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Engineering Services in a Mission Critical Environment: Engineering Services – Science and Technology Operations' Infrastructure Support at Los Alamos National Laboratory

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Engineering Services in a Mission Critical Environment: Engineering Services – Science and Technology Operations' Infrastructure Support at Los Alamos National Laboratory

by

Evan Alexander Bly

Report

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science in Engineering

The University of Texas at Austin

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Dedication

To Gloria,

Your unwavering love, support, and encouragement have been a constant source of strength throughout this journey. You have been my anchor, offering patience and understanding when I needed it most. Thank you for always believing in me.

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I would like to convey my genuine thanks to my advisor and supervisor of this report, Dr. Sheldon Landsberger. His support and trust in me have helped me culminate my tenure as a student with this research. He has been a faithful ally in my studies and has always pushed me towards excellence.

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Abstract

Engineering Services in a Mission Critical Environment: Engineering Services – Science and Technology Operations' Infrastructure Support at Los Alamos National Laboratory

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The University of Texas at Austin, 2025

Supervisor: Sheldon Landsberger

As an engineering team within a facilities-driven organization, Engineering Services – Science and Technology Operations (ES-STO), supports Los Alamos National Laboratory (LANL), playing a pivotal role in the U.S. nuclear stockpile mission. This report outlines ES-STO's contributions through the installation of crucial systems such as HVAC units, compressors, and scientific specialty equipment, as well as providing expert consultation to optimize laboratory operations. ES-STO's goal is to ensure that LANL's infrastructure and research facilities are aligned with mission-critical needs, supporting both operational efficiency and safety in the nuclear stockpile management and maintenance. This report discusses the installation processes, ongoing consultations, and the significant impact of our efforts on national security objectives.

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Chapter I: Introduction

The nuclear stockpile mission of the United States is a critical element of the nation’s national security strategy, ensuring the maintenance and readiness of the nation's nuclear deterrent. The primary objective of this mission is to sustain a safe, secure, and effective nuclear arsenal, capable of deterring adversaries and responding to potential nuclear threats. It is a vital component of the U.S. defense posture, serving as both a strategic deterrent and a safeguard against nuclear proliferation.

The management and stewardship of the nuclear stockpile are entrusted to the Department of Energy (DOE), with the national laboratories – Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), and Sandia National Laboratories (SNL) – playing a pivotal role. These laboratories are responsible for conducting the scientific research and technical work necessary to ensure the continued safety, security, and effectiveness of the nation's nuclear arsenal. They also lead efforts in nuclear weapons science, materials analysis, and the development of advanced technologies to sustain and modernize the stockpile without the need for nuclear testing. Through their expertise, these national laboratories contribute significantly to maintaining the credibility of the U.S. nuclear deterrent while ensuring compliance with international nonproliferation agreements.

The U.S. nuclear stockpile mission encompasses a broad range of activities, including the modernization of existing nuclear warheads, ensuring the reliability and safety of the stockpile without the need for nuclear testing, and maintaining the capability to quickly replace or repair warheads if required. This mission is integral to the nation's defense strategy, requiring continuous innovation, rigorous testing, and close collaboration between government agencies, national laboratories, and the military to ensure the security and effectiveness of the nuclear deterrent.

The aforementioned Los Alamos National Laboratory (LANL) is one of the main branches and an original establishment for the development and stewardship of the nation's nuclear stockpile. LANL's scientific and operational strengths are vital for managing the risks we currently face. As the global environment changes, the Laboratory must be ready to meet new challenges while delivering on current programs and deliverables. LANL is committed to partnerships with the National Nuclear Security Agency (NNSA), Department of Energy (DOE), Department of Defense, Congress, and other institutions central to its mission.

"LANL uses a comprehensive framework – the Laboratory Agenda – that is aligned with DOE/NNSA strategies and ties the Laboratory's long-term strategic intent to actionable, near-term milestones with institutional or cross-organizational impacts.

Figure I-1 LANL Lab Agenda (Triad, 2025)

The Laboratory Agenda (Figure I-1) is updated annually by the Leadership Team (LT), consisting of the Laboratory Director's Office and the Associate Laboratory Directors. The LT identifies action leaders who coordinate the implementation of each Critical Outcome and report progress to the LT throughout the year.

The Laboratory Agenda communicates institutional priorities that require additional near-term attention and focus, thereby informing decisions at all levels – ranging from institutional investments to organizational strategies to individual performance goals. In parallel, long-term investments in Capability Pillars advance high quality R&D and maintain continued strength in the scientific capabilities underlying all LANL missions. The strategic objectives outlined by LANL are nuclear deterrence, threat reduction, technical leadership and trustworthy relationships, respectively defined as:

- Nuclear Deterrence: Lead the nation in evaluating, developing, and ensuring effectiveness of our nuclear deterrent, including the design, production, and certification of current and future nuclear weapons.
- Threat Reduction: Anticipate persistent and emerging threats to global security; develop and deploy revolutionary tools to detect, deter, and respond proactively.
- Technical Leadership: Deliver scientific discoveries and technical breakthroughs to advance relevant research frontiers and anticipate emerging national security risks.
- Trustworthy Relationships: Consistently demonstrate and be recognized by diverse stakeholders for trusted and trustworthy operations." (Triad, 2025)

Within the framework mentioned by LANL, the national laboratory hierarchy continues to be broken down further from the level of the Leadership Team into Associate Laboratory Directors (ALD) and their respective directorates, which in turn house divisions to serve different aspects of LANL's agenda and missions. The Facilities and Operations Directorate (ALDFO) oversees Operations Support and Nuclear Safety which in turn contain the divisions of Science and Technology Operations (STO) and Engineering Services (ES). This report goes into detail on the support of the nuclear stockpile mission at LANL as it pertains to these two divisions.

Engineering Services – Science and Technology Operations (ES-STO) provides a myriad of supporting capabilities to ensure that 20 divisions and 59 groups within the hierarchy of LANL all meet their mission objectives in the overall support of LANL's Lab Agenda and strategic objectives. This group within ES and deployed to serve STO is utilized for facility planning, cutting-edge design, technical project management, drafting, and administrative and project support.

The aim of this report is to provide insight into the depths of which the nuclear stockpile mission runs across Los Alamos National Laboratory, showing that mission support is widespread throughout organizations and projects which may not seem interconnected at first glance. By explaining the roles and responsibilities of ES and STO divisions, reviewing the processes implemented and in refinement within ES-STO, exhibiting examples of projects executed in support of the strategic missions, and discussion of these projects and their impact to the nuclear stockpile mission, it will be made obvious the impact of the assorted groups on LANL's mission objectives. This report seeks to provide the often-overlooked importance of ongoing collaboration and the role of engineering in supporting national security objectives. (Triad, 2025)

Chapter II: Description of Organizations

The Facilities and Operations Directorate (ALDFO) is the branch of the Leadership Team (LT) of LANL which governs Operations Support and Nuclear Safety through various groups and divisions. Within ALDFO are the divisions of Engineering Services (ES), and Science and Technology Operations (STO), which are individually tasked with separate mission objectives, while simultaneously collaborating to maintain the facilities within STO, allowing scientists and researchers to meet their goals and objectives year over year.

