National Nuclear Security Administration

Lawrence Livermore National Security, LLC

Performance Evaluation Report (PER)

NNSA Livermore Field Office

Evaluation Period:
October 1, 2020-September 30, 2021

December 10, 2021

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Executive Summary

This Performance Evaluation Report (PER) provides the National Nuclear Security Administration (NNSA) assessment of Lawrence Livermore National Security, LLC (LLNS), performance of the contract requirements for the period of October 1, 2020, through September 30, 2021, as evaluated against the Goals defined in the Performance Evaluation and Measurement Plan (PEMP). The NNSA took into consideration all input provided (e.g., CAS, Program Reviews, etc.) from NNSA Program and Functional Offices at Headquarters and in the field.

LLNS overcame significant challenges and earned a Very Good Rating on Goal 1, exceeding expectations on many Objectives and Key Outcomes. Despite the impacts of COVID-19, LLNS successfully executed NNSA program priorities, continuing to successfully deliver on our nation's challenging stockpile requirements and lead the Weapons Laboratories in strengthening the underpinning and future of stockpile stewardship. LLNS earned Excellent ratings on Goals 2-4, exceeding expectations on nearly all Objectives and Key Outcomes. LLNS continued to successfully deliver at a very high level across the balance of the NNSA mission portfolio including Non-Proliferation, Emergency Management, Incident Response, and Nuclear Counterterrorism while effectively supporting DOE and Strategic Partnership Project (SPP) programs. The National Security missions were successfully executed by leveraging and advancing the frontiers of Science, Technology, and Engineering (ST&E). LLNS earned a Very Good rating on Goal 5, exceeding expectations on many Objectives and Key Outcomes with relatively few issues. On Goal 6, LLNS earned an Excellent rating as it exceeded expectations on nearly all Objectives and Key Outcomes through its strong partnership with NNSA and effective leadership in overcoming historic challenges.

Goal 1: Mission Execution: Nuclear Weapons
LLNS Total Fee Allocation: $14,432,774

LLNS earned a rating of Very Good and 89 percent of the award fee allocated to this Goal. Despite the impacts of COVID-19, LLNS exceeded many of the Objectives and Key Outcomes and met the overall cost, schedule, and technical performance requirements with many accomplishments that greatly outweigh issues. No significant issues in performance exist. Contractor is generally meeting performance expectations within expected costs.

NIF achieved the highest yield to date in a DT experiment. This shot was ~8x higher yield than the previous NIF record and 25x higher than experiments performed prior to Fiscal Year (FY) 2021. Transformational new capabilities have been demonstrated in, technical issues using the Optical Thomson Scattering diagnostic, produced >10x higher quality high-density-carbon capsules for ignition implosions, achieved the highest radiation temperature using the JOLIE platform, and executed the first NIF shot studying a high explosive (TATB). NIF executed 368 total shots in FY 2021 supporting 169 shots for the High Energy Density (HED) program and 86 shots for the Inertial Confinement Fusion (ICF) program. LLNS' target fabrication team delivered two key advances in target fabrication, Tetracage capsule support and much-reduced

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fill-tube sizes. The Pu NIF target fabrication operations began in Superblock. The first experiment was executed using a novel target.

LLNS met or exceeded performance expectations on the Defense Programs "Getting the Job Done List." LLNS successfully completed 145 of 150 milestones including all three of the Defense Program (DP) Level-1 milestones. Five milestones were "Red;" Installation of specialized equipment was late by 3 weeks, another milestone was delayed due to competing priorities for personnel in Superblock and three milestones delayed due to the inability to hire experienced schedulers.

LLNS successfully supported the Weapons Survivability program mission, demonstrated most recently with the completion of a L1 milestone/FY20-21 pegpost which baselined the enterprise capabilities for hostile environments weapons survivability. LLNS is also an important contributor to and demonstrated leadership on the Warheads Working Group effort within the Air Force/NNSA NGRV study. Of concern however is cost/schedule performance on the NIF/DLI project. LLNS has demonstrated it is taking steps to correct these project control deficiencies, but concerns remain about further cost overruns, and delivery of final capability to our international and interagency partners. Performance on overall WS elements however, particularly the L1 milestone and FY20-21 pegpost, are noteworthy and slightly outweigh project management deficiencies on NIF/DLI.

LLNS completed modeling and analysis of non-stockpile devices to inform aging induced features and completed initial research and development on a viable advanced manufacturing option, in support of FY 2022 SCDS Assess Lifetimes & Mitigate Aging pegpost.

LLNS achieved Baseline Design Review (BDR) for Nightwatch, a transformational capability for the future of stockpile surveillance. W80-1 and W87-0 system teams continued support of Pantex activities including surveillance, rebuilds, retrofits, and repairs. B83-1 closed out activities for the PISA Issue Resolution Group allowing for a restart of nuclear explosive operations (NEOs).

LLNS completed L2 milestone 7108, bipolar solid-state pulsed power (BPSSPP) demonstration on FXR at the Contained Firing Facility (CFF). LLNS made significant technological advances/contributions in both the Advanced Sources and Detectors Major Item of Equipment Project and the Neutron Diagnosed Subcritical Experiments (NDSE) diagnostic systems. NDSE schedules that are comprehensive, integrated, and actionable continue to be a challenge for the multi-site teams. LLNS delivered multiple line-replaceable units (LRUs) to LANL. These LRUs are 95 percent production ready. LLNS initiated assembly and testing of additional LRUs which are 98 percent production-ready.

