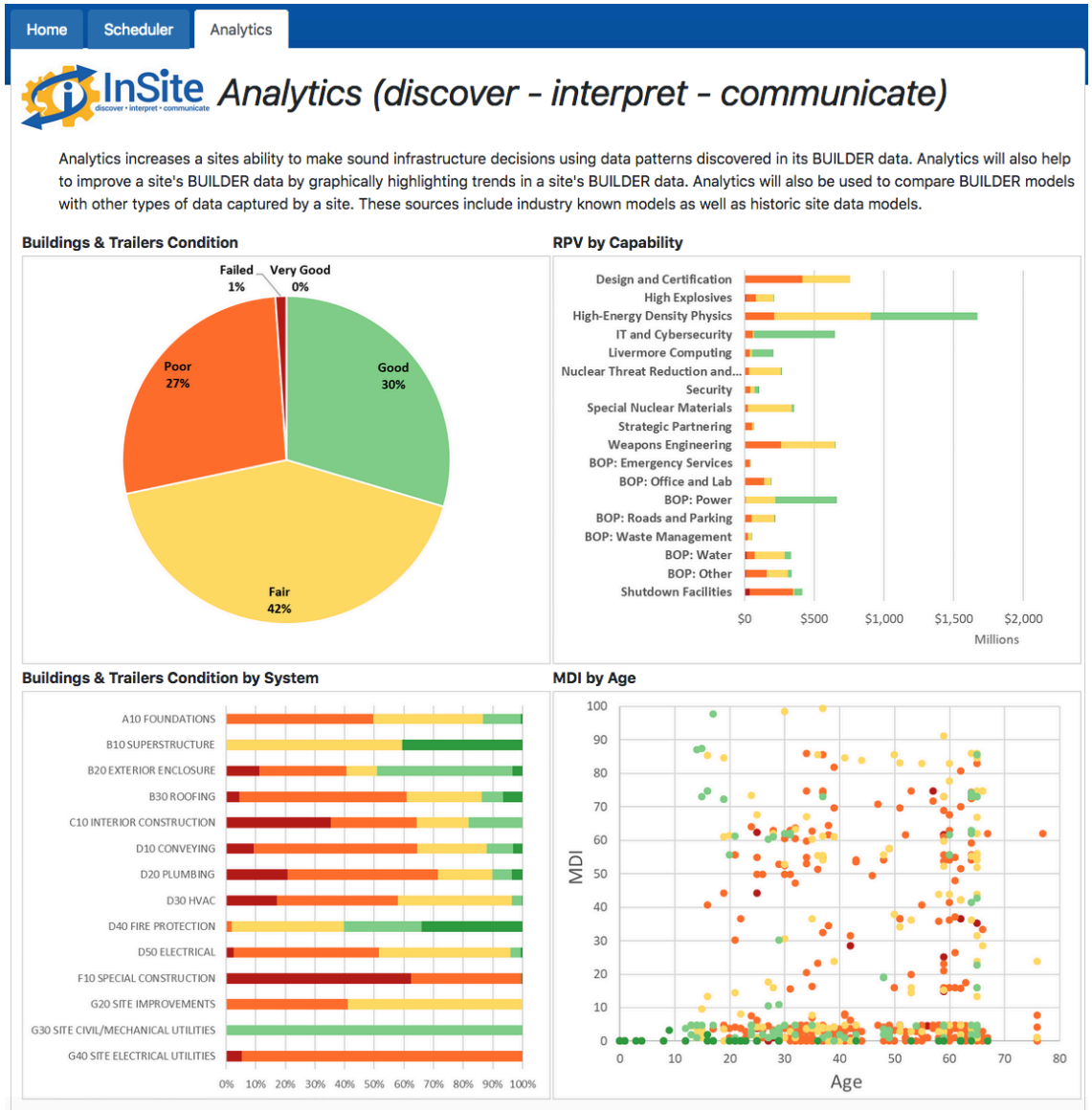
INSITE: INTEGRATION OF G2/BUILDER AND CMMS

Recently, LLNL developed an application called InSite that provides an integration bridge between LLNL's real assets and their condition data and the NNSA BUILDER application.

