Decision Applications Division

Group Overviews

Decision Applications Division Organization

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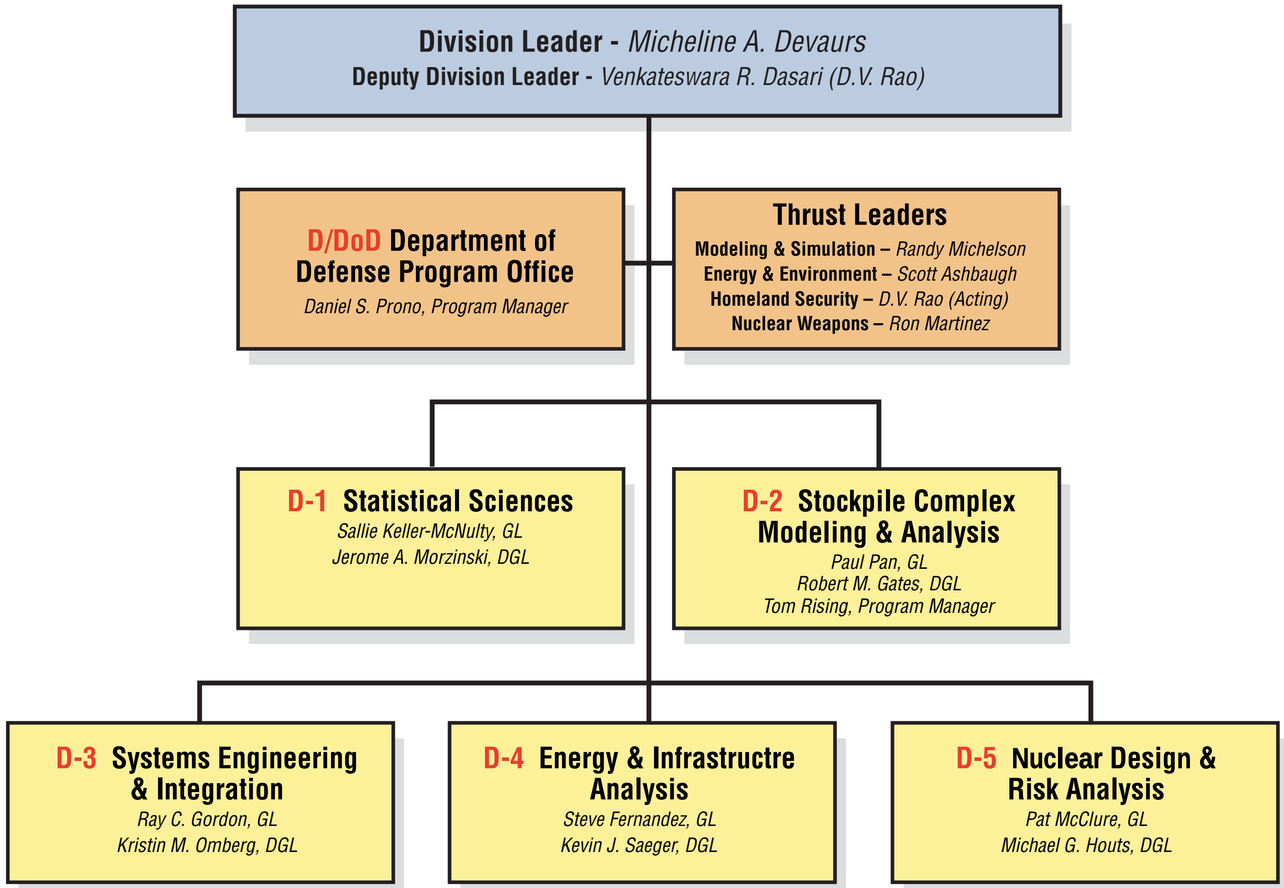
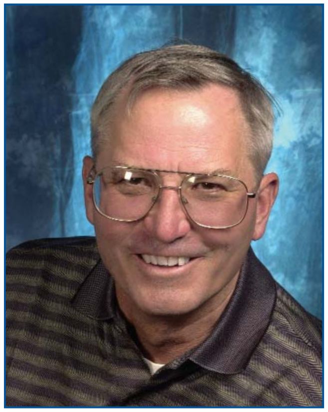


Decision Applications Division Organization Chart (2/04)

Decision Applications Division Management Team



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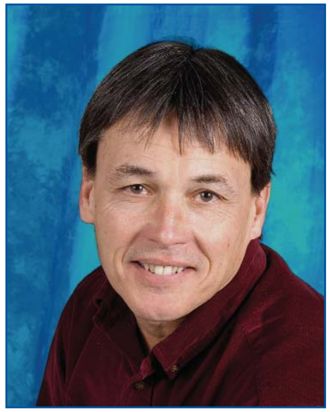

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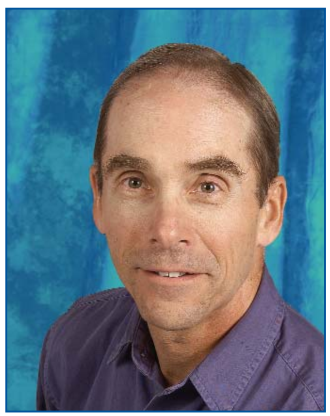

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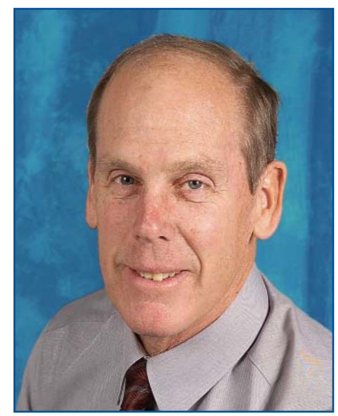

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D-1 Statistical Sciences

The Statistical Sciences Group was formed in 1967 to enhance the quality of research at the Laboratory by providing a center of statistical excellence. We work with scientists, engineers, and policy makers both within and outside of the Laboratory to bring statistical reasoning and rigor to multidisciplinary scientific investigations and to apply them to problems of national importance. Our work includes developing, understanding, representing, and communicating cutting-edge statistical techniques for decision making under uncertainty. The group has extensive experience in developing techniques for collecting, analyzing, combining, and making inferences from diverse qualitative and quantitative information sets such as experiments, observational studies, computer simulations, and expert judgment.