Engineering Services is a division comprised of approximately 650 dedicated professionals offering a comprehensive suite of services, including facility planning, cutting-edge design, technical project management, drafting, and administrative and project support. ES prides itself on its approach focused on collaboration, ensuring that they strike the perfect equilibrium between scope, schedule, and budget to exceed the clients' (scientists, researchers, facility operators, and management) expectations and return a quality result every time. The members of the division bring a wealth of knowledge, skills, experience, and an unwavering commitment to customer satisfaction to every project. The tenets of the engineering leadership team are to support LANL projects in an innovative, effective, and customer-focused manner. ES has a dedicated focus on a strong safety culture and strict compliance with government security standards.

Science & Technology Operations division ensures customers succeed with deliverables, while maintaining a safe facility environment. They improve processes, build relationships, and better understand scope, deliverables and programmatic changes. STO is one of the largest facility operations directorates (FOD) at LANL and they oversee 2.2 million square feet of facilities where low to moderate hazard scientific work is performed. The Technical Areas (TA) they cover include a large portion of TA 03, and TA's 33, 36, 46, 48, 57, 59, and 66. For these areas STO manages all maintenance, construction, and operations. There are at least 250 buildings across 23+ Technical Areas and 8+ campuses within the footprint of STO on the LANL Campus. STO's skilled workforce encompasses engineering, material handling, facility maintenance, equipment operation, and various non-technical roles in support of nuclear deterrence, threat reduction, technical leadership, and the establishment and maintenance of trustworthy relationships with the citizenry of the United States and collaborating government agencies.

Engineering Services – Science and Technology Operations (ES-STO) is the meeting of the two aforementioned divisions within one group. ES-STO supports 10+ divisions and 30+ groups providing necessary services to maintain, repair, modify, and design facilities in support of the interests, research, mission objectives, and deliverable schedules for the customers residing in and utilizing STO facilities. ES-STO makes use of the breadth of knowledge gained through years of experience and collaborative efforts alongside engineering professionals including disciplines of Mechanical, Electrical, Structural, Instrumentation and Controls, Fire Protection, Architectural, Civil, and Nuclear Engineering to assist customers – both the facility operations team and the scientist and researcher teams – with assessments, scoping, budgeting, troubleshooting, repairs/replacement/modification/design, and technical support to ensure engineering specifications and codes are compliant, effective, and efficient. (Triad, 2025)

Chapter III: High-Level Description of Customer Organizations

As previously stated, ES-STO supports more than 10 divisions and 30 groups across the STO footprint. Among these are the Associate Laboratory Directorates (ALD) of Chemical, Earth & Life Sciences (ALDCELS), Physical Sciences (ALDPS), Global Security (ALDGS), and Weapons (ALDW). Within these ALDs, the most consistent customers served by ES-STO in association with the strategic nuclear missions of LANL are:

- C – Chemistry
- ISR – Intelligence and Space Research
- MPA – Materials Physics and Applications
- MST – Materials Science and Technology
- NEN – Nuclear Engineering and Nonproliferation
- PF – Prototype Fabrication
- PT – Pit Technologies
- SIGMA

Across these divisions are projects and research including:

- Chemical and radiochemical purification of single elements
- Novel methods for measuring purified radioisotopes and stable elements

- Work with samples across a wide range of activity levels, from non-radioactive samples through tracer activities to irradiated actinide target materials.
- Health physics and bioassay
- Manufacturing, production, fabrication, and finishing
- Non-proliferation and deterrence
- Prototype fabrication
- Nuclear forensics
- Fate and transport of radioactive isotopes
- Intelligence and space research
- Nuclear detonation detection technology
- Stewardship of the US nuclear weapons deterrent
- Nuclear deterrence and nonproliferation
- Material science
- Quantum research and technology
- Modeling and simulation
- Material synthesis, processing, properties, and performance
- Weapons material performance
- Research, development, component manufacturing
- Global threat reduction
- High-precision and complex machining and processing
- Fundamental science of plutonium in molten salt environments for application in actinide separations in support of LANL's production goals

- Delivering top-quality plutonium pit-related products and services
- Maintaining and enhancing the performance of nuclear components
- Surveilling pits in the stockpile stewardship program

To successfully carry out these intricate and resource-demanding objectives, one crucial but oft overlooked component must be acknowledged: the role of system engineering and facility management. System engineering, which is frequently sidelined in discussions about cutting-edge scientific initiatives, serves as the backbone that supports the sophisticated equipment, advanced computational methods, and highly specialized scientific endeavors involved in these complex tasks run by LANL's various ALDs. This multifaceted discipline ensures that all components work seamlessly together, creating a robust infrastructure that underpins the success of these operations. It's in this space that the essential contributions of ES-STO come into play, providing the critical support needed to drive forward LANL's nuclear strategic objectives. These objectives, which are foundational to national security and scientific advancement, rely heavily on system engineering to maintain the functionality, efficiency, and safety of the complex systems that make these ambitious goals achievable.

Chapter IV: Project Workflow and Scope of Work

With a solid understanding of the Los Alamos National Laboratory, along with the organizational components such as the Associate Laboratory Directorates (ALDs), Engineering Services (ES), Science and Technology Operations (STO), and the integrated role of Engineering Services – Science and Technology Operation (ES-STO), we can now explore how ES-STO effectively supports its customer base. These customers often face the challenge of balancing competing resources while striving to meet the specific requirements outlined in their deliverables. In this context, ES-STO plays a pivotal role in ensuring that these diverse demands are addressed with efficiency and precision. Furthermore, the support provided must be aligned with the stringent codes, standards, and regulations imposed by a variety of governing bodies, including the Department of Energy (DOE), the National Nuclear Security Administration (NNSA), LANL itself, as well as state and federal requirements. The intersection of these factors—customer needs, resource management, and compliance with complex regulatory frameworks—requires a delicate balance that ES-STO is uniquely equipped to manage, ensuring that all objectives are met in a timely and compliant manner.

The genesis of any project internal to LANL and STO is the STO Project Execution Workflow (Figure IV-1) and the identification of a gap in resources, capabilities, or efficiency. These are key factors in the selection of additional programmatically funded scientific and research equipment, or the improvement or repair of facility equipment as demand increases or scope changes within the facility. This in turn, leads to a need for improvements or new initiatives. Identifying these problems early on is key to making sure the project addresses fundamental needs and contributes to the facility's overall goals.

