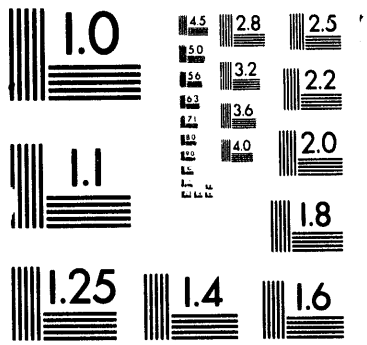
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RISK MANAGEMENT AT LAWRENCE LIVERMORE NATIONAL LABORATORY

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RISK MANAGEMENT AT LLNL[1]

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INTRODUCTION

Managing risks at a large national laboratory presents a unique set of challenges. These challenges include the management of a broad diversity of activities, the need to balance researcher flexibility against management control, and a plethora of requirements flowing from regulatory and oversight bodies. This paper will present the experiences of Lawrence Livermore National Laboratory (LLNL) in risk management and in dealing with these challenges. While general risk management has been practiced successfully by all levels of Laboratory management, this talk will focus on the Laboratory's use of probabilistic safety assessment and prioritization techniques and the integration of these techniques into Laboratory operations.

Probabilistic safety assessment and prioritization techniques are applied at LLNL in five general areas: (1) facility operations; (2) functional management; (3) program management; (4) budgeting and (5) work for outside sponsors. This paper will focus on LLNL risk management in the first four areas, i.e., those that are internally focused. However, the Laboratory does provide a wide range of risk analysis research and application capabilities for outside sponsors, mostly the DOE and other Federal agencies, and LLNL expertise in many areas of risk assessment is widely recognized. For example, risk assessment methods have been developed at LLNL for estimating seismic risk at commercial nuclear power plants and DOE facilities and to help in the safeguarding of nuclear materials at DOE and commercial nuclear facilities (Cummings and Al-Ayat, 1989). Another example is the environmental risk assessment methods being developed for the

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State of California Environmental Protection Agency (McKone, 1993) and for the DOE (Daniels, 1993).

FACILITY OPERATIONS

The use of probabilistic safety assessment techniques at the facility operations level is part of a multi-step process of categorizing the hazards of individual LLNL facilities, identifying the higher hazard facilities, preparing safety analysis reports, and performing in-depth risk analysis of important aspects of the facilities. Often, such risk analyses are done for specific purposes, including the evaluation of facility upgrades. The focus of such analyses is usually safety systems designed to protect employee and public health. An example of such an analysis is the fault-tree analysis of the Plutonium Facility's electrical distribution system.

There are several levels of risk analysis done for LLNL facilities depending on the potential for harm of the hazard involved. For all facilities with a hazard classification and for other prescribed hazardous operations, the Laboratory requires that safety procedures be written. These procedures are of two types. Facility Safety Procedures (FSP) define basic ground rules to be followed in a facility. Operational Safety Procedures (OSP) are specific to a particular activity and are used to add to or modify FSP requirements. Both types of procedures require a qualitative evaluation of risk. The level of approval is graduated depending upon the level of risk involved.

In recent safety analyses a risk matrix has been constructed and used to determine the acceptability of results. In this approach bounding accidents are postulated, a subjective estimate made of their probability of occurrence and their consequences quantitatively evaluated. Each accident is put into a bin based on its probability level (4 levels) and consequence rating (4 levels) and each bin dofined as either of high, medium, low or negligible risk. Safety features are added and Operational Safety Requirements defined to assure that all accidents are of low or negligible risk.

Such a risk matrix was constructed for LLNL's High Explosives Application Facility, which supports HE formulation and testing to 10 kg quantities. Formal analysis of consequences were performed on eight identifies hazards, e.g., HE transport, seismic, and six bounding accidents, e.g., explosive detonation, toxic material spill, fire. Of these six bounding accidents, only one fell into the low risk bin. The others were in negligible risk bins (Morse and Weingert, 1989).

Probabilistic safety assessment techniques have been used to analyze specific types of hazards such as an aircraft accident involving our Plutonium Facility and a toxic gas release from our Microfabrication Facility. The aircraft accident study (Vogt, 1991) was done to support accident analyses for the LLNL Environmental Impact Statement/Environmental Impact Report published in 1992.

Since the 1980 Livermore earthquake, whose epicenter was located a few miles from LLNL, extensive upgrades and retrofits have been made to certain LLNL facilities. Although risk assessments were not done to support the selection of these modifications the choices were based, in part, on risk assessment results. More recent upgrades and evaluations are based on seismic design guides prepared by LLNL for use at DOE facilities (Kennedy, 1990). These are based on both risk assessment experience as well as engineering judgment.

FUNCTIONAL MANAGEMENT

Risk assessment techniques are a key part of functional management in several areas of Lab operations. The environmental protection department personnel use probabilistic safety assessment techniques for monitoring and managing environmental issues. Often these risk analyses are done to respond to requests from regulators. They vary in size and complexity from large, comprehensive models of the transport and health effects of Superfund Site groundwater contamination to pro forma analyses required by the Clean Air Act. Frequently, risk analyses are required by the NEPA for new Laboratory facilities and operations.