Core competencies of the group include computationally intensive statistical methods, Bayesian methods, hierarchical methods, statistical reliability, uncertainty quantification, experimental design, spatial-temporal methods, degradation/aging methodology, Monte Carlo methods, applications of statistics to general science, and knowledge discovery and dissemination.

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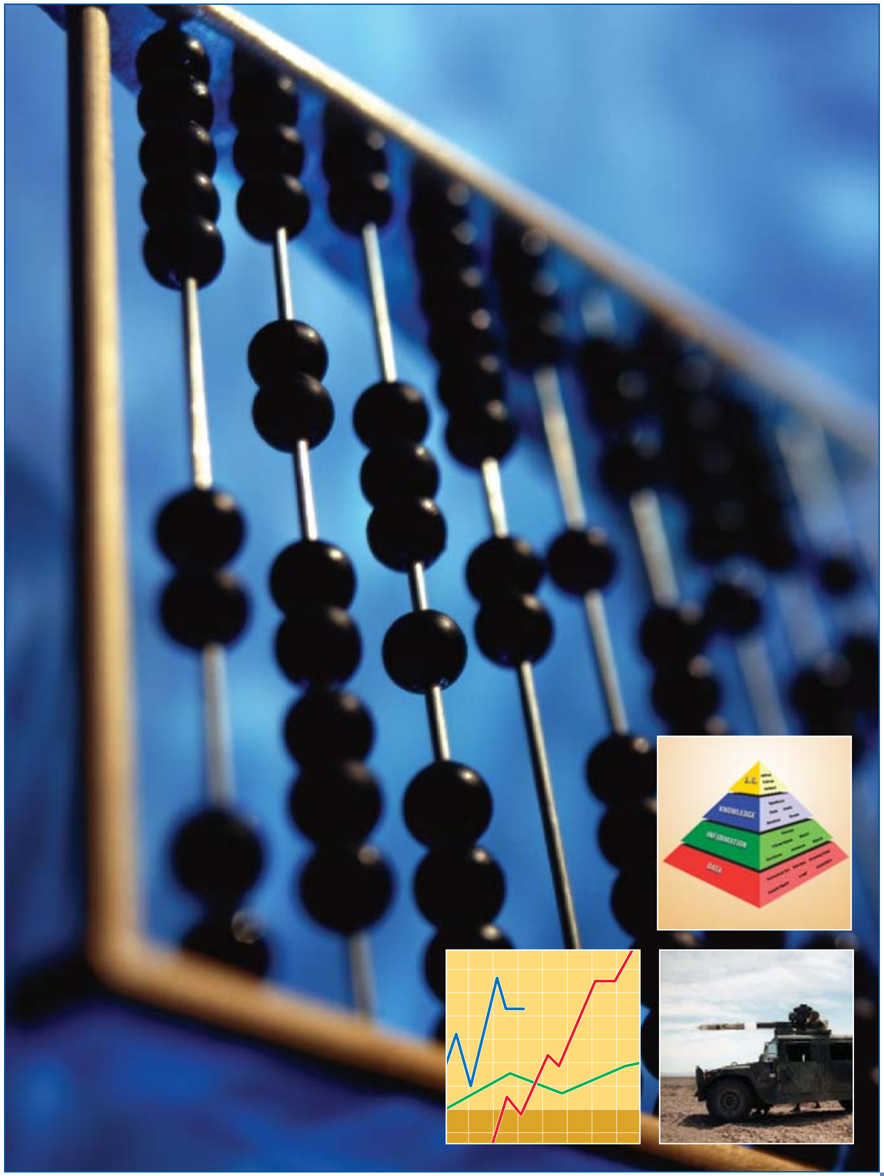
Biological Sciences Applications

This research involves managing and analyzing information about biological systems. For example, to develop early warning and surveillance systems for biological threat agents, we may be interested in rapid identification of organisms and pathogens, identification of geographic soil locations and background microorganism content, or classification of ecological microclimates. Research involves large-scale epidemiological simulation, genetic data analysis, and ecological and environmental statistics.

Computational Statistics

Researchers in D-1 need computational environments to do rapid prototyping of new methods, particularly Markov chain Monte Carlo (MCMC)-based methods. We employ modern techniques from statistics, computer science, and applied mathematics in search of such environments. The complex problems we solve often involve massive data sets with characteristics (e.g., many dimensions, nonhomogeneity) that make them difficult to tackle with traditional statistical methods. These analytical methods are computationally intensive, and often make use of visualization tools to help understand the structure of large data



sets. Currently, we are developing an extensible object-oriented system, "YADAS," to perform these analyses.

Information Integration Technology

Information integration technology (IIT) is a framework of processes and methodologies used to combine and integrate information from diverse sources to produce traceable, mathematically rigorous assessments of system performance. The framework is flexible (e.g., real data, experimental data, results of computer simulations, and expert opinion can all be used) and supports a range of objectives from estimating reliability to decision-making under uncertainty. We create qualitative representations of complex systems and then, with the help of automation tools, transform those into quantitative, statistical models to produce full distributions, with uncertainties, for performance metrics. We are using IIT in collaboration with partners from the weapons community, from industry, and from the DoD.

