LA-UR-92-1729

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Los Alamos National Laboratory's

Lead Lab Proposal

Plutonium

June 1992

Los Alamos National Laboratory Qualifications for Lead Laboratory in Plutonium/Pit Technology

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LOS ALAMOS NATIONAL LABORATORY QUALIFICATIONS
FOR
LEAD LABORATORY IN PLUTONIUM/PIT TECHNOLOGY

Executive Summary

The United States and the Department of Energy (DOE) stand at a crossroads. For DOE to successfully manage and maintain nuclear weapons technology in an ever-changing world, it must address an array of new factors, such as the breakup of the Soviet Union; aging weapon facilities; an assortment of safety, health, and environmental issues; and constrained budgets. Taking these factors into consideration, DOE and its contractors must develop and implement a new integrated, comprehensive, and consolidated program that maintains a robust technology base and meets the present and future goals of Complex 21.

No single nuclear weapons technology area has felt this impact more severely than nuclear materials production (particularly the production of plutonium). To ensure that this area continues to succeed, we propose to assume the role of lead laboratory for plutonium/pit technology. As lead laboratory, we will design, build, and operate facilities and processes at Complex 21 that are essential for plutonium operations and pit manufacture. Moreover, we will support the enduring stockpile; to preserve this expertise, we will also produce new pits.

To meet these goals, we have developed an aggressive and innovative plan that addresses facility construction, technology development and demonstration, and operational training and programmatic integration. As a constituent of the Complex 21 plan, our interim plan is to make residue treatment and stabilization operations as efficient and advanced as possible.

We will form a Complex 21 Plutonium Facility Project Office staffed with a dedicated team of technical and management experts who will define, plan, and implement advanced plutonium facilities. In addition, this organization will incorporate senior staff from the Complex who have extensive experience in the operations of special nuclear materials facilities throughout the United States. Expertise will cover nuclear materials processing, manufacturing, transportation and storage operations, analytical chemistry, and waste management. An A/E firm will also provide senior technical facility and project management expertise.

At present, we are implementing a base line flow sheet (Fig. 1), which consists of six major areas: site return processing, manufacturing, chloride recovery operations, nitrate recovery operations, waste management, and analytical chemistry. Because we have more than 15 years experience in the science of plutonium, we will effectively develop and implement technologies and facilities that address specific issues in each area.

We presently operate the only full-dimensional plutonium system in the country. To integrate the flow sheet process into our system, we will use a very formal development approach, which consists of (1) addressing the problem, (2) understanding how to control the chemistry, (3) engineering the process, and (4) designing special facilities and equipment. This approach will ensure that we avoid false starts and costly delays.

Because of our unique facilities and multidisciplinary staff, we possess extensive experience and expertise in an array of technical areas. Internationally, we lead the world in weapons forums such as JOWOG. Domestically, we are viewed as a lead laboratory in many areas, including most areas in Complex 21. We extensively collaborate with DOE contractors and commercial vendors, thereby ensuring that technology is successfully transferred to organizations across the United States. For example, we are presently working with DOE to augment its Stockpile Evaluation/Pit Surveillance program with a pit-rebuilding function. In addition, we have taken the lead role in the Rocky Flats Residue Elimination Program.

At Los Alamos, we handle all manner of plutonium, from the leanest scrap to extensive waste. In addition, we develop and produce high-quality components and innovative processes. For example, we supplied ultrapure metal to Rocky Flats—they used this metal as blend stock to meet component production commitments. We also use programs such as the Automated Retirement and Integrated Extraction System and the Experimental Chloride Extraction Line to meet the needs of DOE and its organizations.

We have an extensive track record in applied research and development and manufacturing, as well as working with manufacturing plants. For example, we initially designed almost every production process at Rocky Flats. Scrap forms that cannot be processed elsewhere are sent to Los Alamos for recovery. We maintain the only full-breadth plutonium processing capability in the United States. This system's components include waste management and disposal, residue recovery, and component manufacturing. In addition, we continue to produce weapons assemblies for the Nevada Testing Program; an associated effort involves the processing and recycling of all residues.

Our extensive work with A/E firms continues to grow. To meet this need, we established a group whose sole function is to procure A/E and construction services. This group ensures that A/E procurement is in accordance with federal requirements, including the Brookes Act and DOE requirements, develops design criteria in accordance with DOE Order 6430.1A, reviews proposals, selects and interviews the short-list firms, and negotiates with the most technically qualified firm. Presently, we have six A/E firms under contract to assist on small to moderate construction projects and develop larger projects. The total annual budget for these firms is approximately $10 million.

An ever-changing climate and constantly evolving technologies require a lead laboratory that can maintain a robust technology base and meet the present and future goals of Complex 21. Los Alamos National Laboratory has the expertise, facilities, and multidisciplinary staff to successfully fulfill this function.

1.0 STRATEGY AND PLANNING

The Department of Energy (DOE) and the United States have entered a watershed period relative to nuclear weapons technology as a result of an array of factors, including dramatic changes in the world order; the aging of weapon production facilities; enhanced emphasis in safety, health, and environmental issues; and constrained budgets. No single area has felt this impact more severely than nuclear materials production, especially plutonium. To achieve the goals of Complex 21 and maintain a robust technology base, DOE and its contractors must develop and implement an integrated, comprehensive, and consolidated program.

The program must ensure that we maintain a strong scientific and technical manufacturing base that fully complies with federal and state operating guidelines. To meet these goals, we must (1) understand the functions of materials processing and component manufacturing; responsibly handle waste; and store, safeguard, and manage growing inventories of excess materials; and (2) coordinate the manufacture, quality assurance, and assembly of non-SNM (Special Nuclear Materials) weapon primary components such as shells, inserts, and tubulation.

For this program to succeed, it must simultaneously manage technology selection and demonstration, interpret individual engineering design features "in relation to" the facility, participate in the design and selection of special facility equipment, consult with A/E during construction and cold testing, and participate with the M&O contractor for hot start-up, staffing, training, and operations. Because these synergistic activities require close coordination, they should be managed by one leader.

Los Alamos National Laboratory is uniquely qualified to manage this project and proposes to become the lead laboratory for plutonium/Pit technology. We envision our responsibility to require a nonparochial style of leadership that draws upon other DOE contractors. To complement our own expertise, we will rely on the other contractors' experience for guidance on their new technology requirements and collaborate in areas of mutual interest. We have an impeccable track record of the integrated management of such facilities, most recently the TA-55 Complex. Other significant facilities exemplifying extensive contractor and collaborator involvement include the Clinton P. Anderson Meson Physics Facility (LAMPF), Manuel Lujan, Jr. Neutron Scattering Center (LANCE), and Weapons Engineering Tritium Facility (WETF).

Our programmatic goal is to meet both present and future DOE needs and requirements. Meeting this goal will require (1) facilities essential to plutonium operations and pit manufacture and (2) the capability to support the enduring stockpile and produce new pits, thereby preserving such expertise. Based on these needs, we propose an aggressive and innovative plan to design, build, and operate required replacement facilities for Complex 21. This comprehensive plan will address facility construction, technology development and demonstration, and operational training and programmatic integration. As a constituent of the Complex 21 plan, our interim plan is to make residue treatment and stabilization operations as efficient and advanced as possible.

At present, we are augmenting our processing facilities to ensure a robust and flexible capability that can (1) effectively meet the requirements of the Weapons Research, Development, and Testing (WDR&T) program and (2) preserve the expertise needed to resume weapon component production in the future. To ensure the viability of this approach, we will fabricate test devices needed for the Nevada Test Site (NTS), perform stockpile evaluation (surveillance) of primaries, and remanufacture systems withdrawn from stockpile for evaluation. Throughout these operations, we will collaborate with an array of contract personnel, thereby maintaining an acceptable level of competence.

To ensure this program maintains its focus and commitment, we should be unambiguously assigned the technical lead; moreover, we should be responsible for coordinating all contract efforts that involve the development of this Complex-wide research, development, demonstration, and testing program.

1.1 Understanding of DOE Program Needs

For the Complex 21 program to succeed, it must first ensure credibility of operations. Credibility requires that DOE, the contractor, and lead laboratory respond to public issues and participate in formulating and discussing public-policy issues regarding the plutonium industry. Recognized internationally for excellence in science and technology and an unyielding requirement for high-quality performance, we possess an outstanding track record is managing large and complex projects in which science makes a difference. Our reputation is strong, in part because we are fully committed to openness and in being a "good neighbor" to the environment and surrounding community. We have worked extensively with DOE to address plutonium development issues, some of which led us to develop Complex 21.

From a technical standpoint, we have always maintained a complete capability in critical materials areas such as plutonium. In fact, we alone have a complete set of technologies and facilities to successfully improve, manage, and advance plutonium operations. We have extensive expertise in shipping and materials management, chemical processing and component fabrication, waste management, process automation, nondestructive assay instrument design, analytical chemistry, operator training, and facility design and operation. Our approach to advanced design and development is very straightforward and includes the following elements:

First: We ensure a sound *understanding of fundamentals* (chemistry and metallurgy). This capability allows us to properly identify problems, understand each process, and more importantly, identify how processes affect system performance.

Second: We identify and develop logical *process-control* mechanisms. These mechanisms include sensors and measuring devices that apply our expert control of fundamentals.

Third: We *engineer our processes and equipment*. This engineering cannot take place without an understanding of fundamentals and without mechanisms to control processes. At this point, we can consider features of automation.

Fourth: We completely *engineer* the facility and *special facility equipment* (SFE). Before we determine SFE, we must establish processing and operating parameters that meet specific process needs.

Because the foundation of our technology base is the ability to follow this protocol, we can successfully develop and demonstrate advanced concepts. In fact, we have patented and/or production-demonstrated almost every technology in use today for plutonium separations and purification. Furthermore, we developed and demonstrated the current manufacturing technology base. To meet DOE program needs for Complex 21 phases in design and development, construction, startup and test, and operation, we will continue to apply this protocol; concurrently, we will incorporate developments from all contractors into a master plan for plutonium operation at Complex 21. In collaboration with other contractors, we will develop technology selection criteria, thereby ensuring that the most advantageous developments are incorporated into the facility. Developing selection criteria will involve the use of process simulation modeling, which our modeling and processing experts presently use for plutonium/Technology Assessment and Selection Panel (TASP). Simultaneously, we will begin compiling facility feature and special facility equipment criteria based on the current base line flow sheet and known "good practices" throughout industry. The outcome of this process will be a consensus-design-criteria document reflecting the requirements of the base line flow sheet, including material balance, equipment sizing and numbers, labor, waste generation, and reagent requirements.

For details regarding our overall strategy in approaching the four phases of Complex 21, please consult section 1.3 of this document.

