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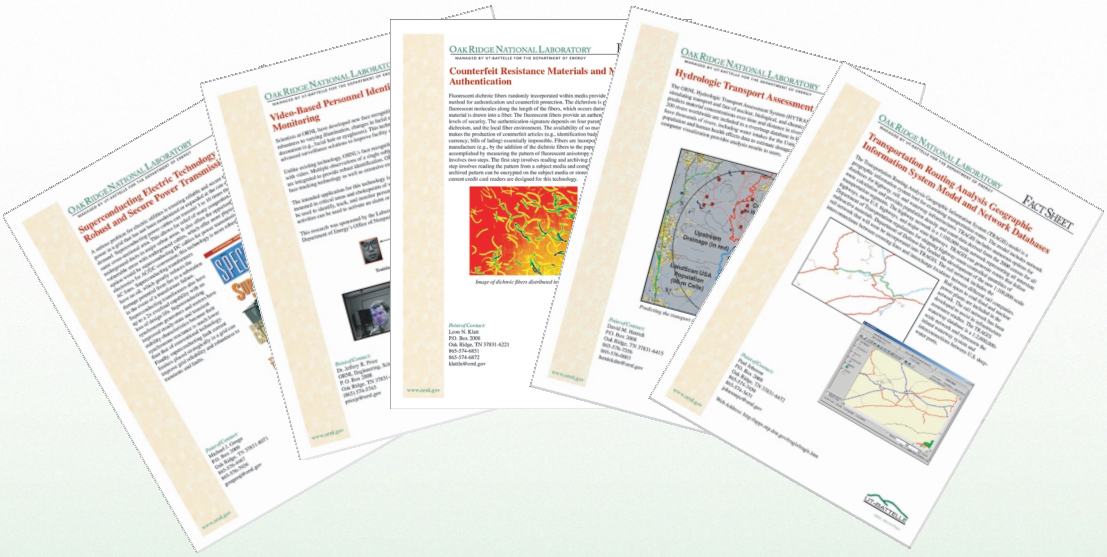
Energy Infrastructure Assurance Capabilities at ORNL



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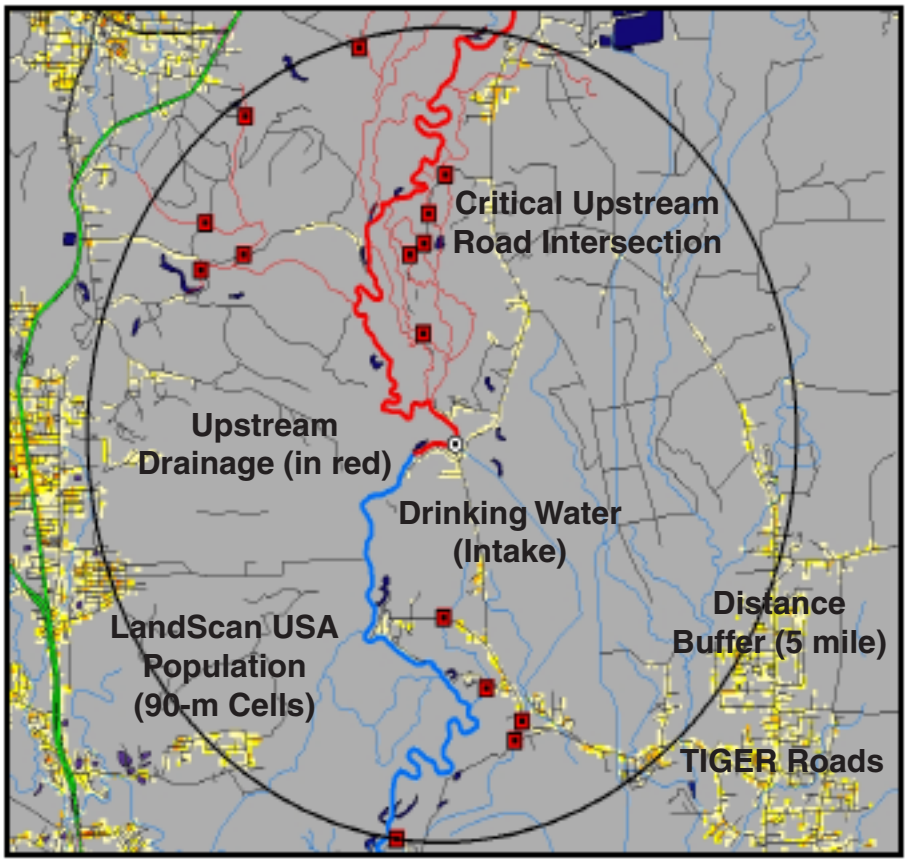
Hydrologic Transport Assessment System (HYTRAS)

The ORNL Hydrologic Transport Assessment System (HYTRAS) is a numerical model for simulating transport and fate of nuclear, biological, and chemical agents in water bodies. The model predicts material concentrations over time and distance in rivers or lakes. At present, approximately 200 rivers worldwide are included in a river/map database in HYTRAS. A new river database will have thousands of rivers, including water intakes for the United States. Also, HYTRAS utilizes population and human health effects data to estimate dosage effects to at-risk populations. Advanced computer visualization provides analysis results to users.

National Hydrography Data



Predicting the transport of hazardous materials in water using the HYTRAS.

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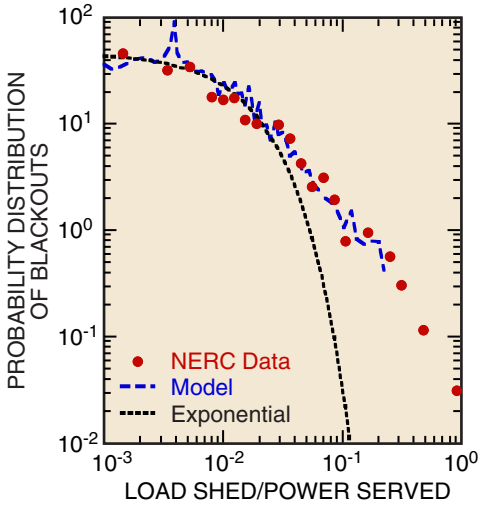
Simulations of Management of the Electric Power Network

Systems Operation is Fundamental to Evaluating Vulnerabilities

In the United States there is on average a blackout every 13 days. The probability of a blackout of a given size decreases slowly with its size (the decrease is algebraic instead of exponential, as would be expected from multiple independent failures).

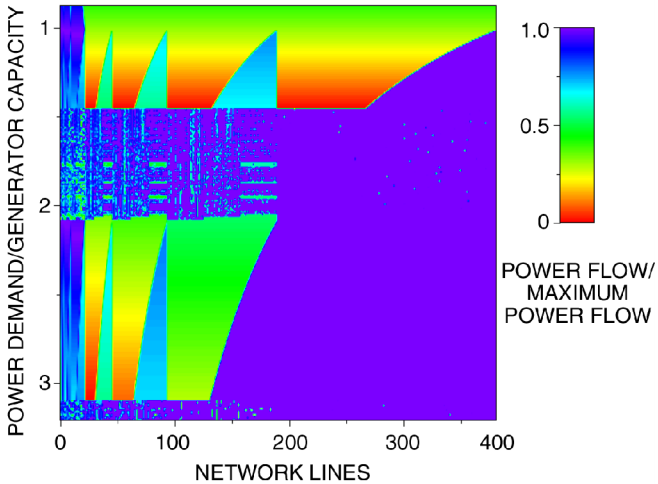
Each blackout may be attributable to a set of specific causes. However, looking at the global dynamics of a long series of blackouts, we see that repeated cascading phenomena are the results of pushing the system close to its operational limits. An evaluation of the vulnerability to blackouts must include the operational conditions and the opposing forces that govern the system; for example,

- increased load demand pushes toward system limits, but
- engineering response to failures and investment in new power plants push away from system limits.



Comparison of the probability distribution of the blackout sizes in the United States with the results from the OPA model.

There is no static equilibrium among these forces, and a dynamical model has been developed to incorporate them in evaluating blackout dynamics. This model explains the probability of blackouts (especially large catastrophic blackouts) and gives insight on how to reduce them (e.g., evaluation of generator capacity margins, monitoring demand fluctuations, or operating policy near limits). This work is done as collaboration between ORNL, Power Systems Engineering Research Center, and Alaska University. It is supported in part by Consortium for Electric Reliability Technology Solutions and National Science Foundation.



Stress on the transmission lines caused by a continuous increase on load demand.

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Radiation Safety Information Computational Center

The mission of the Radiation Safety Information Computational Center (RSICC) is aligned to support DOE's science and energy missions. A unique software collection, nowhere else available, and a specialized staff performs stewardship of 1500 state-of-the-art, old, and new nuclear science-based software and their data. These analytical tools are made available through continuous technical staff awareness of current nuclear science needs and directions. RSICC's a 40-year-old center of intensive use by the U.S. and Non-U.S. nuclear science and engineering communities. RSICCs broad science applications support the missions of many DOE offices, including Nuclear Energy Science and Technology, National Nuclear Security Administration, Defense Programs, Naval Reactors, Basic Energy Sciences, and Fusion Energy. RSICC's intrinsic operational logistics have been shaped by its DOE mission objectives as a "Specialized Information Analysis Center," whose main function is identification, acquisition, qualification, modification, and dissemination of the tools necessary to model and analyze projects involving nuclear physics, engineering, and safety.