InSite provides an automated method for updating the BUILDER database using specialized software. InSite employs several crosswalk tables and algorithms used to translate LLNL's inventory and inspection data into BUILDER inventory and condition.

InSite also keeps track of BUILDER inventory and condition data in order to ensure LLNL data and NNSA BUILDER data alignment. This synchronization feature improves the overall quality of LLNL's data in BUILDER and increases the accuracy of LLNL's infrastructure analytics.

LLNL's InSite application was the first application to achieve NNSA BUILDER and Computerized Maintenance Management System integration.



Integration of BUILDER and the LLNL Computerized Maintenance Management System will enable the sophisticated analyses of NNSA's infrastructure data.

COSTLAB: FULL LIFECYCLE COST MODELING

» CostLab is one of many maintenance and operations models that can predict budgetary requirements to maintain LLNL's real property assets at an acceptable level of condition

» This risk-based model can produce a decade-long prediction of the maintenance needed for site-wide real property investments

» CostLab also has a Risk Calculator that leverages the CostLab data to determine the correct level of replacement investment to refresh mission-critical infrastructure

» CostLab was refined by a decade-long collaboration between LLNL and CBRE in full lifecycle cost modeling

» CostLab sustainment model and Risk Calculator represent a sophisticated lifecycle toolset for LLNL's and NNSA's infrastructure assessment and planning activities

The CostLab Risk Calculator budgetary model evaluates the necessary investments to replace real property. Shown here is LLNL's deferred maintenance for high-mission-consequence equipment after a 10-year, annual $25M buy down.

THE advanced infrastructure modeling tools being developed at NNSA and LLNL have made it possible to analyze infrastructure trends that account for both past investments and model future budgets. This capability allows NNSA and LLNL to anticipate capital equipment replacement expenditures early in the FYNSP planning cycle.

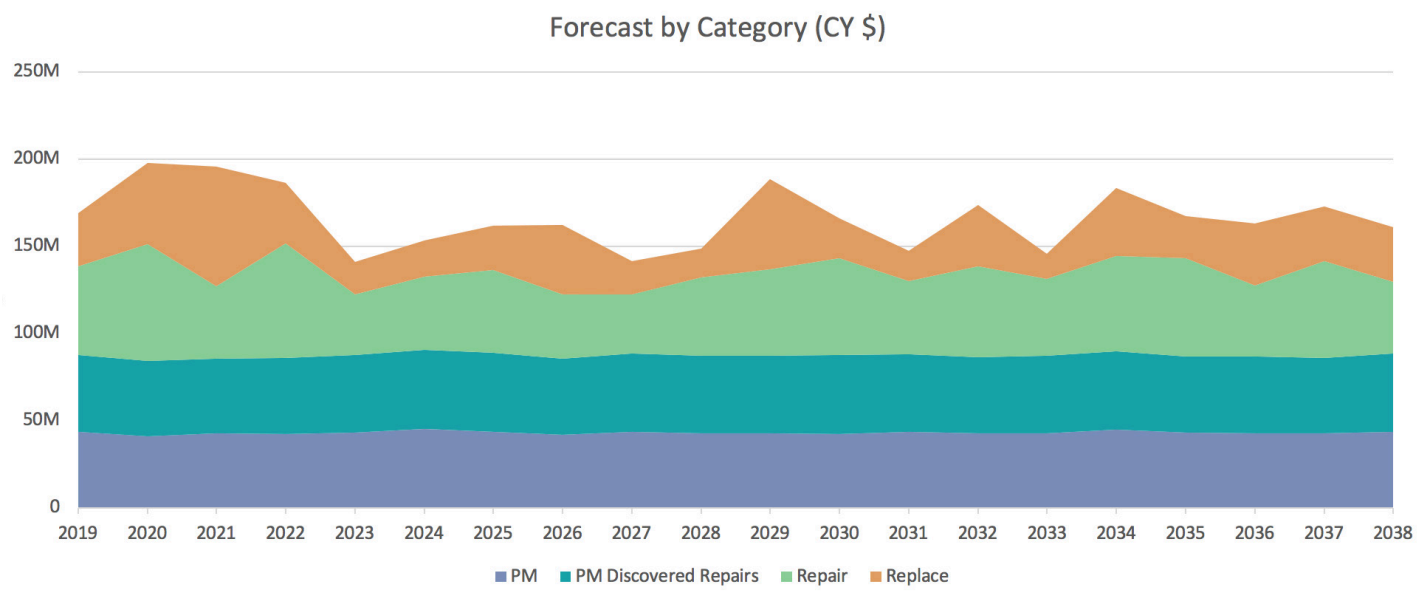
One such tool, CostLab, is the result of a decade's worth of collaboration between LLNL and Whitestone Research (now CBRE). CostLab is one of LLNL's maintenance and operations sustainment models that can predict budgetary requirements to maintain our real property at an acceptable level of condition. Models, including CostLab, have been