1.2 Organizational Commitment and Implementation Plans

Fully committed to the success of Complex 21, we will manage the overall plan by using an approach similar to plans already in place at TA-55, Molecular Laser Isotope Separation (MLIS), the Nuclear Materials Storage Facility (NMSF) and the Special Nuclear Materials Research and Development Laboratory (SNML), which has proceeded through Title I design. We will form a Complex 21 Plutonium Facility Projects Office staffed with a dedicated team of technical and management experts who will define, plan, and implement advanced plutonium facilities. In addition, this organization will incorporate senior staff from the Complex who have extensive experience in the operations of SNM facilities throughout the United States. Expertise will cover nuclear materials processing, manufacturing, transportation and storage operations, analytical chemistry, and waste management. An A/E firm will also provide senior technical facility and project management expertise. We will choose organization members from the various DOE laboratories, M&O Contractors, DOE, and other experienced contractors. Under our leadership, we will address the need by bringing together an integrated approach with a diversity of views and talents. In addition, this approach will ensure that the technology expertise at all facilities continues to contribute, thereby maximizing the potential for success of the facility design.

1.3 Overall Strategy to the Four Phases of Complex 21

1.3.1 Design and Development—Phase I

As lead laboratory, we will identify a lead laboratory senior manager. We will establish an office in Washington, DC, where the Plutonium Program Office team will work with DOE and A/E. Once we select a site, we will establish the Resident Field Office, which will be responsible for construction oversight and startup and operation plans.

We will immediately establish a team with strong Los Alamos leadership to develop requirements documents for the facilities. These documents will address specific technical standards that reflect established good practices in the plutonium community, as well as all applicable statutes, codes, regulations, orders, and other requirements. These documents will support the technology flow sheets and design criteria and will provide the basis for establishing a project base line and concomitant concept design. We will ensure that effective change-control procedures are established to manage flow sheet changes.

We will design technology development and demonstration plans for technologies selected for the base line design—these plans will ensure that the technology is ready for implementation on schedule. Our responsibility will be to assign development and demonstration plans to qualified contractors. If implementing a technology carries with it significant risks, we will identify demonstrated backup technologies.

The team must also ensure that the actual plans and specifications that A/E develops are reviewed and approved, making sure that they conform to the requirements and criteria documents.

1.3.2 Construction/Startup and Testing—Phase II

During the project's final design and construction phases, the Plutonium Project Office team will serve as the technical "right arm" of DOE and the A/E firm. The team will

- serve as technical advisor (with the A/E/ firm) and have signoff authority, within the content of the established charge-control formalism, on engineering drawings that relate to processing technology, equipment, and special facility design features.
- specify process equipment and verify that design details are translated into the actual construction.
- validate chemical processes as improvements occur; translate changes into specifications for construction.

To avoid costly change orders, we must perform tightly controlled coordination. During this phase, we will also work with DOE and the M&O firm to develop a comprehensive training program for the site.

1.3.3 Startup and Testing—Phase III

The site Resident Field Office will play a crucial role during this phase. We will establish a Joint Test Group (JTG) consisting of representatives from the construction contractor, the M&O, the laboratories, and DOE. Once we complete construction tests and operational performance tests, we will begin the testing and certification process; we will also develop site utilities and equipment based on equipment and subsystem tests and technology performance tests. We will evaluate the technology's performance against the requirements documents; we will certify technology once we determine that it can produce deliverables that meet specifications.

1.3.4 Production and Stockpile Support—Phase IV

Our role as lead laboratory will change significantly once the facility is built and successfully functioning. During this phase, we will function as the technical right arm of DOE and the M&O contractor, a role not significantly different from that evolving for the Los Alamos Technology Office at Rocky Flats. We will act as an overall troubleshooter, providing ongoing technical support for manufacturing, recovery, analytical chemistry, and waste management processes. The entire operation must remain robust and flexible, so that we can effectively respond to programmatic, environmental, regulation, or technical changes. To ensure that facilities remain responsive and up to date with technology, we will establish and oversee a formal technology exchange activity with the plant and establish a regular review and assessment mechanism for evaluating the state of technology and facility operation. As lead laboratory, we will manage the evaluation of new/improved technologies against the base line and participate in the introduction of advances and innovations.

1.4 Strategies for Working with Other Laboratories and M&O Contractors, Including Apportionment of R&D and Manufacturing Support Functions

We fully understand the need for a strong policy and approach for managing our national plutonium asset. The United States has invested significantly in the synthesis and management of plutonium and in the maintenance of our strategic nuclear weapon stockpile. Our overall strategy reflects our strong commitment to capitalizing on this investment for future operations and in assuming responsibility for the future management of this strategic resource. Our strategy is to involve the resources of the Complex, in a team approach, with us taking the lead. Other laboratories, contractors, DOE, and other organizations will help us build and operate the best facilities Furthermore, we are committed to supporting a cross section of promising ideas and approaches that will improve the overall quality of operations, which include process technologies and aspects of facilities operations. Management and assessment tools, such as process modeling and selection criteria, will be used as much as possible, thereby ensuring consistent decision making. We will also support a foundation of long-term projects designed to provide the seeds for future development.

1.5 Innovative Approach to Complex 21, Including Overall Plant Criteria, Process Modifications, Technology Developments, Waste Minimization and Treatment, and Storage

The Complex 21 research and development effort represents an extension of our existing integrated program. Developed by TASP ten years ago, the ever-evolving base line flow sheet for plutonium is presently in full development at Los Alamos (Fig. 1). We need to demonstrate the process in an integrated format and measure the synergistic effect of each process on the overall flow sheet. Because we have already modeled the flow of materials, we can easily interpret and assess changes and impacts on the flow sheet.

The flow sheet consists of six major boxes. The Site Return Processing and Manufacturing boxes represent the primary flow of materials and the areas in which maximum material use will minimize the burden on residue recovery, thereby minimizing waste generation. The Chloride and Nitrate Recovery boxes represent the secondary flow of materials, in which residues are recovered and plutonium is returned to the fabrication sequence. These two boxes also represent the areas in which technology will impact the processing and storage of "national asset plutonium." The Analytical Chemistry box represents the application of both on- and off-line analytical technologies to improve the overall quality of plutonium handling. The Waste Management box includes all processes necessary to treat both solid and liquid waste that emerges from the plant. This waste will need to be stabilized and packaged for long-term storage and isolation. The following sections further discuss these six areas.

1.5.1 Site Return Processing

An integrated system, the ARIES Project (Automated Retirement and Integrated Extraction System) will demonstrate innovation technologies required in Complex 21 to process site-return components to usable metals. Demonstrated technologies will form a fully integrated, advance system of plutonium processes that will cut open, recover, and purify
the plutonium metal, thereby making it acceptable for fabrication processes.

Developed by Los Alamos scientists, this elegantly simple approach will perform as a single integrated operation and recycle almost all process materials, thereby demonstrating a nearly waste free and minimum hazard approach to pit recovery. Our project incorporates on-line accountability and process control, automation in part handling, a unique set of process sensors based on an understanding of fundamental process chemistry, and proven process equipment.

1.5.2 Manufacturing

Because manufacturing technologies are our particular strength, we have successfully developed a number of manufacturing processes, including the near-net-shape casting process, a technique used by us, Lawrence Livermore National Laboratory (LLNL), and the United Kingdom (UK). During the mid-1980s, we participated closely with Rocky Flats in the successful development of die casting system. Although this system was ready for production, Rocky Flats abandoned the concept because it was believed that the benefits of the system had been already achieved through improvements in traditional casting systems. In collaboration with Rocky Flats, we are presently improving parameter and atmosphere control, and as well as remotization. During 1992, we will install the most advanced induction-heated, tilt-pour casting system in TA-55. Operators will perform casting in very high vacuums. In addition, this system nearly eliminates radiation exposure because the operator can use a remote control to operate the furnace during the process. Ongoing research focuses on mold design and *in situ* component annealing, thus eliminating heat-treating and handling steps.

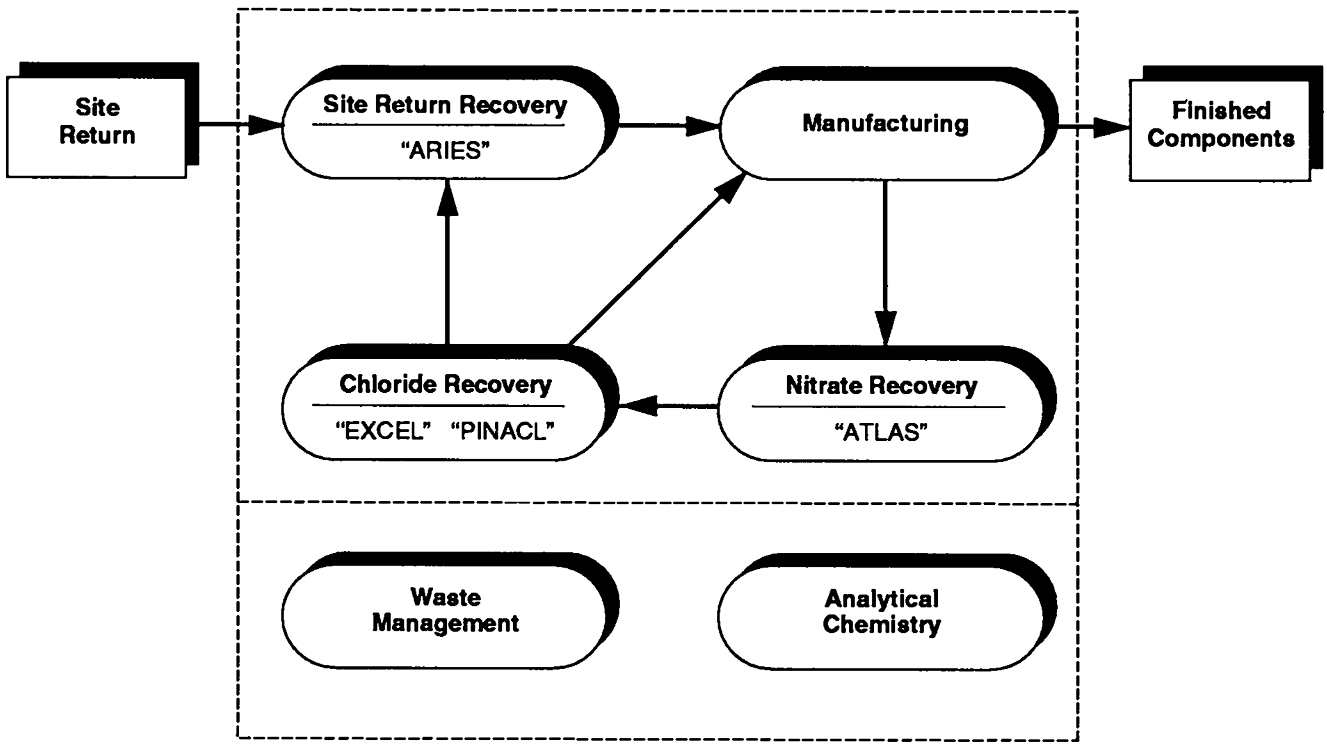

Fig. 1. Complex 21 base line flow sheet (U).