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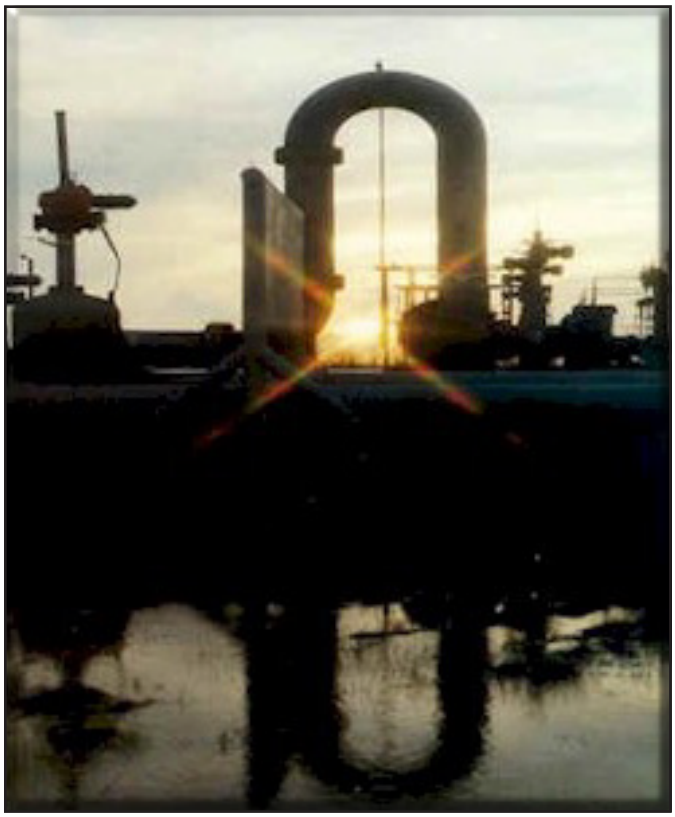
Strategic Petroleum Reserve (SPR) and Refinery Modeling and Assessment

ORNL has a long history of assessing the size, quality, and drawdown capabilities of the U.S. Strategic Petroleum Reserve (SPR). ORNL maintains several models for the DOE/Fossil/SPR Office to assess the capabilities of the reserve for handling disruptions in oil supply and preparing for energy security emergencies. The models help determine if and when drawdowns are needed and the potential impacts of those drawdowns on oil markets and the economy in general.



The Strategic Petroleum Reserve, located at Bayou Choctaw Louisiana and other sites, is capable of rapidly adding oil to the market during supply emergencies.

ORNL maintains a detailed model of U.S. refineries that can be used to assess the potential impacts of a significant change in the quantities and/or types of crude oil available for processing and/or changes to the refinery infrastructure (i.e., changes that might occur as the result of war or terrorism). This set of models can also be used to assess the potential impacts of relaxing regulatory constraints, such as the current mandated regional differences in the technical characteristics of gasoline and diesel fuel.

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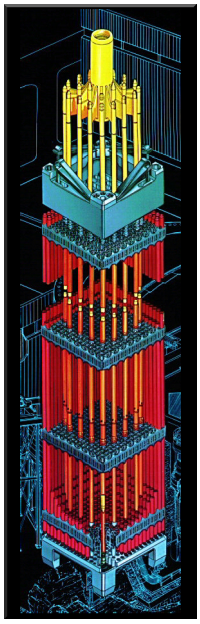
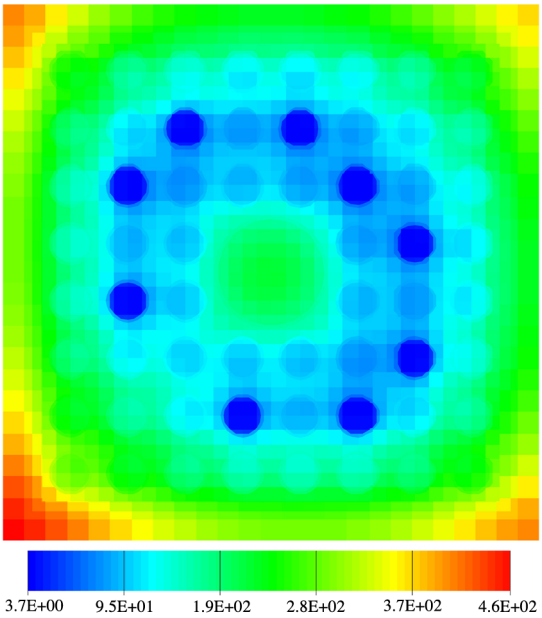
Spent Nuclear Fuel and High-Level Waste Source Term Characterization within the SCALE Code System

The SCALE code system is one of the premier analysis packages used within the DOE complex and within industry for predicting the basic nuclear source term characteristics (nuclide inventory, decay heat, radiation source terms, etc.) associated with the irradiation of nuclear fuel and production of high-level waste. The system has used the ORIGEN-S point depletion and decay code as the basis for developing easy-to-use sequences for the nuclear characterization. The sequences use neutronic modules that provide ORIGEN-S with the nuclear data (e.g., cross sections) appropriate for the fuel geometry, reactor conditions, and operating history. The system has been used for spent nuclear fuel (SNF) source term characterization in safety, safeguards, and nonproliferation activities. The analysis sequences provided within SCALE have been well validated for light-water reactor (LWR) fuel designs and are continuously maintained at ORNL under a configuration control and software QA program that tracks changes in the software and documentation. A continually maintained and updated analysis package such as SCALE is essential to ensure that the capability to predict source term characteristics for SNFs sources for current and emerging reactor designs is available.



LWR fuel assembly



SAS2D fuel assembly flux profile

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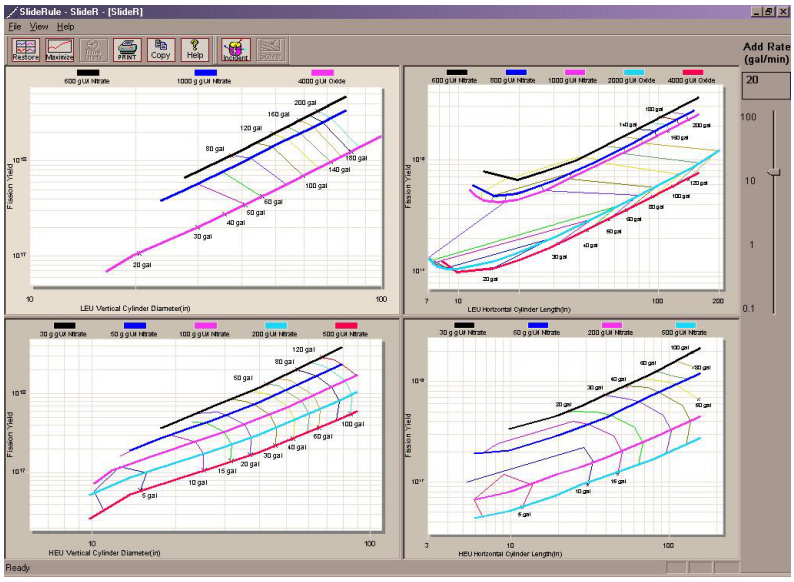
Rapid Response Tool for Criticality Accident Recovery Team

Rapid "in-hand" and electronic tools have been developed to provide pertinent information needed to guide response team actions and help characterize some types of nuclear criticality accidents. The "nuclear criticality slide rule" uses a series of sliding full-page graphs that function similarly to the scales on a slide rule. This tool was developed based on the realization that visual demonstration of trends (e.g., dose versus time or distance) is helpful to response personnel for planning quick and decisive action. The hand-held version provides rapid assessments for direct radiation approximations. The PC version is useful to solve for parameters that depend upon multiple independent parameters such as variable shielding, distances, and anticipated time-related radiation doses to personnel. The slide rule is designed to provide estimates of the following: magnitude of the fission yield based on personnel or field radiation measurements, neutron and gamma dose at variable unshielded distances from the accident, the skyshine component of the dose, time-integrated radiation dose estimates at variable times/distances from the accident, 1-minute gamma radiation dose integrals at variable times and distances from the accident, and dose-reduction factors for variable thicknesses of steel, concrete, and water.

The slide rule estimates unknown data based on data available to emergency response personnel, including exposure information about accident victims, estimates of potential exposures to emergency response reentry personnel, estimation of future radiation field magnitudes, and fission yield estimates.



