Department of Energy
Washington, DC 20585

AUG 4 1998

The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W.
Suite 700
Washington, D.C. 20004

Dear Mr. Chairman:

The Implementation Plan (IP) for Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 97-2 requires a quarterly status report. Enclosed is the Department of Energy's quarterly status report for the third quarter, Fiscal Year (FY) 1998.

The following IP deliverables have been completed during the quarter and are attached: IP Commitment 6.1, Deliverable 1, Assessment Report of the Criticality Research Program; IP Commitment 6.6.2, Deliverable 1, and IP Commitment 6.6.3, Deliverable 1, Assessment Report of Additional Training Needs and Review of Supplementary Curricula, which contains the review of Site Qualification Programs; and, IP Commitment 6.9, Deliverable 2, Nuclear Criticality Safety Program Plan.

The following IP milestone has been met: IP Commitment 6.4, Milestone 1, a criticality safety web site at Los Alamos (http://con.lanl.gov/test/index.htm) became operational in May 1998. Three additional milestones are overdue; however, they will be completed prior to the end of FY 1998. These milestones are: Publish data and calculations from the Criticality Safety Information Resource Center Pilot Program on the DOE web site (IP Commitment 6.2.1, Milestone 5); Publish the Y-12 evaluations on the DOE web site (IP Commitment 6.4, Milestone 2); and, each DOE site will conduct surveys to assess line ownership of criticality safety (IP Commitment 6.7, Milestone 1). Four of the ten applicable sites have yet to conduct the required surveys.

The Department has made significant progress in implementing Recommendation 97-2; however, stabilizing the funding continues to be a challenge. To address long-term funding stability for the Nuclear Criticality Safety Program, the Department has developed a Memorandum of Understanding (MOU) between the offices of Defense Programs; Environmental Management; Environment, Safety and Health; Energy Research; and the Chief Financial Officer. This MOU establishes a mechanism whereby, beginning with FY 2000, participating offices maintain individual budget lines for the Nuclear Criticality Safety Program. It also provides a process for resolving budget shortfalls. The MOU is currently awaiting final approval from the participating Secretarial Officers.

Funding for FY 1999 is a significant unresolved issue which jeopardizes ongoing Nuclear Criticality Safety Program activities at Oak Ridge and Argonne National Laboratories, and to a lesser extent, at the Los Alamos National Laboratory. The shortfall at Oak Ridge is of particular concern because it could result in permanent shutdown of the Oak Ridge Electron Linear Accelerator, a facility which provides a unique capability to the Nuclear Criticality Safety Program. The Assistant Secretary for Defense Programs has requested the support of the Assistant Secretary for Environmental Management to resolve near-term funding shortfalls. Environmental Management is reviewing its budget situation and preparing a response. Defense Programs has also kept the Departmental Representative to the DNFSB informed about this issue so it can be raised to higher management if necessary. I will keep you informed about the funding situation as we work on resolving this important issue.

Sincerely,

Robin Staffin
Deputy Assistant Secretary
for Research and Development
Defense Programs

Enclosure

cc (w/encl):
M. Whitaker, S-3.1

ACRONYMS

ANL	Argonne National Laboratory
CSBEP	Criticality Safety Benchmark Evaluation Program
CSEWG	Cross Section Evaluation Working Group
CSSG	Criticality Safety Support Group
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
ENDF	Evaluated Nuclear Data File
ENIWG	Experimental Needs Identification Working Group
ER	Office of Energy Research
FY	Fiscal Year
ICSBEP	International Criticality Safety Benchmark Evaluation Program
INEEL	Idaho National Engineering and Environmental Laboratory
IP	Implementation Plan
LACEF	Los Alamos Critical Experiments Facility
LANL	Los Alamos National Laboratory
NCPP	Nuclear Criticality Predictability Program
NCSP	Nuclear Criticality Safety Program
NCSPMT	Nuclear Criticality Safety Program Management Team
OECD-NEA	Organization for Economic Cooperation and Development - Nuclear Energy Agency
ORELA	Oak Ridge Electron Linear Accelerator
ORNL	Oak Ridge National Laboratory
RSICC	Radiation Safety Information Computational Center
SRS	Savannah River Site
USNRC	United States Nuclear Regulatory Commission

QUARTERLY STATUS OF THE IMPLEMENTATION PLAN
FOR
DEFENSE NUCLEAR FACILITIES SAFETY BOARD RECOMMENDATION 97-2
THIRD QUARTER FY 1998

The Department of Energy (DOE) began implementation of Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 97-2 in January 1998 by formally establishing the Nuclear Criticality Safety Program Management Team (NCSPMT) and the Criticality Safety Support Group (CSSG). Both the NCSPMT and the CSSG met several times during the quarter and are performing their respective chartered functions in supporting the Response Manager's execution of the Implementation Plan (IP).

Accomplishments and key issues addressed during the period are as follows:

- An assessment report of the criticality research program was completed (IP Commitment 6.1. Deliverable 1). This action fulfills IP Commitment 6.1.

- A Criticality Safety web site at Los Alamos (http://con.lanl.gov/test/index.htm) became operational in May 1998 (IP Commitment 6.4 Milestone 1). While progress is being made to develop this web site, the NCSPMT is reviewing various options for web architectures which could involve multiple sites hyper linked together in a coordinated fashion.

- The Y-12 evaluations are being prepared for publication on the web site and will be made available in August 1998 (IP Commitment 6.4, Milestone 2).

- An assessment report of additional training needs and review of available supplementary curricula, which contains the review of site qualification programs, was completed (IP Commitment 6.6.2 Deliverable 1, and IP Commitment 6.6.3 Deliverable 1).

- Individual site surveys to assess line ownership of criticality safety were completed by DOE at Savannah River, Rocky Flats, Idaho, Chicago, Oak Ridge, and Richland. DOE Oakland is conducting the survey in conjunction with implementing Integrated Safety Management at Building 332, which should be completed in September 1998. DOE Albuquerque will complete surveys of line ownership of criticality safety at Los Alamos, Sandia, and Pantex no later than October 1998. This commitment (IP Commitment 6.7 Milestone 1) will remain open until all surveys are complete.

- The Nuclear Criticality Safety Program Management Team Program Plan for Fiscal Years 1999 - 2003 was completed (IP Commitment 6.9 Deliverable 2). This action fulfills IP Commitment 6.9.