developed to integrate the CBRE asset sustainment catalogs with the LLNL equipment registry, mission consequence ratings, and condition assessments.

CostLab produces a decade-long prediction of the preventative maintenance, corrective maintenance, and replacement maintenance, scalable from the equipment to capability to site-wide levels.

The CostLab Risk Calculator, an equipment replacement analytical tool, leverages the CostLab data to determine the correct level of replacement investment to refresh mission-critical infrastructure. The model allows the user to adjust inputs including annual budget, mission consequence, capability, Mission Dependency Index, and system and asset type to analyze the impacts to infrastructure.

The CostLab sustainment model and Risk Calculator represent a sophisticated lifecycle toolset for LLNL's and NNSA's infrastructure assessment and planning activities.



The infrastructure equipment replacement budgetary module, available within CostLab, evaluates the necessary investments to replace high mission risk equipment.

EQUIPMENT DATA ARCHIVE AND DECISION SUPPORT (EDADS)

» The Equipment Data Archive and Decision Support (EDADS) system is a web-based tool used to prioritize $30M annual of programmatic equipment investments on a $1 billion programmatic equipment base

» EDADS has logged over 800 requests for weapons related equipment investments

» EDADS was recently licensed and has been distributed to other National Security Enterprise (NSE) sites to support their weapons-related programmatic equipment investment decisions

» EDADS was instrumental in providing programmatic equipment information in support of NNSA's Programmatic Recapitalization Working Group Data Call on Programmatic Equipment in the NSE

The Equipment Data Archive and Decision Support (EDADS) tool manages both new purchases and refurbishments of equipment. A T-base lathe (pictured above) was requested for a refurbishment.

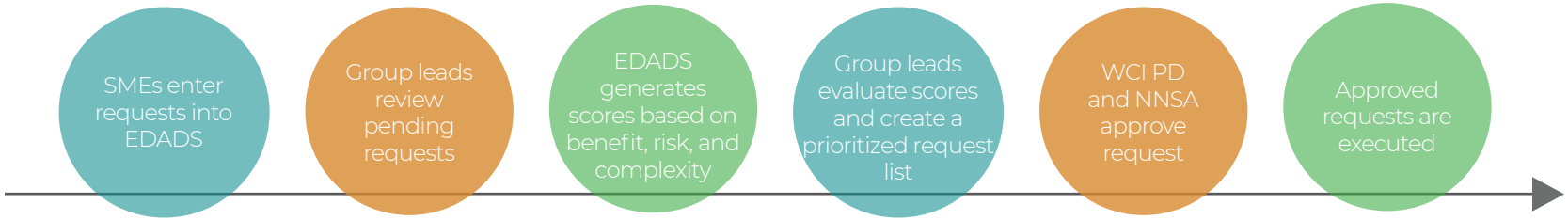
THE Equipment Data Archive and Decision Support (EDADS) system is a web-based information system developed by LLNL for managing and prioritizing programmatic equipment investment requests. EDADS provides access to infrastructure portfolio and condition data to support project planning, understanding, investment prioritization, and portfolio management.

EDADS prioritizes programmatic equipment investments on a core billion-dollar-class capital equipment base.

With EDADS, analysts and managers can:

- » Collect, analyze, track, and manage equipment requests
- » Apply benefit, risk, and complexity gradings to requests
- » View a common set of integrated facility and equipment portfolio data to support fully informed investment decisions

EDADS merges data from external sources with user-entered data to provide these capabilities.



Equipment requests are vetted for completeness, then scored and prioritized at multiple points before being sent to NNSA for approval. Involvement of knowledgeable SMEs and support from program staff is an essential element for successful planning and prioritization.