LLNS made excellent progress in ASC and High-Performance Computing (HPC) in FY 2021. NNSA's first Exascale computer project, El Capitan, is on schedule and will be placed in production by May 2024. LLNS continued its outstanding progress with its Integrated Codes (IC) usage of Physics & Engineering Models (PEM) Libraries, advancing the fidelity and efficiency of 3D simulations, and ensuring those capabilities will be fully available when next generation platforms, like El Capitan and ATS-4, are deployed. LLNS successfully completed the ASC L1 milestone, performing a series of nuclear-weapons-relevant, 3D calculations with next generation

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integrated codes, using Sierra, Trinity, and Astra.

LLNS Sierra HPC capability had a major impact on enhancing the AAR, W80-4 LEP, and W87-1 programs by significantly decreasing simulation time and increasing fidelity in simulations of interest. In addition, three major Large Scale Computing Initiative (LSCI) projects were performed on the Sierra architecture: testing new algorithms, uncovering algorithmic bottlenecks at large scale, and unprecedented simulations in support of LLNS design activities. Sierra is fully utilized and delivering on ATCC-10 campaign. LLNS demonstrated a 15x speed-up on Sierra for high-fidelity HE burn on a high-resolution simulation. LLNS led the Tri-Lab ASC high-performance computing Commodity Technology System CTS-2 procurement project, with a contract award in September 2021.

LLNS made excellent progress in W80-4 LEP Phase 6.3 activities and preparations for entry into Phase 6.4 in FY 2022. PRTs have been progressing design maturation and working to address producibility issues. Technical activities included conducting numerous physics experiments, physics analysis verifying a critical subsystem design's performance, compatibility testing, engineering testing and extensive chemistry experiments. LLNS worked closely with Holston to resolve production issues. LLNS successfully executed several hydrodynamic experiments, and multiple small scale hydro experiments., a breach occurred at Confined Firing Facility (CFF) after execution of an experiment and CFF operations have been paused. Programmatic impact is a concern and is being evaluated. LLNS identified substantial schedule risk causing high risk to producibility. LLNS successfully stood up an independent alternative design activity focused on producibility to address this risk. Calculations verified the risk mitigation design has an acceptable impact on physics performance, and fabricated prototype hardware. LLNS supported 6 B-52/LRSO flight tests to gather environmental data and completed the first high fidelity engineering ground test, demonstrating the baseline design can survive expected thermal and vibration environments. LLNS completed most W80-4 gate reviews; however, many were more than 30 days late to the target dates, due to outside production issues, pressures of COVID, and staffing issues. LLNS W80-4 NEP PRT negotiated the use parts for builds of the Main Charge Subassembly to permit some schedule relief.

LLNS did not meet some of the W80-4 Level 2 milestones associated with schedule development. The Project Controls Team, along with the program engineers continue to be short staffed, which has impacted the Schedule and Earned Value (EV) data quality. LLNS hired additional program controls staff this year to help resolve the issue. Despite hiring difficulties and COVID impacts, the W80-4 program at LLNS is seeing a small recovery of schedule delays. Significant effort continued on staffing, schedule recovery, and schedule logic cleanup.

LLNS completed the Polymer Enclave building at commendable pace and has begun executing programmatic work. LLNS actively participated in all W87-1 PRT and IPT activities meeting associated deliverables; led component down selects and trade studies with production agencies and is planning appropriate life-of-program buys. LLNS continued progress toward Pit production and completed numerous Engineering Evaluations at KCNSC and at LANL.

LLNS designed and built the Environmental Flight Test Unit and delivered it to Sandia for integration into the aeroshell; developed, fabricated, and began assembly of the RAPTER unit for

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the first primary subsystem engineering tests; produced full sized special material parts that meet current W87-1 specifications; also supported Production Agency capability development. LLNS completed a dozen design down selects and fully documented the decisions.

LLNS Weapon Production Quality group released over 750 Engineering Authorizations, processing over 750 NSE Engineering Authorizations, supporting 334 product realization team activities, and supported over 30 engineering evaluations in FY 2021 fully enabling stockpile systems and modernization programs. LLNS continued to work to resolve roadblocks and mitigate difficulties that have slowed machining and testing of direct cast samples in support of the FY 2021 Stockpile Capabilities Delivery Schedule (SCDS) pegpost. This milestone remains yellow due to competition with other LEP activities and is currently being assessed for re-baselining. LLNS continued to support all Ground-Based Strategic Deterrent (GBSD) related activities and provides regular input to NNSA and Air Force on GBSD programmatic planning documents. LLNS did not meet all W87-1 FY 2021 needed scope and deliverables. LLNS's risk management program is slowly maturing compared to Federal Program Office expectations and other W87-1 sites; LLNS was late in hiring a W87-1 risk program manager as a result of COVID but is actively working on hiring.

LLNS demonstrated proof-of-principle for high precision measurements of gamma-ray branching ratios in the beta decay of long-lived fission products. Decay branching ratio measurements of fission products are important to stockpile stewardship applications and evaluations of fission product yields. LLNS achieved time-resolved temperature measurements to understand emission opacity and measured absolute x-ray emission spectroscopy on multiple samples concurrently in a dense, high-temperature plasma, providing key constraints on plasma models. LLNS experienced delays in general operations metrology improvements and information requested that are preventing closure of Primary Standards Laboratory Survey.