Following the casting and heat-treating steps, components proceed to machining, an area in which we have pioneered the dry-machining concept, which requires no organic cutting aids or cleanup solvents. To preserve the surface finish of components and control chip oxidation, we enclose lathes in well-engineered, isolated, and inert atmosphere gloveboxes We remotely collect chips by using a venturi tube and rapidly deliver them to a pyrochemical consolidation process. Following this process maximizes recovery, provides rapid recycle, and minimizes materials handling. Finally, on-machine gauging concepts (variable impedance transducers), coupled with lathe control software, will provide instantaneous tool path compensation. This technology, coupled with automatic temperature control on the pot chucks, will allow immediate on-machine part certification. Although none of these concepts have ever been attempted on production lines, it is through such innovations that a revolution in component manufacturing will take place.

The two other manufacturing steps directly involving plutonium are joining and density measurement. We are presently developing several waste-free joining techniques that use lasers. For example, we recently installed a one-kilowatt Nd:YAG laser for use in multipurpose joining applications in nuclear weapons. The highest power laser in use in these types of operations, the ND:YAG has a multiplexing capability that successfully replaces systems requiring three electron-beam-welding systems to perform the same function. In the density measurement area, we have abandoned the use of hazardous fluids such as freon and bromobenzene and have instead taken the lead in developing gas pycnometry as a potential replacement. Preliminary tests with metal samples have proved successful and the scale-up process continues to grow.

1.5.3 Chloride Recovery Operations

Molten chloride, salt-based processes serve as the basis for removing plutonium from weapon components and its subsequent purification. These processes include americium extraction from metal, electrorefining of impure metal, and conversion of oxide to metal. The recovery of salt residues involves chloride-based aqueous processes, including dissolution in hydrochloric acid media, solvent extraction and ion exchange purification, precipitation, and calcination of oxide before its conversion back to metal. We have long been the international leader in molten salt pyrochemistry, holding almost every patent in this technology area. In 1965, we transferred the molten salt extraction (MSE) and electrorefining processes to both Rocky Flats. Put into production almost immediately, these processes continue to successfully serve this facility. Before Rocky Flats shutdown in 1989, we introduced several significant MSE advances into production operations, including an advanced salt system compatible with other pyrochemical operations and an oxident that successfully eliminates half of the processing steps. We have also developed and plan to introduce an even more advanced direct oxide reduction system that incorporates *in situ* reagent regeneration and recycle. Known as muticycle direct oxide reduction (MCDOR), this technology can potentially reduce waste generation and radiation exposure by more than 90%. We plan to perform an integrated demonstration of this advanced system; currently at the engineering design stage, this integrated demonstration will couple remote handling with sensors.

We recently set into motion the Experimental Chloride Extraction Line (EXCEL), a project designed to unify all aqueous processes into a fully integrated system. The only chloride salt treatment system in the United States, our technology involves the innovative development of chloride-resistant gloveboxes and piping systems, advanced sensors, and noninvasive spectrophotometric measurement techniques. This pilot-scale demonstration represents the base line of technology for the entire chloride recovery system in Complex 21.

1.5.4 Nitrate Recovery Operations

Approximately six years ago, we began to develop an integrated demonstration of nitric-acid-based recovery technologies—this project is called ATLAS (Advanced Testing Line for Actinide Separation). A prototype project for advanced concepts, ATLAS's goal is to demonstrate, in an integrated fashion, recovery techniques for plutonium-bearing residues. The base line flow sheet consists of pretreatment technologies such as pyrolysis and leaching, cascade dissolution, anion exchange, precipitation, evaporation, and acid recycle. We possess a firm fundamental understanding of these technologies and continue to place a significant effort on advanced process control techniques. During ATLAS's initial design phase, we developed a number of innovations, including several award-winning (R&D 100) sensor systems and an advanced process control system. These innovative features, which we plan to integrate into Complex 21, are bringing the concepts of process control and accountability to fruition. Currently, ATLAS is gathering data relative to integrating processes and optimizing unit operations.

We have developed an integrated nitric acid treatment system that includes reagent regeneration and recycle. This system has the potential to reduce the amount of liquid leaving the facility by more than 90% and reduce the amount of resulting sludge by more than 95%.

In the longer term, advanced separation techniques, such as ion-specific extractants, will allow us to remove additional actinides from the waste stream, thus reducing discharge to levels below regulatory concern or low level waste.

1.5.5 Waste Management

The most important area on the Complex 21 flow sheet is waste management. Our major goals in this area are to minimize the volume of waste requiring treatment and minimize/eliminate the actinide content of generated waste.

We have participated in waste management activities since the field began, safely handling more than 200,000 cm^3 of low-level radioactive, transuranic (TRU), and mixed waste. Much of this experience comes from our work at TA-55, where our expertise in applied research worked hand-in-hand with production. Since its startup in 1978, this facility has provided us with an excellent opportunity to solve real-world waste problems in an environment that permits us to demonstrate and evaluate actual waste. The lead laboratory for Complex 21 must have this type of experience to ensure its success.

Los Alamos waste management personnel have readily met waste management challenges through the implementation of several processes. For example, by developing and implementing at TA-55 the in-drum cementation process for TRU waste, we increased throughput capacity by more than 300% and reduced labor by 50%. This process is unique because it can pretreat and cement aqueous, nonpolar organic liquids and particulate wastes in the same drum. One example of such a process is the enhanced evaporator process, which brought about an increase in throughput efficiency of 100% and a 60% reduction in labor. Much of the evaporator's improvements result from the automation of the process using planning information document (PID) control loops. We are presently installing a third process improvement, a conversion of the TRU solid waste operation to an in-line system whose in-line assay and drum-leading ability will significantly reduce labor and plastic associated with bagout operations.

Another example of our expertise in the waste management field is TA-50's controlled air incinerator (CAI). The CAI is the only incinerator in the United States capable of burning both solid and liquid TRU mixed waste. Successfully tested using actual waste and presently awaiting NEPA (National Environmental Protection Act) approval for start-up, the CAI has the potential to reduce by 100-150 times combustible waste; in addition, CAI will destroy solvents in the waste that are Resource Conservation Recovery Act (RCRA) hazardous. This incinerator will be an excellent alternative to conventional operations that bulk-package combustibles.

One area of increasing importance is in certifying TRU waste drums for acceptability at WIPP (Waste Isolation Pilot Plant), especially for the absence of free liquid. At Los Alamos, we have progressed beyond standard x-ray radiographic inspection by applying computer tomography (CT) to waste drum certification. CT uses x-rays to scan the drum in a series of horizontal slices from a 360° perspective. It then uses computer manipulation of the data to produce a detailed view of each slice, showing the inner structure as density variations. All slices can also be combined within the computer program to yield a three-dimensional look at the waste form. The advantages of this system include much better detection limits on surface liquid and the ability to look at structural details such as inhomogeneity and cracks within the interior of the waste drum.

1.5.6 Analytical Chemistry

An essential component of the plutonium program, analytical chemistry provides quality analyses in broad range of technical areas, including accountability, quality assurance of product oxides and metals, process samples, process control, and waste streams. We possess an extensive array of analytical techniques and continue to develop new and improved capabilities, particularly in the use of automation. Our automation activities have focused on minimizing personnel exposure to radiation, reducing generated waste (particularly mixed waste), and improving measurement reliability.

Technologies such as inductively coupled plasma-atomic emission spectrometry (ICP-AES) and mass spectrometry (ICP-MS) provide measurement with sub-ppm detection limits of metallic impurities for most of the periodic table. We have demonstrated the feasibility of laser ablation, inductively coupled plasma-mass spectrometry (LA-ICP-MS), which effectively measures trace impurities in uranium oxide and propose to develop the analytical technique to provide the impurity analyses required for plutonium oxide and metal.

Accurate isotopic measurements provide accountability, product certification, and input for nondestructive analysis (NDA) measurements. We have two automated, thermal-ionization mass spectrometers for high-precision isotopic measurements. We recently developed a technique using total-evaporation in conjunction with a multicollector mass spectrometer, which significantly improves the precision of isotopic ratio measurements. The accuracy of the measurements is limited to presently available reference materials.

Identifying and tracking sample portions and analytical results place a crucial role in the accountability and timely reporting of results. To meet this need, we have in place a Laboratory Information Management System (LIMS) that bar-codes samples and voice inputs to computers for data entry at glovebox operating stations. The system improves efficiency and essentially eliminates transcription errors in data entry. Many of its standard analytical methods have been automated.

We are presently testing, evaluating, and implementing process analytical chemistry (PAC) techniques for chemical monitoring and control. ATLAS provides integrated PAC technologies that supply real-time chemical information; scientists then apply this information to optimize the processing, thereby avoiding process upset.

A three-level approach to PAC development involves at-line instruments (ion chromatography, automated titration, and ICP-MS), on-line measurements that make use of available commercial instrumentation and advanced data analysis techniques (fiber-optics spectrophotometry, on-line x-ray florcences [XRF], and gamma spectrometry), and compact, chemistry-specific sensor development (high-acid sensor, chloride sensor, and uranium/plutonium electrochemical sensor).

1.5.7 Automation

An important area, process automation impacts all aspects of the Complex 21 flow sheet. As a result of our extensive expertise and experience in this area, we currently operate six systems that provide routine plutonium service.

One example of automation is the plutonium dissolution robotics system, which uses a commercial cylindrical axis laboratory robot from Zymark Corporation. We designed and fabricated approximately 60% of the automated stations that the robot accesses to dissolve metallic plutonium, dispense the solution by weight into bar-coded vials, and enter all required information into the analytical LIMS.

At the other size extreme, we have engineered a large gantry robotics system named ROBOCAL (which stands for robotics calorimetry system) designed to perform NDA of various processing feeds and wastes generated by the plutonium processing facility at Los Alamos. This system combines several calorimeters designed by Mound Laboratory, an artificial-intelligence-based, gamma-isotopic analyzer designed by engineers at Rocky Flats, a 16′ by 12′ by 8′ commercial gantry robot made by CIMCORP Robotics, and three stacker/retriever storage devices made by KARDEX Systems. Los Alamos engineers modified the commercial devices and worked with the NDA engineers to integrate this system with a sophisticated control package that we designed. Our automated system can replace manual NDA analysis of materials. Using this system, a worker introduces several samples into the stacker/retriever and a control computer user interface selects the desired analyses. More than 100 items can be temporarily stored in this system, including standards that allow continual verification of the NDA analysis accuracy. Continuous operation is possible with this instrument, which significantly increases plant NDA analysis output.