EDADS also provides programmatic equipment information in support of NNSA's Programmatic Recapitalization Working Group (PRWG) Data Call on Programmatic Equipment in the Nuclear Security Enterprise (NSE).

EDADS has been licensed and distributed to other NSE organizations to support their weapons-related programmatic equipment decisions. In addition, EDADS is now used by LLNL's institutional directorates for managing their operational support equipment and rolling stock inventory.

Going forward, LLNL will continue to use the EDADS planning data to improve the cost estimating and planning efforts of programmatic equipment acquisitions and integration to facility recapitalization.

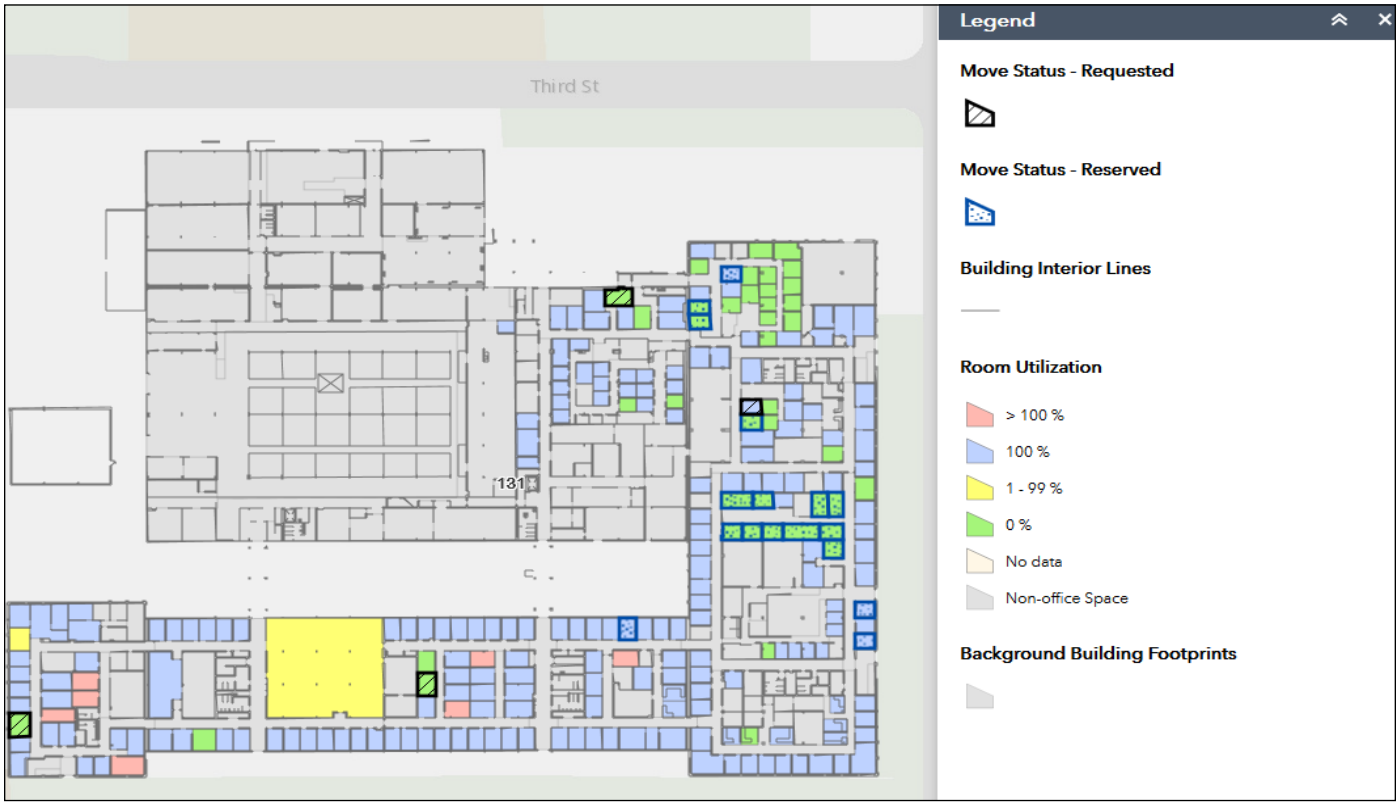
MOVE MANAGEMENT SYSTEM (MMS)