Once the need for the project has been identified, the customer – which can be a tenant of the facility or the facility owner themselves – requests and creates a Facility Service Request (FSR). This request is processed alongside thousands of other requests within a ticketing system, tracking the progress, cost codes, assignment, and associated

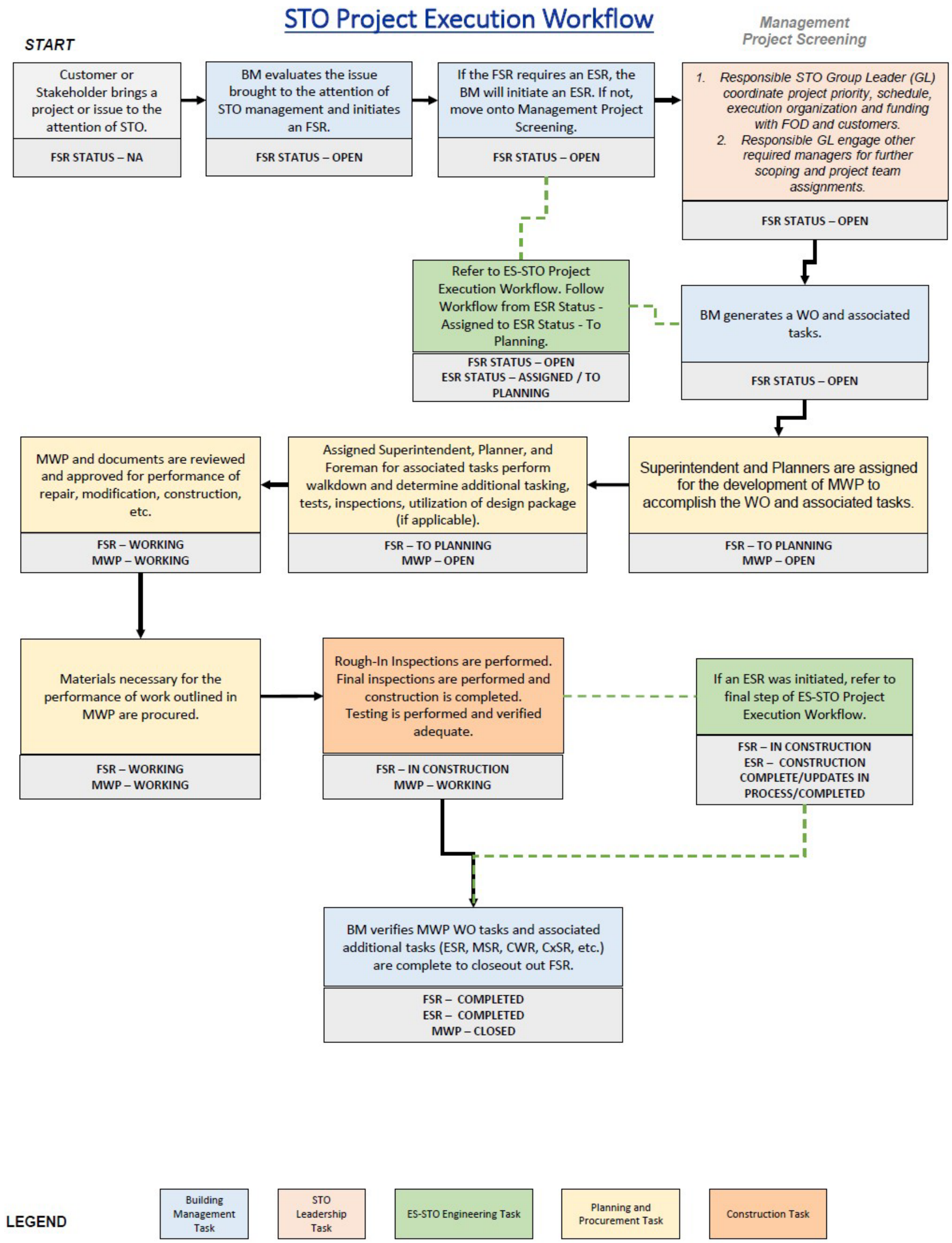

Figure IV-1: STO Project Execution Workflow Diagram tasks necessary for the FSR to succeed.

Based on the complexity of the FSR and Engineering Service Request (ESR) can be initiated. ESRs are often requested when the customer and facility owner are unsure of how to go about accomplishing the goal, are familiar with the complexity of the issue and know that the project requires engineering deliverables, or if the craft assigned to the project believe the request is outside of the "skill of the craft" and require engineering guidance in order to perform the work tasked by the FSR. At this stage, the ES-STO Project Execution Workflow (Figure IV-2) comes into play and the engineering management team of ES-STO is assigned to both the FSR and associated ESR. For continuity and ease of tracking throughout this report, we will refer to this line of questioning and requests as FSR-EAB4385 and ESR-EAB4385, with any additional tasks or documents produced as a result bearing the same suffix number formatting of -EAB4385.

At the onset of an ESR, ES-STO management is assigned to the ESR for disposition and assignment to team members to begin the engineering process outline by the Engineering Standards Manual (ESM) at LANL. It is at this stage that the engineering management team can determine that an FSR is within the skill of the craft and available for consultation if necessary, that the project is appropriate for engineering disposition internal to LANL, or that the engineering request is too great to be handled by the internal engineering resources offered and that the request must be bid out for contract by an Architectural and Engineering Firm.