Perhaps the most significant example of automation is the metal preparations line. This third-generation automation (we developed the first in the early 1950s) is designed to introduce impure plutonium nitrate solutions, precipitated plutonium peroxide/oxide, hydrofluoriate to plutonium tetrafluoride, and finally a reduction to metal or alloys. This automation system reduces radiation exposure. We transferred the first-generation system designs to Savannah River and Rocky Flats; in addition, we provided extensive on-site training and demonstration.

In the near future, we plan to develop a robotics system named SWAMI (Safeguards Waste Assay and Measurement Instrument). Designed to automate the NDA analysis of low-level plant-processing waste, SWAMI will consist of off-the-shelf equipment and an engineered control system that we will design and build in-house.

We are presently developing an array of additional automation and robotics systems designed to address specific operational requirements.

1.5.8 Technology Base Summary

For more than 15 years we have continued to advance the science of plutonium. For example, we continue to operate the only full-dimension plutonium operation in the country. In addition, we are the driving force behind the technology development area. We are installing and plan to demonstrate at TA-55 the entire Complex 21 flow sheet. Our current goal is to integrate significant sections of the flow sheet to measure the synergistic effect of changes and thereby optimize the processes. We follow a very formal development approach, which includes (1) understanding fundamentals of the chemistry and metallurgy (define the problem first), (2) understand how to control the chemistry, (3) engineer the process using the understanding of control, and (4) design the special facilities equipment after understanding the process constraints. Our experience has shown that this approach effectively avoids false starts.

Because of our unique facilities and multidisciplinary staff, we possess extensive experience and expertise in an array of technical areas. Internationally, we lead the world in weapons forums such as JOWOG and other foreign exchange agreements. Domestically, we are viewed as a lead laboratory in many areas, including most areas at Complex 21. We extensively collaborate with DOE contractors and commercial vendors, thereby ensuring that technology is transferred to organizations across the United States.

1.6 Plans to Maintain Technical Competence and Backup Capabilities in Plutonium Technology

To ensure technical competence, the work force must design and operate plant-scale equipment and produce actual product components. If we involve a highly competent work force throughout the project's duration, we will gain both the confidence and expertise in starting up new facilities.

Maintaining a highly competent work force requires a multifaceted approach. First, we must prototype and demonstrate at a production scale all equipment specified for the Complex 21 base line. This prototyping will allow operators to become a part of the technology development and understand the nuances of equipment selection and operation. Because the pilot plants will continue to function during the transition from the current Complex to Complex 21, personnel from the complex will retain their expertise.

Second, we intend to continue to support the WRD&T Testing program by supplying plutonium components and assemblies. Each test requires the fabrication of the test assembly plus a small number of backup assemblies. We will use this manufacturing as an opportunity to demonstrate the entire manufacturing and certification function, thus allowing us to maintain the certification capability.

Third, at the request of the Albuquerque Operations Office/DOE, we are presently using a pit-rebuilding function to augment its Stockpile Evaluation/Pit Surveillance program. In collaboration with DOE, we are exploring the possibility of rebuilding surveillance components as they are removed from stockpile for testing. We are initially focusing on establishing the capability to rebuild W88 pits but are also considering rebuilding other designs as well. These assemblies will have to meet War Reserve (WR) quality and certification (diamond stamping). This augmentation to an existing program will allow us to maintain the highly critical competence in manufacturing and component certification.

And fourth, through the Los Alamos Technology Office at Rocky Flats, we are taking a lead role in the Rocky Flats Residue Elimination Project (REP). This project will help us deal with the backlog of residues located at Rocky Flats as a necessary step in final decontamination and decommissioning of that site. Together with RFO and the M&O Contractor, we will determine the required flow sheet and the base line design. With contractor support, we will design, fabricate, and test-operate new equipment and gloveboxes before we ship to Rocky Flats. We will oversee the installation and startup of the new systems and provide technical support throughout the duration of the REP. To the extent possible, this activity will be used as a prototypical demonstration for Complex 21.

These four interrelated facets represent a very strong approach toward maintaining technical competence. We will employ actual operators during the prototyping and processing operations and process actual production materials at a production scale, select and design equipment, and prepare specifications for procurement. The equipment being demonstrated will be the actual Complex 21 equipment. And finally, the products emerging from the process lines will be usable products either for return to stockpile or for use at NTS. This suite of processing operations, including the intellectual expertise, represents a true backup capability during the construction and after the startup of Complex 21.

2.0 TRACK RECORD IN RELATED APPLIED R&D AND MANUFACTURING

We have always maintained a full-spectrum capability to handle plutonium. This capability includes dealing with the leanest scrap and waste, as well as producing high-quality components. Our mission has been to develop improved techniques and transfer the technology to the production plants as quickly as possible. Because we have a full-spectrum capability and have continued to process material at a production scale, we have an excellent understanding of the production problems and have effectively addressed them. There are numerous examples in which technology development and exchange has taken place, much of it involving joint efforts with other contractors. Some of the work has taken place at TA-55, such as the CRAC Cell development, Ion Exchange system prototyping, Dry Machining, and Pyroredox. Other projects have taken place at other venues, such as the Die Casting Program, Super Critical Cleaning, and Advanced Casting system concepts. We have *extensive* experience working with manufacturing processes. The most recent innovations in manufacturing have resulted from collaborations with the production plant.

2.1 Proven Performance in the Plutonium Technology Relative to Research, Process Development, and Innovation in Developing New Concepts and Ideas

Although the plutonium recovery and weapon component production efforts of Los Alamos date historically to 1944, the major production activities were transferred to the Defense Production Complex in the early 1950s. The actual recovery of plutonium from residues and conversion to metal was conducted at Los Alamos on a relatively constant basis until 1967. Figure 2 shows the growth in the employment at Los Alamos since that time and depicts the program expansion, particularly after TA-55 was commissioned.

1967	^{238}Pu Heat Source for Artificial Heart & Space Programs
1968	Reactor Fuels Development and Prototype Fabrication R&D
1977	Fast Flux Test Facility Fuel Fabrication
1977	^{241}Am Recovery and Purification for the Isotope Sales Pool
1978	CSMO Scrap Recovery and Material Return
1980	Pure Metal Production and Residue Recovery
1982	Milliwatt Heat Source Surveillance and Processing R&D
1983	ONMP PUREX Oxide Conversion to Metal

Since the mid-1980s, the direct population in plutonium sciences has grown very slowly, although there has been a significant growth in the indirect support areas. The current programmatic base includes

1. Advanced process demonstration and new concept development for Complex 21.

2. WRD&T materials, test components, and fabrication development.
3. National Stockpile Evaluation/Pit Surveillance Program.
4. National ^{238}Pu Process R&D and Surveillance Program.
5. National Center of Expertise in Nuclear Fuels Development.
6. Residue Elimination Program Support to RFO and RFP.
7. Weapon Dismantlement and Nonproliferation Development.
8. Work-off of Los Alamos and other DOE residue inventories.

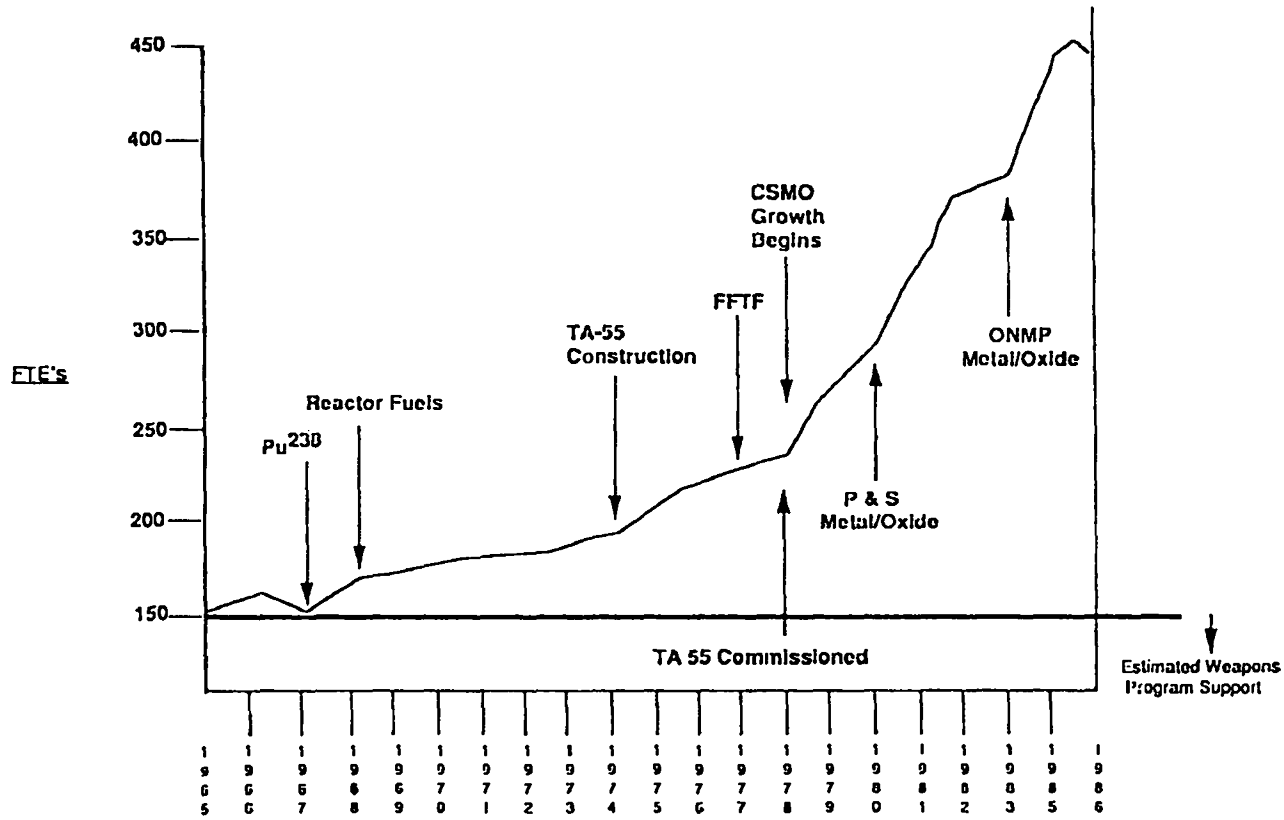

Fig. 2. All defense/energy programs—Los Alamos plutonium operations (U).