» The Move Management System (MMS) is a tool that leverages two existing software packages that together provide a new, more effective institutional process for space optimization and employee moves

» The MMS has been thoroughly verified and validated and is widely used by the entire Laboratory

» With this tool, LLNL can, for the first time, see real-time office utilization data, which allows for detailed planning to address space needs

» The MMS has become a reliable source of truth for space occupancy, and is a game-changer across the institution



The Move Management System (MMS) tool interface leverages the existing Geographic Information System (GIS) platform to provide a clear picture of LLNL's space usage.

LLNL is facing major office and laboratory space demands (*see pages 16–19 for more information*). LLNL's occupiable spaces are managed by our eight different directorates. Over time, this management gap has created a decentralized space situation where institutional space management has been compromised.

To optimize space use at LLNL's two sites, LLNL identified the need for an improved, institution-wide moving procedure for employees. Called the Move Management System (MMS), this tool leverages two existing software packages already in use at LLNL: the Enterprise Asset Management (EAM) tool to process move requests and reservations, and ArcGIS to generate maps to visualize the system. Together, this web-based tool provides a new, more effective institutional process.

LLNL had tested the MMS through a pilot project that provided insight into the institution's true needs. The pilot project included a subset of LLNL's directorates to ensure its flexibility of working within existing move management practices at the directorate level.

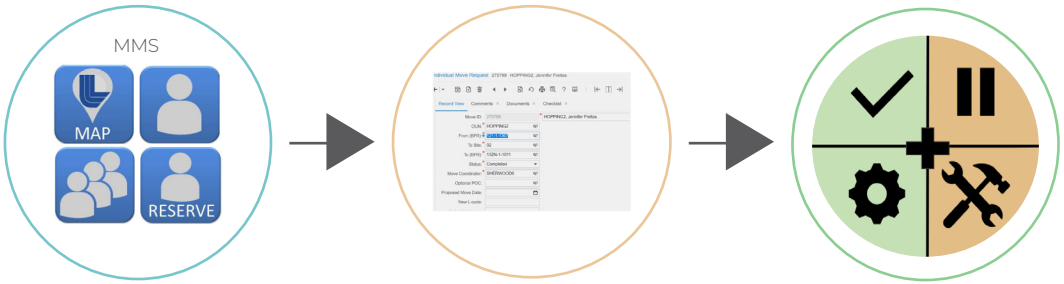
LLNL's roll-out and validation of the MMS enables LLNL, for the first time, to see real-time office utilization data. Real-time understanding of space data allows detailed planning needed to address space needs.

The MMS has been a valuable tool and has enabled the following space utilization improvements:

- Enhances the way LLNL analyzes current space and forecasts future space needs
- Produces and uses quality data to drive more informed space decisions
- Enables an end-to-end process by establishing the framework to automate future move and space requests in a web-based management system; this is now a Laboratory standard

Some of the MMS features include location updates that are automatically logged in the MMS once a move is completed; a reserve room feature used for summer intern and mission growth new hires; documentation of satellite, or secondary, offices for the first time; maps that ensure more accurate floor plans and room data; and eliminates the need for an annual labor-intensive building walk-around space survey.

The MMS has become a reliable source of truth for space occupancy and has also established a framework for other systems to leverage data. It also provides automatic updates of a person's location in the LLNL directory. For example, emergency management is looking to use MMS to access live room-level data to understand where people are located onsite for emergency planning. The MMS has proved itself as a game-changer across the institution.



A user can initiate an office space move or reservation using the MMS tool. From there, moves and reservations aggregate into LLNL space utilization data.