- One three-day criticality safety course and one five-day criticality safety course were conducted at the Los Alamos National Laboratory. A total of 22 people attended this training.

There are six attachments to the quarterly report. Attachment A contains a complete IP commitment and deliverable/milestone status. Attachment B provides a summary of deliverables/milestones due during the next quarter. Attachment C contains current NCSPMT and CSSG members. Attachment D is the assessment report of the criticality research program (IP Commitment 6.1. Deliverable 1). Attachment E is a report which contains an assessment of additional training needs and review of supplementary curricula and a review of site qualification programs (IP Commitment 6.6.2 Deliverable 1, and IP Commitment 6.6.3 Deliverable 1). Attachment F is the NCSPMT Program Plan (IP Commitment 6.9 Deliverable 2).

The Department has made significant progress in implementing Recommendation 97-2, thereby maintaining important criticality safety infrastructure. However, stabilizing the funding continues to be a challenge. To address long-term funding stability for the Nuclear Criticality Safety Program, the Department has developed a Memorandum of Understanding (MOU) between the offices of Defense Programs; Environmental Management; Environment, Safety and Health; Energy Research; and the Chief Financial Officer. This MOU will establish a mechanism whereby participating offices maintain individual budget lines for the Nuclear Criticality Safety Program. It also provides a process for resolving budget shortfalls. The MOU is currently awaiting final approval from the participating Secretarial Officers. This action should provide greater funding stability in the out-years.

Funding for FY 1999 is a significant unresolved issue which jeopardizes ongoing Nuclear Criticality Safety Program activities at Los Alamos, Oak Ridge, and Argonne National Laboratories. The shortfall at Oak Ridge is of particular concern because it could result in permanent shutdown of the Oak Ridge Electron Linear Accelerator facility. This facility is essential to the Nuclear Criticality Safety Program because it is the only facility in the United States with adequate energy resolution capability necessary for acquisition of neutron cross section data important to criticality safety. The Assistant Secretary for Defense Programs has requested the support of the Assistant Secretary for Environmental Management to resolve expected funding shortfalls. Environmental Management is reviewing its budget situation and preparing a response. Defense Programs has also kept the Office of the Departmental Representative to the DNFSB informed about this issue so that it can be raised to higher management if necessary.

ATTACHMENT A: IP COMMITMENT AND DELIVERABLE/MILESTONE STATUS

Commitment	Deliverable/Milestone	Due Date	Status
6.1 Reexamine the experimental program in criticality research	1. Assessment report of criticality research program	March 1998	Completed
6.2.1 Perform CSIRC pilot program	1. Identify an experiment to archive	November 1997	Completed
	2. Archive logbook(s) and calculation(s) for that experiment	December 1997	Completed
	3. Videotape the original experimenter	January 1998	Completed
	4. Digitize data and calculations	February 1998	Completed
	5. Publish data and calculations	April 1998	Overdue: Should be completed in July 1998
6.2.2 Continue to implement the CSIRC program	1. Collocate logbooks (copies or originals) from all U.S. critical mass laboratories	December 1998	On Schedule
	2. Screen existing logbooks with original author/experimenter	December 1998	On Schedule
	3. CSIRC program plan	December 1998	On Schedule
6.3 Continue and expand work on ORNL sensitivity methods development	1. Technical program plan	July 1998	On Schedule
	2. Document initiation of priority tasks from the program plan in the quarterly report to the Board	January 1999	On Schedule
6.4 Make available evaluations, calculational studies, and data by establishing searchable databases accessible through a DOE Internet web site	1. DOE criticality safety web site	March 1998	Completed
	2. Y-12 evaluations on DOE web site	June 1998	Overdue: Should be completed in August 1998
	3. Calculations compiled by the Parameter Study Work Group on DOE web site	September 1998	On Schedule
	4. Nuclear Criticality Information System Database on DOE web site	March 1999	On Schedule
6.5.1 Revise and reissue DOE-STD-3007-93	1. Revise DOE-STD-3007-93	September 1998	On Schedule
6.5.2 Issue a guide for the review of criticality safety evaluations	1. Departmental guide for reviewing criticality safety evaluations	May 1999	On Schedule

Commitment	Deliverable/Milestone	Due Date	Status
6.6.1 Expand training course at LACEF	1. Expanded LACEF training course	July 1998	On Schedule
6.6.2 Investigate existing additional curricula in criticality safety	1. Assessment of additional training needs and review of available supplementary curricula	June 1998	Completed
	2. Initiate a program which addresses identified needs	December 1998	On Schedule
6.6.3 Survey existing contractor site-specific qualification programs	1. Report on the review of site qualification programs	June 1998	Completed
	2. Guidance for site-specific criticality safety training and qualification programs	September 1998	On Schedule
	3. Guidance to procurement officials specifying qualification criteria for contractor criticality safety practitioners	September 1998	On Schedule
	4. DOE Field will provide line management dates upon which contractors will have implemented guidance in Deliverable #2, above	March 1999	On Schedule
6.6.4 Federal staff directly performing criticality safety oversight will be qualified	1. Qualification program for Departmental criticality safety personnel	December 1998	On Schedule
	2. DOE criticality safety personnel qualified	December 1999	On Schedule
6.7 Each site will conduct surveys to assess line ownership of criticality safety	1. Individual sites issue report of findings	June 1998	Partially overdue: 6 surveys have been completed; the 4 remaining surveys will be completed by October 1998
6.8 The Department will form a group of criticality safety experts	1. Charter for Criticality Safety Support Group approved by the NCSPMT	January 1998	Completed
6.9 Create NCSPMT charter and program plan	1. NCSPMT charter	January 1998	Completed
	2. NCSPMT program plan	June 1998	Completed