Also throughout the 1980s, we conducted research, development, and demonstration activities on the Special Isotope Separation (SIS) program, using the Molecular Laser Isotope Separation approach. Aimed at the separation of plutonium isotopes, this technology development used laser light to excite and dissociate the plutonium hexafluoride molecule in the gas phase in an isotope-selective process. During the several-year life of the program, we brought the technology from concept through proof of principle and feasibility demonstration to operation of an Engineering Demonstration System that used a combination of prototype and full-scale equipment and demonstrated isotope enrichment.

2.2 Proven Development of Prototypes, Pilot- and Production-Scale Demonstration, Ability to Understand and Solve Production Problems, and Introduction of Changes and New Processes into Production

We have actively responded to DOE requests to supply the necessary materials to meet programmatic milestones. Of significance was the need, through the 1980s, to supply ultrapure metal to Rocky Flats for use as blend stock in meeting component production commitments. The feed stock consisted of the entire spectrum, from lean residues to purex oxide. The rate at which we tooled up and the quantities indicate the responsiveness of the TA-55 design and the level of understanding achieved concerning production problems. Concurrently, we initiated technology development and exchange efforts to install updated technology into Rocky Flats facilities, with the emphasis on having Rocky Flats become self-sufficient in both scrap recovery and metal supply to the foundry.

Throughout this period of time, we continued to supply ultrapure metal to both the Los Alamos and LLNL WRD&T programs in support of the Research and Testing programs. In fact, Los Alamos manufactured components for both laboratories. We have now assumed responsibility of the spit surveillance portion of the Stockpile Evaluation program. This responsibility will allow us to ascertain the impacts that aging and manufacturing techniques have on stockpile components.

An noted above, we designed, built, and operated a Pilot-Scale Engineering Demonstration System plutonium isotope separation plant as a part of the SIS program. This facility, located in room 201 of the plutonium facility at TA-55, was fully operational and used many components that were full scale for plant operation. It successfully demonstrated all aspects of the technology needed for design of a production plant.

Additional examples of process technology demonstrations at the pilot- and production-scale are outlined in section 1.5, including both ATLAS and EXCEL processing demonstration modules that have direct application to Complex 21.

2.3 Experience Working with Manufacturing Processes

We have an extensive track record in applied R&D and manufacturing and a strong history working with manufacturing plants.

DOE's entire basis for the TA-55 operation is applied R&D and in demonstrating improvements at a production scale. In fact, essentially every production process at Rocky Flats had its genesis at Los Alamos. TA-55 processes every scrap form and the plutonium is recovered as pure plutonium metal—the facility even process scrap forms that no other facility can process. These scraps include residues from the fabrication of components used in NTS events, which involve radiochemistry tracers, tritium-contaminated metal, beryllium-contaminated metal and standards, thorium-contaminated residues, and others. We developed all the stockpile alloys and the techniques for reproducing them at a production scale.

Los Alamos maintains the only full-breadth plutonium processing capability in the United States. This capability includes waste management and disposal, residue recovery, and component manufacturing. Because of this expertise, we can focus on making significant improvements in processing while exercising the capability on a production scale. During the 1980s, much of the product resulted from applied R&D efforts on actual production residues. During this period, a vigorous technology exchange took place between RFP and Los Alamos, the goal of which was to transfer the process improvements into the production operations.

We also continue to produce weapon assemblies for the Nevada Testing program, including the associated effort of processing and recycling of all residues. Major changes in actual manufacturing techniques have continuously occurred, including dry machining, laser welding, metal casting molds, supercritical cleaning, gas pycnometry, melt consolidation of turnings; on-machine gauging, and the use of automation.

The basis for the design and operation of the plutonium operations at Los Alamos has been applied R&D and Demonstration. We have continued to promote a vigorous technology exchange program both nationally and internationally. This DOE investment has been very successful, based on the success we have experienced in improving production processes.

3.0 EXPERTISE AND PERSONNEL

Since 1943, the Chemistry and Metallurgy Division at Los Alamos, numbering 400 scientists and technicians, has pioneered all the processes for plutonium purification, metal preparation, and metal fabrication. Below is a brief chronological history of plutonium sciences leading up to the current configuration of Los Alamos plutonium capabilities.

<u>1943-1946</u>

Development of processes and methods for

- purification of plutonium nitrate solution;
- preparation of plutonium tetrafluoride and other compounds;
- reduction of plutonium compounds to metal;
- fabrication of metallic shapes;
- analysis of plutonium materials; and
- recovery and recycle of plutonium residues.

Devices, fabrication, and assembly:

- fabrication and assembly of plutonium devices for Trinity test, Nagasaki drop, and Bikini tests.

Plutonium process facilities:

- stainless-steel glovebox facilities with elaborate HVAC system.

Health and safety:

- development of radiation detectors; and
- development of safe handling procedures for plutonium.

<u>1947-1978</u>

All stockpile warhead production until early 1950s.

Transfer of plutonium production technologies, including personnel and equipment, (early 1950s) from Los Alamos to

(a) Rocky Flats—aqueous, metal production, and metal fabrication.

(b) Savannah River—aqueous and metal production.

(c) Hanford—aqueous and metal production.

<u>Los Alamos' Research and Development Role</u>

Major discoveries and advances were made in

<u>Plutonium Metallurgy</u>—vacuum casting, metal working, machining, phase diagrams, crystal structure, alloy development, and solid-state physics.

<u>Pyrochemical Processes</u>—electrorefining, molten salt extraction, direct oxide reduction, and pyroredox.

<u>Aqueous Recovery Processes</u>—basic R&D in process chemistry, and development of processes for virtually all types of residues.

<u>Plutonium Reactor Fuels</u>—both metal and ceramic reactor fuels developed and studied.

<u>Heat Sources for Space Applications</u>—first plutonium-238 heat source developed at Los Alamos, program still continues.

<u>Safeguards</u>—development and use of computerized accountability system in the 1960s led to development and use of real-time accountability systems DYMAC (1978) and MASS (1980s).

<u>Non-Destructive Assay (NDA)</u> - coincidence neutron counters, gamma-ray spectrometers, and other NDA equipment developed at Los Alamos.

<u>Special Isotope Separation</u>—the Los Alamos approach to plutonium isotope separation based on Molecular Laser Isotope Separation (MLIS) was developed from the research concept stage through operation of a pilot-scale Engineering Demonstration System (EPS) during the 1980s.

<u>Los Alamos' Plutonium Facility Design Role</u>

Design of TA-55 was initiated in 1972 and operation of the facility started in 1978.

1978-Present

Operation of the new plutonium facility (TA-55) in 1978 introduced a new era for SNM operations in the DOE complex. Real-time accountability for Nuclear Materials Safeguards became an integral part of daily operations. TA-55's fully integrated plant filtration system for gloveboxes, hoods, and laboratories with provision for operation of inert gas gloveboxes was the first of its kind. Automated alarm and emergency power systems guaranteed safe operation of the ventilation system the primary requirement for a plutonium facility. New environmental standards required close cooperation of the plutonium operations with Health, Safety, and Environmental groups from Los Alamos. TA-55 design criteria eventually led to the preparation of DOE Order 6430.1.

R&D in plutonium metallurgy, pyrochemistry, aqueous recovery, reactor fuel development, and heat source development continue to be major programs at TA-55. In the early 1980s, we helped solve the RFP metal shortfall by producing large amounts of pure plutonium metal. This was accomplished by increasing the TA-55 electrorefining output. The flexibility of the TA-55 facility permitted this scale-up to take place in less than six months.

Research and development continue in all plutonium technology areas. Recently, we have emphasized efforts to minimize waste and reduce operator radiation exposure. To accomplish these objectives, we are improving the efficiency of existing processes, introducing new innovative approaches, and the recycling or reusing reagents.

3.1 Technical and Managerial Qualifications and How Competency will be Maintained

We have a strong track record in managing both the construction of major facilities and managing the operation of those facilities once they are completed. Figure 3 shows the number of individuals who are directly involved with plutonium sciences and facility management (approximately 500). These individuals cover all the essential areas for Complex 21 operations. There are equal numbers of people who are indirectly involved in areas such as Health, Safety, Environment, Training, Personnel, etc. In reference to the direct employees, there are greater than 15 technical disciplines represented, including chemistry, physics, metallurgy, and chemical, nuclear, civil, mechanical, electrical, and electronic engineering. The technical staff versus technical support breakdown is approximately 40% staff and 60% technician. Approximately 75% of the technical staff have advanced degrees.

Competency is maintained through several established programs, as well as aggressive R&D programs. Established programs directly related to this functional area are

1. Advanced process demonstration and new concept development for Complex 21
2. WRD&T materials, test components, and fabrication development
3. National Stockpile Pit Surveillance Program, including component rebuilds
4. National ^{238}Pu Process R&D and Surveillance Program
5. National Center of Expertise in Nuclear Fuels Development

6. Residue Elimination Program support to RFO and RFP
7. Weapon Dismantlement and Nonproliferation Development
8. Work-off of Los Alamos and other DOE holdings