 ICF program performed the first experimental test of an integrated Sierra design at Sandia National Laboratories' Z-facility. This experiment pushed the diagnostics and target fabrication efforts as intended to pave a pathway for future experiments and excellent data was obtained. The first known swelling measurements of α Pu were made using new dilatometry instrument. LLNS worked to install and bring into operation a Cold Hearth Melter (CHM) to produce uranium-6 percent niobium (U-6Nb) ingots at Y-12. LLNS and LANL jointly completed a qualification plan for direct-cast uranium alloy for future use in the stockpile

In support of 87-1 Pit Certification, four equation-of-state experiments were executed at JASPER to measure the shock performance of the pit material being generated at Plutonium Facility 4 (PF-4) and compare it to behavior of legacy material. COVID-19 is impacting the Hydrodynamic and Subcritical Experiments Experimental Support and could lead to schedule delays. LLNS completed 651 high explosive shots at HEAF in support of stockpile and modernization activities.

Livermore Independent Diagnostic Scoring System (LIDSS) successfully fielded six unmanned aerial vehicles (UAVs or drones). This test was the first ever to be supported with drones deployed remotely in commanded by engineers at LLNS. The data collected by the drones was downloaded to LLNS allowing for a score to be sent to the Air Force shortly after the test. In alignment with Administration priorities, Integrated Deterrence and Competition (IDC) has

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recently been designated as a fourth LLNS Mission Focus Area, where Integrated Deterrence is consistent with the DOD (and NNSA) Integrated Strategic Deterrence approach to deterrence and conflict.

Goal 2: Mission Execution: Global Nuclear Security
LLNS Total Fee Allocation: $2,061,825

LLNS earned a rating of Excellent and 95 percent of the award fee allocated to this Goal. Despite the impacts of COVID-19, LLNS exceeded nearly all of the Objectives and Key Outcomes and met the overall cost, schedule, and technical performance requirements with many accomplishments that significantly outweigh very minor issues, if any. No significant issues in performance exist. Contractor is meeting performance expectations within expected costs.

LLNS provided superb support and leadership in implementing nuclear security engagement with partners worldwide and took the lead for engagement in the Middle East and North Africa. LLNS provided outstanding subject-matter expert support to the Insider Threat Mitigation Functional Team, and also provided technical support for radiological security activities in Africa, Middle East, East Asia, and Europe by developing training for partners with improved timeliness of deliverables. In addition, LLNS provided technical expertise on the use of a machine learning algorithm that will be used to reduce the rate of nuisance alarms and provided advanced modeling and analysis support to evaluate performance of radiation detector equipment in new operational scenarios using synthetic spectra.

LLNS successfully led the development of the complex Low Yield Nuclear Monitoring testbed with outstanding project management, systems engineering, and mission assurance practices, resulting in an executable plan to support seven integrated field experiments. LLNS' innovative research in ground-based nuclear detonation detection included developing a new global-scale seismic tomography model and initiating transition of an atmospheric transport computational fluid dynamics code. LLNS led a multi-institution, international effort to deliver a world-class experimental facility to advance and demonstrate innovative applications of neutrino technologies. LLNS led an effort to develop and apply advanced data analytical techniques to improve the ability to detect nuclear proliferation activities. LLNS also led an effort to improve the capability to model the output from uranium enrichment technologies. Nuclear forensics scientists made substantive advances in the analysis and interpretation of forensics signatures, identified emerging signatures, developed new methodologies that may significantly reduce uncertainties, and led laboratory-based teams to plan major new research thrusts.

LLNS provided creative and high-quality support for state-level safeguards policy studies, safeguards human capital development initiatives, international engagement efforts in North Africa, development of training materials, and technology development projects for international safeguards applications. LLNS provided timely and high-quality support for end-user reviews in the dual-use export license adjudication process and for End-User Review Committee proposals. LLNS was a valuable contributor to the suite of nuclear nonproliferation and arms control engagement activities, seminars, and workshops with foreign partners. LLNS maintained its status as a designated laboratory for the Organization for the Prohibition of Chemical Weapons by

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demonstrating outstanding analysis capabilities and receiving the highest possible grade in its annual environmental and biomedical proficiency tests.

LLNS successfully provided impactful training, exercise, and operational support for: Superbowl LVI Preparation activities, Los Angeles Airport Visible Intermodal Prevention and Response team, Federal Bureau of Investigation (FBI) Guam and the 94th Civil Support Team, FBI Stabilization Teams in Los Angeles and San Francisco, San Diego Navy Joint exercise, San Jose Police Department and Hazard Material Teams, Green Day US-Israeli cooperative agreement, San Diego Navy Joint Exercise, Marble Challenge 21, and Golden Virginia 14. LLNS demonstrated successful program execution of the Capability Forward Initiative through support for new response equipment development and validation, development of new training facilities and training aid development, and skill set participation in 70 domestic and international training events and one international exercise. LLNS successfully executed a series of 14 experiments at Site 300 to collect key data in support of upcoming integrated experimental suite and completed modeling pressure-temperature-volume relationship for a specific material that will support a real-world uncertainty calculation capability. LLNS continues National Nuclear Material Archive (NNMA) identifications, nominations, analysis, and evaluation efforts and is meeting or exceeding expectations.

Goal 3: DOE and Strategic Partnership Project Mission Objectives
LLNS Total Fee Allocation: DOE $6.7M ($1.92M FF + $4.78M AF)

LLNS earned a rating of Excellent and 99 percent of the award fee allocated to this Goal. Despite the impacts of COVID-19, LLNS exceeded nearly all of the Objectives and Key Outcomes and meeting the overall cost, schedule, and technical performance requirements with many accomplishments that significantly outweigh very minor issues, if any. No significant issues in performance exist. Contractor is meeting performance expectations within expected costs.