ATTACHMENT B: DELIVERABLES/MILESTONES DUE DURING THE NEXT QUARTER

Commitment	Deliverable/Milestone	Due Date	Status
6.2.1 Perform the CSIRC Pilot Program	5. Publish data and calculations	April 1998	Overdue: Should be completed in July 1998.
6.3 Continue and expand work on ORNL sensitivity methods development	1. Technical program plan	July 1998	On Schedule: Plan will be completed on July 31, 1998. Execution will begin in October 1998.
6.4.2 Make available evaluations, calculational studies, and data by establishing searchable databases accessible through a DOE Internet web site	2. Y-12 evaluations on the DOE web site	June 1998	Overdue: Should be completed in August 1998.
	3. Calculations compiled by the Parameter Study Work Group on the DOE web site	September 1998	On schedule: Work on formatting the information will begin in August with publication on the web completed in September.
6.5.1 Revise and reissue DOE-STD-3007-93	1. Revise DOE-STD-3007-93	September 1998	On Schedule: Change notice has been issued by EH-34 to the DOE Technical Standards Program Office for action.
6.6.1 Expand Training	1. Expand LACEF training course	July 1998	On Schedule: Course development is continuing. Course will be piloted in September 1998.
6.6.3 Survey existing contractor site-specific qualification programs	2. Guidance for site-specific criticality safety training and qualification programs	September 1998	On schedule: Assessment of training needs, existing curricula, and site qualification programs will be used in developing guidance for issuance in September 1998.
	3. Guidance to procurement officials specifying qualification criteria for contractor criticality safety practitioners	September 1998	On schedule: Same as above.
6.7 Each site will conduct surveys to assess line ownership of criticality safety	1. Individual sites issue report of findings	June 1998	Partially overdue: All DOE sites have completed the surveys and briefed their management except DOE-OAK and DOE-AL. These surveys will be conducted according to planned criticality safety assessments and will be completed no later than October 1998.

ATTACHMENT C: NCSPMT AND CSSG MEMBERS

NCSPMT
(All DOE Headquarters)

NAME	ORGANIZATION
Roger Dintaman (Co-Chair)	Defense Programs
Dennis Cabrilla (Co-Chair)	Environmental Management
Jerry McKamy	Environment, Safety and Health
Ray Schwartz	Energy Research
Richard Person	Materials Disposition
Matthew Hutmaker	Nuclear Energy
William Lake	Civilian Radioactive Waste Management

CSSG
(DOE and Contractors)

NAME	ORGANIZATION
Adolf Garcia (Chairman)	DOE-Idaho
Dennis Cabrilla	Environmental Management
Jerry McKamy	Environment, Safety and Health
Richard Anderson	Los Alamos National Laboratory
Calvin Hopper	Oak Ridge National Laboratory
Thomas McLaughlin	Los Alamos National Laboratory
James Morman	Argonne National Laboratory
Thomas Reilly	Westinghouse Safety Management Solutions, Inc.
Robert Westfall	Oak Ridge National Laboratory
Robert Wilson	Safe Sites of Colorado

ATTACHMENT D

DEPARTMENT OF ENERGY
ASSESSMENT REPORT
OF THE CRITICALITY RESEARCH PROGRAM

JUNE 1998

ASSESSMENT REPORT OF THE CRITICALITY RESEARCH PROGRAM
Critical Experiments Program Element

AN UPDATED LIST OF CRITICAL EXPERIMENT NEEDS

June 1998

SUMMARY

This report is an update of LA-12683, *Forecast of Criticality Experiments and Experimental Programs Needed to Support Nuclear Operations In the United States of America: 1994-1999*, published in July 1994. This update, generated by the chair of the Experiment Needs Identification Workgroup (ENIWG), is intended to examine new experimental needs generated since the last publication. It includes a listing of the newly proposed experimental programs and an overview that has specific information pertaining to prioritizing critical experiments.

INTRODUCTION

The 28 proposals collected, as part of the periodic update of the experimental needs list of high priority experiments, were collected from the criticality safety community. Input was collected from the Experiment Needs Identification Workgroup (ENIWG) and participants of the Nuclear Criticality Technology Safety Project (NCTSP). Not all the collected proposals are new or independent. Some of these proposals represent reaffirmations or extensions of the experimental needs documented in LA-12683.

RESULTS

Table I is a short summary of the collected experiments and includes an estimate of ranking and resource requirements. A more complete description of the experiments is contained in Appendix A. The ranking estimate of low, medium, or high reflect the current priorities. The resource requirements are an estimate of the experimental program funding necessary to complete the experiment or experimental program. The relative range used in ranking resource requirements is as follows: "Low" was considered to be less than $250k; "Medium" was considered to be greater than $250k and less than $1,000k, and; "High" was considered to be greater than $1,000k.

Table II is a consensus ranking of the newly collected critical experiments combined with the current priority list. The members of the Criticality Safety Support Group met and discussed the current experimental program and blended these new experiments into the existing priority list. The table contains two different "Identifier" columns. Initially this appears confusing. However, if old and new designators were not provided, changes in the scope and names of experiments which were listed in LA-12683, dated July 1994, would render some of them unrecognizable to the current reader who was familiar with the older experimental needs document. Thus, this portrayal provides a cross-walk of priority experiments from past to present.

Appendix A is a listing of the experiment programs documented in LA-12683. The 100, 200, 300, . . . etc. series numbers used in LA-12683 are included in Appendix B to help relate those programs to the newly proposed experiments.

Appendix C is the results of an independent survey conducted by R.M. Westfall, ORNL, concerning the opinions of the criticality safety community. The survey concerned the current and proposed activities as part of the DOE response to DNFSB Recommendation 97-2. Both Table II and this survey show that the experimental priorities and the experimental program recommended by the Nuclear Criticality Safety Program Management Team are strongly supported by the criticality safety community at large.

CONCLUSIONS

The conclusions of the yearly reevaluation of the DNFSB 97-2 experimental program are that the program is indeed driven by DOE's criticality safety needs. Many of the proposed measurements can be incorporated into current experimental activities without a large reallocation of resources. Two new experiments involving: 1) slowing down and thermal scattering properties of materials and 2) the design of reprocessing, spent-fuel handling, and waste disposal for MOX-fueled devices are not part of the current experimental program and will be included. Several of the experiments in Table II (e.g., the spent fuel burn up and MOX worth measurements) can be conducted as replacement measurements in a suitably tailored critical assembly with the appropriate neutron spectra. This could result in significant savings of program resources over building a new experimental assembly.