Monte Carlo

Current D-1 research on Monte Carlo methods is focused on the use of biasing (i.e., importance sampling) techniques to improve convergence in simulations of time-dependent physical processes, as conducted in Stochastic Simulation/ Monte Carlo Methods. Coupling this algorithm with importance sampling has been a part of the statistical physics work in which configurations of a large system are visited using MCMC. Importance sampling is useful in improving the mixing of the chain and aids in reducing variability. Examples of recent work include simulating physical processes such as the movement of pollutants, neutrons, or agents; rare event simulation; and simulating from distributions with widely separated peaks.

Reliability

Reliability analysis is the name given to investigations into system performance and availability and how they change with time or with improved materials or processes. It involves modeling systems when objective test data are scarce or nonexistent, as with one-of-a-kind questions. Determining optimal experimental design is often part of the analysis. We analyze information that may come from real-world data, expert opinion, computational models, and physical experiments and attempt to understand the relationship between system test conditions and performance. We apply reliability analysis to problems in industry, defense, and other government agencies. We use many techniques, such as hierarchical Bayes models, Poisson processes, and MCMC.

Statistical Population Bounding

The basic population bounding problem is to determine bounds that contain a desired fraction of a population. Whereas confidence limits bound the mean with a specified level of confidence and prediction limits bound individual predicted points, tolerance bounds contain a specified proportion of a population with a desired confidence. In extensions from the basic problem, we consider distributions as they age over time, multiple populations, assessment of measurement processes, and bounds on probabilities. Examples of areas where we have applied population bounding include environmental exposure, material properties, measurement and production system variation, and nondestructive measurement techniques.

Uncertainty Quantification

We support Laboratory certification efforts by developing methodologies to quantify uncertainty in all aspects of stockpile performance. We model and analyze both physical data and results of computer simulations. When analyzing the results of computer models, we are concerned with how far apart the actual outcome and predicted outcomes are likely to be at a specific point in light of evidence at other specified points. Methods developed and applied include Bayesian (data combining) methods, analysis of expert judgment, linear and nonlinear modeling, multivariate analysis, and analysis of variance components. We apply these methods in a variety of areas, from sampling issues that arise in core surveillance to resolution of significant findings.

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D-2 Stockpile Complex Modeling and Analysis

The Stockpile Complex Modeling and Analysis Group, D-2, develops modeling tools, systematic analyses, and integrated planning options through the systems engineering process to assist the weapons complex and the nation in formulating informed and timely decisions; this mission is achieved using the group's analytical capabilities as well as its technical expertise.

The systems engineering mission is accomplished through facility modeling, nuclear planning and analysis, the pit manufacturing capability program, modern pit facility (MPF) manufacturing systems modeling and analysis, systems analysis and planning, and project risk management.

FOCUS AREAS

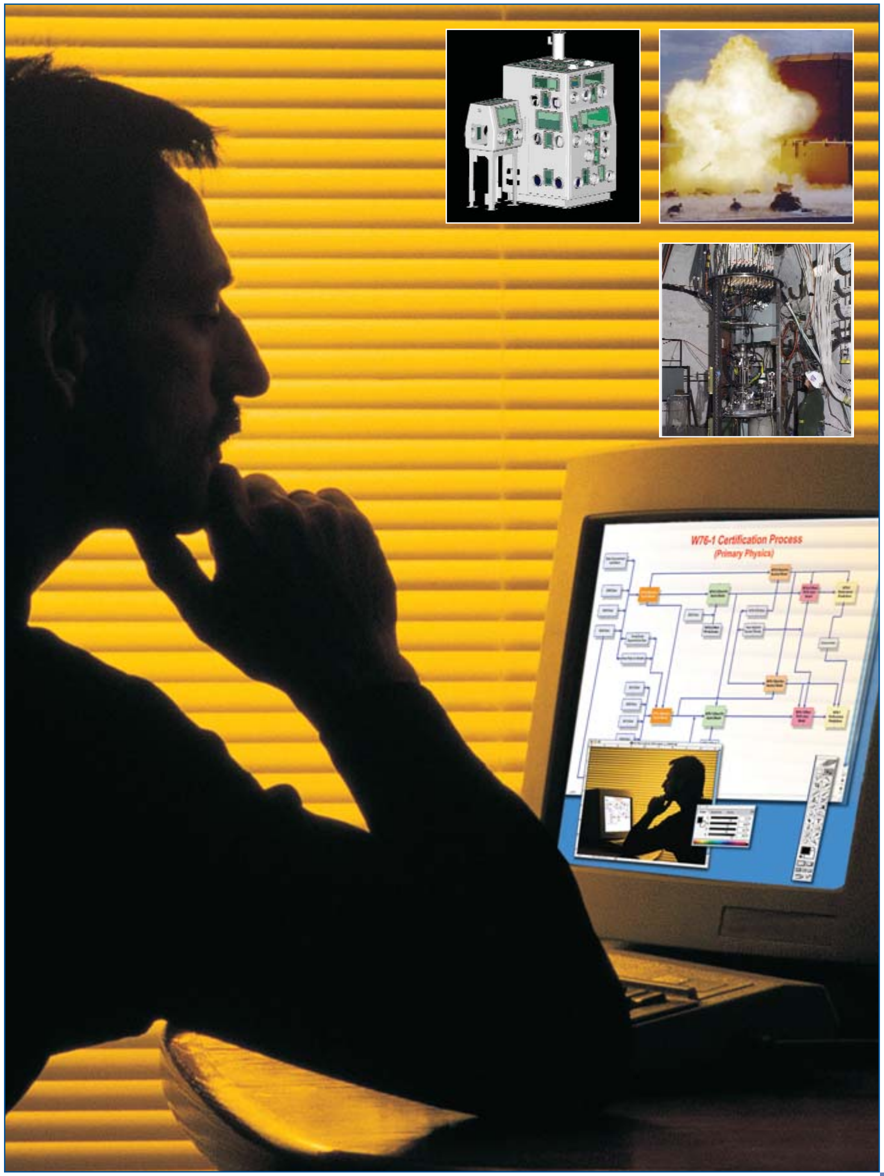
Non-nuclear Facility Planning and Analysis