LLNS successfully executed high-impact work in support of the DOE and SPP sponsors. This work was strategically integrated with the DOE/NNSA mission and leveraged, sustained, and strengthened many of the LLNS' unique capabilities, facilities, and skills as demonstrated with accomplishments in the core competency areas of high-performance computing, advanced materials and manufacturing, biodefense and resilience, and atmospheric science. LLNS earned numerous prestigious awards from professional societies and U.S. Government sponsors demonstrating the quality of work and its strategic value. Two LLNS scientists were recipients of the 2021 DOE's Office of Science Early Career Research Program award.

LLNS continued to direct research infrastructure, unique capabilities, and a dedicated team of scientists and engineers to support the fight against the pandemic with tools and information to better understand COVID-19. LLNS scientists developed a machine learning model to assist in COVID-19 drug discovery efforts, which was a finalist for the Gordon Bell Special Prize for High Performance Computing-Based COVID-19 Research.

LLNS, along with partners Intel, Supermicro, and Cornelis Networks, deployed "Ruby," a high-performance computing (HPC) cluster. Funded by DOE, NNSA, and the Coronavirus Aid,

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Relief, and Economic Security (CARES) Act, the 6-petaFLOP peak, Intel Xeon Platinum-based cluster is used for unclassified programmatic work supporting NNSA's stockpile stewardship mission, open science, and the search for therapeutic drugs and designer antibodies against SARS-CoV-2. LLNS researchers have begun using Ruby to compute the molecular docking calculations needed for discovering small molecules capable of binding to protein sites in the structure of SARS-CoV-2 for drug discovery purposes and are able to screen about 130 million compounds per day when using the entire machine.

LLNS and University of California Merced scientists and collaborators from the Max Planck Institute of Biophysics in Germany used carbon nanotubes to enable direct drug delivery from liposomes through the plasma membrane into the cell interior by facilitating fusion of the carrier membrane with the cell, as reported in research appearing in the *Proceedings of the National Academy of Sciences*. Infusing drugs into disease-ridden cells has remained a major challenge for modern pharmacology and medicine.

LLNS led a team of international scientists and found that elevated carbon dioxide emissions from human activities increase the uptake of carbon by plants but may decrease storage in soil. The team synthesized 108 elevated carbon dioxide (CO_2) experiments in various ecosystems to find out how much carbon is absorbed by plants and soil in research appearing in the journal *Nature*.

LLNS engineers have demonstrated that aerodynamically integrated vehicle shapes decrease body-axis drag in a crosswind, creating large negative front pressures that effectively "pull" the vehicle forward against the wind, much like a sailboat. The research appears in the *Proceedings of the National Academy of Sciences*. The DOE's Hydrogen and Fuel Cell Technology Office selected two LLNS researchers for the 2020 Technical Program Area Award in Hydrogen Fuel R&D. This award recognizes the computational materials science team at LLNL for their exceptional support to the HydroGEN Advanced Water Splitting Materials and Hydrogen Materials Advanced Research Consortium (HyMARC) consortia efforts.

LLNS researchers have demonstrated the capability to measure nuclear decay in high-rate superconducting quantum sensors in the search for sterile neutrinos. A team of interdisciplinary researchers, led by Livermore and the Colorado School of Mines, has demonstrated the power of using nuclear decay in high-rate quantum sensors in the search for sterile neutrinos in findings that are the first measurements of their kind. The research was reported in *Physical Review Letters*.

LLNS scientists have discovered the first antidote against nerve-agent poisoning that crosses the blood–brain barrier (BBB). With a combination of organic synthesis, computational modeling, and a battery of detailed in vitro and in vivo assays, they discovered a novel central nervous system- permeable compound. Their research, published in *Scientific Reports*, comes on the heels of a recent resurgence of nerve agents in transnational conflicts. When used as a chemical weapon, chlorine gas disperses so rapidly that evidence of its release can be hard to find. At the American Chemical Society meeting, researchers at LLNL reported identifying biomarkers in plant tissue that might provide forensic tools for confirming chlorine-gas release.

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> ## Goal 4: Mission Execution: Science, Technology, and Engineering
> ## LLNS Total Fee Allocation: $21.8M ($17.7 FF + $4.1M AF)

LLNS earned a rating of Excellent and 99 percent of the award fee allocated to this Goal. Despite the impacts of COVID-19, LLNS exceeded nearly all of the Objectives and Key Outcomes and met the overall cost, schedule, and technical performance requirements with many accomplishments that significantly outweigh very minor issues, if any. No significant issues in performance exist. Contractor is meeting performance expectations within expected costs.

LLNS' research strategy and investments, including the Laboratory Directed Research and Development (LDRD) program, successfully advanced the frontiers of science while maintaining a strong foundational expertise in core competencies, and developing the skills of the workforce. LLNS' research developed excellence in core capabilities that impacted DOE/NNSA missions; produced new intellectual property resulting in high profile publications; enabled workforce development and staff retention; and expanded the frontiers of ST&E.

LLNS researchers derived and synthesized a novel set of polymers that increased the heat of formation and decreased carbon content compared to a similar class of polymers. These metrics suggest that the polymers could be used to develop materials with better physical and mechanical properties, increasing performance and safety, to compete with current polymers. These materials are intended to explore the design space and bridge the gap between inert and detonable polymers for use in highly energetic formulations. This research was highlighted on the back cover of a recent issue of the journal *Polymer Chemistry*.

LLNS developed a technique to incorporate machine learning and neural networks into one of the most complex and time-consuming computational physics simulation codes. The neural network modes significantly speed up calculations of physical processes occurring in an imploding target during inertial confinement fusion experiments. This development opens a path to achieving higher-quality physics simulations without increasing computing costs and could help shape the next generation of LLNL supercomputers.