PC Slide Rule

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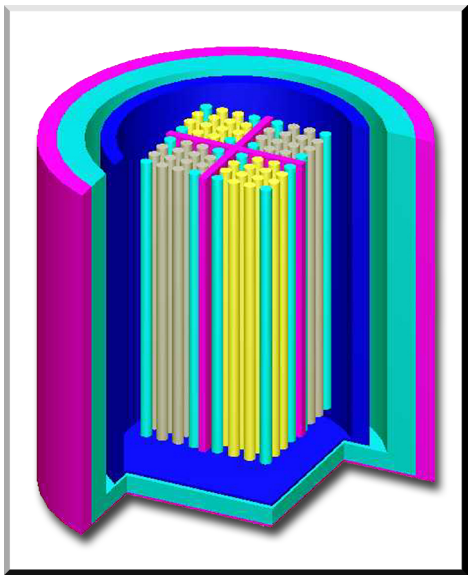
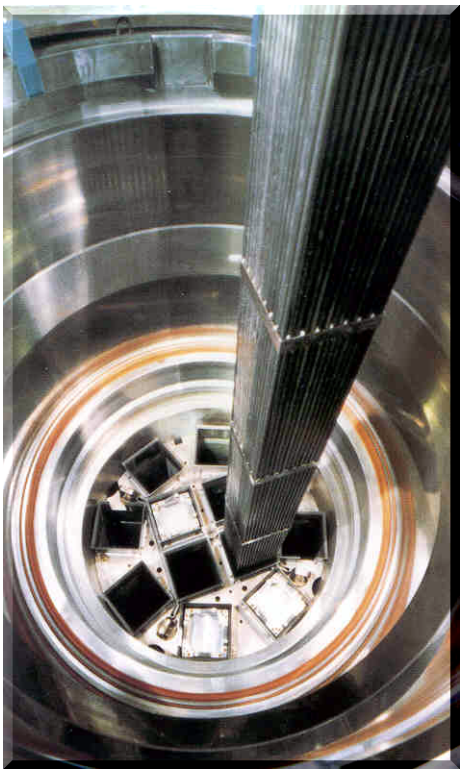
Criticality Safety Analysis Capability within the SCALE Code System

The SCALE code system is one of the premier analysis packages used within the DOE complex and within the nuclear industry for production safety analyses of fissile material operations (e.g., transport, storage, disposal, handling, and fabrication processes). The system contains the KENO Monte Carlo codes together with problem-independent nuclear data libraries and the data-processing codes needed to prepare problem-dependent data for analysis of user-specified configurations. The standard analysis sequences provided within SCALE have been well validated during their 20-year history and are continuously maintained at ORNL under a configuration control and software QA program that tracks changes in the software and documentation. A continually maintained and updated analysis package such as SCALE is essential to ensure that an adequate margin for subcriticality consistent with safe practice can be readily ascertained for all forms and conditions envisioned for fissile material.



KENO Shipping Cask Model



Loading Fuel Assembly into Shipping Cask

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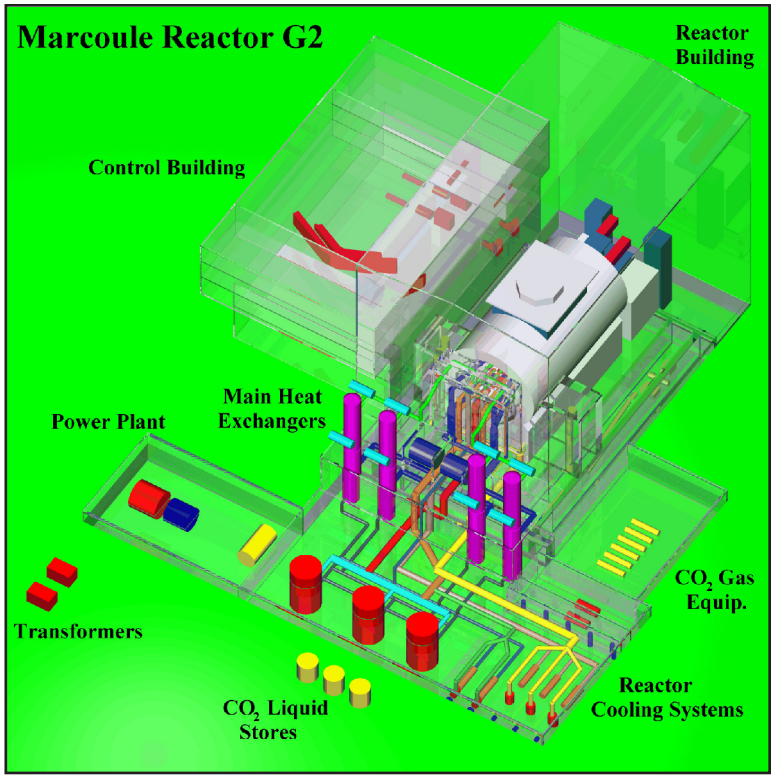
Industrial/Nuclear Facility Vulnerability — Visual Interactive Site Analysis Code (VISAC)

VISAC is a Java-based expert system that provides mission planners with a coordinated capability to predict and analyze the outcomes of different accidents/incidents at various nuclear and industrial facilities. The incidents can range from simple individual equipment sabotage to complex sorties that utilize a range of military weapons, simulated truck or car bombs, or satchel charges. The target facility is generated by either customizing existing 3-D CAD models for near real-time analysis or creating a new model from scratch. Using event/fault tree methodology, VISAC provides the probability of facility kill, the probability of undesirable collateral effects (chemical or radiological releases), and an estimate of facility down time. VISAC is supplied with a library of models that can be customized by the user in both geometry and logic to approximate a number of facilities of interest.

Graphical Representation of a VISAC Facility Model



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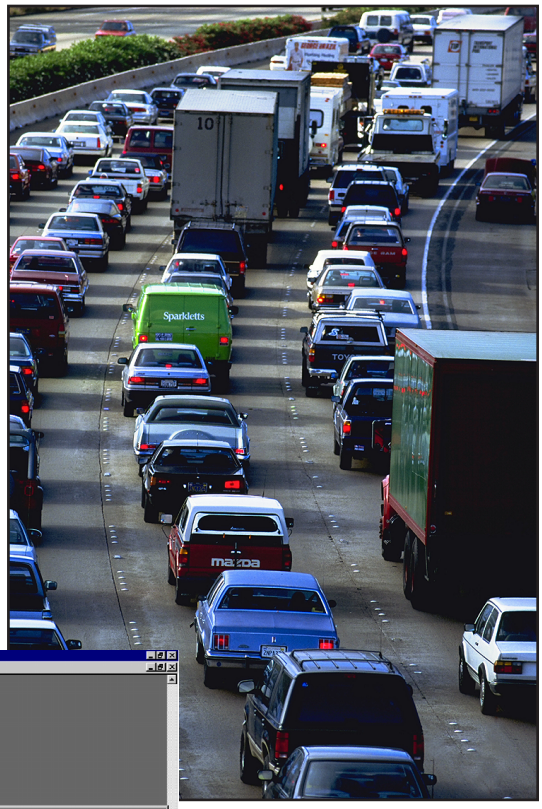
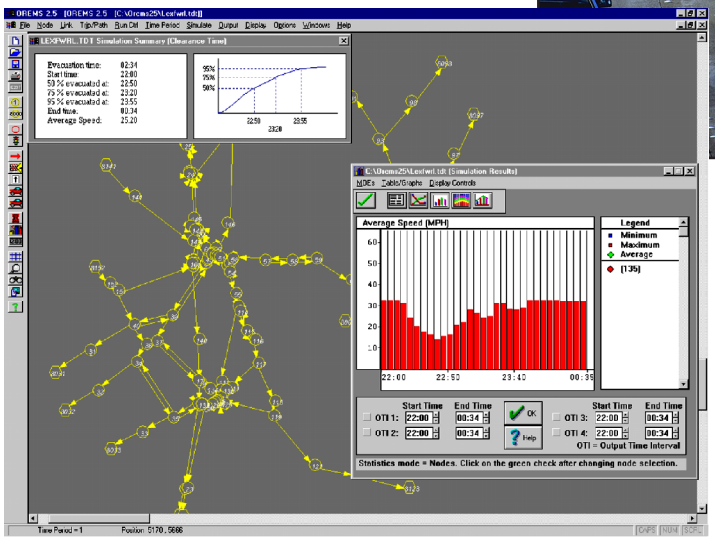
Emergency Management Evacuation Model

Emergency planners in U.S. cities are revising their evacuation plans for responding to a variety of threats: an approaching hurricane, an accident at a local chemical plant, a flash flood due to a dam failure, or a terrorist threat to detonate a weapon of mass destruction in the center of the city. Is it feasible to evacuate the population at risk before the onset of damage? Will the event arrive during the evacuation? How many people's lives will be in jeopardy? Where will traffic jams occur? Are there ways to speed up the evacuation?



The Oak Ridge Evacuation Modeling System (OREMS) is a quantitative evacuation time modeling system. It has a preprocessor for editing a database used in evacuation modeling, a simulation model, and a postprocessor for displaying the results of the simulation. OREMS can be used to estimate clearance times for evacuating an area, for predicting traffic bottlenecks, and to evaluate traffic control strategies.

OREMS is the only evacuation simulation model that uses state-of-the-art traffic simulation codes derived from U.S. Department of Transportation (DOT) models. Furthermore it is the only model of its kind endorsed for use by DOT in regional evacuation planning. OREMS was developed to replace out-of-date technology found in other evacuation simulation solutions.