The Non-nuclear Facility Planning and Analysis Team members have an extensive history in discrete event simulation modeling and systems engineering. Within the Laboratory, this work has been applied to the high-power detonator production facility expansion as well as to non-nuclear component production. A model of the Laboratory's high-power detonator facility expansion guided Dynamic Experimentation (DX) Division management in setting equipment requirements and designing procedures to transition into an expanded facility. Currently, we are developing a model that integrates all of the many production operations for non-nuclear components at the Laboratory. The model will provide a bird's-eye view of operations and processes across the geographically dispersed facilities in Materials Science Technology (MST) and Engineering Science Applications (ESA) Divisions.

TA-55/PF-4 Planning and Analysis

Members of the Nuclear Facilities Planning and Analysis Team are leading the detailed planning and analysis for improvements in the Laboratory's existing pit production and plutonium research infrastructures. With the aging Plutonium Facility (PF-4) and many different projects competing for limited space, NMT Division senior managers have asked D-2 to help in the planning and decision-making process for allocating limited budget, personnel, and space to ensure that the Lab meets or exceeds National Nuclear Science Administration (NNSA) programmatic requirements over the next five to ten years.

The planning and analysis skills that the team used to provide a top-level roadmap for the PF-4 and TA-55 project are now being used to develop detailed options for modifications to individual



rooms and projects planned for fiscal year 2004

Team members have worked with Nuclear Materials Technology (NMT), Chemistry (C), Project Management (PM), and Security (S) Division managers to achieve consensus on a roadmap for equipment and infrastructure upgrades to PF-4. The roadmap was presented to senior NNSA officials, resulting in a restructuring of planned funding for PF-4 infrastructure improvements in FY04.

Complex Manufacturing Systems Modeling and Analysis for Modern Pit Manufacturing

The Complex Manufacturing Systems Modeling and Analysis Team uses a combination of modeling, simulation, and analysis tools to perform a systematic, detailed analysis of manufacturing systems for the MPF. The team gathers data and then performs a detailed analysis of various customer scenarios using to provide data-rich numerical and graphical representations of overall system performance. For example, the system can be operated virtually to evaluate if green-field new-builds, modifications, expansions, or transformations can be economically or efficiently completed and operated as designed.

Project Risk

Programmatic systems engineering and risk analysis services are needed wherever mission success depends upon the performance of programs or projects involving the integration of complex systems. The Project Risk Team uses a comprehensive systems-based project risk analysis method and has applied it to more than 20 major projects.

A typical risk analysis produces cumulative probability distribution functions that describe the confidence levels for achieving a desired result for a given project. D-2's analyses identify the most important contributors to risk, and hence, the most promising candidates for mitigation actions. Quantitative project risk analysis results can also be used to provide a rational basis for setting baseline schedules and cost targets and for establishing appropriate contingencies for projects.

The Risk Team is increasingly assisting in early program/project definition and decision-making. This systems engineering-level work involves many of the same methods and tools but often requires more rapid response and yields less quantitative results.

Risk analysis results have been applied to the following projects:

- Qual 1 pit
- Interim capacity upgrades program integration
- Physics analysis
- Nuclear materials safeguards and security upgrades

The Project Risk Team also assists the Laboratory's Enterprise Project (EP) Strategic Planning Team with a risk-based prioritization of alternative path forward strategies for EP implementation.

Pit Manufacturing

A D-2 team manages the LANL Pit Manufacturing Capability Program. As such and under the direction of NNSA, they are the complex-wide responsible party for reestablishing the United States' pit manufacturing capability and assuring the U.S. is prepared to manufacture reserve pits. This team identifies, develops, and deploys technologies to improve and update the pit manufacturing process. One of the main goals is to sustain a modern pit manufacturing capability that extends beyond the W88 Manufacturing and Certification Program and into pit manufacturing within the enduring stockpile.

W76-1/Mk4A Project Integration

A multidisciplinary team has been assembled to provide overall project integration for the W76-1/Mk4A Life Extension Project (LEP) at Los Alamos. The LEP Team is completing Phase 6.3 of the refurbishment on the Lab's portions of the W76/Mk4 warhead with a first production unit expected in 2007. The Project Integration Team provides tools and support to the LEP and the Project Director to establish and maintain control of a $250+M, eight-year effort.

The team maintains the schedule and cost baselines for the LEP; manages the D-2 risk management personnel; and manages the project support personnel from several Laboratory organizations.

Planning and Integration Office

The Planning and Integration Office was established in an effort to capture the work funded in by the Weapons Programs so that budget and priorities could be adjusted to meet the changing NNSA requirements. D-2 works with the Accelerated Strategic Computing Initiative (ASCI) and readiness in technical base and facilities (RTBF) to define their work in terms of projects.