TABLE 1 - SUMMARY OF PROPOSED EXPERIMENTS, 1998

Ident.	Description	Requestor	Category	Priority	Resources
98-1	Component Flooding Safety Benchmark Experiments	Steve Payne, DOE/AL Dave Heinrichs, LLNL	Extension of 501	High	Low
98-2	Single Unit / Array Benchmark Experiments	Dave Heinrichs, LLNL Adolf Garcia, DOE/ID	Extension of 501	High	Medium
98-3	Component Flooding Transient Behavior Experiment	Rick Paternoster, LANL Dave Heinrichs, LLNL	Extension of 504	Medium	High
98-4	Fissile Waste Matrix Benchmark Experiments	Blair Briggs, INEL	Restatement of 502, 609	High	Low
98-5	Pu Nitrate Solution with Boron & Gadolinium Poisons	Davoud Eghbali, WSRC	New 300 series	High	High
98-6	Experiments Representative of Fissile Accumulations in Yucca Mountain Tuff	Wesley Davis, Yucca Mtn	609 Ongoing	High	Low
98-7	Worths of Fission Products and Actinides in a Thermal Spectrum	Dale Lancaster, TRW Bill Lake, DOE/RW	Restatement Of 702, 502	Medium	Medium
98-8	Worths of Absorber, Structure and Reflector Materials In a Thermal MOX Spectrum	Dale Lancaster, TRW Bill Lake, DOE/RW	Restatement Of 702	Medium	Medium
98-9	Inelastic Scattering of Np237 Above Fission Threshold	Chuck Goulding, LANL	Restatement Of 601	High	Low - Medium
98-10	Central Ratio Measurements of Pu239 in Different Spectra	Bob Little, LANL Phil Young, LANL	Restatement Of 608	Medium	Low
98-11	Special Moderator Parameters	Calvin Hopper, ORNL	New base-theory	Medium	Medium
98-12	Slowing Down Experiments in Water	Lester Petrie, ORNL	New base-theory	High	Low-Medium
98-13	Positive Bias in Pu / MOX Systems	Calvin Hopper, ORNL		Medium	Medium
98-14	Intermediate Enrichment Experiments	Calvin Hopper, ORNL Santiago Parra, NRC	Extension of 609	High	Medium
98-15	Critical Mass Experiments at Very Low Temperatures	Rene Sanchez, LANL Rick Paternoster, LANL	Extension of 107	Medium	Low
98-16	Bubble Formation and Reactivity Effects in Fissile Solutions	Prof. Sharif Hagar Univ. of New Mexico	207 Ongoing	Medium	Low
98-17	Radionuclide Extraction from Fissile Solutions	Prof. Gary Cooper Univ. of New Mexico	Extension of 504	Low	Low
98-18	Delayed Neutron Parameters in Higher Actinides	David Loaiza, LANL Ken Butterfield, LANL	605, 605a Ongoing	Medium	Low

98-19	Spectra and Yield Measurements of Delayed Neutrons	David Loaiza, LANL Ken Butterfield, LANL	605, 605a Ongoing	Medium	Low
98-20	Prompt Burst Behavior in LEU (5 – 20%) Solutions	Charlene Cappiello, LANL Ken Butterfield, LANL	Extension of 504	Medium	Low
98-21	Reactivity Temperature Coefficient in Dilute Pu Solutions	Rene Sanchez, LANL Rick Anderson, LANL	Extension of 504	High	High
98-22	Criticality Accident Alarm System (CAAS) Testing Program	Bill Casson, LANL	Restatement of 503	Medium	Low
98-23	Criticality Accident Dosimeter Intercomparison Studies	Bill Casson, LANL	Restatement of 503	Medium	Low
98-24	Neutron Dosimeter Calibration Studies	Bill Casson, LANL	Restatement of 503	Medium	Low
98-25	Environmental Neutron Dosimetry Studies	Bill Casson, LANL	Restatement of 503	Medium	Low
98-26	Transport of Low-Energy Neutrons in Various Materials	Bill Casson, LANL	New base-theory	High	Low
98-27	Source Jerk / Pulse Neutron Subcritical Measurements	David Loaiza, LANL Chuck Goulding, LANL	Restatement of 505	High	Low
98-28	Intermediate Neutron Energy Measurements	Bill Casson, LANL	609 Ongoing	High	Low

TABLE II - 1998 RECOMMENDATIONS FOR PRIORITY OF CRITICAL EXPERIMENTS

PRIORITY	1998 IDENTIFIER	1994 IDENTIFIER	EXPERIMENT DESCRIPTION	RELATIVE PRIORITY	RELATIVE COST	BENEFITS ACRU TO
1	98-2, 98-4, 98-6, 98-14, 98-28	107, 502i, 603, 609	Intermediate energy spectrum (ZEUS)	HIGH	LOW	DP, EM, MD, RW
2	98-6, 98-14, 98-2, 98-4	102, 502a, 702, 502g, 303	Fast, intermediate, and thermal energy spectrum with fissile / fissionable material	HIGH	MEDIUM	EM, MD, RW
3	98-7	206, 207, 102 502a, 702	Reactivity and replacement measurements with SHEBA (CERES, U233, MOX, etc)	HIGH	LOW	RW, EM, NRC
4	98-1	None	Component safety benchmark experiments	HIGH	MEDIUM	DP, DoD
5	98-22, 98-3, 98-16, 98-21,	301, 503, 504	Criticality accident simulation. Equipment and methodology qualification	MEDIUM	LOW	DP, EM, MD, RW
6	98-8, 98-9, 98-10, 98-13, 98-	601, 605, 605a,605b,401	Critical mass measurements and neutron parameters for Actinide isotopes	MEDIUM	MEDIUM	DP, EM, MD, RW
7	98-8	None	Lattice experiments with MOX fuel pins	MEDIUM	MEDIUM	RW, MD, DP
8	98-11	707, 304	Special moderators, situations & anomalies (Be, BeO, D_2O, etc)	MEDIUM	MEDIUM	EM, MD, RW, DP
9	98-5, 98-20, 98-21	601, 301, 303	Static benchmark experiments in fissile solutions	HIGH	VERY HIGH	DP, EM
10	98-27	505, 701	Source jerk, pulsed neutron measurements for subcritical systems	HIGH	MEDIUM	DP, EM, EH, RW, NRC
11	98-12, 98-26	606, 703, 704	Neutron scattering & transport benchmarks.	HIGH	MEDIUM	DP, EM, EH, RW, NRC,

APPENDIX A

DESCRIPTION OF PROPOSED EXPERIMENTS, 1998

TITLE:	Component Flooding Safety Benchmark Experiments
IDENTIFIER:	98-1
DESCRIPTION:	To simulate flooding/dissolution accident. Several experiments are proposed using LACEF/RFP HEU hemishells and HEU uranyl nitrate solutions.
PROGRAM NEED:	DP – Will provide computational benchmark needed for storage & transportation of components & systems
CATEGORY:	Extension of 501 experiment series
PRIORITY RECOMMENDATION:	High priority
RESOURCE REQUIREMENT:	Low, Material at LACEF
REQUESTOR (S):	Steve Payne, DOE/AL, (505) 845-6300 Dave Heinrichs, LLNL, (925) 424-5679 Tom McLaughlin, LANL Rick Paternoster, LANL, (505) 667-4728