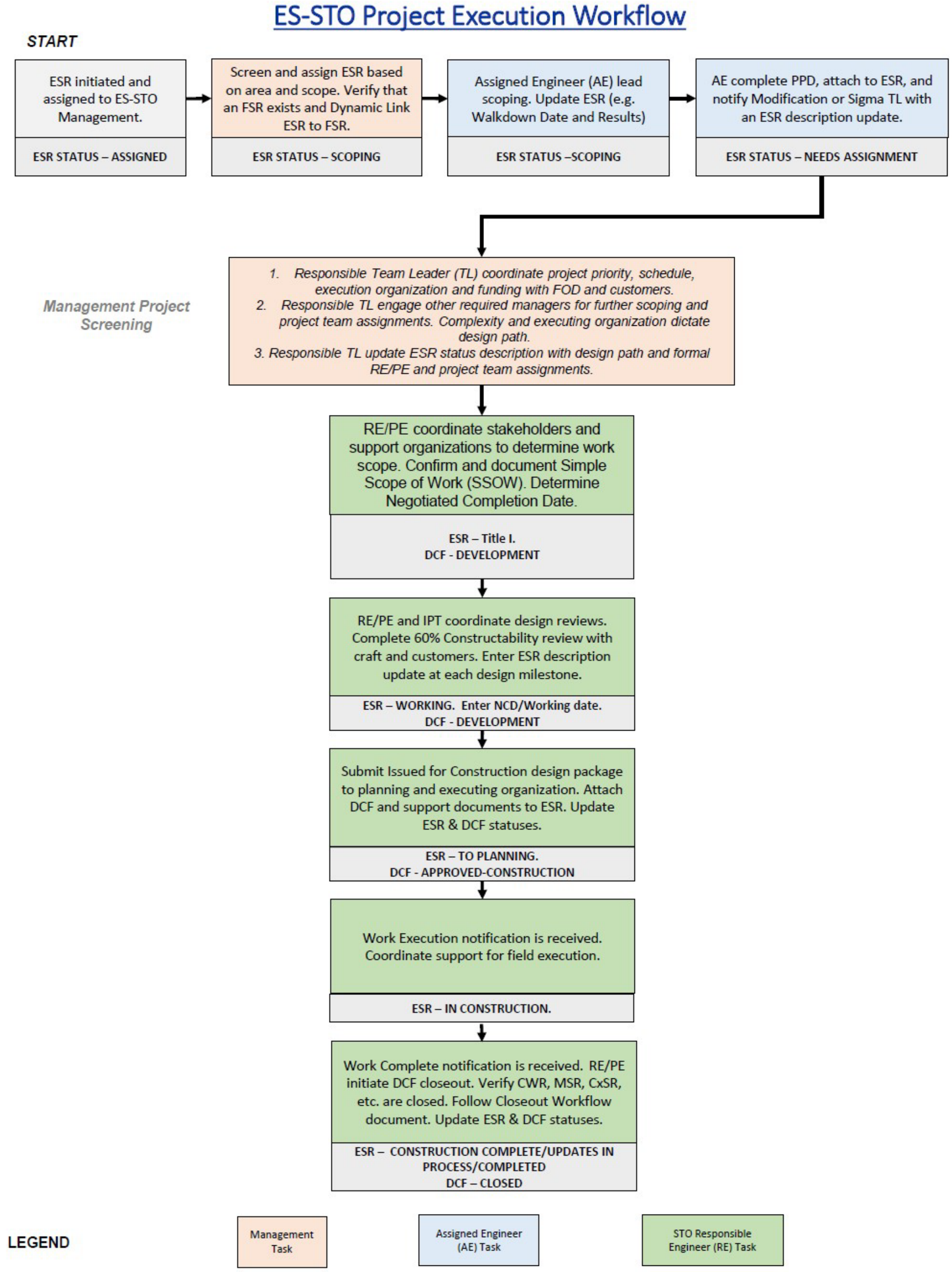

Figure IV-2: ES-STO Project Execution Workflow Diagram

Assuming that FSR-EAB4385 and ESR-EAB4385 are within the capability of the engineering team at ES-STO and require engineering output documentation for repair, replacement, or new construction, the engineering Group Leader (GL) will assign the project to the appropriate System Engineer (SE) and their respective Deputy Group Lead (DGL). *For the purposes of this report, Deputy Group Lead (DGL) and Team Lead (TL) are interchangeable terms and serve the same function within the hierarchy of the ES-STO management structure.* If the engineering team at ES-STO would not have the capability to produce engineering outputs for the required project or that the project is considered capital by the DOE, then the project would be contracted and bid for by a design and build agency. This report will not cover the nuances required of this path as it does not pertain to the personnel involved in ES-STO.

At this stage, ESR-EAB4385 would enter a status delineated as "Scoping." In the Scoping phase of the project, an assigned engineer (AE) from the system engineering team familiar with the facilities and systems housed therein will conduct a walkdown. The walkdown consists of a formal meeting onsite for the project that has been proposed to discuss with stakeholders what will be involved in the project and the goal that the customer has in mind. From this, the assigned engineer will create a Preliminary Project Determination form (PPD) which will succinctly inform the Facility Design Authority Representative (FDAR – often the group leader for ES-STO) of the requirements and affected systems that this design will entail. The PPD also will inform the ES-STO management team of the resources from the group needed and how to allocate these resources. Once the PPD has been completed by the AE, the PPD will be updated into the

ESR tracking system and the status of the ESR will be updated to "Needs Assignment." The PPD is then linked to the respective ESR identification number (in this case, ESR-EAB4835), which would also be dynamically linked to the corresponding FSR.

Upon notification of the completed PPD via the ESR status update to "Needs Assignment," the DGLs of ES-STO would convene with the Respective Group Leader for STO-FOD on the priority of the FOD project or if it is for a programmatic customer, then this would be addressed via the leadership team of the respective ALD requesting this work. Based upon the priority level and resource availability, the DGLs will determine amongst themselves which team is best suited for the work. For the sake of this report, we will assume that ESR-EAB4385 is the utmost priority for STO-FOD and a programmatic customer, ALDPS. As a result of this high need, resources may be shuffled to accommodate the pressing needs of the project, relegating other projects to a lower priority status. Based on discussions amongst the ALDPS, STO-FOD, and ES-STO leadership, an initial timeline and cost estimate threshold will be set.

After the decision has been made for which DGL's team will be assigned, the workload of the members across the team is reviewed and assignments are made. These assignments are based on a multitude of factors but typically boil down to relative experience and expertise in the disciplines required to execute the project effectively and efficiently as well as current workload and at which stage current assignments are at within their design and execution phases. Project and design engineers within ES-STO routinely have five or more projects with anywhere from one to all five of the projects being priority items across STO-FOD and the ALDs served by STO-FOD. For the purposed of this report, we will assume that Mechanical, Electrical, Controls, and Structural engineering are all required to execute ESR-EAB4385. As a result, the DGL of these engineers will make the ESR update for ESR-EAB4385 that the project will be moved to "Title I" status, assignments have been made, what those assignments are and their respective responsibilities, as well as the anticipated timeline and support required to execute the design phase of the project.

For ESR-EAB4385, assume that the senior mechanical engineer assigned to design this priority project will act as the Responsible Engineer. This title is often synonymous with the role of a Project Engineer with the exception that the Responsible Engineer leads and drives the project, as well as designing some aspects of the project. When assignments are made for a design within ES-STO, there are always two engineers of each discipline to ensure that design and review of the design are performed independently. As with most high-fidelity efforts within the STEM field, a senior engineer is often the reviewer for the design effort, ensuring that the highest probability is attained for errors to be caught and lessons learned to be applied within the design to match with codes and standards employed by the more junior designer.