The primary focus are the weapons programs in the Weapons Engineering and Manufacturing (WEM) and Weapons Physics (WP) Directorates; however, the Laboratory's Threat Reduction (TR) Directorate is also initiating an effort based on the nuclear weapons example. Primavera Enterprise (P3e) software identifies interrelationships between the different kinds of scope, work activities, and resources, and evaluate impacts based on these relationships.

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D-3 Systems Engineering and Integration

The Systems Engineering and Integration Group, D-3, uses an interdisciplinary approach to complex systems analysis in the following programmatic areas: biological defense and countermeasures; conventional and nuclear military systems; and nuclear systems, primarily in the area of advanced fuel cycle technologies. We develop the models, simulations, and other requisite analytic tools necessary to capture the complex relationships and system-of-systems interdependencies of the problems presented to us. This end-to-end, system-of-systems approach and operational perspective distinguishes our work and creates the unique niche for a demanding customer set that includes the DoD and DHS operational communities.

The group received a 2003 R&D 100 Award for creating the Biological Aerosol Sentry and Information System (BASIS) program, which is a key part of the National BioWatch Program announced during President Bush's State of the Union address in 2003.

Core competencies of D-3 include nuclear weapon effects, software system design and development, systems analysis, systems integration, distributed computation, strategic studies, and fusion systems and fuel cycles.

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Systems Analysis and Integration for Homeland Defense

D-3 supports the DHS and the NNSA by providing systems analyses in the areas of biological countermeasures (BASIS, BioNet, and associated programs) and radiological countermeasures (the Maritime Study). D-3 also provides systems integration expertise for multilayer, systems-of-systems for homeland security including the BASIS, BioWatch, and Unconventional Nuclear Warfare Defense (UNWD) projects.

Systems Analysis, Engineering, and Code Development for Defense Applications

D-3 supports NNSA and the DTRA by providing systems analyses and engineering for stockpile stewardship and advanced concepts weapons systems such as the Advanced Concepts Technology Development (ACTD) and Tunnel Target Defeat (TTD).

D-3 also provides systems analyses and modeling and simulation software for conventional weapons applications such as the Graphical Interface and Aggregate Control (GIAC) project. The GIAC team supported numerous large-scale joint military exercises in Europe and Korea, for which they won a

Laboratory Distinguished Performance Award and laudatory comments from high-level military commanders.

Systems Analysis and Code Development for Nuclear Fuel Cycle Applications

D-3 provides systems analyses and simulation code development in support of the Advanced Fuel Cycle program and the fundamental science of transmutation of nuclear waste.

Nuclear Weapons Studies Requirements and Analysis

Under the broad category of nuclear weapons studies, institutional analyses are performed to support the formulation of several Laboratory positions including stockpile planning, advanced concepts analysis, and weapons requirements. Weapons studies have addressed a broad range of nuclear weapons concerns ranging from estimating stockpile size in a START III environment and tritium requirements over the next 20 years, to plutonium-pit production in the twenty-first century and integrated security and use control risk assessments, to weapons effects analysis and lectures on the history of the weapons programs for the Laboratory's Theoretical Institute of Thermonuclear and Nuclear Studies (TITANS).

Maintaining a broad-based nuclear weapons analysis capability is critical to the identifying the pressing issues and making recommendations to the decision makers who are guiding the weapons programs.

Current projects utilizing this capability are the robust nuclear earth penetrator (RNEP) advanced concepts feasibility study, reliability replacement warhead planning, Earth penetrator weapons effectiveness tools development, and long-term nuclear weapons strategy and technology studies.

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D-4 Energy and Infrastructure Analysis

The Energy and Infrastructure Analysis Group, D-4, performs basic and applied research to secure the nation's energy infrastructure. Our staff works in close cooperation with physicists, engineers, mathematicians, statisticians, and economists to develop large-scale yet detailed models of these industries and infrastructures. Our macro models and micro simulations quantify the physical, operational, and economic behavior of energy networks including the generation, transmission, and distribution of electric power, natural gas, oil, coal, and nonenergy infrastructures important to energy security (transportation, water, communications, and public health). Often these models are combined within interdependency, optimization, and risk assessment frameworks.

Our research activities include developing and testing new technologies for the next generation of electrical grids. These will be integrated into a complete M&S architecture. The programs supporting the next-generation electrical grid must sense the health of the grid and input this data into new models and tools. D-4 also helps govern the DOE's Energy Infrastructure Training and Analysis Center (EITAC) through a steering group that includes Sandia and Argonne. The first EITAC visualization capabilities will be Los Alamos products.