LLNS conducted the first shot in a series that will transform the understanding of high explosives by producing never-before-captured experimental data quantifying the response of laser-driven high explosives during reaction. These results will allow researchers to critically evaluate predictive computational capabilities and the Laboratory's world-class thermochemical code.

LLNS scientists developed the first-ever living 3D-printed aneurysm to improve surgical procedures and personalize treatments. The scientists replicated an aneurysm in vitro by 3D-printing blood vessels with human cerebral cells; this procedure was described in the journal *Biofabrication*. The platform, when combined with computer modeling, represents a significant step to developing patient-specific care for aneurysms based on an individual's blood vessel geometry, blood pressure and other factors, and could help overcome one of biomedical engineering's biggest hurdles: the time it takes for new surgical techniques and technologies to leap from the laboratory to the clinic.

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LLNS developed an ultra-compact, lightweight, and minimally invasive optoelectronic neural implant that can be used for long-term studies of brain activity. POEMS (Polymeric Opto-Electro-Mechanical Systems), a new implantable device, is built upon a new platform which represents the first time that scientists have integrated optical capabilities into a patented flexible thin-film neural implant. Capable of delivering light for neural activation, the device could be used for high resolution and minimally invasive diagnoses of brain disorders, in human–machine interfaces or wearable technologies. The breakthrough was published in *Materials Letters*, where it was featured on the cover and chosen as an Editor's Pick.

LLNS researchers developed a groundbreaking method for transporting liquids and gases using 3D-printed lattice design and capillary action phenomena. In a paper published in *Nature* and featured on the publication's cover, LLNS researchers describe 3D-printed micro-architected structures capable of containing and flowing fluids to create extensive and controlled contacts between liquids and gases. The breakthrough technique has transformative and broad-ranging impacts on many fields involving multiphase processes, including electrochemical reactors for converting carbon dioxide or methane to energy, advanced microfluidics, and the delivery of fluids in low- or zero-gravity environments.

LLNS invested in developing its ST&E workforce and was able to attract, develop, and retain high-caliber employees. LLNS scientists, participating in 10 project teams, recently earned DOE Secretary Achievement Awards. Four Livermore scientists were selected as 2020 fellows of the American Physical Society. A Livermore atmospheric scientist was honored with the American Geophysical Union's 2020 Bert Bolin Award. The Institute of Electrical and Electronics Engineers elevated Bronis de Supinski to the rank of fellow, recognizing Lawrence Livermore Computing's Chief Technology Officer for his leadership in the design and use of large-scale computing systems. A LLNS physicist was selected as a fellow of the Society of Automotive Engineers, a computational scientist was selected as a fellow of the Association for Women in Mathematics, a computational mathematician was selected as an esteemed member of the Society for Industrial and Applied Mathematics 2021 Class of fellows, and a computational scientist was awarded 2021 James Corones Award in Leadership, Community Building and Communication. Recently retired LLNS scientist was named a recipient of the NNSA Administrator's Distinguished Service Gold Award.

LLNS performed well in innovation and technology transfer to industry through partnerships that include both CRADA and licensing agreements. Livermore researchers are among the developers of the top 100 industrial inventions worldwide, winning an R&D 100 award at this year's annual event. Five Laboratory employees garnered two national technology transfer awards, one for a radiation simulation training tool and the other for a new ventilator to assist COVID-19 patients, and "best in class" awards from the Department of Energy's Technology Transfer Working Group. Two teams of Livermore scientists and engineers won regional awards for technology transfer from the Federal Laboratory Consortium. LLNS scientists and engineers won five grants through the Department of Energy's Technology Commercialization Fund. Livermore, IBM, and Red Hat combined forces to develop best practices for interfacing HPC schedulers and cloud orchestrators, an effort designed to prepare for emerging supercomputers that take advantage of cloud technologies. A CRADA funded project launched the GEOSTARE 2 satellite, also known as Tyvak-0130, on a SpaceX Falcon 9, and successfully reached orbit.

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LLNL's submissions of Accepted Manuscripts (AMs) for FY 2020 publications decreased slightly, 79 percent, from prior fiscal years. Submission of 85 percent of AMs is considered as "full compliance" but ~ 80 percent is considered acceptable.

Goal 5: Mission Enablement
LLNS Total Fee Allocation: $12,370,949

LLNS earned a rating of Very Good and 90 percent of the award fee allocated to this Goal. Despite the impacts of COVID-19, LLNS exceeded many of the Objectives and Key Outcomes and met the overall cost, schedule, and technical performance requirements with accomplishments that greatly outweigh issues. No significant issues in performance exist. Contractor is meeting performance expectations within expected costs.

LLNS' Environment, Safety, Health, and Quality programs supported mission execution in an effective, efficient, and responsive manner. The explosives safety site plans (ESSP) process continues to mature with six ESSPs completed and approved in FY 2021. LLNS received the NA-50 Award of Excellence for having no reportable injuries in its High-Hazard facilities with an increased operations tempo. LLNS' ES&H programs provided excellent support to the COVID-19 pandemic response. Health Services administered 2,888 COVID-19 tests and 4,718 vaccine doses. Respirator Services personnel conducted a study on N95 filtering facepiece respirators with coronavirus, which was accepted in a peer-reviewed journal. LLNS's Certified Laser Safety Officer authored a chapter in "Laser Safety for Very High-Powered Lasers" in the Manual of Laser Safety; and was selected to serve as General Chair to the 2022 International Laser Safety Conference. Two members of the Laser Safety Program received Director's Institutional Operational Excellence Award for Laser Inventory Database Project. Management should continue its focus on timely development of Corrective Action Plan to improve hazardous energy controls which should also improve Conduct of Operations and Worker Safety and Health programs.