OREMS Display Screen

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Emergency Management Research

We have been conducting research on emergency management for a variety of hazards, including natural disasters, hazardous material releases, chemical warfare emergencies, nuclear accidents, and terrorist incidents.

NATURAL DISASTERS. Natural disaster losses grow yearly, and the potential for a catastrophic disaster, which could lead to the total collapse of the insurance industry and financial markets, looms on the horizon. We have investigated generic social processes related to the adoption of mitigation for natural hazards, human responses to natural hazard warnings, evacuations, organizational processes in a disaster, and the effectiveness of training and public education. Our work experience includes the hazards of hurricane, flood, tornado, dam failure, earthquake, volcano, and tsunami.

HAZARDOUS MATERIALS. The chemical accident in Bhopal, India, led to increased interest in problems of hazardous materials release. Title III of the 1986 Superfund Amendments and Reauthorization Act (SARA) set forth planning requirements for states and local communities with haz mat problems. In support of a requirement in Title III reviewing emergency systems for chemical accidents, we conducted research to assess community preparedness for chemical accidents. In particular, we identified the technology, the procedures, and management practices used to alert and notify the public in conjunction with a chemical release. We have investigated the response of people in chemical accidents, evacuation due to chemical accidents, decontamination, and sheltering options for population protection.

CHEMICAL WEAPONS. The United States is in the process of disposing of the nation's stockpile of chemical weapons. The Final Programmatic Environmental Impact Statement for the disposal program recommended a community-based emergency preparedness program. The Chemical Stockpile Emergency Preparedness Program (CSEPP), jointly managed by the Army and the Federal Emergency Management Agency (FEMA), has the ambitious goal of achieving state-of-the-art plans with maximum public protection. ORNL has been involved with that program since its inception and has been the chief provider of technical support for the planning, training, and reentry programs.

NUCLEAR ACCIDENTS. The Three Mile Island accident dramatically increased public awareness of emergency planning for nuclear power plants. It led to massive regulatory changes and new requirements for responding to an accident. We have been involved with work for the Nuclear Regulatory Commission, the Department of Energy, FEMA, and the Three Mile Island Public Health Fund concerning radiological emergency preparedness. Among the topics we have investigated are evacuation planning issues, warning systems, public information programs, the adequacy of emergency plans, the impacts of the Three Mile Island accident, and protective action liability issues.

Disposal of Clothing During Decontamination

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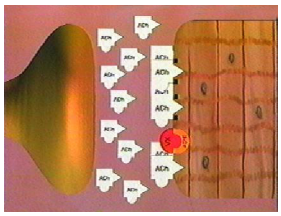
Chemical Warfare Agent Emergency Response Training

ORNL has developed a variety of training materials for emergency responders and planners concerning chemical warfare agent releases. Materials include classroom courses, CD-ROMS, and videos that could be distributed or modified for use in counter terrorism training.

Topics covered include worker operations, mass care, emergency medical treatment, decontamination, use of auto-injectors, personal protective equipment, public information, command and control, and protective actions. All materials have been reviewed and approved by U.S. Department of Defense and the Federal Emergency Management Agency.

Training videos have been developed on protective action decision making, chemical agent characteristics and effects, using simulation models in emergency management, emergency medical response, and sheltering in place.



Computer Animation of Nerve Agent Effects

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Biological Warfare Agent Training

The threat of use of biological warfare agents is no longer confined to the battlefield. Due to recent events involving biological and chemical agents, civilian communities far removed from centers of armed conflict have come to realize they too are vulnerable. The ability to save lives in the event of a biological agent release turns on provision of immediate and correct medical care in the field and hospital. Being able to ensure availability of life-saving care depends on reaching both military and civilian medical personnel with information on biological warfare agents and on keeping their skills and knowledge current. The unique interactive, multimedia instructional program, Medical Management of Biological Agent Casualties, is the product of a partnership that blends the expertise of three federal agencies. The U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID), is responsible for educating military health care providers on current medical defense against biological agents. The Federal Emergency Management Agency (FEMA) has extensive experience in developing dual-use (military/civilian) educational programs based on military doctrine for dealing with chemical warfare agents and counts as one of its primary constituencies the civilian emergency response community. The Department of Energy's Oak Ridge National Laboratory is preparing the training course. The program presents medical treatment protocols for immediate care of both military and civilian casualties, as well as information on agent detection and containment, decontamination, and self-protection strategies (i.e., use of vaccines and personal protective equipment). This CD-ROM delivers training for medical professionals, field/hospital medical support personnel, and nonmedical personnel that is applicable for military audiences as well as for civilian counterparts and interested lay persons.

Slammer at Ft. Detrick

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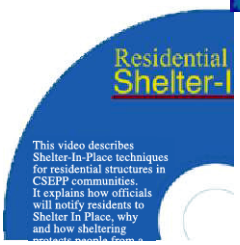
Residential Shelter-In-Place Video

The purpose of this training video is to teach residents how to shelter in place during an accidental or intentional release of chemical agent vapor. Although intended for residents living in the areas served by the Chemical Stockpile Emergency Preparedness Program (CSEPP), residents in other areas that could be affected by a release of hazardous chemical vapors may also find the training useful. The training has been developed by ORNL for the Federal Emergency Management Agency (FEMA) and the United States Army's Soldier and Biological Chemical Command (SBCCOM). It is available in VHS and DVD formats.

At the end of the training the viewer should understand

- how to prepare a home emergency supply kit,
- how warnings for protective actions are disseminated to the public,
- how to develop a plan for sheltering in place,
- the appropriate procedures for expedient sheltering in place,
- how to prepare a safe room for sheltering in place,
- how chemical agent vapor penetrates structures and vehicles, and
- when and how to end sheltering in place.



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Re-ACT FAST II VIDEO

Refresher on Agent Characteristics and Toxicology
First Aid and Special Treatment II

This video was designed for the Chemical Stockpile Emergency Preparedness Program (CSEPP) as a refresher course to prepare emergency workers to recognize and provide initial treatment to persons exposed to nerve (VX and GB) and blister (vesicant) (H, HD, and HT) agents. The target audience are those qualified to perform emergency medical treatment, such as emergency medical technicians, paramedics, ambulance operators, nurses, and others who may provide assistance to persons exposed to nerve and blister agents. The video describes signs and symptoms of nerve and blister agent exposure, appropriate decontamination procedures, and the pre-hospital treatment for nerve agent poisoning using appropriate doses of atropine and 2-PAM chloride.

This revision includes details on donning and removing CSEPP approved PPE.

At the end of the training, participants should be able to describe

- the characteristics of nerve and blister chemical warfare agents in the aging stockpile, the potential hazards, routes of exposure, and effects on the human body;
- the signs and symptoms of nerve agents and the appropriate response treatment (including the recommended dosages of atropine and 2-PAM chloride for various age groups);
- the signs and symptoms of blister agents and the appropriate response treatment because there is no antidote;
- the CSEPP-approved decontamination procedures; and
- the procedures for putting on and removing CSEPP-approved personal protective equipment for emergency workers.

This video is available in both VHS and DVD formats. Other CSEPP training materials are available on the Oak Ridge National Laboratory Emergency Management Program.

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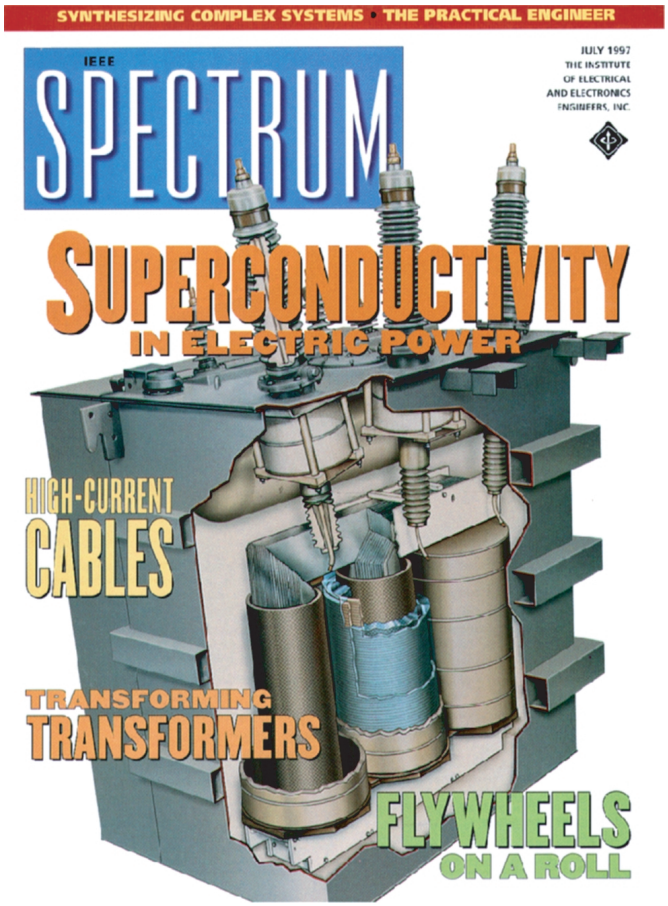
Superconducting Electric Technology for Robust and Secure Power Transmission

A serious problem for electric utilities is ensuring reliable and secure transmission and distribution of power in a grid that has not been modernized or expanded at the rate of increase in generation and demand. Superconducting power cables can transmit 3 to 10 times the current of a copper cable in the same cross-sectional area. This allows for relief of many congestion problems in existing underground ducts in major urban areas. It also offers the opportunity to replace overhead lines in vulnerable areas with underground cables, which offer more physical security. Another technology option would be superconducting DC cables for power transmission with cryocooled power electronics for AC/DC conversion; this technology is more robust and secure than separate 3-phase AC lines. Superconducting transformers have no oil, which greatly reduces the damage potential from fire to a substation in the event of a transformer failure. Superconducting transformers also have up to a 2× overload capability with no loss of design life. Superconducting synchronous generators and motors have improved steady-state and transient stability characteristics because their synchronous reactance is much lower than that of conventional technology. Finally, superconducting fault current limiters placed strategically in a grid can improve grid reliability and robustness to transients and faults.