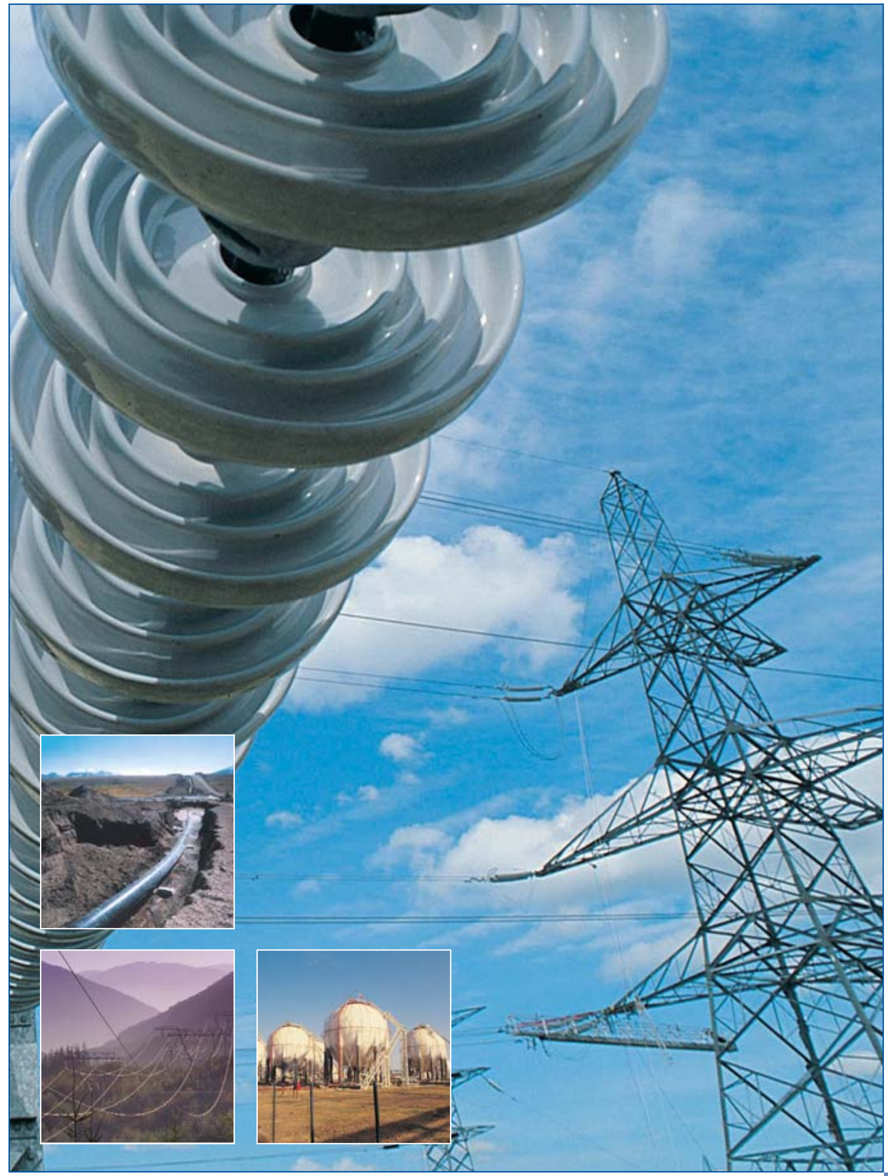
D-4's core competencies include infrastructure modeling, simulation, and analysis, economic and financial analysis, air quality, environmental analysis, and energy and transportation systems.

FOCUS AREAS

Economics

The economics team provides the Laboratory and the nation with economic expertise in two primary areas: economic studies for institutional decision making and economic models for inclusion in simulations of complex infrastructures. The institutional analysis provides information to Laboratory decision makers on the economic aspects of proposed actions. Economic considerations underlie a significant number of the decisions made in areas such as energy, transportation, and communications. To adequately simulate the characteristics of these sectors, economic considerations must be included in the simulation.

Institutional analysis at Los Alamos encompasses an eclectic collection of projects and analysis techniques. Project areas include macroeconomic modeling, monetary and financial flows analysis, natural resource and energy economics, environmental analysis, and engineering economics. The economics team has been providing economic analysis for the facility upgrades and restructuring



planned in the Laboratory's new facilities plan.

This broad agenda necessitates a variety of analytical methods. Our economists have used general equilibrium models, regression, statistics, data mining, linear programming, and other methods as needed to complete commissioned analyses.

The team has developed simulations to model the physical aspects of national infrastructure systems such as transportation networks and energy transmission grids. Increasing the versatility of these simulations to model future conditions requires including of economic considerations.

Data Management and Information Systems

The data management and information systems effort provides the national infrastructure and network data used in the NISAC simulations and for DoD, DHS, and DOE programs outside the Laboratory. Network data from this program has provided the real transportation data for TRANSIMS, created the needed data source for Clean Coal Technologies, and provides the source data for the division's simulations and analyses.

The transportation simulator TRANSIMS requires data that defines various road networks. Road networks for Dallas/Ft. Worth, Portland, and Chicago were developed under this program. Research is underway on methods to streamline the generation of road networks for TRANSIMS.

The Clean Coal Technology Demonstration Program is a unique partnership between the DOE and industry. This program's primary goal is to successfully demonstrate a new generation of advanced coal-based technologies, with the most promising technologies moving into the domestic and international marketplace. The demonstrations are at a scale large enough to generate the data needed to make judgments about the commercial viability of a particular process and will improve global environment and energy security by using technologies and services provided by U.S. industry.

Visualization

The D-4 Visualization Team has experience in many areas of scientific, geographic, statistical, and information visualization. Using commercial tools such as geographical information systems (GIS), mathematical analysis tools, simulation systems with graphical or visual front ends, or by developing custom software, the team helps analysts, simulation scientists, and decision makers understand, share, or present their data more effectively.

The team also operates the D Division Visualization Laboratory, which offers high-performance graphics processors; a range of visualization and graphics tools; a large-screen, stereo-enabled projection environment; quadraphonic sound; and some motion tracking for virtual reality applications.

The Visualization Team collaborates with other laboratories, industry, and academia in researching advanced perceptualization, which includes more than just visual sensory modes, a sense of "presence" or "immersion," and the use of richer cognitive models beyond merely geometric or psychometric in a readily understandable format.

Network Analysis

This D-4 team handles analytics tasks that characterize network performance of a diverse set of infrastructures such as electric, gas, pipeline, telecommunications, and transportation networks. Analyses focus primarily on normal or off-normal conditions arising within a regional or local network. Site-specific analysis can also include service and outage area estimates, as well as estimates of outage duration based upon component criticality considerations.