At the "Title I" phase of Appendix B, additional terms are introduced into the flow chart, such as SOW (Scope of Work), DCF (Design Change Form), and NCD (Negotiated Completion Date). The Responsible Engineer will coordinate all members of the assigned design team and the greater integrated project team (IPT) for an additional and more comprehensive scoping walkdown than what was performed by the AE. At this scoping walkdown, all necessary disciplines are present along with various independent groups, such as Industrial Hygiene (IH), Radiological Controls Technicians (RCT), members of craft (electricians, pipefitters, carpenters, refrigerant fitters, riggers, etc.), and the stakeholders of the project). With this larger walkdown performed, the design team will draft a SOW encompassing a brief overview of the project, scope for each discipline involved in the design, assumptions made for the project, a timeline for design deliverables, the anticipated cost breakdown of the design, disclosure statements about potential additional costs from outside organizations, and finally signature blocks for the system engineer, the customer, an operations manager, and the ES-STO DGL that oversees the building or area where this project will take place.

The design deliverables mentioned for the SOW document often include formal dates set for design reviews at the following milestones: Equipment Review and Verification, 30%, 60%, 90%, and 100%. This design package will come as a Design Change Form (DCF) which contains various procedurally developed steps for a design to take place and captures all necessary data for design inputs, outputs, and closeout of the design package. This document can include work instructions and/or drawing packages. The Negotiated Completion Date is the agreed upon date of delivery of the signed design package for planning and execution by the superintendents, foreman, and craft to build the design and bring it to fruition for the customer(s) and stakeholder(s). The DCF is signed by the reviewers for each discipline, any outside organization involved (such as IH or RCTs), the building manager from STO-FOD that represents the area or building where the project is to be executed, the responsible engineer, and the FDAR for ES-STO.

Once the SOW has been signed by all parties, the project will be moved to a "Working" status and the design will commence. At the 60% milestone for design review, a constructability review is conducted in the field along with the preliminary design package. This is a key step in the design process which allows the engineering design team to receive invaluable feedback and input from outside organizations along with the planning and execution teams on the ability to execute the design in the field. Are there changes that need to be made to the design based on component and material availability? Is the design achievable with the resources available? Are there issues with maintenance and clearances necessary to operate the equipment? Are there factors unaccounted for or not captured on original drawings of the facility which might impact the design? Has anything since the onset of the design and scoping walkdown changed which will impact the direction of the design? These questions are important to catch as early as possible in the design to avoid unnecessary rework as well as communicating the intent of the design team well before construction will be taking place.

The completion of the constructability review often coincides with a smooth transition to the completion of the design package and issuance of the DCF and associated input/output documents to the work planning and execution organization. For the sake of simplicity, we will assume that ESR-EAB4385 had no major comments or revisions. If either of these aspects took place within the design review process, then the project NCD would be adjusted to allow for additional time to make these design adjustments. This would often be met with a return to an earlier stage in the project to avoid a lack of formal review in the redesign of the project. At this stage, ESR-EAB4385 will be updated to a status of “To Planning” and we swiftly return to Appendix A to continue with the planning and execution phases of the project process.

Once ESR-EAB4385 is update to a “To Planning” status, the Building Manager (BM) for the project would begin on the Work Order (WO) which will be formally assigned to the Superintendent that oversees the area where the work will be taking place for FSR-EAB4385. FSR-EAB4385 would then be updated to a “To Planning” status, matching the respective ESR. The Superintendent will then allocate a planner for the project to be developed into a Mobile Work Package (MWP) via the WO system. This will clearly delineate all execution, safety, and briefing documents necessary for the various members of craft to perform the work. With the MWP developed, Foreman will be assigned to the WO and a task will be created for each discipline of the craft personnel required. For instance, WO#EAB4385-01 would be assigned to pipefitters, while WO#EAB4385-02 would be assigned to electricians, and so on and so forth for all required disciplines to execute, build, test, and inspect the design in the field. Many documents associated with planning, procurement, and execution of work within LANL’s structure and hierarchy are proprietary and will therefore be simplified for the remainder of the report.

With the Work Orders open, the superintendent, planner, and foreman will meet for a planning and execution walkdown to determine tasks, inspections, testing, and utilization of the design package. In this phase, the PE/RE is often invited for clarification of any questions which may arise while reviewing the design package with the formally assigned planning and execution teams. From this stage, approval will be acquired by the superintendent to begin work on the design construction for FSR-

EAB4385/WO#EAB4385 and the MWP and FSR statuses will both be updated to "Working." Once in a "Working" status, procurement of all necessary material will occur and resources for the craft will be scheduled appropriately based on timeline for the execution and material procurement. Throughout the construction effort there will be various inspections and tests required per national, state, and federal codes, standards, and regulations, will be called out and performed via documentation in MWP or the DCF. This portion of the construction and execution phase is summarized within Appendix A as: "Rough-In Inspections are performed. Final inspections are performed, and construction is completed. Testing is performed and verified adequate."

It is at this stage in the project's lifetime that the execution and construction will be deemed complete, thus beginning the cascading process to closeout and verify complete all associated tasks and documents associated with FSR-EAB4385, ESR-EAB4385, and WO#EAB4385. All parties associated with the design, planning, construction, testing, and inspection of the project will be informed and assigned to closeout their various projects. As this report centers on ES-STO, the engineering closeout process will be the focus of this report. As previously mentioned, the DCF is a procedural document and it also contains a clearly defined and laid out process to closeout the design document and capture what occurred in the construction, testing, and inspection phases of the project. The closeout section of the DCF includes, but is not limited to capture and record keeping of:

- The work order which the design was performed under.
- All testing and inspection documents associated with construction.

- Changes to or as-built drawings of the design as it was performed in the field.
- Maintenance for the system(s) installed.
- Updates into LANL's electronic database system.

Once this information is verified complete, the respective parties will feed their information back to the SE, RE, and BM for the project at which time the ESR, WO, and FSR will be closed along with any other processes necessary to facilitate this project.

Chapter V: Description of Individual Projects with an in Support of Nuclear Aspects and Missions

With a firm understanding of the Project Workflow and Scope of Work employed by STO-FOD, ES-STO, and LANL, it is now time to showcase how STO and ES-STO support the U.S. nuclear stockpile mission.

I. CHILLERS, HVAC, AND BOILER SYSTEMS

Heating and cooling challenges are often overlooked when locations are determined within the limited space available across LANL property. Projects often require specific temperature bands to be maintained year-round, regardless of harsh weather conditions and seasonal challenges which Los Alamos and greater Northern New Mexico encounter. These weather conditions range from wildfires to snowstorms and the challenge of a lack of humidity is another main factor which is routinely not accounted for by many manufacturers that operate in coastal regions. As a result, this is a continuous challenge for ES-STO engineers to address with customers and stakeholders across STO-FOD.