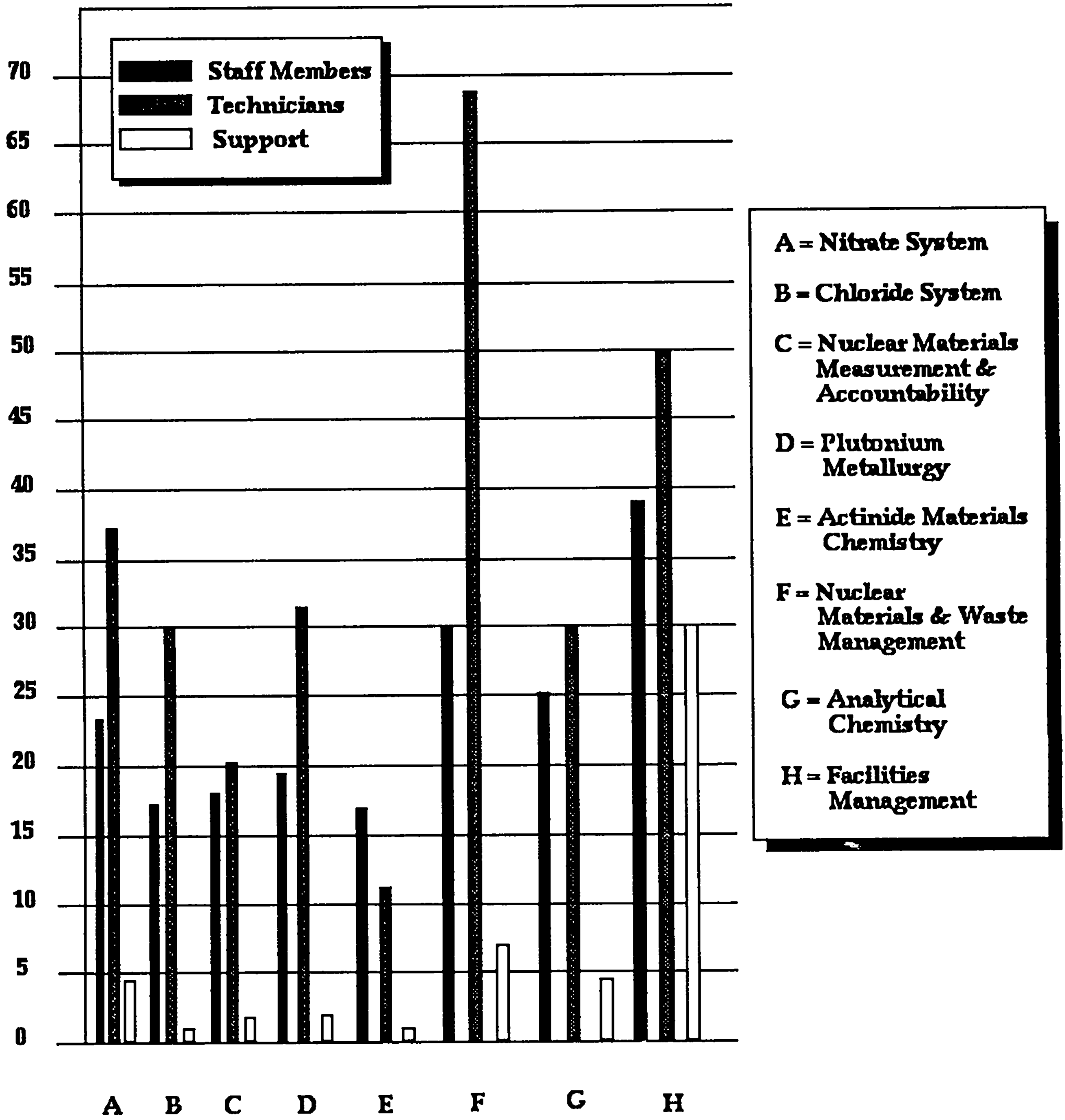

Fig. 3. Plutonium sciences and facility management personnel chart (U).

By participating in such programs, we can continue to operate all production equipment at a full production scale; in addition, we can produce full-scale components. This capability helps us maintain a good understanding of both the materials and the production processes. In addition, competency will be maintained by incorporating technical activities of other DOE contractors into the development plans for the base line flow sheet. The Pu/TASP forum has outlined a significant portion of those tasks, which will need to be carried out to complete the base line flow sheet validation.

By focusing on the real problem, Los Alamos engineers and scientists have acquired a reputation for simple and producible process designs, unlike other designs that only treat the problem's symptoms. Our approach emphasizes concurrent and liaison engineering with RFP. For a number of years, we have supported direct technical contact with RFP through Technology Exchange and Personnel Exchange and currently support a resident office at Rocky Flats with 25 engineers on site. Today, we have a large staff of trained personnel—we will commit and maintain this staff to perform the R&D and manufacturing support required to perform the lead laboratory activities for the Complex.

3.2 Availability of Personnel to Perform Applied R&D and Manufacturing Support

As stated earlier, we are prepared to fully staff an office in Washington, DC, in support of DOE and the A/E. We can also staff an office at the contractor site to likewise support the contractor and the A/E. We have a long history of successfully operating satellite offices. Most recently, we supported a staff office in Washington, DC,. in support of the New Production Reactor (NPR). We also currently staff the Los Alamos Technology Rocky Flats Office (LATO/RF), with approximately 25 individuals in residence. The mechanism for staffing includes (1) change of station assignments, (2) extended travel, (3) regular travel, and (4) direct hiring at the resident site. The mechanisms for handling these types of assignments have been well established at Los Alamos. A unique feature of the RFTO is that in addition to Los Alamos engineers, the office manager has overtly solicited the participation of other DOE contractors in the office. Currently, four other contractors have assigned engineers to the RFTO office. This example shows how Los Alamos can pull together a multifaceted team of people who represent various contractors to provide the necessary support for DOE.

We will also use the same teaming approach relative to performance of R&D functions. Again, the Pu/TASP has outlined a list of necessary development activities that we need to to complete the base line flow sheet validation. We will ensure that these developments are completed on time and that a decision mechanism will be used to select technologies. Personnel and facilities from throughout DOE will continue to be tapped to complete these developments.

4.0 EXPERIENCE WITH MANUFACTURING AND PRODUCTION

4.1 Experience Working with the Plants

Since the late 1970s, we have focused on supporting an integrated technology development and demonstration program. Inherent in this program is the need to first have a good understanding of the problem from a fundamental standpoint. We established a very formal program with RFP in 1983, the purpose of which was to clearly identify key problems and initiate development efforts focused on those problems. At the same time, we formally established JOWOG 30 with the UK. Both the UK and RFP were interested in the deployment of advanced technology for new facilities and upgrading technologies in existing facilities.

Relative to the UK, Los Alamos hosted a vigorous R&D and exchange program wherein scientists came, on assignment, from the UK to perform joint research and to develop new equipment. Numerous equipment packages were developed and manufactured here at Los Alamos, demonstrated on plutonium containing materials, shipped to the UK, and subsequently set-up for demonstration at Aldermaston. Los Alamos scientists were heavily involved in all phases, including the start-up and operation of equipment in the UK. Equipment included advanced casting technology installed in a suite of gloveboxes, advanced induction heating systems, an entire chemical, processing system installed in a suite of gloveboxes, solid-state process controllers, and the world's most advanced materials accountability and safeguards system. This exchange continues today, with us providing advanced NDA equipment and a large number of lessor equipment and materials items.

In 1989 Los Alamos, through its Technology Office at Rocky Flats, took the lead in evaluating the Plutonium Recovery Modification Project (PRMP) for the RFP and redefined the project design base line. The PRMP was intended to revitalize Building 371 at RFP for the purpose of processing manufacturing residues and stockpile returns to provide pure metal for the Building 707 foundry. The design base line was cumbersome and technically outmoded, in some instances using process technology that had already been discontinued or upgraded in Building 771, the facility PRMP was intended to replace. The redefined base line, using technologies that had been demonstrated at Los Alamos, provided dramatic improvements in operational efficiency. For example, waste generation was decreased by 75% compared to the original base line and then current RFP operating practice. Significant improvements were also realized in such diverse areas as radiation exposure to operators and in materials control and accountability. A major contributing factor was the Los Alamos experience in executing a fully integrated and comprehensive program that allowed for a "big picture" approach with an appreciation for the high degree of interaction that exists between essential process and support activities.

4.2 Experience Solving Manufacturing Problems and Introducing Specialized Techniques into Manufacturing

We have extensive experience working with all phases of the manufacturing, residue recovery, and waste management processes needed for Complex 21. We have always maintained a full-spectrum and production-scale capability to handle plutonium. The initial level of experience has involved weapon engineering in the metallurgy/manufacturing area to include the introduction of new manufacturing techniques such as heat treating, machining tooling, and joining technologies. More recently, significant improvements have been made in the chemical processing areas. Some examples of experience in all areas, in which direct transfer to production was achieved, include

- Molten Salt Extraction: A new salt and oxidant system was developed in the laboratory and transferred to production at RFP. The result was a significant reduction in radiation exposure, reduced waste generation, and half of the normal processing steps.

- Ion Exchange: An advanced ion exchange resin was developed in the laboratory, together with an advanced process control system. The new system operates almost automatically with on-line analytical control. The result are a four-fold reduction in waste and a similar reduction in radiation exposure.

- Direct Oxide Reduction: Most of the entire first-generation process was transferred to production after an extensive demonstration at Los Alamos. The demonstration involved personnel exchanges with RFP and the direct transfer of equipment to RFP. The result is a significant reduction in radiation exposure and reduced workplace hazards.

- Aqueous Chloride Processing: Limited recovery of chloride salt-based residues has taken place. We established the base line for salt processing and were in the process of transferring the separations/purification technology to RFD at the point of their shutdown. Again, extensive RFD involvement in the project was essential.

- Cascade Dissolvers: RFP and Los Alamos scientists installed at Los Alamos an advanced cascade dissolver system for use in treating residues. The improvements in the system were successful and the decision was made to incorporate the changes in production operations at RFP.

- Casting Hardware: RFD and Los Alamos scientists have been working on advanced mold materials for quite some time. Improvements are continuously introduced into production operations at RFP.

- Alloys: We are responsible for all of the stockpile alloys and have continuously worked with RFP metallurgists to incorporate processing parameter control to accomplish the desired alloy and phase structure.

Many more examples of technology transfer exist. In some cases, some collaborations decided not not implement a technology, even though it had been successfully tested and process demonstrated. Projects of this nature include

- Die Casting: Collaboration and consultation between RFP and Los Alamos personnel resulted in the successful development of a production die casting system with the goal being to produce near specification weapon cast shapes. Once demonstrated, an evaluation was made as to the overall cost benefit and the decision was made to abandon the project in preference to current, albeit improved, casting technology.

- CRAC Cell: RFP and Los Alamos scientists installed at Los Alamos the advanced Coaxial Removable Anode Cup Electrorefining system for a demonstration of the concept. The system was run in a demonstration mode for two years. The performance of the system did not achieve the desired level and the decision was made to not use the technology.

- CEPOD Dissolvers: This electrolytic dissolution technique has been considered for replacing a variety of dissolution steps. There has been a long history of test demonstrations, some of which appear to be successful whereas others appear to be a failure. To date, our test demonstrations have proven inconclusive and therefore, a recommendation to implement in production has not been forthcoming.

Examples of technologies in which production implementation was imminent include

- Dry Machining: A technique for machining a plutonium component without the use of cutting oils and consequently without the need for cleaning solvents. The result is the elimination of mixed waste, the very significant reduction overall waste, and reduced radiation exposure.

- Multiple Cycle Direct Oxide Reduction: An innovative technique for converting plutonium oxide to metal while *in situ* regenerating the process reagents. The result is the near elimination of waste and the significant reduction in radiation exposure. The operation is in the process of being integrated with adjacent processes and automated.

- Super Critical Fluid Cleaning: An innovative technique for cleaning oils off of weapon components with the use of recyclable non-hazardous solvents. This is a joint Rocky Flats/Los Alamos program.

- Site Return Handling: An elegantly simple and innovative approach to removing the plutonium from site returns, purifying it, and returning it to the production sequence is being developed and involves *in situ* molten salt extraction and aspects of automation. It also involves the use of systems engineering principles to obtain a well integrated operation.

These are examples across operations and represent only a few of the numerous examples in which manufacturing understanding improvements have resulted. All the improvements resulted from the joint development of operations. Generally, the teams consisted of RFP and

Los Alamos personnel, although there are numerous examples in which academic and outside contractors also participated.