Appropriate interpretations of system-level metrics that result in degradations to commercial delivery capability and to varying system conditions throughout a typical year are reviewed. Network analyses often includes three components: regional system, local operational area, and on-site. These analyses use both quantitative and qualitative processes. Electric networks are analyzed to identify transmission/subtransmission lines that are critical for power transfer and subtransmission system configuration. The analysis can be extended to other considerations, including the availability of generation units for local system demand and voltage stability.

Results from D-4's network analysis effort assist decision makers in the areas of policy analysis, investment and mitigation planning, education and training, vulnerability and criticality assessments, consequence management, and real-time crisis assistance.

Software Systems

The Software Systems Team, along with the Mathematical Modeling Team, recently started to develop the Interdependent Energy Infrastructure Simulation System (IEISS). IEISS simulates the physical and operational behavior of interdependent energy infrastructures during incidents and disruptions. It can identify and rank critical components across energy infrastructures, estimate outages, and quantify feedback

This tool's primary advantage is its ability to model the interdependencies between energy networks and to identify how a system's physical components behave during disturbances and contribute to their severity and measures the criticality of assets in a consistent manner across energy infrastructures. It also assesses potential feedback between energy transmission systems (cascading failures). It is possible to examine thousands of possible scenarios quickly to pinpoint what caused the most severe impacts. We can also determine the geographic extent of outages, including which customers are affected.

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D-5 Nuclear Design and Risk Analysis

The Nuclear Design and Risk Analysis Group, D-5, is a multidisciplinary team of scientists and engineers. We provide the modeling and analysis capabilities for designing and evaluating potential risks of complex systems, focusing on nuclear systems. D-5 goes beyond just providing answers: we provide answers in context to overall decision processes. We ensure that decision makers have all available knowledge to make an informed regulatory, design, or risk decision.

D-5 is a leader in the design of reactors for government applications, including space nuclear power. We are also a leader in the analysis of risk related to nuclear facilities, nuclear reactors, and nuclear weapons. D-5 employs a wide range of tools, including state-of-the-art radiation transport models, complex three-dimensional thermal-hydraulic models, combined experimental and modeling capabilities, and state-of-the-art logic modeling tools that encompass linguistic and numeric data. D-5 can provide answers to any questions involving nuclear systems.

D-5's core competencies include design and analysis of nuclear reactors; thermal hydraulics and computational fluid mechanics; application of radiation transport codes; probabilistic risk and safety assessments; probabilistic system and vulnerability modeling; facility safety analysis report development; nuclear weapons studies; explosive safety, logic-evolved decision trees and decision analysis; and custom software and engineering tool development.

FOCUS AREAS

Nuclear Safety and Regulatory Analyses

D-5 is supporting several Nuclear Regulatory Commission (NRC) directed research activities in the areas of safety performance and regulatory issues affecting the design and operation of nuclear power plants. Recent studies include a reliability assessment of an Emergency Core Cooling System (ECCS) during a Loss of Coolant Accident (LOCA) and a risk-informed regulation study to quantify the risk significance of nuclear power plant licensing amendments to improve operation and/or cut unnecessary costs. In addition, D-5 has helped the DTRA construct the world's largest plutonium storage facility (50 metric tons of plutonium) at the Russian Institute PO Mayak. D-5, which is the U.S. safety and design certification authority for this facility, ensured the design for DTRA in terms of security, materials control and accountability; safety of the storage of weapons-grade plutonium; and thermal performance of the facility.

Code Development

D-5 developed and maintains the Transient Reactor Analysis Code (TRAC). This powerful, system-level analytical tool has multiple applications to complex systems, including nuclear power plants, experimental facilities, and space reactors. TRAC also is a best-estimate tool to predict complex system response to off-normal events. D-5 is also assisting the NRC as it begins the licensing activities associated with new reactor designs and other advanced systems.

Risk-based Prioritization

D-5 uses risk-based prioritization tools such as human system optimization, application code development, logic models, and probabilistic modeling to assist with making informed decisions about risk issues and prioritizing resources. Even the most highly automated systems require human involvement, ranging from periodic supervisory assessment to emergency intervention to ultimate decision making based on system outputs.

Because information technologies increasingly comprise the key element of system functioning, the demands on human cognitive skills such as planning, maintaining situation awareness, and decision making with incomplete information are also increasing. A comprehensive understanding of human cognitive characteristics, e.g., requirements, tendencies, limitations, and the application of a decision-centered design approach, is therefore essential in development of efficient and effective information systems. Applying logic-evolved decision trees to vulnerability assessment and information loss has been one of D-5's growth areas. This methodology continues to find increased acceptance in the weapons community. The growth in the area of probabilistic system and vulnerability model is driven mostly by the events of September 11. D-5, together with Sandia National Laboratories, is performing vulnerability assessments for all operating civilian nuclear reactors.

Small Reactors

D-5's dedicated team of engineers is focused on developing space fission reactors. This team has developed several innovative reactor concepts, including a compact, robust, and safe reactor that is cooled by heat pipes. Several prototype units of the heat-pipe-cooled reactor have been built and tested successfully by D-5 and the National Aeronautics and Space Administration (NASA). NASA intends to use this reactor to enable ambitious, electrical power-rich exploration anywhere in our solar system.

Weapons Safety

D-5's work in the area of stockpile stewardship supports the Laboratory's mission to reduce the danger of nuclear mishaps. Our expertise in this area is focused on designing safety into nuclear weapons production and maintenance processes, conducting nuclear explosive risk and damage assessments, and evaluating the safety of testing programs related to nuclear weapons. We also develop custom software for these assessments.