Major upgrades have been provided to various Materials Physics and Applications (MPA) facilities who describe their work as: “We develop new technologies that solve pressing national energy and security challenges by exploring and exploiting materials and their properties, [and] developing practical applications of materials” (Triad, 2025).

With world-class research in materials science ranging from the atomic to macroscopic scales enabling the development of new technologies that solve pressing national energy and security challenges, it is paramount that the large footprint which they possess as LANL’s “flagship experimental fundamental science organization” have adequate cooling and heating for their laboratory spaces.

In 2021, “STO Engineering temporarily designed one chiller to continue facility operations and developed a replacement design in parallel. The old chillers were served by an unreliable cooling tower, resulting in poor cooling capabilities for the facility. The two new 300-ton chillers are air cooled, eliminating the reliance on the cooling tower and are located outside the facility, freeing up space for future upgrades in the mechanical room” (McEahern, 2021) (figure V.I-1).

At another location operated by MPA, ES-STO provided a smaller, but just as necessary chiller upgrade on a legacy building within LANL’s main campus. This chiller was sized and selected by ES-STO in 2021 while working around the customer’s schedule for installation as to not impact their mission objectives (McEahern, 2021) (figure V.I-2).

The chiller showcased in Figure V.1-1 not only supports programmatic research for MPA, but also for Chemistry division (C) by way of the group: Inorganic, Isotope & Actinide Chemistry Group (C-IIAC) and Nuclear & Radiochemistry Group (C-NR). These organizations also provide vital support for the nuclear stockpile mission at LANL and were supported by the upgrade provided in 2021.

Figure V.I-1: MPA and C Chiller (McEahern, 2021)

Figure V.I-1 depicts the chillers for the MPA and C-division facility.

C-IIAC operates within the fields of, but not limited to, the design and synthesis of novel catalytic materials, the production of high-value-added fuels and chemicals, running batch and continuous flow packed bed reactors, and the characterization of catalytic materials with analytical instruments in various phases of matter (Triad, 2025).

C-NR, on the other hand, operates within the bounds of nuclear and radiochemistry choosing to focus on the field of separations, chemical analysis and radiochemical measurements. In support of the nuclear stockpile mission and objectives of C-division, members of C-NR develop new inorganic separations for both the chemical and radiochemical purification of single elements, with "novel methods for measuring purified radioisotopes and stable elements will be a key component of the research, and measurements may involve mass spectrometry, gamma-ray spectrometry, beta decay counting, and/or alpha spectrometry. The methods have applications in nuclear forensics, environmental studies related to fate and transport of radioactive isotopes, and stewardship of the US nuclear weapons deterrent" (Triad, 2025).

Figure V.I-2: MPA Chiller (McEahern, 2021)

Figure V.I-2 depicts a chiller for an MPA facility.

In 2022, an equally large undertaking was designed by ES-STO and installed by STO-FOD at the main campus location for Materials Science and Technology Division (MST) supporting the cooling needs for their efforts within the strategic objectives of

LANL. In early 2022, MST's main facility needed a facility upgrade for its aging cooling system, maintained by two 300-ton chillers. With one out of service and beyond repair, while the other was nearing its service life, STO-FOD and ES-STO coordinated to install a 300-ton portable chiller installation until a permanent solution could be procured and put into place. The permanent solution is designed and currently under construction. (McEahern, 2021) (figure V.I-3).

Figure V.I-3: MST Chiller (McEahern, 2021)

Figure V.I-3 depicts the chiller for the MST facility.

This chiller was needed to continue MST's mission to "serve the nation by providing world-leading, innovative, and agile materials science and technology solutions for national security missions" (Triad, 2025). MST delivers materials science, technology, and hardware essential to ensure weapons materials performance, integrating the understanding across materials synthesis, processing, properties, and performance to benefit all endeavors from research to development to component manufacturing.

The final mention for cooling is that of LANLs global security branch of strategic mission initiatives. Occupying the same space across various campuses with STO-FOD's envelope and LANL property are Intelligence and Space Research (ISR) and Nuclear Engineering and Nonproliferation (NEN) divisions. The chillers at a shared facility for global security were installed around 2001 when the facility had first been built. Increasing maintenance costs and reduced reliability had the potential to impact facility operations, resulting in the request and design for an updated chiller system which was installed between 2022 and 2023. The first new chiller began operation in 2022 with the second unit becoming operational in 2023. Each chiller provides over 325 Tons of cooling to the facility. These chillers provide support and cooling to a tremendous amount of heat output across various instruments in support of both ISR and NEN (Figure V.I-4).

ISR division is made up of various groups within the facility, categorizing and describing them thusly:

- The Space Instrument Realization Group (ISR-5) provides engineering and technical expertise to support the development and deployment of space-based custom instrumentation for national security applications (Triad, 2025).
- The Space Data and Software Systems Group (ISR-3) contributes key skills and experience in software, computing, operations, and data systems that are essential to meeting ISR's (Intelligence and Space Research) scientific and national security missions (Triad, 2025).

The Space Remote Sensing and Data Science Group (ISR-6) focuses on developing and deploying sophisticated, customized detection systems and analysis tools to address needs in nuclear non-proliferation, space domain awareness, atmospheric science, and planetary science and exploration (Triad, 2025).

Hand in hand with ISR's focus on nuclear non-proliferation is the Nuclear Engineering and Nonproliferation division itself describing their mission as "Addressing complex national security issues and meeting the world's nuclear challenges. NEN leads the LANL Global Security mission in: detecting and preventing the development or use of nuclear weapons and improvised nuclear devices; reducing and limiting nuclear arms and the spread of nuclear and radioactive materials, technology, and expertise; providing the capability and conducting critical, subcritical, and fundamental physics measurements to develop and maintain the Nation's Nuclear Safety and Security Expertise, and; conducting research and development that supports the nation's energy security" (Triad, 2025).