The LLNS Safety Basis Program successfully implemented the safety basis safe harbor standards and requirements and remains compliant with 10CFR830, Subpart B. LLNS was proactive in adjusting to changes of DOE Standards and 10CFR830. A significant number of Conditions of Approval and directed actions in recent submittals exposed the need for improvement in the overall quality of the submittals and timely responses to LFO comments. While LLNS provided an adequate level of detail in Startup Notification Reports (SNR) to justify the type and rigor of proposed Readiness Reviews, the schedules slipped even within 6 months of the projected dates provided in the quarterly SNRs. Continued senior management focus is needed to ensure the dates published for startup events can be met by the laboratory such that they meet mission objectives and allow integration with federal oversight and federal readiness actives. LLNS made progress on several key, nuclear facility improvement projects to replace aging components and increase reliability. LLNS needs to continue focused efforts on qualifying and retaining Level III Cognizant System Engineers. LLNS supported the review panel for the Defense Programs Packing (DPP)-3 consistent with the Statement of Work. The DPP-3 review was productive and on schedule.

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LLNS provided information for the FY 2021 NA-50 Master Asset Plan, which was used to finalize 16 Area Plans and the development of seven additional plans. LLNS successfully executed the biennial NA-50 Deep Dive. The current office space needs at LLNL, presented at the Deep Dive, are being planned and implemented. Infrastructure systems needing upgrades, such as water and sewer, were recognized and prioritized for future repairs. Utility Systems need attention to assure successful growth of the lab in support of its mission. LLNS made significant progress in the demolition of B175 and started the characterization activities at multiple other sites. Additionally, LLNS initiated and supported EM in the removal of LLNL's highest priority process-contaminated facilities to reduce risk, cost, and open footprint for new mission facilities

The Exascale Computing Facility Modernization project met cost and schedule expectations with Critical Decision (CD)-2/3 metrics of CPI=1.0 and SPI= 0.98. The project is 91 percent complete, on budget and on schedule while progressing safely on all work sites. The project successfully completed an annual peer review. The Emergency Operations Center (EOC), part of the NA-1 Enhanced Minor Commercial Standards Pilot, is over 80 percent complete based on cost at the end of the fiscal year and is on cost (CPI=1.01) and ahead of schedule (SPI=1.09). The Digital Infrastructure Capability Enhancement (DICE) project's conceptual design report was completed. The project completed an Independent Cost Estimate and an Independent Project Review prior to the scheduled CD-1 in October.

The LLNS facility maintenance management program exceeded expectations in delivering NA-50's FY2021 Make It Happen List, "Implement SAFER" and "Advance science-based infrastructure stewardship."   LLNS delivered the BUILDER software ahead of schedule and was the first site to include utility data, provided further development and expansion of the Safety, Analytics, Forecasting, Evaluation, and Reporting (SAFER) system to include 120K work orders for four standard maintenance metrics. LLNS achieved a high reliability for all nuclear facility vital safety systems, and successfully removed $31M of deferred maintenance (DM) of which $10.2M were indirect funds. The increasing maintenance work order backlog is of concern, which in August reached 7,000 total work orders for Real Property and Installed Equipment repairs and modifications. The backlog increased at an average rate of 22 percent per year since 2017. LLNS has not implemented the measures needed to reduce and achieve a balanced backlog against its general and operational goals to achieve sustainment. LLNS has not completed a thorough optimization and life-cycle efficiency review of its PM Task Code procedures for many of its Balance of Plant equipment.

LLNS made progress in meeting programmatic goals including shipments of newly generated and older LLW, providing support to D&D projects, disposal of the HOTSPUR legacy neutron target, recovery of radioisotope thermoelectric generators, and meeting STP milestones. LLNS successfully completed all assigned TRU waste shipments to the Waste Isolation Pilot Plant per the approved shipping schedule and successfully achieved 68 percent storage reduction, which are significant accomplishments.

LLNS' progress on sustainability goals is trending in the right direction; however, LLNS has a declining state in its advanced electric metering infrastructure and requested funding to maintain and improve it. Without an effective metering program, LLNS struggles to manage energy use

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and implement energy and water conservation initiatives. Potable water use, while improving, is above the DOE/NNSA goal and is of increasing concern as much of the Livermore area and California remains in exceptional drought.

LLNS received an Excellent, 100 percent, rating from NA-MB Financial Performance, based on its FY 2021 Performance Measures. LLNS delivered efficient, effective, responsible, and transparent financial management operations and systems this period and during FY 2021. LLNS received a rating of pass in all measures. Significant accomplishments were noted for: (i) LLNS supporting NNSA's enhanced indirect rate monitoring process; (ii) voluntary participation in the "Guidance & Best Practices Payment Integrity Working Group" to assist DOE CF-10; and (iii) providing prompt responses to MB-64's requests for FY 2020 and FY 2021 Nuclear Material and Stockpile classified accounting activities that previously could not be completed due to COVID restrictions. Due to large complex procurements, LLNS did not meet its overall small business goals (actual 38.7 percent versus target of 45 percent), was below expectations in its goals for four out of the six socio-economic small business categories (SB, WOSB, HUBZone and SDVOSB), and only exceeded expectations in two small business categories (SDB and VOSB).However, Supply Chain Management (SCM) created a Microstrategy dashboard that will alert the organization of expiring agreements. This will allow SCM reach out proactively to requesters and engage in discussions early in the acquisition planning process. Supply Chain's Strategic Sourcing savings were $50,134,000 and achieved a 6.36 percent savings versus the target of 4 percent against a total invoice spend of $788.2 million.