TITLE:	Single Unit / Array Benchmark Experiments
IDENTIFIER:	98-2
DESCRIPTION:	Pit storage criticality benchmark. Realistic pit configuration driven to critical by additional SNM. Single and multiple units are proposed including various AT-400 packing and storage matrix materials.
PROGRAM NEED:	DP – Storage & transportation of components & system
CATEGORY:	Extension of 501 experiment series
PRIORITY RECOMMENDATION:	High priority
RESOURCE REQUIREMENT:	Medium, Material at RFP, LLNL
REQUESTOR (S):	Dave Heinrichs, LLNL, and (925) 424-5679 Adolf Garcia, DOE/ID Mark Lee, DOE/OAK Rick Paternoster, LANL, (505) 667-4728

TITLE:	Component Flooding Transient Behavior Experiment
IDENTIFIER:	98-3
DESCRIPTION:	Flood realistic SNM configurations with seawater and observe transient critical behavior to benchmark accident prediction models
PROGRAM NEED:	DP – To provide a benchmark of a possible criticality accident and help establish magnitude of energy release, source terms, and physical material parameters
CATEGORY:	Extension of 504 experiment series
PRIORITY RECOMMENDATION:	Medium priority
RESOURCE REQUIREMENT:	High, major involvement of WRD&T
REQUESTOR(S):	Rick Paternoster, LANL, (505) 667-4728 Dave Heinrichs, LLNL, (925) 424-5679 Mark Lee, DOE/OAK

TITLE:	Fissile Waste Matrix Benchmark Experiments
IDENTIFIER:	98-4
DESCRIPTION:	Critical experiments are needed with fissile material in specified waste matrices. Some of these waste matrix materials include: $Al2O3$, CaCl, CaO, cellulose, concrete, and $Fe2O3$. Experiments, using a variety of fissile/fissionable materials, are requested to test both waste matrix material and fissile/fissionable cross section data over fast, intermediate, and thermal neutron spectra.
PROGRAM NEED:	DP, EM, RW – Such systems are encountered in D&D efforts, process sludge and settling tanks, in situ vitrification, and waste remediation efforts (including waste storage, retrieval, characterization, volume reduction, and stabilization)
CATEGORY:	Restatement of 502, 502a experiment series Depending on desired spectra may fall into 609 series
PRIORITY RECOMMENDATION:	High priority
RESOURCE REQUIREMENT:	May be accomplished with ZEUS
REQUESTOR(S):	Blair Briggs, INEL, (208) 526-7628

TITLE:	Pu Nitrate Solution with Boron & Gadolinium Poisons
IDENTIFIER:	98-5
DESCRIPTION:	Need experimental data to evaluate code biases for ongoing operations involving Pu solution mixed with soluble poisons
PROGRAM NEED:	DP, EM, RW – Storage, processing, and transport at WSRC, LANL
CATEGORY:	New experiment in 300 series, possibly 301.
PRIORITY RECOMMENDATION:	Medium priority
RESOURCE REQUIREMENT:	High, no US facility left working with Pu solutions
REQUESTOR(S):	Davoud Eghbali, WSRC, (803) 952-2368

TITLE:	Intermediate and Thermal Spectrum Experiments Representative Of Fissile Accumulations in Yucca Mountain Tuff
IDENTIFIER:	98-6
DESCRIPTION:	Experimental data needed for various Si/U, Si/Pu, as well as H/U, H/Pu, & H/U+Pu of postulated fissile disposition in Yucca Mountain storage configurations.
PROGRAM NEED:	MD, EM, and RW – Storage at Yucca Mountain
CATEGORY:	Extension of 609 experiment series
PRIORITY RECOMMENDATION:	High priority
RESOURCE REQUIREMENT:	May be accomplished with ZEUS.
REQUESTOR(S):	Wesley Davis, Yucca Mtn Project, (702) 295-4557 Daniel Thomas Peter Gottlieb

TITLE:	Worths of Fission Products and Actinides in a Thermal Spectrum
IDENTIFIER:	98-7
DESCRIPTION:	Measurement of worth of CERES fission product samples in SHEBA with ability to vary neutron energy spectrum. CERES samples are natural-U, each loaded with a specific fission-product isotope. Measurements will quantify the worth of each fission-product isotope and provide benchmarks for burn up calculations.
PROGRAM NEED:	Measurements and calculations will reinforce the basis for burn up credit and help license burn up credit

CATEGORY: Restatement of 702
PRIORITY
RECOMMENDATION: High priority
RESOURCE
REQUIREMENT: Low, if SHEBA facility can be used.
REQUESTOR(S): Dale Lancaster, TRW, (703) 205-3817
Phillip Fink, ANL, (630) 252-1987
Bill Lake, DOE

TITLE: Worths of Absorber, Structure and Reflector Materials In a Thermal MOX Spectrum

IDENTIFIER: 98-8

DESCRIPTION: Critical array of MOX fuel pins used for replacement measurements of various absorber, structural, and reflector materials. Critical experiments with lattices of MOX pins will be needed in preparation for reactor disposition of WG-Pu. Existing documentation for old MOX experiments is limited. Worth of absorber, structural, and reflector materials needs to be determined because MOX spectrum is harder that U spectrum.

PROGRAM NEED: MD, DP, and RW – Important to MOX program issues and will help license burn up credit. Reliable measurements of MOX lattices will demonstrate adequacy of calculations with Pu isotopes, which can support actinide-only burn up credit.