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D/DoD Department of Defense Program Office

The Department of Defense Program Office is part of the D Division organization and is responsible for the planning and Laboratory-wide integration of DoD non-nuclear weapons defense programs. The office strives to enhance the DoD programs portfolio through effective communications and interactions with DoD sponsors, opportunity assessments, program development, integrating Laboratory-wide efforts, contributing to strategic planning, aiding with Los Alamos proposal development, and supervising DoD programs execution. The DoD Program Office goal is to support the Laboratory, the Threat Reduction Directorate, and D Division strategic plans and to apply the Laboratory's expertise to the broad spectrum of military technological needs.

FOCUS AREAS

Conventional Weapons Technologies

The conventional weapons technologies area exploits and enhances the core strengths of the Laboratory in conventional munitions, high explosives and energetic materials, advanced warheads, and lethality and survivability. The Laboratory is developing new energetic materials that perform as well as today's best materials but have improved properties, including safety. As part of this work, Laboratory researchers are developing new models to predict quantitatively how explosives will behave in abnormal environments such as accidents or fires. The Laboratory is developing initiation systems based on exploding foil technologies to provide design flexibility, enhance weapons safety, and lower production costs. The Laboratory is also implementing major improvements in computer codes to simulate the behavior of weapons systems and subsystems. Researchers are investigating new, physics-based computations of material behavior to significantly improve our ability to predict explosives effects.

Defense Advanced Concepts

Defense advanced concepts programs are often relatively small efforts to develop or understand technologies and to focus them on specialized DoD applications. Optimally, a successful concept grows into a major program. These efforts tend to change from year to year. Presently, Los Alamos is developing high-power microwave technology with several potential applications. Laboratory scientists are also working on biomimetic computing and understanding eye-brain function These projects should lead to advanced detection systems that emulate how humans "see." The Laboratory is also working on concepts for detecting and even defeating enemy underground facilities.

Defense Sensor Technologies

Defense sensor technologies work is focused on developing sensors for treaty verification, space-based surveillance, satellite protection, and the battlefield. Los Alamos is supporting the Air Force in detecting nuclear explosions, primarily using detectors (W-sensors) integrated into Air Force satellites orbiting Earth. This support includes developing and maintaining specialized software and models for assessing radio sensor performance and radio signal propagation through Earth's ionosphere, on-orbit sensor testing, and systems and data analysis. These, and other, sensors are also used to study "space weather," allowing us to understand satellite performance and reliability. Los Alamos has also developed an ultrasonic device to nonintrusively detect chemicals in various containers such as artillery shells and 55-gallon drums for treaty verification and counterproliferation programs.

High-Performance Computing

The Laboratory's high-performance computing initiatives are developing a computing environment that solves large-scale, complex problems for both defense and dual-use applications. Los Alamos is working with IBM on a project to develop a new generation of high-performance computing. There is also a large effort to develop and use reconfigurable computers for intelligent sensors as well as for large "main frame" computation.

Modeling, Simulation, and Analysis Applications

DoD synthetic environments are virtual representations of the physical and behavioral phenomena of complex military systems that are achieved through mathematical modeling and simulation. These environments are used for training (eliminating the costs of thousands of troops, planes, and ships in the field) and for testing novel war fighting strategies and tactics against new threats or using new weapons and information. Los Alamos is working on tools for this training and analysis regime. There is also a need to simulate complex infrastructures, such as the entire power grid, to determine vulnerabilities or even efficient points of attack that could shut down enemy command and control. We have several projects in the area of understanding infrastructures. Additionally, using complex agent-based and statistical models, we can understand and predict some human behavior. Based on these concepts, Los Alamos developed a model and simulation of terrorist networks and how they might respond to different stresses.

Directed Energy

There are numerous needs within the DoD for directed-energy systems, ranging from man-portable to large missile systems. Los Alamos is currently working with the U.S. Navy on free-electron laser technology, for potential installation on warships. This technology has the potential to rapidly destroy attacking missiles. We are also working on concepts for making high-powered, directed microwave systems much smaller and more useful.

System Performance and Reliability

Major weapons systems, e.g., an entire new fighter jet, often cannot be tested or even designed without extreme costs or potential of destruction. Los Alamos is designing statistical tools to allow prediction of the overall system behavior using data from limited subsystem testing and from computational models. These statistical tools allow designers to understand failure points and then focus design efforts on these points. We are also developing hardware and software to predict the component failure. This allows repair or replacement of parts when they actually become worn rather than on a maintenance schedule. This vastly improves reliability as well as cutting costs.

Chemical, Nuclear, and Radiological Defense

Advanced technologies that provide defenses and responses to WMDs are a major focus area for DoD programs. Traditionally, the quartet of chemical-biological-nuclear-radiological threats defines WMDs. The chemical-nuclear-radiological systems characteristically have close technical ties to nuclear weapons and conventional munitions activities and are part of the DoD programs. The CHS handles biological threats. There are DoD programs to detect hidden nuclear devices and to understand the systems and requirements to position detectors for maximum efficiency. We are also starting a major program to develop technology and operational methods to decontaminate affected areas after a radiological attack.

Missile Defense

The DoD has identified missile defense as a major element in the ongoing force transition ordered in response to changes in the international threat since the end of the Cold War. These changes predicate a need for a more dispersed and faster responding defense net. Our DoD missile defense projects are providing the research and development for advanced missile defense systems that will meet the challenging performance requirements inherent in responding to increased global threats.

Military Space Applications

Los Alamos' history of developing and building small satellites and instruments for satellites puts us in position to aid in many military problems in space. Current research includes developing sensors and data analysis to give real-time, battle theater information and systems to measure and understand threats to the United States' complex, existing satellite network.

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