Cover of IEEE Spectrum issue devoted to superconducting electric technology

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OAK RIDGE NATIONAL LABORATORY FACT SHEET
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Counterfeit Resistance Materials and Methods of Authentication

Fluorescent dichroic fibers randomly incorporated within media provide a significantly improved method for authentication and counterfeit protection. The dichroism is provided by an alignment of fluorescent molecules along the length of the fibers, which occurs during manufacture as the base material is drawn into a fiber. The fluorescent fibers provide an authentication mechanism of varying levels of security. The authentication signature depends on four parameters, the *x* and *y* positions, the dichroism, and the local fiber environment. The availability of so many nondeterministic variables makes the production of counterfeit articles (e.g., identification badges, passports, credit cards, currency; bills of lading) essentially impossible. Fibers are incorporated into the media during manufacture (e.g., by the addition of the dichroic fibers to the paper pulp media). Authentication is accomplished by measuring the pattern of fluorescent anisotropy of the media. The authentication involves two steps. The first step involves reading and archiving the pattern of the media. The second step involves reading the pattern from a subject media and comparing it with the archived pattern. The archived pattern can be encrypted on the subject media or stored in a database. Equipment similar to current credit card readers are designed for this technology.

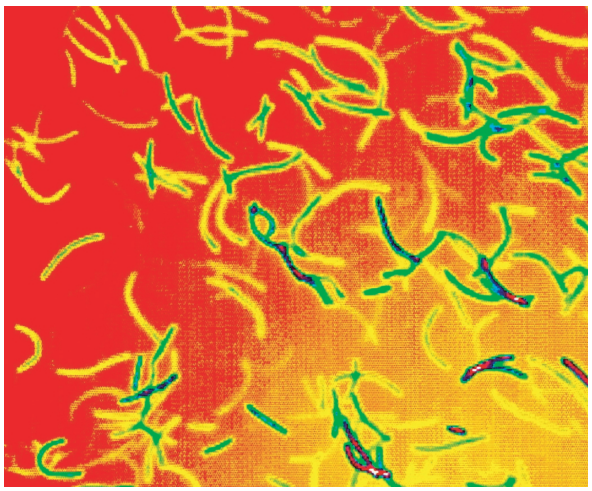
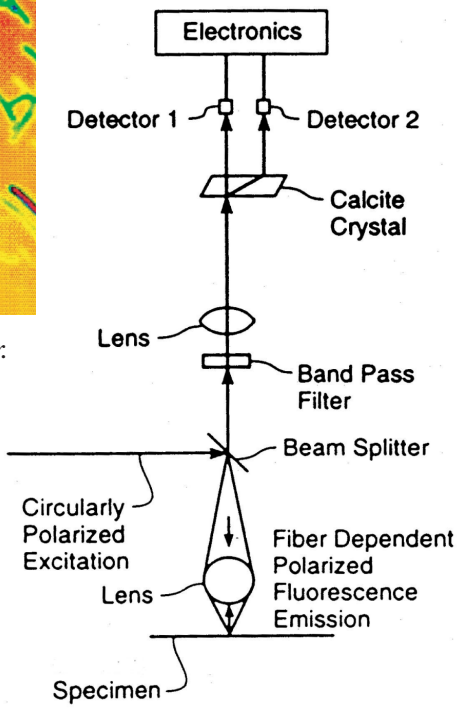


Image of dichroic fibers distributed in paper.



A concept for a paper document reader.

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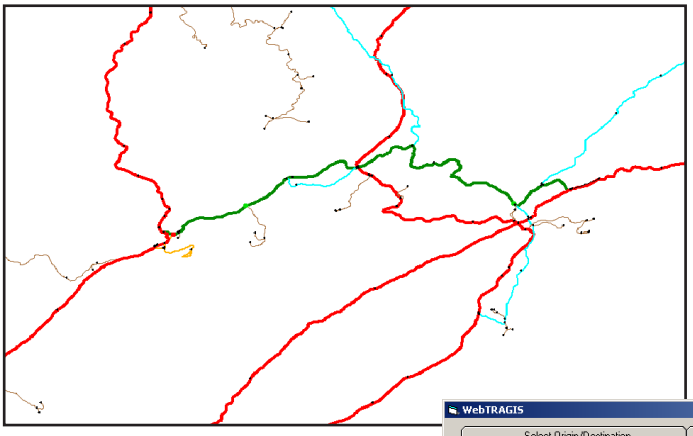
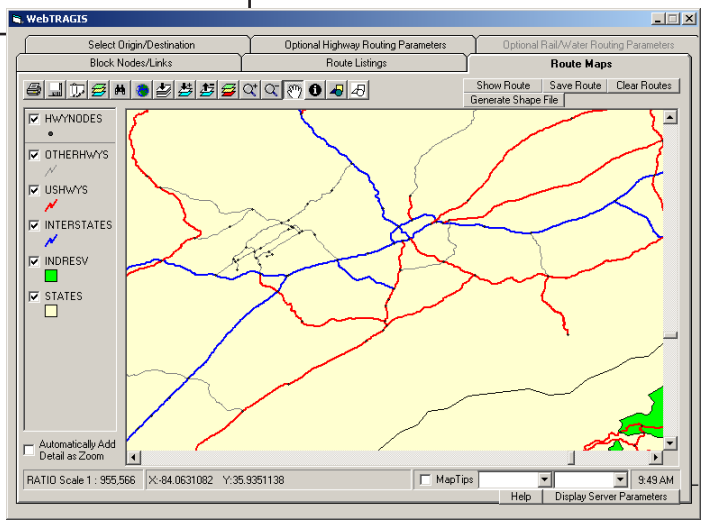
Transportation Routing Analysis Geographic Information System Model and Network Databases

The Transportation Routing Analysis Geographic Information System (TRAGIS) model is a geographic information system tool for examining transportation routes. The model includes network databases for highway, rail, and waterway infrastructures. TRAGIS includes numerous options for route calculation and provides population density and count data derived from the 2000 census for all transportation segments. The highway network is a 1:100,000-scale network representing all interstate highways, most U.S. highways, and major state highways. TRAGIS can generate routes that follow Department of Transportation regulations for shipping highway-route-controlled quantities of radioactive materials. Department of Defense has funded the development of the new 1:100,000-scale rail network that will soon be incorporated into TRAGIS. The rail network includes the interconnections between crossing lines and interchange locations between different rail companies. Rail spurs to coal-fired and nuclear power plants are included in the network. The rail network has been developed to assist in infrastructure assurance studies. The TRAGIS waterway database is a 1:2,000,000-scale network and represents the inland waterway system and interconnections between U.S. deep-water ports.





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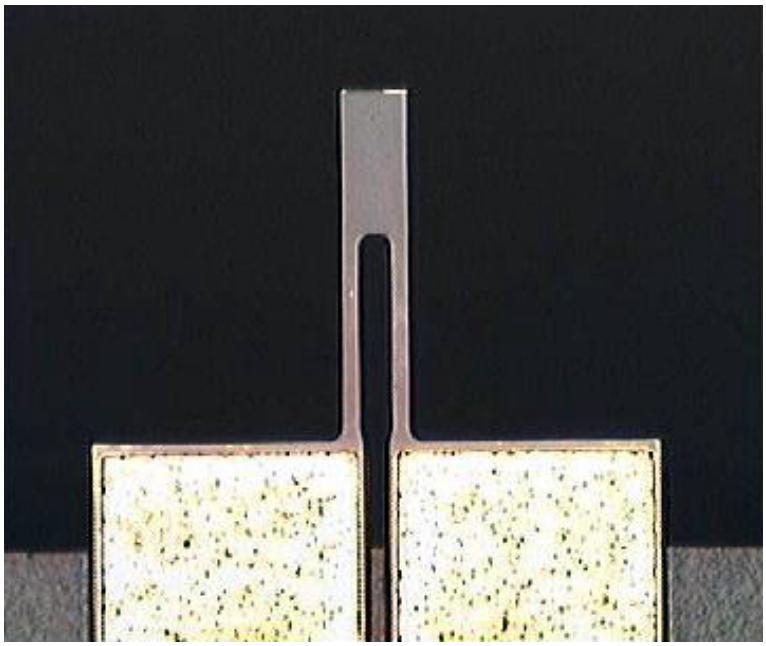
Explosives Detection

Mass-produced micromachined microcantilevers can be used as sensors for detection of explosive vapors and particulate matter. The same cantilever design can be used in two independent approaches to detecting explosives. The sensitivity of the microcantilever depends on its geometry.