Safeguards and Security Department personnel use probabilistic safety assessment techniques to prioritize their efforts and to choose among alternative procedures. Formal risk assessments for the vulnerabilities of key facilities against malevolent acts, particularly attempted theft of nuclear materials, are performed and updated regularly. Following DOE policy, these assessments estimate the probability of a successful malevolent act assuming that such an act is attempted. The probability of adversary success is determined using traditional risk assessment techniques, including fault trees. However, unlike most safety risk assessments, the adversaries are assumed to be rational and to maximize their probability of success. These analyses are often facilitated by the use of the ASSESS methodology and computer software for performing vulnerability assessments (Al-Ayat, Cousins, and Matter, 1989). The Laboratory risk, as determined by these risk assessments, is an important part of the Laboratory's Site Safeguards and Security Plan that is approved by DOE and is a large factor in DOE's assessment of Laboratory safeguards and security performance. Risk reduction as determined by such risk assessments is the means for ascertaining the cost effectiveness of upgrades and adjustments to the Laboratory safeguards and security system.

PROGRAM MANAGEMENT

Several large Laboratory programs use probabilistic safety assessment techniques to choose among alternative technical directions, particularly when the options vary greatly in the end technologies' impacts on safety and health. One example is the choice of enhanced safety concepts to incorporate into existing nuclear weapons or into possible future designs (Bookless, 1992). Both existing and proposed weapons systems are analyzed using techniques of varying complexity. Probabilistic safety assessment techniques, similar to what were developed for nuclear reactor safety studies, are used to assess risk scenarios involving weapons. First, accident scenarios are identified and their occurrence frequencies estimated. Second, calculations and experiments are used to assess the environment created by the accident. Third, the weapon's response is calculated using chemical, thermal, and structural computer codes. Fourth, the amount of radioactive material release and the consequences of that release are estimated.

Because few of the probabilities are precise, probabilistic safety assessment is viewed as a tool to make relative evaluations of nuclear weapons systems, not as an absolute measure of the risk associated with a given system. Assessment results are used to identify those operations that present the highest risk, to judge the value of design features in reducing risk, and to assess the effectiveness of operational measures in reducing risks.

BUDGETING

Risk-based prioritization is playing an increasing role in Laboratory overhead budgeting. Last year the Plant Operations Directorate, which includes the Laboratory's plant engineering and environmental, safety, and health support departments, used a "risk totem" approach (Grose, 1987) to allocate funding among departments. This year most of the Laboratory's indirect overhead budget, including Plant Operations, was evaluated using averted risk and a multi-attribute utility function. (The Laboratory's indirect overhead budget is in excess of $200 million.) All activities covered by the budget were defined functionally using a work breakdown structure, the risk reduction expected from funding each activity was analyzed, and activities were prioritized according to their benefit (i.e., risk reduction) to cost ratios.

Risk reduction from overhead budget items were evaluated in ten areas, reflecting Laboratory management's objectives for overhead funding:

Employee health and safety
Public health and safety
Environment
Safeguards and security
Regulatory compliance
Public concerns and understanding
Employee skills and motivation
Facilities and equipment
Business management
Mission objectives

For each of these areas, criteria and scales were developed to measure how an activity contributes to risk reduction. In some instances, the appropriate unit of measurement was readily available, but for others, special scales needed to be constructed. A multi-attribute utility function was assessed from Laboratory management and used to aggregate the scores for each activity to obtain an overall measure of the benefit of each activity. The utility function is a mathematical formula that reflects the Laboratory management's value judgments about the relative desirability of different levels of risk reduction in each area, and the relative importance of the different types of risk reduction (Keeney and Raiffa, 1976).

Each overhead organization was responsible for developing its own work breakdown structure and scoring its own budget activities on the risk reduction scales and criteria. The 1994 indirect overhead budget consisted of over 700 separate budget items to be evaluated. Training was given to appropriate staff; software was provided for documenting budget activities and facilitating scoring; and guidance and advice was available upon request. The documentation and scoring was then collected in a central database and analyzed by the Laboratory Budget Office. The initial prioritizations were distributed to the overhead organizations for review, revision of scores, and qualitative re-prioritization of budget items judged to be improperly evaluated by the quantitative model. All such qualitative re-prioritizations were justified and documented.

Based on the experience with the 1994 overhead budget, the Laboratory is considering a number of changes to the process for the 1995 budget. These include improvements in the model for measuring risk reduction; adoption of a two-tiered approach with different levels of detail; and centralization of scoring to improve its consistency and accuracy.

A similar risk-based prioritization approach is also used to schedule responses to recommendations and findings by outside review groups (e.g. DOE "Tiger Teams"). Within the constraints of a fixed budget, this helps ensure that the most cost effective actions are performed first. For such prioritizations, risk reduction is usually evaluated for a more narrow set of objectives commensurate with the more limited nature of the activities. In most of these exercises, scoring was performed by a single group of individuals.

CONCLUSIONS

LLNL has always carefully assessed the risks of its activities to assure proper protection of its workers and the public. These assessments have and continue to take different forms depending on the nature and severity of the risks involved. In the early days of the Laboratory, risk assessment tended to be informal and based on the informed judgment of the scientists involved. This was suitable when risk management techniques were in their infancy and the analysis of the researchers involved was often the best guide to the safeguards required.

As technologies matured more formal analyses were required in both safety documentation and risk assessment. This process is still evolving and is becoming more comprehensive as regulatory bodies push for more accurate quantification of the risk being accepted on behalf of the activity undertaken.

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