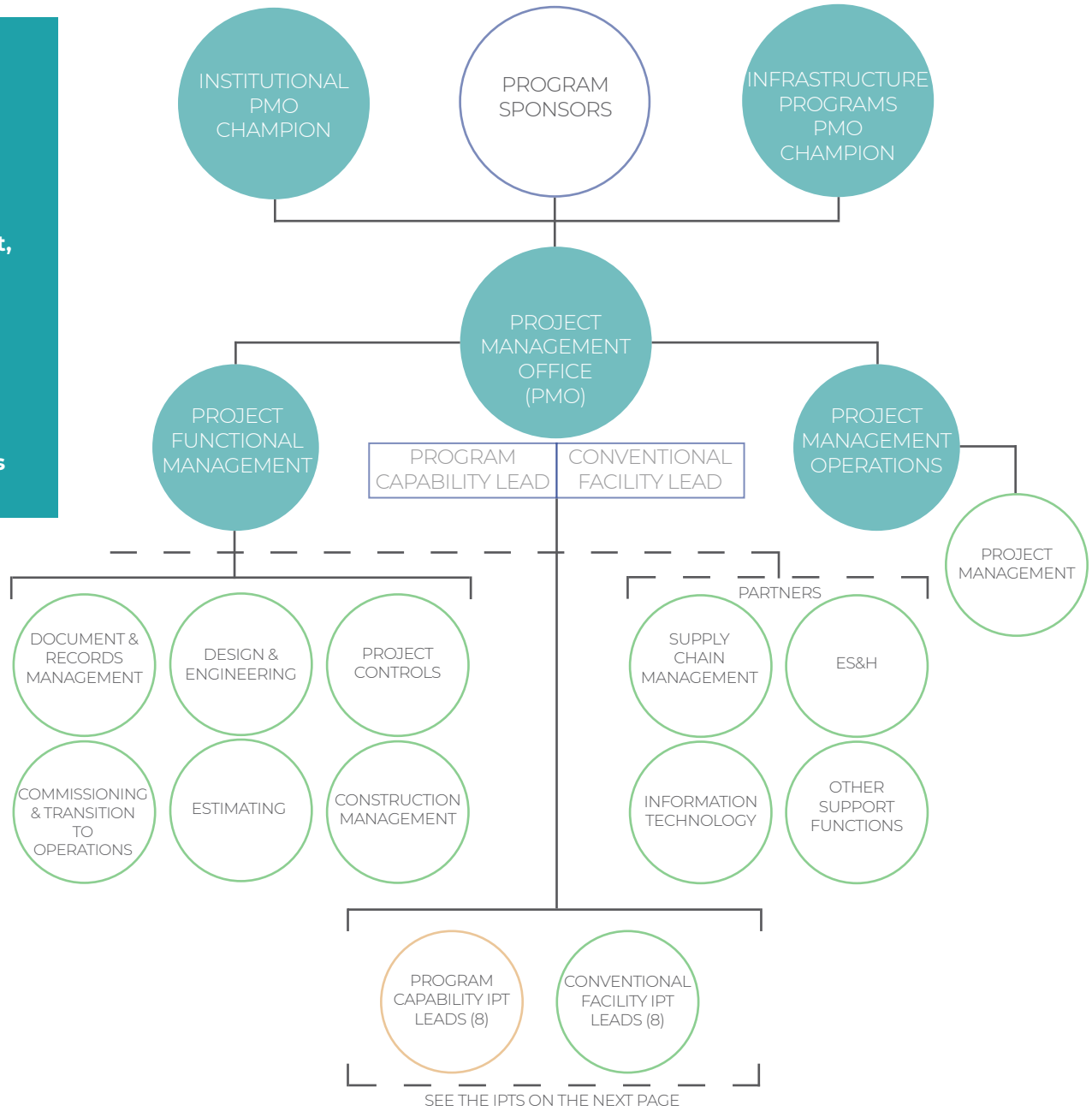
HOW LLNL EXECUTES PROJECTS

» Use a One-Team approach by integrating all executing organizations into a seamless delivery model

» Establish and maintain an LLNL-wide project management system that provides an efficient, risk-based graded approach to project management