In the first approach, rapid internal heating of the microcantilever causes "nanodeflagration" (rapid burning) of explosives. This approach has been used to detect a number of explosives (e.g., TNT, RDX, and PETN).

In the second approach, the microcantilever is coated with a selective layer that is specific for explosive compounds. Preliminary experiments show that coated microcantilevers can detect TNT and DNT. The selective layer can be replaced with layers that are specific for other hazards, such as biological or chemical warfare agents.

Two full-time employees (or full-time equivalents) will be required for two years to develop a multiple-element array. The milestone for the first year of research is to develop a single-element bench-top model. The milestone for the second year is to field test a prototype multiple-element sensor for simultaneous detection of different explosive vapors.



Optical image of a 180-micron-long cantilever for nano deflagration of adsorbed explosive molecules.

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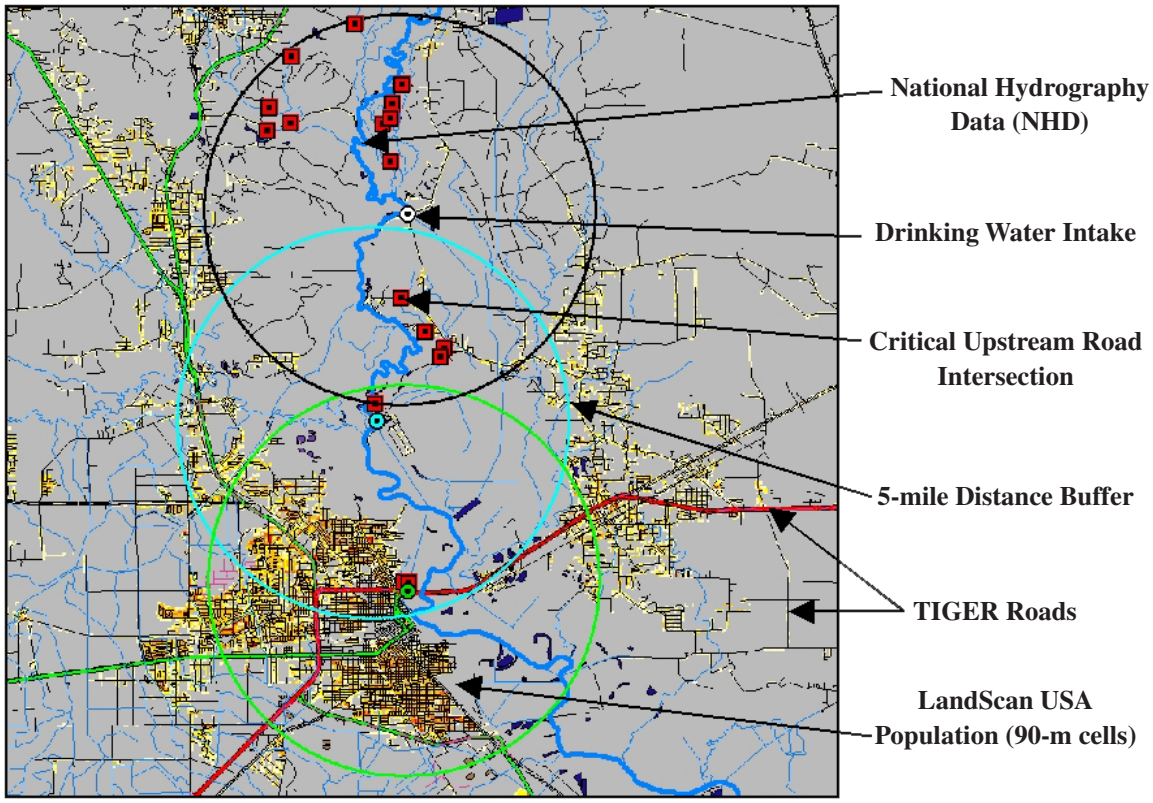
Vulnerability Assessment Model for Dams and Drinking Water Intakes

ORNL has developed a geospatial model for georeferencing surface drinking water intake locations and surface impoundments (dams) to the National Hydrography Data (NHD). There are about 7000 intakes in U.S. Environmental Protection Agency's (EPA's) surface drinking water intakes database and 80,000 dams in the National Inventory of Dams (NID). Accurate location information of these critical energy (hydropower and transportation) infrastructure elements is essential for infrastructure protection and management. Other geospatial information (land cover, population, roads, water supply pipelines data) can be analyzed in combination to develop a vulnerability assessment model for these infrastructure elements.

Water Infrastructure Security



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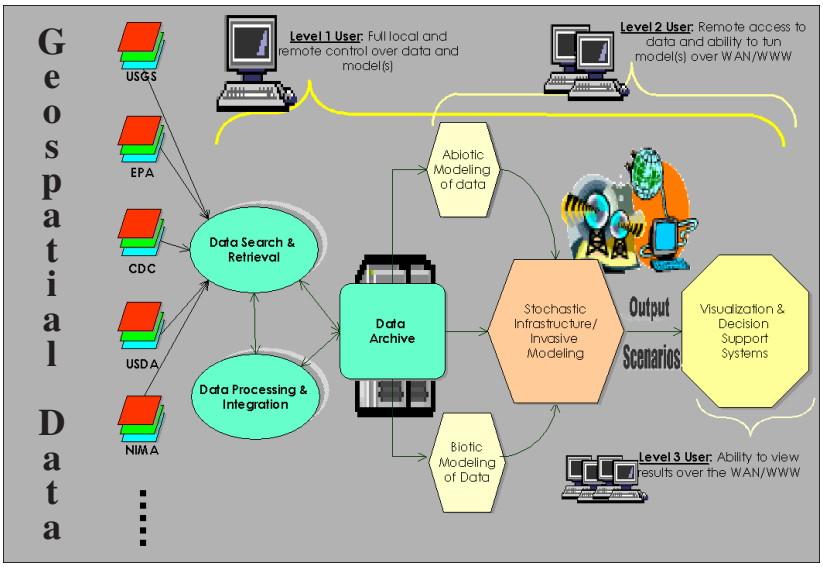
Spatiotemporal Threat Assessment and Modeling System

ORNL is designing an architecture that combines an integrated intergovernment georeferenced database system (access to online and archived data) with a stochastic modeling environment. The goals are to (1) assess federal needs, requirements, and data systems; (2) design the proposed architecture of a Threat Assessment and Modeling System; and (3) develop and test a system demonstration prototype. This work is based on related ongoing efforts at ORNL that include threat reduction and emergency response modeling. The initiative is built upon ORNL's strong experience in geographic information system and remote sensing, software agents, and stochastic modeling to analyze the spatiotemporal impact of invasive agents.

The system is designed for spatiotemporal infrastructure and/or invasive modeling for preventing and mitigating energy, agricultural, and environmental risks. The architecture will serve as the foundation for a comprehensive intergovernmental georeferenced database system that integrates data sources, defines data formats, and defines protocols to access on-line and archived data across distributed sources; allows stochastic/epidemic/invasive modeling of dispersal and impacts of pests, disease vectors, and contaminants; defines user-friendly GUI and various levels of user access to control the data, modeling, and visualization environments through direct and remote access over WAN/WWW protocols to improve accessibility and portability; and Improves data exchange among agencies and departments.



Spatioemporal Threat Assessment and Modeling System

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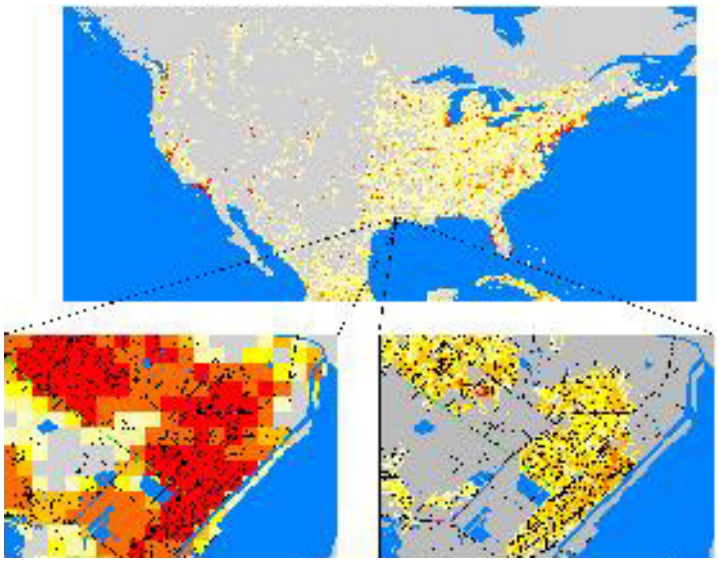
LandScan USA: High-Resolution Population Distribution Model

ORNL is developing very high resolution (90m) population distribution data (LandScan USA) for the United States as part of the ORNL LandScan global population project. A pilot study has been completed in a 29 county area in southeast Texas (around Houston and Port Neches) in order to develop the necessary algorithms and identify and resolve issues surrounding development of LandScan USA. LandScan USA is more spatially refined than the resolution of block-level census data and includes demographic attributes (age, sex, race). The model includes development of an "ambient population" (average over 24 hours) for global LandScan and development of spatial distributions for "residential or nighttime population" as well as for "daytime population" as part of LandScan USA. Locating daytime populations requires not only census data, but data on places of work, journey to work, and other mobility factors. The combination of both residential and daytime populations will provide the best estimate of who is potentially exposed to ambient pollutants.