CATEGORY: Restatement of 702
PRIORITY
RECOMMENDATION: Medium priority
RESOURCE
REQUIREMENT: Medium.
REQUESTOR(S): Dale Lancaster, TRW, (703) 205-3817
Bill Lake, DOE

TITLE: Inelastic Scattering Parameters of Np237 Above Fission Threshold

IDENTIFIER: 98-9

DESCRIPTION:

PROGRAM NEED: Major uncertainty in determination of critical mass of Np237

CATEGORY:
PRIORITY
RECOMMENDATION: Medium priority

RESOURCE REQUIREMENT:	Medium.
REQUESTOR(S):	Chuck Goulding, LANL

TITLE:	Central Ratio Measurements of Pu239 in Different Spectra
IDENTIFIER:	98-10
DESCRIPTION:	
PROGRAM NEED:	DP – needed to resolve XS uncertainties and enhance current DOE operations
CATEGORY:	Restatement of 608
PRIORITY RECOMMENDATION:	Medium priority
RESOURCE REQUIREMENT:	Low.
REQUESTOR(S):	Bob Little, LANL Phil Young, LANL Don Wade, LANL John Becker, LANL

TITLE:	Special Moderator Parameters
IDENTIFIER:	98-11
DESCRIPTION:	Needed to determine influence of special moderators (Be, graphite, D2O, HD poly) on fissile material in homogeneous and heterogeneous systems
PROGRAM NEED:	EM – needed to resolve XS uncertainties and enhance current DOE storage and transport operations
CATEGORY:	New experiment to resolve baseline theoretical problems
PRIORITY RECOMMENDATION:	Medium priority
RESOURCE REQUIREMENT:	Medium.
REQUESTOR(S):	Calvin Hopper, ORNL, (423) 576-8617

TITLE:	Slowing Down Experiments in Water
IDENTIFIER:	98-12
DESCRIPTION:	Completion of NIST Cf-source, water sphere experiments. Need to complete larger spheres which is most severe test of epithermal slowing down.

PROGRAM NEED: DP, EM, RW – Needed where slowing down in water is important

CATEGORY: New experiment to resolve baseline theoretical problems
PRIORITY RECOMMENDATION: High priority
RESOURCE REQUIREMENT: Low.
REQUESTOR(S): Lester M. Petrie, ORNL

TITLE: Positive Bias in Pu / MOX Systems
IDENTIFIER: 98-13

DESCRIPTION: Calculations of MOX show a marked positive bias. Additional experiments are needed to resolve the source of the bias and eliminate it in future Pu cross-section evaluations

PROGRAM NEED: DP, EM – needed to resolve positive bias issues for Pu / MOX operations

CATEGORY:
PRIORITY RECOMMENDATION: Medium priority
RESOURCE REQUIREMENT: Medium.
REQUESTOR(S): Calvin Hopper, ORNL, (423) 576-8617

TITLE: Intermediate Enrichment / Low H/U Experiments
IDENTIFIER: 98-14

DESCRIPTION: Experiments with intermediate enrichment are needed to support downblending of HEU from retired stockpiles. Low H/U experiments which produce intermediate neutron spectra are also of interest for transportation and storage of high-level waste.

PROGRAM NEED: EM – needed to resolve XS uncertainties and enhance current DOE operations

CATEGORY: Extension of 609 experiment series
PRIORITY RECOMMENDATION: Low priority
RESOURCE REQUIREMENT: Medium.
REQUESTOR(S): Calvin Hopper, ORNL, (423) 576-8617

TITLE:	Critical Mass Experiments at Very Low Temperatures
IDENTIFIER:	98-15
DESCRIPTION:	Measurement of critical mass of U235 at optimum moderation cooled to LHe temperature. Clayton predicted critical masses of 35 g for U235 and 16 g for Pu239 under optimum conditions at LHe temperatures. No data exists for these extreme temperatures.
PROGRAM NEED:	DP, NE – Of interest for space reactor application
CATEGORY:	Extension of 107 experiment series
PRIORITY RECOMMENDATION:	Medium priority
RESOURCE REQUIREMENT:	Low.
REQUESTOR(S):	Rene Sanchez, LANL, (505) 665-5343 Rick Paternoster, LANL

TITLE:	Bubble Formation and Reactivity Effects in Fissile Solutions
IDENTIFIER:	98-16
DESCRIPTION:	These are basic physics questions to help understand reactivity quench mechanisms in fissile solutions. Many variable affect bubble formation and reactivity quench: viscosity, gas saturation, temperature and pressure, and solution agitation. These mechanisms affect the yield and source term in a solution process accident.
PROGRAM NEED:	DP, EM – needed to enhance understanding of accident conditions in process solutions and for potential use on solution reactor for isotope production
CATEGORY:	Extension of 207 experiment series
PRIORITY RECOMMENDATION:	Low priority
RESOURCE REQUIREMENT:	Medium.
REQUESTOR(S) :	Prof. Sharif Hagar, Dept. of Chem./Nucl. Engr. University of New Mexico

TITLE:	Radionuclide Extraction from Fissile Solutions
IDENTIFIER:	98-17
DESCRIPTION:	Proof-of-principle for direct high-efficiency extraction of medical isotopes from an operating solution fueled reactor

PROGRAM NEED:	NE – Isotope Production
CATEGORY:	Possible extension of 504 experiment series
PRIORITY RECOMMENDATION:	Low priority
RESOURCE REQUIREMENT:	Low, if SHEBA assembly used.
REQUESTOR(S):	Prof. Gary Cooper, Dept. of Chem./Nucl. Engr. University of New Mexico

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TITLE:	Delayed Neutron Parameters in Higher Actinides
IDENTIFIER:	98-18
DESCRIPTION:	Measurement of delayed neutron yield and decay half-life for higher actinides. Brady-England predictions of delayed neutron yields and decay constants are significantly different than experimentally measured values for U-235, Pu-239, and Np-237. Only Brady-England predictions are available for higher actinides.
PROGRAM NEED:	MD, EM, NE - Important for reactor physics and accelerator transmutation of actinide waste
CATEGORY:	Restatement of 605, 605a, 605b experiments
PRIORITY RECOMMENDATION:	Medium
RESOURCE REQUIREMENT:	Low, Already underway.
REQUESTOR(S):	David Loaiza, LANL Ken Butterfield, LANL

TITLE:	Spectra and Yield Measurements of Delayed Neutrons
IDENTIFIER:	98-19
DESCRIPTION:	Measurement of delayed energy spectrum for higher actinides important for reactor physics and accelerator transmutation of actinide waste
PROGRAM NEED:	MD, EM, NE – Energy spectrum of delayed neutrons affects the kinetics of reactors and high-multiplication accelerator targets such as those envisioned for accelerator transmutation of waste.
CATEGORY:	Extension of 605, 605a, 605b experiments
PRIORITY RECOMMENDATION:	Medium
RESOURCE REQUIREMENT:	Low, Already underway.