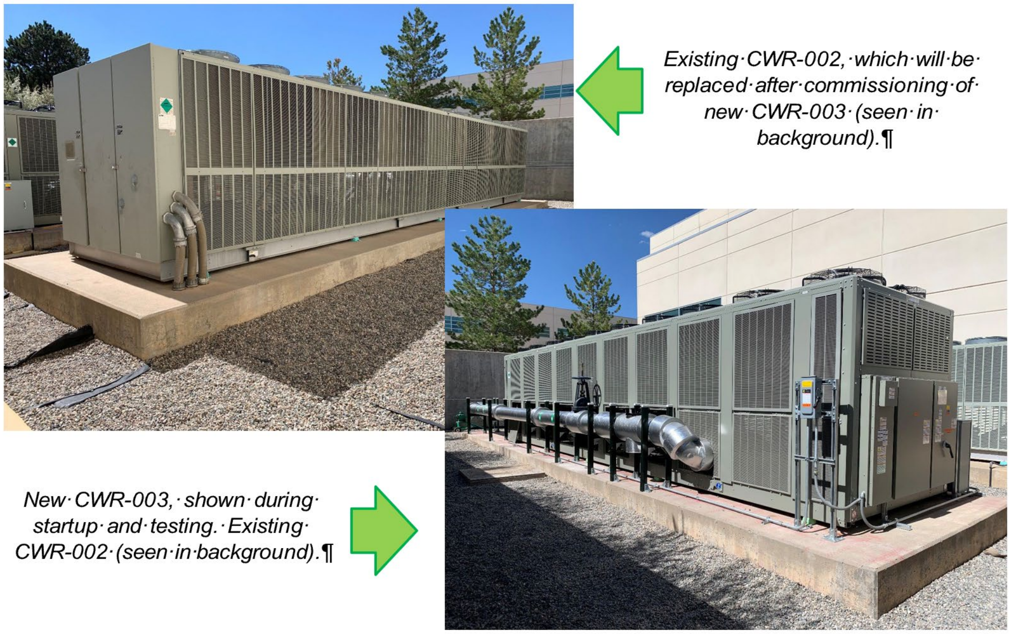

Figure V.I-4: Global Security Chillers (McEahern, 2021)

Figure V.I-4 depicts the old and new chillers for the global security facility.

Cooling is not the only issue which requires an engineering solution when it comes to maintaining an appropriate environment to accomplish the nuclear mission objectives across STO-FOD's envelope. Heating is a routine problem that needs to be sorted and addressed as the design efforts for Los Alamos require consistent heating solutions in freezing temperatures often accompanied by icy and snowy conditions every winter. This is often the case for facilities which were designed around steam boilers that required upgrades to electrical or gas boiler systems to maintain heat in the facilities. Many of these system upgrades have been performed since 2019, but the most pressing need was from 2021 to 2022 where a research facility which focuses on the research into biological effects of radioactive and other materials was in dire need of an upgrade of a system from 1974 (Figures V.I-5 and V.I-6).

Figure V.I-5: Old Pumps Circa 1974 (McEahern, 2022)

Figure V.I-6: Old Boiler Circa 1974 (McEahern, 2022)

Figure V.I-5 and Figure V.I-6 (left to right) depict the old pumps (left) and boiler (right) from the original 1974 construction of the facility.

This project removed existing equipment including the gas-fired boiler, pumps, expansion tank, and piping system. The new design and construction resulted in the installation of a modernized system. This system included variable speed secondary loop pumps, a primary loop pump, an expansion tank, and a modern gas-fired boiler. The expansion tank was replaced and relocated from the ceiling to the finished floor elevation for easier maintenance. The project also added Automated Logic Controls Building Automation System monitoring and control for the boiler and pumps (McEahern, 2022) (Figures V.I-7, V.I-8, and V.I-9).

Figure V.I-7: Primary Pump 2022 (McEahern, 2022)

Figure V.I-8: Secondary Pumps 2022 (McEahern, 2022)

Figure V.I-7 and Figure V.I-8 (left to right) depict the upgraded primary pump and expansion tank (left) and the new secondary pumps (right) for the boiler system.

Figure V.I-9: Boiler 2022 (McEahern, 2022)

Figure V.I-9 depict the new boiler installed in 2022.

II. Compressors

While heating and cooling are consistent issues in facilities at LANL, delivering clean, oil-free air also poses a routine challenge as facilities are repurposed and updated to meet increased demands by ever evolving technologies across the STO-FOD envelope.

One such instance is that of MPA and their need for a dedicated compressor to accompany increased capabilities and capacity for prototyping and manufacturing utilizing 3D printing technology in combination with traditional manufacturing requirements necessary to maintain the nuclear stockpile at LANL. As previously mentioned, MPA solves pressing national security challenges by exploring and exploiting materials and their properties, to develop practical applications of materials (Triad, 2025). This was the case for the compressor designed and installed in 2024 and its application as a dedicated facility compressor with one sole-purpose – to supply reliable, clean, oil-free air year-round at one of their flagship experimental fundamental science and research facilities (Figure V.II-1).

Figure V.II-1: MPA Compressor

Figure V.II-1 depicts the newly installed compressor for MPA in 2024.

III. Unique Laboratory Equipment

Facility equipment is not all that ES-STO assists LANL's customers and stakeholders. Engineering solutions are often needed for novel equipment and unique challenges posed to the laboratory environment required by the scientific and research community which makes up the majority of LANL employees.

MST's endeavors do not simply end with weapons material performance and component manufacturing. The division also applies fundamental materials expertise to a range of national security needs including nuclear energy, nonproliferation, and global threat reduction (Triad, 2025). To facilitate these extensive needs and with improved cooling capabilities planned within their main facility, MST requested ES-STO to provide a design for a precision TEM (Transmission Electron Microscope) along with upgrading the utilities provided to various SEMs (Scanning Electron Microscope) which they were already utilizing for their research within the facility (Figures V.III-1, -2 and -3).

MST goes on to state, “we anticipate the advent of a new era in materials science, where we will transition from observing and exploiting the properties of materials to a science-based capability that creates materials with properties optimized for specific functions.” As such MST’s mission is to ensure performance, safety, reliability and security of materials of importance to the nation through excellent science. We deliver innovative and rapid solutions to meet fundamental materials science, stockpile, energy, and global security needs. We apply a multidisciplinary approach to push the state-of-the-art in materials science to be responsive to emergent national security requirements, trusted stakeholders, and production agency needs (Triad, 2025).

Figure V.III-1: MST TEM

Figure V.III-1 depicts a TEM operated by MST.

Figure V.III-2: MST SEM 1

Figure V.III-2 depicts various SEMs operated by MST.