LandScan USA is developed in standard (commercial) geographical information system and ASCII data formats. LandScan USA has great potential for applicability in various socioenvironmental studies, including exposure/health risk assessment, urban sprawl estimation, and estimating populations at risk from natural and anthropogenic disasters. The LandScan model has significant potential to be modified for other applications and is currently being considered as the primary tool to estimate spatial distribution of pesticide usage in urban watersheds.

LandScan USA 2000



30 arc second **3 arc second**

LandScan USA GIS Data Modeling

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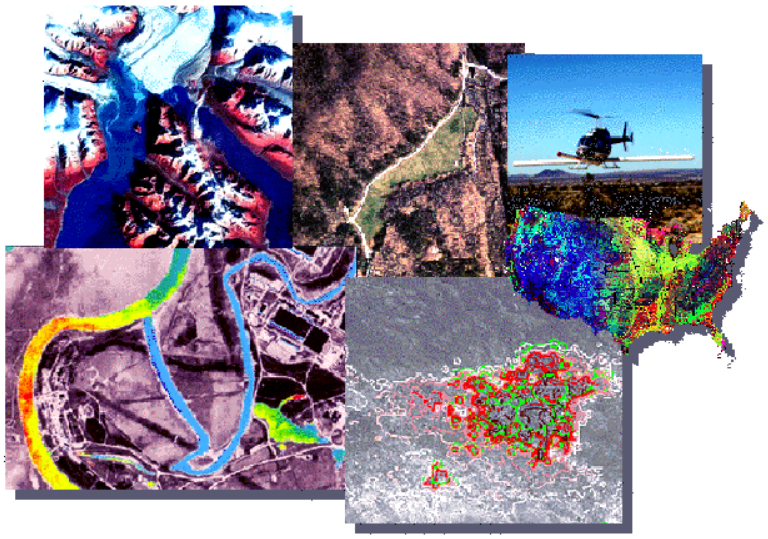
Geographic Information Systems and Remote Sensing

The Geographic Information Science and Technology (GIST) Group at the ORNL has been a leader in the development, implementation, and application of systems, science, and technology for geographic information since 1969—well before the advent of commercial GIS. ORNL has developed a unique geographic information science and technology center, complete with state-of-the-art equipment to computerize, analyze, and display spatial information in 2D or 3D forms. Regional, national, and global databases have been implemented for a wide range of geographic applications and spatial modeling activities. The mission of GIST is to support national energy, environmental, and security programs through research, development, and application of geographic information and analysis systems. The GIST group offers a full suite of expertise in geographic information system and remote-sensing technologies to solve multidisciplinary and complex problems with advanced spatial modeling and simulation. Existing capabilities of the GIST group include 3D terrain analysis and visualization, 3D urban model development and visualization, feature extraction from imagery, transportation routing, hydrologic modeling, population-at-risk studies, assessment of air training routes, studies of coastal habitat change from satellite imagery, environmental impact analysis, and emergency management.

Current GIST capabilities include

- Advanced digital remote sensing
- Development of advanced GIS algorithms
- Designing and implementation of decision support systems
- Advanced image analysis and interpretation
- Automation of imagery-processing and feature-extraction techniques
- Computer cartography and thematic mapping
- 3D visualization and animation
- Digital terrain modeling
- Demographic modeling
- Global positioning systems



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Video-Based Personnel Identification and Monitoring

Scientists at ORNL have developed new face recognition technology that provides unparalleled robustness to varying illumination, changes in facial expression, and modifications to facial decoration (e.g., facial hair or eyeglasses). This technology could be instrumental in developing advanced surveillance solutions to improve facility safeguards.

Unlike existing technology, ORNL's face recognition approach is specifically intended to be used with video. Multiple observations of a single subject, obtained through time and/or multiple cameras, are integrated to provide robust identification. ORNL also possesses complementary model-based face-tracking technology as well as extensive expertise in surveillance video processing.

The intended application for this technology is active facility monitoring. Inexpensive cameras can be mounted in critical areas and chokepoints of secure facilities. The video from these cameras can then be used to identify, track, and monitor personnel activities. Unauthorized personnel and abnormal activities can be used to activate an alarm or notify security personnel.

This research was sponsored by the Laboratory Directed Research and Development Program and the Department of Energy's Office of Nonproliferation Research and Engineering (NN-20).

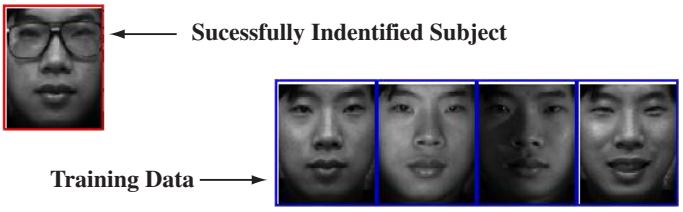

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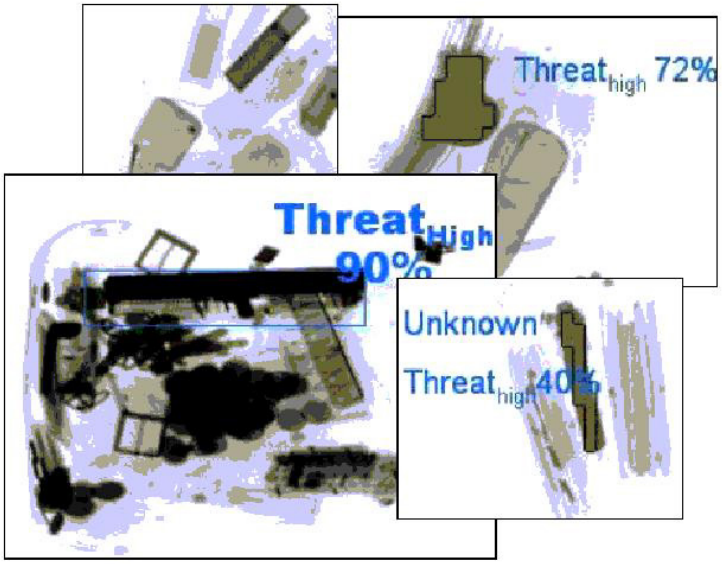
Image Analysis

Operator-Assisted Threat Assessment:
A technology to improve reliability of X-ray baggage screening

ORNL has developed an image-based approach for assisting X-ray baggage-screening personnel in identifying potential threat items in X-ray imagery of carry-on baggage. The technique seeks to identify threat items, including guns, knives, grenades, pipebombs, and improvised explosive devices. ORNL's methodology has focused on identifying and testing the region-based image characteristics that could potentially indicate a threat object. ORNL's focus-of-attention (FOA) technique breaks with traditional pattern- or template-based techniques for object identification by analyzing small, local spatial regions and evaluating the threat potential of such regions through a decision method based on historical precedence through a training process. Regions that could potentially contain items that pose a threat are assessed and displayed to an operator with a confidence value for the assessed threat. Operator-assisted technologies such as the ORNL's FOA, represent a necessary step in the evolution of reliable and accurate inspection systems that achieve full automation.



This technology was evaluated under the sponsorship of the National Safe Skies Alliance in cooperation with the Federal Aviation Administration Tech Center.

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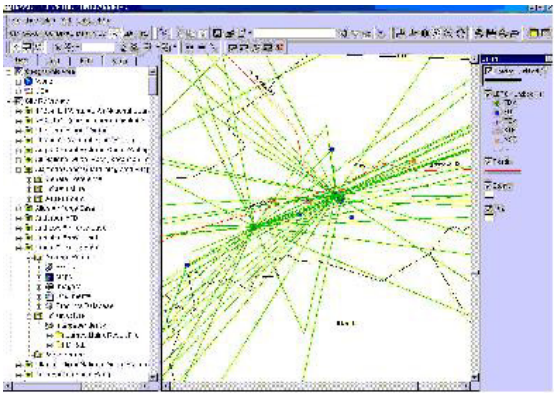
Software Agent Infrastructure Interdependencies Analysis Tool

This technology utilizes knowledge management and autonomous intelligent agents extensively for use in knowledge preservation to data mining, to knowledge banks all the way to storing, retrieving, and integrating data with other sources. Once search engines find pertinent data, it is sent to data marts, where it undergoes a rudimentary correlation and possibility analysis. Patterns and probabilities emerge from statistical modeling following the entry of data into this data mart. We are developing technology to support collecting huge amounts of data and to access that data quickly.