LLNS effectively collaborated and responded to NNSA on multiple data calls, COVID-19 cost reports, accepted, and implemented unilaterally issued contract modifications related to the COVID-19 pandemic without delay and supported the NSE Recruitment/Workforce Strategy Group and participated in joint hiring events. While demonstrating sound agility throughout FY 2021, LLNS was recognized for being one of the "Best" places to work in 2021. In support of Key Outcome 5.5, LLNS was not timely in communicating formally to NNSA of its delays for its Technical Science Managers, Job Description, and Performance Management projects. LLNS did not meet the original FY 2021 due dates and requested an extension into FY 2022. Leadership is fully engaged and committed to project success.

LLNL's Office of General Counsel (OGC) exercised sound judgment and effectively represented LLNL in challenging legal matters. OGC's effective advocacy quickly resolved an employment lawsuit and employment arbitration. OGC successfully navigated through complex issues presented by the COVID-19 pandemic including establishing the legal framework for robust testing and vaccination administration.

LLNS exceeded expectations in cybersecurity despite a maximum telework posture due to the COVID-19 pandemic. LLNS swiftly responded to a US Government-wide supply chain cybersecurity incident and performed detailed follow up actions to rebuild affected infrastructure. LLNS developed and supported enterprise capabilities in classified computing and centralized enterprise identity management. Emphasis on cybersecurity at the Principal Associate Directorates (PAD) level increased at LLNL, with a prime example of the activities at the National Ignition Facility & Photon Science PAD providing increased segmentation and software analysis. LLNS led research into technologies through Cybersecurity Center of Excellence

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(COE) activities. LLNS participated in a Cyber Command Readiness Inspection of its National Security Network connected system with a score of 99 percent.

LLNS successfully delivered effective, efficient, and responsive safeguards and security. LLNS also noted some security continuous improvements. LLNS established three new Strategic Rollup Zones and reconfigured entry points requiring the installation and validation of critical protection system elements, reconfiguring, and updating databases, additional training, and asset categorization and important risk assessment activities in support of planning documentation. LLNS was slow to resolve some significant and long-standing deficiencies identified during an assessment within the Materials Control & Accountability Program.

The final milestone for implementing the revised mobile device policy (MDP) was completed on schedule. Effectiveness of the new rules is managed and reported through the LLNL's Security Incident Report Office (SIRO). With the implementation, LLNS anticipated a rise in the number of correlated security incidents. Although LLNS's three-strike policy was effective, approximately 36 percent of reportable security incidents were directly related to the implementation of the MDP. LLNS communicated security reminders to the Laboratory population and remains vigilant with workgroups being implemented between SIRO, Security Awareness, Directorate Security Officers, and the Management Assurance Office to track, trend, and collaborate on reducing security incidents. LFO will closely monitor the types and context of security incidents as well as incident reporting.

The TESA upgrade project continues to progress with locks being integrated with the wireless system. LLNS upgraded its Central Alarm Station, completed construction of the Site 300 Range Classroom within budget, and completed the Lifecycle Replacement of KIOSK West Gate Drive on schedule and under budget.

LLNS did an excellent job executing the FY2021 Technical Interchange Meeting virtually, where the Enterprise gained a wealth of knowledge with LLNS's Argus achievements. LLNS presented a video which outlined its responsibilities in the Caerus development. The concept was validated, which included rebranding the UMG to the universal data exchange (UDX). Using the UDX/UMG, it was determined that there is a future ability to transition from the Virtual Memory System servers deployed in the field.

LLNS effectively managed its emergency management personnel, resources, and emerging work activities under COVID-19 work controls and a maximum telework posture to assure an acceptable level of readiness and response. LLNS maintained a qualified and proficient Emergency Response Organization by developing and implementing a virtual platform for both training and drills/exercises. Eleven drills and an annual exercise were completed virtually, indicating LLNS can capably provide situational awareness and a common operating picture to response organizations and decision-makers, and demonstrated a virtual capability is possible when the site and/or its response facilities may be unavailable or inaccessible.

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> ## Goal 6: Mission Leadership
> ## LLNS Total Fee Allocation: $8,247,299

LLNS earned a rating of Very Good and 89 percent of the award fee allocated to this Goal. Despite the impact of COVID-19, LLNS exceeded many of the Objectives and Key Outcomes and meeting the overall cost, schedule, and technical performance requirements with many accomplishments that significantly outweigh very minor issues. No significant issues in performance exist. Contractor is meeting performance expectations within expected costs.

LLNS responded to the new national emphasis on accelerating production and certification/qualification timelines. LLNS leadership supported and executed effective partnerships with the production sites. These partnerships will enable them to respond to future requirements in a timely manner for HE fabrication and case production, and to broaden pit reuse options for response to emerging needs. LLNS established beneficial occupancy of the Polymer enclave and has begun executing programmatic work working closely with KCNSC. The Cold Hearth Melter is installed at Y-12 instead of LLNL to expedite progress towards making actual parts. LLNL is working closely with Pantex on an HE enclave, the Explosive Materials Design and Engineering Center (EMDEC). Site 300 and Pantex will have identical capability, with HE additive manufacturing machines running in parallel. LLNS developed alternate approaches to support flight tests at Regan Test Site for the W87. LLNS maintained leadership and strong interactions across the Nuclear Security Enterprise within Weapons Technology Development, and this includes participation with the United States/United Kingdom Ministry of Defence for a strategic collaboration, the Joint Technology Demonstrator Program.