REQUESTOR(S):	David Loaiza, LANL Ken Butterfield, LANL

TITLE:	Prompt Burst Behavior in LEU (5 – 20%) Solutions
IDENTIFIER:	98-20
DESCRIPTION:	Needed to benchmark accident analysis models for LEU solutions at process facilities. Will help establish magnitude of energy release, source terms, and physical material parameters
PROGRAM NEED:	DP, EM, NE – There are several experimental programs which provided benchmarks for transients in HEU solutions; CRAC, KEWB, and the Silene reactor, however, there are few benchmarks of accident-like transients in low enrichment fissile solutions present in fuel processing facilities.
CATEGORY:	Extension of 504 experiment series
PRIORITY RECOMMENDATION:	Medium priority
RESOURCE REQUIREMENT:	Low, Already underway.
REQUESTOR(S):	Charlene Cappiello, LANL Ken Butterfield, LANL

TITLE:	Reactivity Temperature Coefficient in Dilute Pu Solutions
IDENTIFIER:	98-21
DESCRIPTION:	Monte Carlo codes using temperature corrected cross-sections predict large positive temperature coefficients (\$0.15 . deg-C) for dilute Pu solutions. This is a proposal for a series of subcritical measurements using Pu plates and Pu solutions at a Pu processing facility such as LANL TA-55.
PROGRAM NEED:	DP, EM – needed to determine if autocatalytic behavior can exist in dilute Pu
CATEGORY:	Extension of 504 experiment series
PRIORITY RECOMMENDATION:	High priority
RESOURCE REQUIREMENT:	High, Might utilize Pu tank at processing facility (e.g.TA-55)
REQUESTOR(S):	Rene Sanchez, LANL Rick Anderson, LANL

TITLE:	Criticality Accident Alarm System (CAAS) Testing Program
IDENTIFIER:	98-22
DESCRIPTION:	Conduct testing, as required, on the criticality accident alarm systems by exposing them to simulated criticality accidents using devices such as SHEBA and Godiva.
PROGRAM NEED:	DP, EM – required for testing CAAS across DOE complex as part of essential nuclear materials safety program.
CATEGORY:	Restatement of 503 experiment series
PRIORITY RECOMMENDATION:	Medium priority, Ongoing
RESOURCE REQUIREMENT:	Low.
REQUESTOR(S):	Bill Casson, LANL

TITLE:	Criticality Accident Dosimeter Intercomparison Studies
IDENTIFIER:	98-23
DESCRIPTION:	Conduct week-long workshop and training program on personnel nuclear accident dosimeters for nuclear facilities personnel across the DOE complex. Exposure of accident dosimeters to Godiva and SHEBA-type radiation fluences with different neutron spectra to simulate criticality accidents in different facility conditions.
PROGRAM NEED:	DP, EM, EH – Provides valuable opportunities for nuclear facilities to test dosimeter systems on actual neutron fields with magnitudes, time, and energy characteristics of a real accident.
CATEGORY:	Restatement of 503 experiment series
PRIORITY RECOMMENDATION:	Medium priority, Ongoing
RESOURCE REQUIREMENT:	Low.
REQUESTOR(S):	Bill Casson, LANL

TITLE:	Neutron Dosimeter Calibration Studies
IDENTIFIER:	98-24
DESCRIPTION:	Conduct mail-in type exposures of personnel neutron dosimeters for testing of systems energy response to realistic neutron spectra

PROGRAM NEED:	DP, EM, EH – Part of the quality control program for personnel neutron dosimeters as a supplement to the DOE Laboratory Accreditation Program for Personnel Dosimeters
CATEGORY:	Restatement of 503 experiment series
PRIORITY RECOMMENDATION:	Medium priority, Ongoing
RESOURCE REQUIREMENT:	Low.
REQUESTOR(S):	Bill Casson, LANL

TITLE:	Environmental Neutron Dosimetry Studies
IDENTIFIER:	98-25
DESCRIPTION:	Conduct mail-in type exposures of environmental neutron dosimeters for testing of systems energy response to realistic neutron spectra at very low exposure levels
PROGRAM NEED:	DP, EM, EH – Needed for testing of environmental neutron dosimeters to realistic neutron spectra at very low level exposures
CATEGORY:	Restatement of 503 experiment series
PRIORITY RECOMMENDATION:	Low priority, Ongoing
RESOURCE REQUIREMENT:	Low.
REQUESTOR(S):	Bill Casson, LANL

TITLE:	Transport of Low-Energy Neutrons in Various Materials
IDENTIFIER:	98-26
DESCRIPTION:	Benchmark measurement to determine the transport of very low energy neutrons through various materials. Will validate or provide data for updating $S(\alpha,\beta)$ type cross-sections for transport codes such as MCNP. New version of NIST Cf252 source, water sphere experiment using smaller source and HEU shell as neutron multiplier
PROGRAM NEED:	DP, MD, EM – needed to resolve discrepancies in transport problems at or near thermal energies as related to criticality safety and "thermal" critical systems.
CATEGORY:	New experiment in 600 series
PRIORITY RECOMMENDATION:	High priority

RESOURCE REQUIREMENT:	Low, materials at LACEF
REQUESTOR(S):	Bill Casson, LANL

TITLE:	Source Jerk / Pulse Neutron Subcritical Measurements
IDENTIFIER:	98-27
DESCRIPTION:	A program of experimental measurements to develop subcritical measurements useful for assessing criticality of storage configurations, SNM packages, and multiplying configurations.
PROGRAM NEED:	DP, EM, EH – All codes used in criticality safety assessments calculate subcritical keff, yet there are no "subcritical benchmarks" for code validation in the subcritical range. Furthermore, some needed benchmark experiments may have to be done subcritical and it is necessary to have these methods further developed for such measurements.
CATEGORY:	Restatement of 505 experiment series
PRIORITY RECOMMENDATION:	High priority
RESOURCE REQUIREMENT:	Low.
REQUESTOR(S):	David Loaiza, LANL Chuck Goulding, LANL