Critical telecommunication assets and interstate highways.

This visualization tool has been used by the Department of Defense to analyze, assess, and define interdependencies for critical infrastructure elements such as road, rail, electric power, natural gas, and telecommunications. This tool has become a key element of the Critical Infrastructure Protection Program used by the military to assess the impact of commercial infrastructures on military readiness. It has also been used to identify potential vulnerabilities to terrorist attack.

A key challenge to modeling the Department of Energy national energy infrastructure is determining the interdependence of critical infrastructure components. We believe that an agent-based approach to determining these interdependencies would be ideal in determining interdependencies and in assessing the probability and impact of failures within the national infrastructure system. This approach, coupled with the experience and visualization techniques employed for other sponsors, would serve to identify interactions or interdependencies between transportation and other sectors and development of techniques to minimize negative aspects of disruptions to either.

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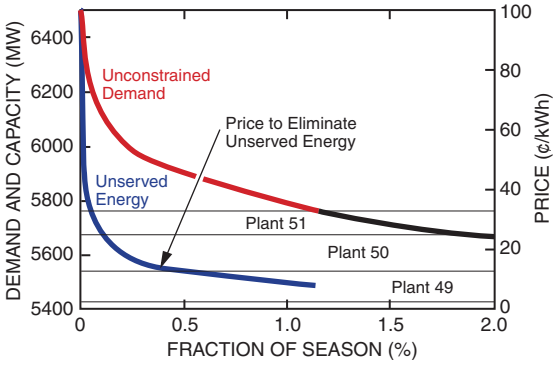
Electric Power Systems Research Program

TVA transmission lines.

A key area of vulnerability in the energy infrastructure is the electric power system. ORNL has a diverse capability for power system analysis at all levels, from industrial motor system modeling and distribution system analysis to performance assessment of regional transmission systems and economic analysis of alternative generation dispatching approaches. Because of its close links with the utility industry, both in the United States and internationally, ORNL has acquired a significant capability for system analysis using utility standard, commercially available software codes. North American Electric Reliability Council (NERC) regional data combine with ORNL's own model development capability to provide an unparalleled ability to perform large-scale system studies. The use of industry standard databases and codes ensures high-quality repeatable results that are widely acceptable to industry, while in-house modeling expertise ensures appropriate handling of unusual requirements.

In addition to technical system analysis, ORNL has developed a significant capability for assessment of the technical and economic impacts of policy alternatives, such as the restructuring of the U.S. utility industry away from a vertically integrated cost-of-service regulated system toward a competitive market. ORNL activities include the assessment of the need for, the cost of, and the options for supplying ancillary services such as system reserves, reactive power and voltage control. We also assess the ability of real-time markets to address system reliability needs from both the supply and demand sides. Our work on transmission-grid reliability issues has been nationally recognized.



Electricity supply, demand, and prices when unconstrained demand exceeds supply.

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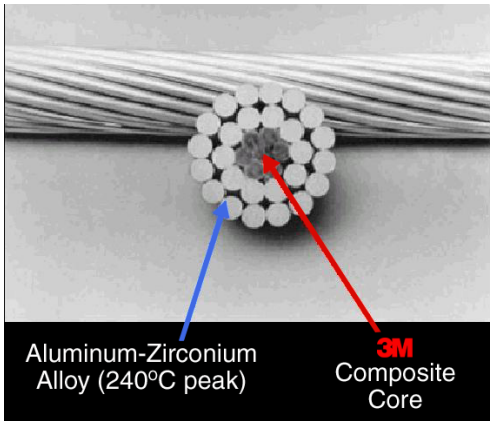
Upgrading Electric Transmission Network Capacity

A crucial problem facing the nation's electrical transmission network is the continuing lack of investment and construction for new transmission lines. As a result, many areas of the country are now facing transmission congestion, resulting in the higher likelihood of outages in the event of emergencies caused by extreme weather conditions or national security situations. One near-term solution is to upgrade the existing transmission lines and transformers with conductors and transformers having a greater capacity but the same footprint.

Southwire SuperTD Cable installation at the Southwire Facilities in Carrollton, Georgia. The first field installation of HTS superconducting cables in the world (www.southwire.com).

The new conductor technologies available today and in development are composite conductors and superconductors. Composite conductors use higher-strength materials and new material compounds to allow the conductor to operate at higher temperatures, permitting the flow of more electric current. Superconductors; due to their unique properties, can carry up to ten times more current than today's copper conductors, these cables are being demonstrated today around the world (www.southwire.com and www.supercables.com). Superconductors would be useful in areas such as central business districts where space constraints make new capacity difficult to install. Also, an underground installation of a superconducting cable would provide a more secure means of energy transport than overhead lines.



3M's composite core conductor uses an aluminum metal matrix containing Nextel fibers that can increase the ampacity of a transmission line by 1.5 to 3 times over conductors presently installed.

Using available technology to build expensive new rights-of-way and new tower systems will cost well over $1 million dollars per mile. However, upgrading existing facilities will significantly improve the overloaded electrical infrastructure at a fraction of the cost.

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ReflectoActive Seals System

The ReflectoActive™ Seals System (RAS) is an active seal technology that provides real-time tamper indication for large arrays of storage containers. It was initiated as a joint development effort between Y-12 Development Division and ORNL and for several years has been undergoing field testing and deployment at the Y-12 National Security Complex.

The RAS provides real-time tamper indication for material control and accountability. The system uses optical fiber technology and has very minimal maintenance requirements. The RAS provides continuous tamper indication for large numbers of containers at a significantly lower cost than other active seal technologies. It can be configured for specific user requirements and is adaptable for various types of container closure designs and container configurations.

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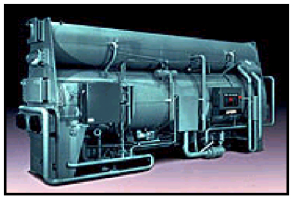
Distributed Energy Resources for a Resilient Infrastructure



Distributed energy resources can provide support to several elements of energy infrastructure assurance: prevention, mitigation, and recovery. Providing locally based electricity generation or electricity plus heating and cooling can reduce the reliance on a centralized grid, improving security. The grid becomes a less tempting target to attack. A shift in the electrical grid to more-responsive loads with self-generation improves the resilience of the system and lowers the vulnerability of the grid to a widespread outage. Smart controls in a distributed environment could allow for autonomous islands or sections of the grid that could be more easily reconnected as the grid is reassembled following a massive outage.

DOE's Office of Power Technologies and Federal Energy Management Program have named ORNL as the leading national laboratory for distributed energy resources and combined heat and power (CHP). Its CHP Laboratory includes a variety of generating and HVAC equipment that allows users to explore different issues in the deployment of CHP. Microturbines, fuel cells, heat exchangers, and desiccant systems can be analyzed alone or in combination to improve system operations. ORNL provides technical design assistance in the deployment of CHP throughout the federal system.

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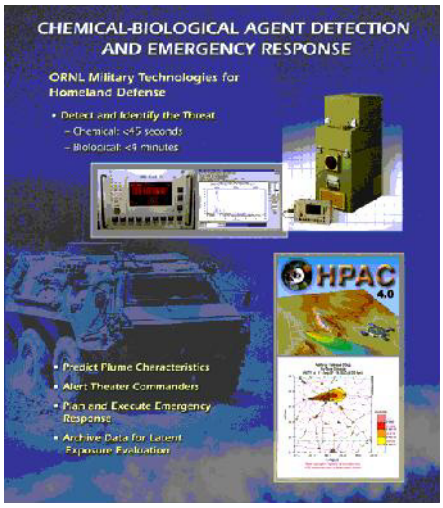
Real-Time Detection and Assessment of Chemical-Biological-Nuclear Threats

ORNL is near completion in the development of a manufacturable Block II Chem-Bio Mass Spectrometer (CBMS) for the U.S. military. This state-of-the-art technology detects all known and unknown chemical agents and a classified list of biological agents in minutes. ORNL is also near completion in the development the Version 4.0 software architecture for the U.S. Military Hazard Prediction and Assessment Capability (HPAC). This is a platform-independent, client-server, web-based architecture. ORNL also is responsible for several modules within HPAC, including the nuclear effects models, the world's most accurate population databases and models, and a new water transport model. HPAC is currently used in all military command centers throughout the world and has been used during the Bosnia conflict, the Atlanta Olympics, the Presidential Inauguration, and Gulf War Illness studies.



Chemical-Biological Agent Detection and Emergency Response.

ORNL proposes to modify and combine these existing and proven tools (including state-of-the-art radiation detectors) to produce near real-time detection and assessment of hazardous material releases, especially releases of chemical and biological agents and nuclear material releases. The CBMS can be modified to measure plume concentration (diagnostics) that can then be input to modified HPAC plume models to predict future migration and concentrations in the hazardous plume (prognostics) as well as the source location of the plume (forensics). Similarly, radiation measurements can be input into the modified HPAC plume models.

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