LLNS demonstrated excellent collaboration through activities and deliverables that provided tangible benefits to reducing the risk of meeting Goal 1 requirements. LLNS is committed to addressing long standing challenges associated with Plutonium Aging and addressing challenges related to sample throughput, as demonstrated by the stand-up of Strategic Roll-up Zones within the Superblock. LLNS was also a significant contributor to developing a program plan on plutonium and pit aging for Congressional stakeholders. LLNS provided enterprise-wide leadership in weapons digital architecture and crafted an enterprise approach to evolve the NNSA's Digital Engineering capabilities. LLNS facilitated the Enterprise Capability Analysis Toolset module development under the pilot phase (part of Defense Programs Integrated Modeling and Analysis initiative) by providing key feedback on envisioned model output formats. LLNS supported the NNSA's Enduring Organizational Improvement Initiative Team of Teams with multiple employees leading cross-complex sub-teams in the areas of Adapting Training, Information Technology Capability and Capacity, and Risk Management.

LLNS leadership acted promptly and decisively in the continued response to the COVID-19 pandemic in coordination with senior NNSA leadership on safety protocols, lessons learned, overall best practices, and a return to the new normal. LLNS placed significant effort on establishing COVID testing capability and secured the required testing certification, bringing capability on-line in December 2020. The onsite Capability for the Return of the Offsite Workforce testing lab is now able to administer 100 tests per day and can offer 100 more per day if needed. Additionally, LLNS planned for, requested, and received approval from the State of California to dispense both Moderna and Pfizer vaccines. LLNS administered approximately

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4,780 vaccines and 2,920 COVID-19 tests.

LLNS demonstrated strong leadership in research activities to address a broad range of scientific challenges associated with COVID-19 medical treatments and response options. LLNS leadership coordinated world-class research infrastructure, unique research capabilities, and a dedicated team of scientists and engineers to support the fight against the COVID-19 pandemic. LLNS and the United Kingdom's ConserV Bioscience Limited collaborated on the development of a broad-spectrum or "universal" coronavirus vaccine. The collaboration takes advantage of LLNL expertise in nanolipoprotein delivery systems and focuses on a vaccine designed to provide broad-spectrum protection against coronavirus pathogens of human and animal origin, including but not limited to MERS, SARS, and SARS-CoV-2.

LLNS leadership and the Center of Global Security Research provided strong multidisciplinary support to national leadership for the Nuclear Posture Review and prepared and implemented the "integrated deterrence review". LLNS leadership continued the development of program-specific Strategic Plans, including the Weapons and Complex Integration Strategic Framework and further work in the NIF and Photon Science and Global Security program areas. LLNS leadership took a major step in unifying these organizations through synergistic ties and changing the culture to that of a fully integrated program that ensures LLNL is aligned with future national challenges and priorities. Decades-long, highly focused planning and continuous leadership led to a NIF shot yielding output, close to the threshold of ignition.

LLNS continued to demonstrate performance results through effective utilization of and improvements to the Site Governance System, including streamlining the governance structure. Effectiveness of the Contractor Assurance System (CAS) was validated through critical and independent self-assessments using the best in class Integrated Health of the Program (IHOP) process. Improvements in the implementation of requirements management are necessary and was self-identified as an area for improvement. LLNS also identified the need for additional staffing across most functional areas. LLNS made improvements in post-event communication, however improvement is needed in the documentation of site-reportable events and the timely completion of fact findings. LLNS has demonstrated significant process improvement by establishing new key performance indicators (KPIs) for several CAS elements to gauge the overall health and long-term performance of the CAS. LLNS effectively implemented a process to identify and communicate to leadership mitigative actions for under-performing KPIs.

LLNS participated in the NNSA Enhanced Minor Construction and Commercial Practices pilot and is on pace to be the first to complete its project, a new Emergency Operations Center. LLNS contributed four designs to the Standardized Acquisition and Recapitalization (STAR) design library. STAR's goal is to increase buying power and accelerate the delivery of offices, light laboratories, and parking facilities by reusing successful designs owned by NNSA from the design library.

LLNS' overall working environment continues to be positive as shown by a recent Glassdoor Employees' Choice Award (third year in a row), recognizing the laboratory as one of best places to work at and #23 nationwide in 2021. LLNS leadership continued to address the results of a Culture Survey with leadership led town hall discussions with staff and conducted more than 100

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Diversity, Equity, and Inclusion (DEI) workshops with over 3,000 staff.   These discussions provided leadership valuable feedback to improve the workplace moving forward. Past actions have included: senior management presentations on specific issues revealed by the Survey, the creation of a Military/Veteran website to further the diversity of the workforce with former military personnel; the utilization of the DEI "dashboard" to measure performance in attracting, retaining, and advancing a thriving workforce; and the retention of a professional minority recruiting service to work on bringing staff demographics in line with the community.

LLNS' demonstrated cooperation and partnership in planning for and paying the NNSA bill to UC for the settlement of the Requa litigation.

LLNS did not meet all W87-1 FY 2021 needed scope and deliverables. LLNS's risk management program is slowly maturing compared to Federal Program Office expectations and other W87-1 sites; LLNS was late in hiring a W87-1 risk program manager as a result of COVID but is actively working on hiring; LLNS did not meet all required deliverables for WDCR execution including key schedule and schedule supporting information, work breakdown structure input, and risk mitigation plans. If all of the WDCR deliverables are not received as needed and planned from LLNL, it will increase the risk that not all the scope, schedule and funding is in the W87-1 baseline, which creates a higher likelihood that the W87-1 WDCR and associated program plans will not be executable within the time established or funding requested.

Schedules are starting to slip on the W80-4 and W87-1 program deliverables. Continued leadership focus is needed to address ongoing technical staffing shortages.