Because of our long history of working with plutonium, we have always maintained the full-spectrum processing capabilities and have exercised those capabilities through execution of numerous DOE program. An essential aspect of each program has been the development of advanced concepts in processing so as to improve a key aspect of the operations such as waste reduction, exposure reduction, and workplace hazard reduction. Examples of these improvements can be found throughout the DOE complex in all areas of materials processing.

4.3 Technology Innovation and Benefits with Regard to Waste Minimization, Waste Treatment, Worker Safety (Including Radiation Exposure), and Efficiency

This area is a particular strength at Los Alamos as evidenced by the track record in performance at TA-55. Relative to waste minimization, Los Alamos has had this as a major focus since the mid 1980's. A number of process developments have resulted in the total elimination of waste while almost all processes have experienced an order of magnitude reduction in waste. These developments have *all* occurred in real plutonium operations after the cold demonstrations with stand-in materials was completed, meaning that the improvements are production demonstrated. Probably the most significant aspect of the improvements is that overall process efficiency has increased, thus offsetting the cost of the developments. Most of these improvements were in the process of transfer to Rocky Flats at the time of the shutdown.

Our approach to process improvement is quite simple. We first start with a definition of the problem—we do not work on symptoms of problems. Almost always, understanding the problem requires an understanding of the fundamental aspect of the process (actual chemistry and metallurgy). Efforts focused on addressing the fundamental aspect of a problem almost always yield very simple and low cost approaches to problem resolution and thereby avoiding costly engineering and facility modifications. Examples of some significant improvements are as follows:

1. Ion Exchange: We have realized as high as 35% reduction in process acids and conditioning fluids as a result of improving the process control mechanism. We are also experiencing up to 50% less plutonium in ion exchange effluents. Finally, we have experienced a significant lengthening of resin life as a result of improved resins and improved process control. In our old system, resins were changed every 6 months because of fouling whereas in the current system resins have been in use for over two years with resin performance continuing to improve. Comparable reduction in radiation exposure has resulted.

2. Multiple Cycle Direct Oxide Reduction: We have realized an 80% reduction in residue salt generation through the introduction of *in situ* reagent regeneration and recycle. We have also experienced a 75% reduction in crucible waste generation through the same mechanism. Because we are regenerating *in situ*, we are able to

avoid 75% of the accountability steps and 75% of the residue handling steps thereby avoiding an equal increment of radiation exposure. Finally, in the Complex 21 Base line Flow sheet, even the 20% of remaining salt will be reused making this process a virtual waste free process. In the mid 1980's this was the single largest bulk waste generator and the single largest point of plutonium loss to waste.

3. Dry Machining/Melt Consolidation: By utilizing oxygen free atmospheres in plutonium machining, we have demonstrated the ability to machine without cutting oils and without chlorinated cleanup solvents. In RFP this represented 15000 gals/yr of carbon tetrachloride and 5000 gals/yr oils. A secondary benefit is the opportunity to directly melt consolidate the turnings without going through an intermediate cleaning process. This one process improvement will result in a down sizing of the Complex facility by as much as 30% and radiation exposure by a comparable amount.

In areas other than chemical processing, significant improvements have also taken place. An example involving Material Control and Accountability is our fully automated ROBOCAL system which takes residue and waste cans and performs a number of NDA measurements, with the result being a decision on accountability and waste discard. A stacker return storage system can hold up to 100 items and the system can run around-the-clock. The results have shown improved accountability, floor utilization, and consistency. Incidental, albeit significant, is the reduction in radiation exposure. We have a large number of additional examples, found in section 1.5 of this report, where automation has brought about improvements in overall operations. Spin-off benefits, in the form of reduced worker hazards, have also been a positive result.

Relative to improved worker safety, we have found that if we focus on first defining the technical problem and then addressing the problem with logical solutions, we also gain significantly in worker safety. This approach has paid significant dividends as measured by our facility radiation exposure data. Figure 4 shows the trend in radiation exposure over the past 10 years in TA-55. We have been able to reduce overall radiation exposure by 75% since 1982. This dramatic drop in radiation exposure has resulted primarily as a result of dealing with inefficiencies in the overall operations and by implementing technical solutions.

Los Alamos is well recognized as a leader in Waste and Hazard Minimization. In 1990 Los Alamos was selected to manage the plutonium waste stream activity resulting from the DOE Waste Minimization Program. Again, this program involved integrating the efforts from a number of contractors and focusing the efforts on specific waste generation problems. To date, there are three National Laboratories, two Contractor sites, and at least two Universities involved in the program. The focus has been on minimizing workplace hazards and waste beginning at the source rather than treating end-of-pipe effluents. Primary emphasis has been in the manufacturing area as this is the initial source of residues requiring subsequent processing. Success in the program will lead to technologies which will reduce waste from Complex 21 to less than 5% of that generated by operations conducted at RFP.

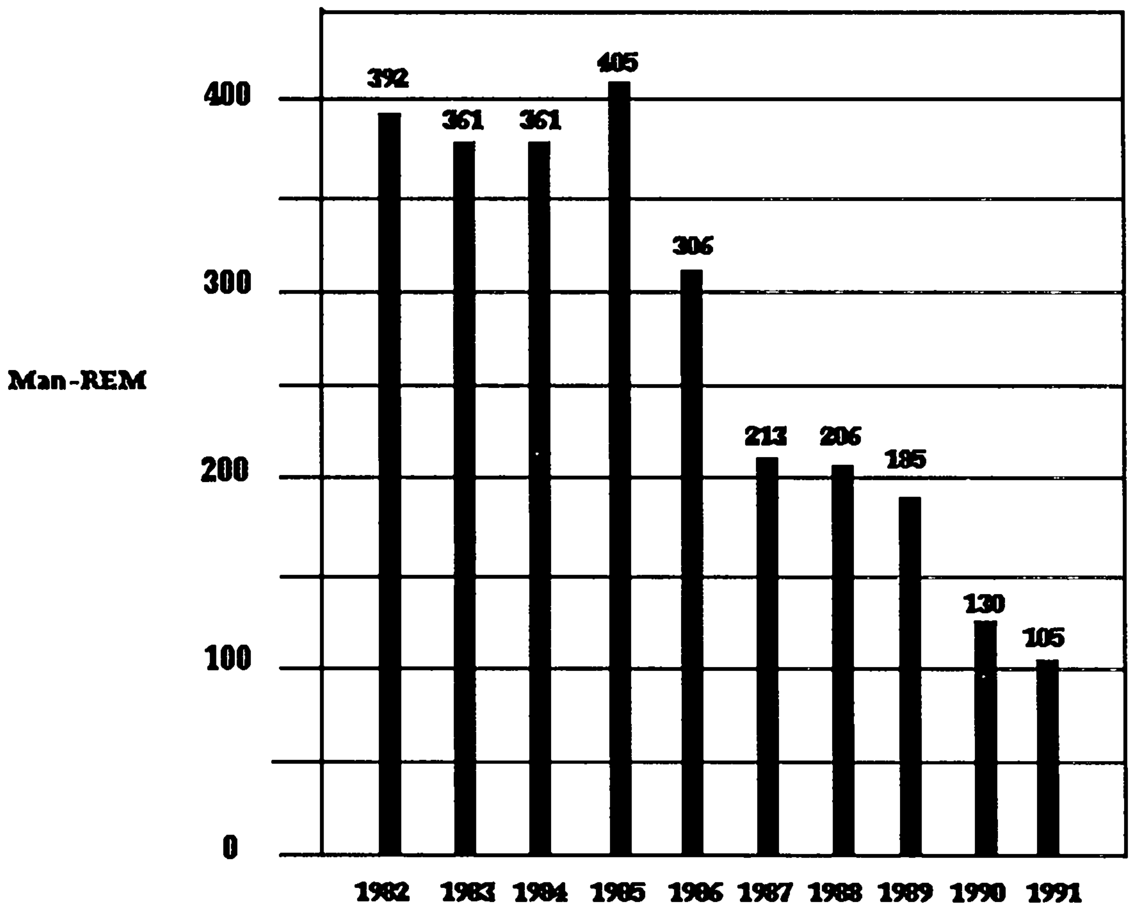

Fig. 4. Los Alamos Plutonium Facility cumulative yearly exposure (U).

4.4 Experience with Cost/Benefits Analyses

Los Alamos National Laboratory is a recognized leader in cost/benefit analysis applied to the management and production of nuclear materials, weapons, environmental cleanup and restoration, waste management, and alternative energy generation. Some examples are listed below.

Environmental Cleanup and Restoration - Los Alamos has recently developed decision analysis techniques which utilize cost/benefit as an attribute. Recent activities include analyzing the cost per cubic meter of waste treatment, storage, and disposal, and developing a method to assess the cost and benefits of new environmental restoration and waste management technologies. Studies have been performed for DOE/CE and PPE.

Military Applications - As an integral part of its ongoing mission for DoD, Los Alamos has performed cost/benefit analyses for potential weapon systems. These analyses evaluate the utility of the weapon system. This includes extensive modeling of engagement scenarios and application environments. The modeling typically addresses the specific application of the weapon system to define the benefit in terms of offensive effectiveness (e.g., targeted assets destroyed) and/or defensive effectiveness (e.g., enemy offensive systems attrition). Benefits are often expressed in terms of blue assets saved or costs not incurred. Life cycle costs are also estimated for each weapon system. These costs include R&D, deployment, fabrication, and maintenance contributions to determine costs over the lifetime of the weapon system. The benefit of the weaponized system is systematically evaluated against costs to determine the cost/benefit for each system being evaluated.

Complex 21 - System analysis, modeling, and integration studies are being performed in support of the weapons complex reconfiguration study for the Technology Assessment and Selection Panel. The process of making complex decisions requires the weighing of many variables. Los Alamos has applied its unique combination of engineering expertise, computer programming skills, and nuclear materials processing experience to develop an advanced simulator capable of providing cost/benefit analysis. the simulator has been used extensively in Complex 21 studies, including applications for plutonium, uranium, and salt processing plants.

5.0 EXPERIENCE WITH A/E FIRMS

Los Alamos has extensive experience in coordinating with A/E Firms on large complex construction projects. We have assumed construction management role, including design and specification of processes, performing both the functional and detail design, and directly interfacing with the A/E on facility design of facilities.

Los Alamos recognizes the unique nature of A/E procurement and has established a group whose sole function is procuring A/E and construction services. This group ensures that A/E procurement is in accordance with federal requirements, including the Brookes Act and DOE requirements, specifically 4700.1 and subpart 936.6 of the DOE Acquisition Regulations "Architect-Engineer Services". This group and the technical organizations develop design criteria in accordance with DOE 6430.1A; A/E selection criteria; proposal advertisements; review proposals including the 254 and 255 forms; select and interview the short listed firms; solicit proposals; and, negotiate with the most technically qualified firm.