» IPTs align to NNSA capabilities and area plans

» Construction delivery has improved since formation of IPTs

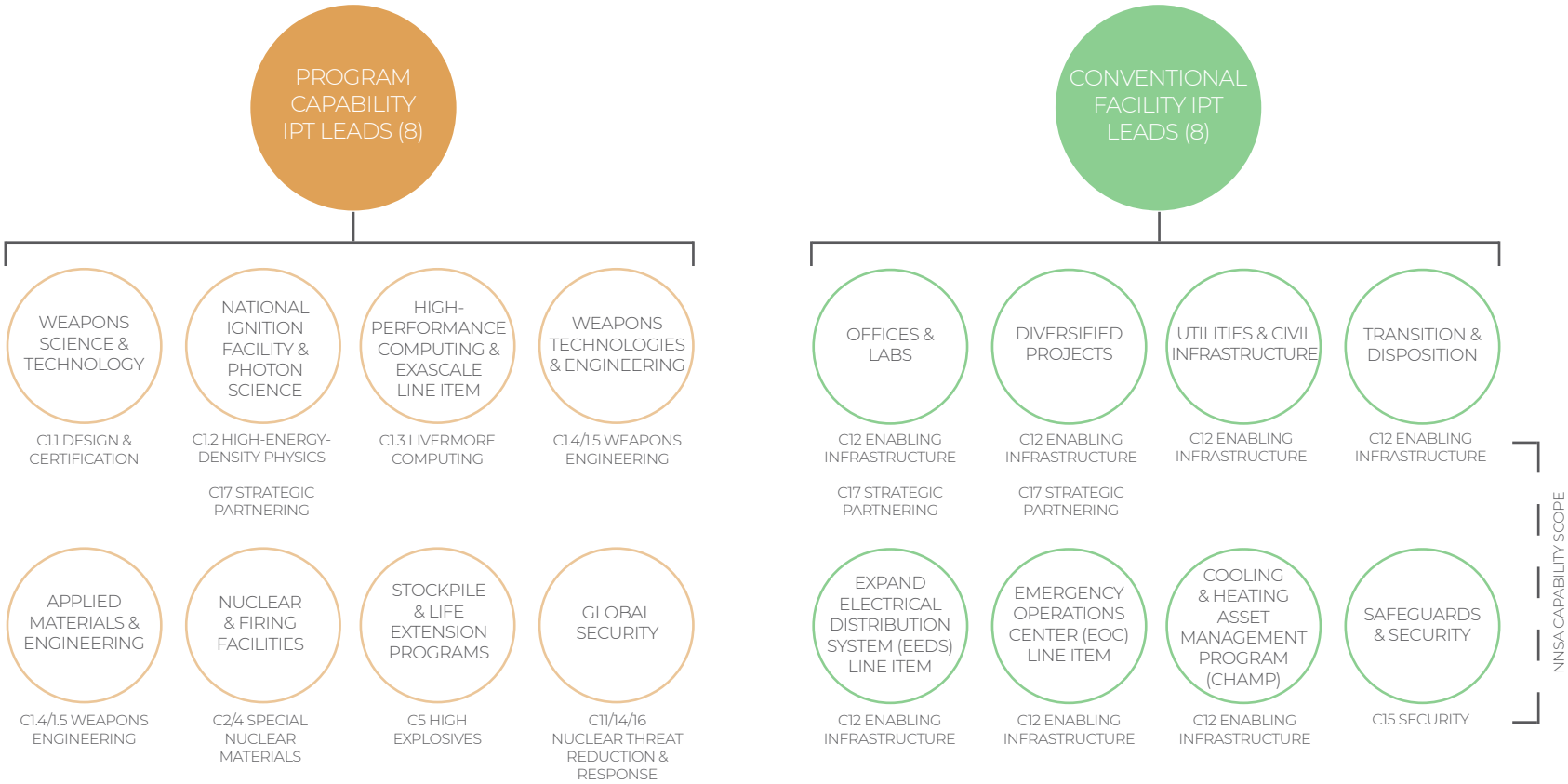


LLNL's tradition of team science, as embodied by LLNL's founders, including (from left) E.O. Lawrence, Edward Teller, and Herb York, inspires the One-Team approach.

INTEGRATED PROJECT TEAMS (IPTS) SUPPORT LLNL PROJECTS

BEHIND every project is an Integrated Project Team (IPT). IPTs help execute infrastructure projects at LLNL by aligning resources with program priorities and developing detailed scope and requirements upfront to improve execution timelines and reduce costs. There are IPTs assigned to each NNSA capability and to every line-item project.

There are two primary groups of IPTs: Program Capability IPTs and Conventional Facility IPTs. Program Capability IPTs manage projects that include both facilities and equipment, whereas Conventional Facility IPTs manage projects that include facilities only.



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