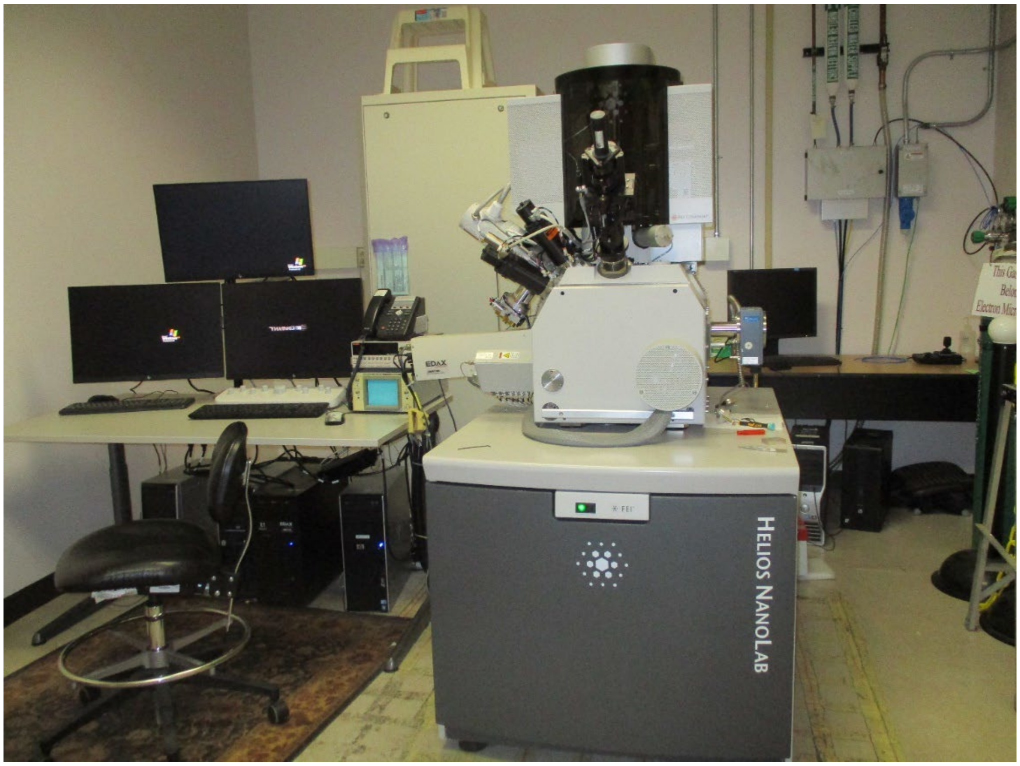

Figure V.III-3: MST SEM 2

Figure V.III-3 depicts another SEM operated by MST.

This project contained a multitude of challenges for the novel equipment that existed and was to be installed (the SEM and TEM), but also for cooling of the individual pieces of equipment spread across various rooms within a wing of the facility. The chillers depicted in Figure V.III-4 were numerous and had to be designed and accounted for within the facilities existing cooling system for HVAC and Chilled Water systems. The chillers (Figure V.III-4) were also upgraded from hastily installed water-to-air chillers to water-to-water chillers to alleviate the cooling load needed for the existing HVAC system. To accompany these chillers and maintain the stable operating conditions needed for the TEM which was to be installed, radiant cooling panels were procured, designed for, and installed.

This was a first for ES-STO and STO-FOD facilities, presenting a significant challenge that was met and STO hopes to employ in future design and build applications. (Figure V-III-5).

Figure V.III-4: MST Small Chillers

Figure V.III-4 depicts various water to water chiller units necessary to cool the SEMs and TEM.

Figure V.III-5: MST Radiant Cooling

Figure V.III-5 depicts a radiant cooling system necessary to maintain temperature and stable operating conditions for the TEM.

Fume hoods are a common installation request which ES-STO receives from the myriad of customers and stakeholders across STO-FOD's envelope. Often these fume hoods are used for various chemical and biological reactions with some applications being applied to research involving thorium and depleted uranium. These designs often require extensive research and involvement with IH and RCT professionals to ensure compliance with air quality and chemical and/or materials interactions guidance to ensure the fume hood use does not result in the degradation of exhaust ducting or other ventilation equipment. An example of a fume hood installation is provided in Figure V.III-6.

Figure V.III-6: MPA Fumehood

Figure V.III-6 depicts a fume hood designed for and operated by MPA.

SIGMA division is a key customer and stakeholder within STO-FOD and LANL at large. Although SIGMA has not been mentioned within this report until this point, many of their project are key to the success of LANL. Sigma Division describes their objectives and mission as:

- “Materials and components for our nation’s nuclear and energy security

- o Developing materials and components using engineering and metallurgical science in support of national security.

- o Sigma Division provides outstanding engineering solutions using metallurgical science to enable the Lab's mission for supporting and improving national security. Utilizing world class expertise and innovation, we are focused on leading the way in manufacturing science related to nuclear weapons, nuclear fuels, ferrous alloys, refractory metals, and a variety of non-metallic materials.

- o Sigma Division’s goal is to provide excellent customer service that meets manufacturing needs on schedule and within budget. Our diverse teams work with the national security complex and industry customers, bringing a wide range of experience to the table to meet any need from concept and process development to fabricated and finished products” (Triad, 2025).

A project requiring similar engineering feats that support MST for their SEM and TEM mission is a project undertaken in 2021 and installed in 2022. “The ES-STO design team supported installation of a Scanning Electron Microscope (SEM, Front) and Plasma-Focused Ion-Beam microscope (PFIB, Rear) in Sigma facilities. This added capacity and capability to the Sigma 2 Characterization Team’s metallographic analysis equipment. Supporting chillers and Power Supplies are shown” (McEahern, 2022) (Figure V.III-7).

Figure V.III-7: Sigma SEM and PFIB

Figure V.III-7 depicts a SEM, PFIB (Left), and supporting chillers and power supplies (right).

Another key project performed for the Sigma facility customer base is that of the Electrochemistry Plating Shop. This project was executed in 2021 where ES-STO worked to lead the effort to update and renovate Sigma's Electrochemistry Plating Shop. This involved working closely with the customers to select the correct equipment, provide power, and implement capable exhaust & drainage. This project was a multi-year effort that involved continual engineering support through design and installation to ensure successful execution and implementation (McEahern, 2021) (Figures V.III-8 and -9).

Figure V.III-8: Sigma Old Electrochemistry Plating Shop (McEahern, 2021)

Figure V.III-9: Sigma New Electrochemistry Plating Shop (McEahern, 2021)

Figure V.III-8 (Left) and Figure V.III-9 (Right) depicts the old Electrochemistry Plating Shop (Left) and the newly renovated Electrochemistry Plating Shop (Right).

Conclusion

In the realm of nuclear deterrence, non-proliferations, global security, and research, Los Alamos National Laboratory has not only been a leader within the infrastructure of the United States of America, but a global leader, recruiting scientists, researchers, engineers, technologists, and professionals from all over the planet over the course of its existence since Project Y in World War II.

At the heart of these industry changing innovations in physics, mathematics, chemistry, biology, materials, and so many other disciplines is engineering and the ingenuity of the forefathers of Project Y. All the scientific research which goes on within LANL would not be possible without the proud members of the LANL community that ensure the facilities operate flawlessly. These facilities house millions of dollars' worth of scientific equipment and represent the investment of countless hours and effort. The world-class research and excellence from some of science's greatest minds, is possible due to the constant effort of LANL's engineering services. ES-STO enables the capability and capacity to procure equipment and renovate spaces available to conduct and implement groundbreaking research.

For this reason, facility engineering and design work must be recognized as critical to national safety and security through its support for cutting-edge technology, research, and applications in state-of-the-art facilities.

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Vita

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