Los Alamos currently has the only DOE approved CSCSC (Cost, Schedule, Control, System, Criteria) system among all Laboratories. This system is consistent with DOE Orders 4700 (Project Management) and 2250 (Cost Controls).

Los Alamos has six A/E firms under contract to assist on small to moderate construction projects and in development of larger projects. Three have local offices and are available on a time and materials task order basis. The other three are available on a negotiated, fixed-price design order basis. The total annual budget for these six firms is about $10M.

5.1 Experience Developing Technical Criteria and Standards for Manufacturing Process

Los Alamos prepares technical criteria and standards for all processes at Laboratory facilities. This includes standard building equipment such as chillers and electrical substations, and special facilities equipment such as lasers, gloveboxes, accelerators and electron microscopes.

The standard facility equipment is specified in construction documents to be furnished and installed by the construction contractor. Los Alamos maintains a 9-volume set of standards which includes standard specifications for many types of equipment. Los Alamos has a very experienced and qualified staff to perform special facility equipment design.

5.2 Experience Working With A/E Construction Firms in a Broad Sense on Projects of the Scale of Those in Complex-21/With Emphasis on those in the Functional Area.

For years Los Alamos has provided technical support to DOE including preparation of the Conceptual Designs and Design Criteria. Since 1987, Los Alamos has taken over contracting authority for A/E and construction contracts. Los Alamos experience with construction of major facilities is broad and recently exemplified by the construction of the TA-55 Plutonium Facility (Mid 1970's), the Target Fabrication Facility-TFF (mid 1980's), the Los Alamos Detonator Facility - LADF (1980's), the Device Assembly Facility - DAF (1980's), the Weapons Engineering Tritium Facility -WETF (1990's), Special Nuclear Materials Storage Facility-NMSF (1980's), and the Materials Science Laboratory-MSL (presently in construction). Other significant construction projects requiring significant A/E interface, but which were not carried through to completion, include the Special Laser Isotope Separation (SLIS) project and the SNML. Los Alamos participated heavily in the specification and construction consultation on the A-90 facility at Aldermaston, England.

With all the above facilities, we developed the entire technical criteria and standards packages that represented the design guidance basis for the facilities. These packages included specifying all processes, support utility requirements and sizing, floor plans, standard structural features, special facility equipment, and special design features required for ease of operation.

In the TA-55 facility, we assumed the A/E role at Title III and completed the project. This required the development of a very cohesive team including technologists, A/E personnel, DOE personnel, and other contractors. The approach taken was to assign the responsibility of preparing criteria, designing processes, performing acceptance testing and performing final operation, to the actual engineer who would eventually operate the equipment in the processing mode. This included the facility equipment such as HVAC, vacuum systems, etc.

The highly successful TA-55 facility is similar in scale to Complex 21 . A similar approach was used in WETF, TFF, and NMSF. The TFF is fully operational and performing marvelously. The WETF has been approved for operation and is expected to begin tritium operations this summer. MSL will be activated soon. An upgrade to the NMSF is ongoing.

The design and construction of the Los Alamos Detonator Facility (LADF) represents a very successful Los Alamos•A/E interaction (Bernard Johnson, Inc.). Design criteria for the facility that housed explosive operations, printed circuit fabrication, and laboratory/office space were prepared jointly by Los Alamos and the A/E. The facility has been fully functional for several years, is operationally efficient, and is the only facility among the design laboratories that has the capability to manufacture detonators.

Another recent example of extensive Los Alamos•A/E is the Device Assembly Facility (DAF). This project involved extensive participation by LLNL and the Pantex Plant. Design, construction, and preparation-for-use of the DAF at the Nevada Test Site began in 1980. Approximately forty Los Alamos, forty LLNL, and five Pantex staff are working intensively with the Raytheon Services Nevada staff.

Other major facilities that have been designed and/or constructed at Los Alamos since 1980 are listed at the end of this chapter.

5.3 Experience with Complete Manufacturing Process

The Special Nuclear Materials Laboratory (SNML) is a recent project involving A/E interface for facility and process design. In 1987 the Laboratory formed an SNML Projects Office in order to establish a dedicated organization containing all the expertise necessary for the technical management of defining, planning, and implementing state-of-the-art plutonium R&D processing facilities. This organization comprised of senior staff experienced in the operations of plutonium facilities as well as senior technical facilities project management expertise hired from private industry (large A/E firms). Several of the staff had previously participated in the design, construction, start-up and operations of the TA-55 plutonium facility.

The $400M Project included plutonium qualified space of approximately 50K square. The Design Criteria, complemented by planning studies, was initially developed for the A/E's. Working with the A/E during preliminary design, comprehensive Design Requirements Base line documents were produced, one for facilities requirements and one for special facilities equipment. These documents, along with the PSAR, comprised the technical controlled scope and base line for detailed design.

A strong "systems engineering" approach was utilized in development of all technical criteria. The Office also conducted and hosted a complex-wide DOE work seminar on the implementation of DOE Order 6430.1A in the area of nuclear non-reactor facilities.

A complex-wide peer review panel o reviewed technical criteria and designs. Also, outside value engineering appraisals were conducted. The technical efforts (Title 1) produced for the SNML project have subsequently been utilized as a technical database and resource for the other sites and associated projects as well as for conceptualizing the modular Plutonium processing approach for Complex 21. We believe that this set of technical criteria documents represents a state-of-the-art resource for SNM processing facilities.

Relative to experience working with A/E construction firms, on the SNML Project, the Laboratory engaged two A/E firms; Fluor-Daniel, Inc. (FDI) for facilities design and Merrick Inc. for special facilities equipment design. The FDI contract represented the largest A/E contract ever engaged by Los Alamos. The FDI management team is the same team now engaged in the FDI contract with DOE for Complex 21. Much of the knowledge gained by FDI and Los Alamos on SNM facilities, processes, and technical requirements stemmed from the Los Alamos SNML project. Similarly, Merrick Company's relationships with the Los Alamos Office resulted in them now being an A/E subcontractor to FDI on Complex 21. The Los Alamos Office also recommended Merrick as Small Business Subcontractor of the year, which they were subsequently named nationally. The most notable example of a complete manufacturing process is the Plutonium Facility at TA-55.

5.4 Experience with Environmental Assessments

We have extensive experience with Environmental Assessments (EA) and Environmental Impact Statements (EIS). Specific accomplishments as to SNM facilities has been very successful. An EA was completed for the SNML Project. Subsequently, DOE requested an EIS which is presently 40% complete. The EIS is being performed in cooperation with Battelle as a DOE subcontractor. Currently three EA's are in preparation for the $50M upgrade to the Chemistry and Metallurgy Research (CMR) facility in conjunction with the SAR. Complete risk analysis and assessment expertise and capabilities also reside at Los Alamos. We have written guidelines accepted by the complex for preparing Safety Analysis Reports. Also completed are the NEPA documentation for a new Nuclear Materials Storage Facility. EA's for the MSL and NMSF resulted in a Finding of No Significant Impact (FONSI).

Los Alamos maintains an experienced well qualified staff to perform Environmental Assessments therefore all EAs to date have been performed in-house. However, Los Alamos is in the process of contracting with two engineering firms to perform this type of service. The procurement process is in the final selection phase and is expected to be complete in the next few months.

Over the last three years Los Alamos has completed five EA and ten more have been submitted to DOE. There are currently eight more in preparation that have not been submitted.

5.5 Experience in Complex 21

We are assisting the A/E firm, FDI, with the completion of both the reconfiguration PEIS and the Design Guidance Manual (DGM). A team of Los Alamos technical experts, representing plutonium, plutonium storage, uranium, lithium, high explosives, Assembly, and tritium have assisted FDI in establishing the design criteria for the DGM. The focus has been to assist in identifying the facility impacts issues associated with the manufacturing, product certification, security, and safeguards. The Los Alamos team is currently reviewing the first draft of the DGM for consistency with the base line flow diagrams. Additionally, the successful Los Alamos base line process modeling efforts have been offered to FDI for cost-benefit analysis. For plutonium, we are performing the entire risk assessment for the base line flow diagram, which will be part of the DGM. We believe the effectiveness of the technical assistance provided to FDI will be further enhanced by the lead laboratory concept.

MAJOR PROJECTS WITH LOS ALAMOS CONTRACT ADMINISTRATION	
TITLE/STATUS/A-E	**DESCRIPTION**
<u>Laboratory Data Communication Center</u> Completed in 1989 **Flatow Moore Bryan Shaffer McCabe**	95,000-square-foot computing and communication facility. DOE administered Title I and II, with Los Alamos contracting Title III and construction
<u>Dual Axis Radiographic Hydrotest Facility</u> Phase 1 completed in 1990 **Stearns-Roger/UEC**	Two facilities totaling about 55,000 square feet. The main facility will contain two 16-MeV accelerators. Los Alamos procured Titles I, II, and III services as well as construction.
<u>Hazardous Waste Treatment Facility</u> Title I design **Holmes & Narver**	The facilities include (1) 12,000-square-foot treatment facility to treat radioactive and chemical waste, (2) 3,500-square-foot support office facility, and (3) hazardous waste to be treated drum storage area. Los Alamos procured Titles I, II, and II services and will procure construction.
<u>Sanitary Wastewater System Consolidation</u> In construction **Bacchus Consulting**	A new sanitary waste treatment and collection system. Los Alamos procured Titles I, II and III services as well as construction.
<u>Material Science Laboratory</u> In construction **Smith Hychman and Grills**	A 55,000-square-foot facility to perform materials research. Los Alamos procured Titles I, II and III services as well as construction.
<u>Nuclear Safeguards Technology Laboratory</u> Title II in progress **Leedshill-Herkenhoff**	A 45,600-square-foot facility at TA-55 to provide fail-safe methods to track and inventory nuclear material. Los Alamos is lead DOE lab for nuclear materials measurement and accountability. Los Alamos procured Titles I, II and III services.
<u>Ground Test Accelerator</u> Completed in 1989 **Holmes and Narver**	A 29,000-square-foot accelerator tunnel and laboratory building with a 49,100-square-foot office building. Los Alamos procured Title I, II and III services as well as construction.
<u>Neutron Scattering Experimental Hall</u> Completed in 1989 **Leedshill-Herkenhoff**	A 20,000-square-foot experimental hall and a 75,000-square-foot support building.

RECENT MAJOR PROJECTS WHERE LOS ALAMOS SUPPORTED DOE CONTRACT ADMINISTRATION
New Detonator Facility
Advanced Radiochemical Weapons Diagnostic Facilities
Central Guard Facility
Test Fabrication Facility
X-Ray Calibration Facility
Space Science Center
Otowi Building
Proton Storage Ring
ATAC Technical Support Facility