TITLE:	Intermediate Neutron Energy Measurements
IDENTIFIER:	98-28
DESCRIPTION:	Make accurate measurement of intermediate spectra on ZEUS or other similar device for application to developing improved detection techniques for radiation survey instruments, neutron spectrometers, and dosimeters.
PROGRAM NEED:	DP, EM, RW – Will contribute to ensuring accurate measurement of intermediate energy neutrons around storage, processing, and transport activities where intermediate energy neutrons may dominate the fission source term.
CATEGORY:	Restatement of 609 experiment series This also has application to dosimetry
PRIORITY RECOMMENDATION:	High priority
RESOURCE REQUIREMENT:	Will be accomplished with ZEUS
REQUESTOR (S):	Bill Casson, LANL

APPENDIX B

EXPERIMENTAL NEEDS IDENTIFIED IN LA-12683

Criticality Experiments Needed to Support Highly Enriched Uranium Operations

Experiment 101	U(93) Metal Reflected by Annealing Salts
Experiment 102	Large Array of Small Units
Experiment 103	Slightly Moderated U(93) Oxide Powder
Experiment 104	Advanced Neutron Source
Experiment 105	High-Energy Burst Reactor
Experiment 106	TOPAZ-II Reactor
Experimental Program 107	Criticality Evaluations of Space Power & Propulsion Assemblies

Criticality Experiments Needed to Support Low-Enriched Uranium Operations

Experiment 201	SP-100 Surety Program
Experiment 202	Atomic Vapor Laser Isotope Separation (AVLIS)
Experiment 203	Uranium Fuel Feed Operations
Experimental Program 204	Monitored Retrievable Storage (MRS) Facility
Experiment 205	Effect of Interspersed Moderation on an Unmoderated Storage Array
Experiment 206	Sheba Reactivity Parameterization
Experiment 207	Sheba Reactivity Void Coefficient
Experiment 208	Benchmark Measurements

Appendix B (continued)

Criticality Experiments Needed to Support Plutonium Operations

Experiment 301	Plutonium Solution in the Concentration Range from 8 g/L to 17 g/L
Experiment 302	Transuranic Extraction (TRUEX) Process
Experiment 303	Effectiveness of Iron in Plutonium Storage and Transport Arrays
Experiment 304	Plutonium with Extremely Thick Beryllium Reflection
Experimental Program 305	Arrays of 3-kg Pu-Metal Cylinders Immersed in Water

Criticality Experiments Needed to Support Plutonium/Uranium Fuel Operations

Experiment 401	Advanced Reactor Design for Metal Fuel (Pu-U-Zr)
Experiment 402	Mixed Oxides of Pu and U at Low Moderation
Experiment 403	Minimum Critical Pu Fraction in Pu/Natural-U Mixture

Criticality Experiments Needed to Support Transportation/Application Operations

Experiment 501	Assessment for Materials Used to Transport and Store Discrete Items and Weapons Components
Experimental Program 502	Waste Processing, Transportation, and Storage
Experiment 502a	Absorption Properties of Waste Matrices
Experiment 502b	*In Situ* Drum Stacking
Experiment 502c	Validation of WIPP Hydrogen Generation Calculations
Experiment 502d	The In-Tank Precipitation (ITP) Process for ^{235}U
Experiment 502e	The In-Tank Precipitation Process for $^{235}U + ^{239}Pu$
Experiment 502f	The In-Tank Precipitation (ITP) Process for ^{239}Pu
Experiment 502g	Determination of Fissionable Material Concentrations in Waste Materials
Experiment 502h	Minimum Critical Mass of Fissile-Polyethylene Mixture
Experiment 502i	Criticality Studies that Emphasize Intermediate Energies
Experimental Program 503	Validation of Criticality Alarms and Accident Dosimetry
Experimental Program 504	Accident Simulation and Validation of Accident Calculations
Experimental Program 505	Evaluation of Measurements for Subcritical Systems
Experiment 506	Safe Fissile Mass Thresholds for an Array of Waste Storage Drums

Appendix B (continued)

Criticality Experiments Needed to Support Transportation/Application Operations (continued)

Experimental Program 507	Simulator Development
Experimental Program 508	Development of a Demonstration Experiment

Criticality Experiments Needed to Resolve Baseline Theoretical Problems

Experiment 601	Critical Mass Experiments for Actinides
Experiment 602	Neutron Absorber Property of PVC
Experiment 603	Effect of Poorly Absorbing, Neutron-Scattering Elements on Critical Size
Experiment 604	Unusual Fissile Shapes
Experimental Program 605	Measurement of Delayed-Neutron Parameters and Time-Dependent, Delayed-Neutron Spectra for ^{235}U, ^{238}U, ^{237}Np, ^{239}Pu, and ^{241}Am
Experiment 605a	Delayed Neutron Fraction Measurement from ^{237}Np
Experiment 605b	Measurement of Time-Dependent Delayed-Neutron Spectra
Experiment 606	Establishing the Validity of Neutron-Scattering Kernels
Experiment 607	Extending Standard ANSI/ANS 8.7 to Moderated Arrays
Experiment 608	Fission Rate Spectral Index Measurements in Three Assemblies
Experiment 609	Validation of Calculational Methodology in the Intermediate Energy Range

Criticality Experiments Needed to Support Criticality Physics Operations

Experimental Program 701	Investigation and Development of Subcritical Measurements
Experiment 702	Spent Fuel Safety Experiments (SFSX)
Experimental Program 703	Differential Parameter Measurements
Experimental Program 704	Homogeneity versus Heterogeneity
Experiment 705	How to Measure Hydrogen
Experiment 706	"Dry Water"
Experiment 707	Anomalous Critical Experimental Results

Appendix B (continued)

Archived Experiments

Experiment 801	Fuel-Processing Restoration Project
Experiment 802	Fluorinel and Storage (FAST) Facility
Experiment 803	Mixtures of Soluble Boron and Cadmium
Experiment 804	Glycol-Water/Boron Mixture
Experiment 805	Carbon-Reflected U(93) Plant (MMES)
Experiment 806	U(93) Metal Reflected by Refractory Materials
Experiment 807	Multi Megawatt Reactor Program (canceled)
Experiment 808	Compact Nuclear Power Source (CNPS)
Experiment 809	Refurbishment or Replacement for the N-Reactor
Experiment 810	Special Isotope Separation (SIS) (canceled)
Experiment 811	Neutron Absorber Property of Pyrex Cylinder Walls

APPENDIX C – EXPERIMENTAL NEEDS SURVEY

Current Topics and Needs Related to Nuclear Criticality Safety in the United States[1]

R. M. Westfall
Oak Ridge National Laboratory

Traditionally the nuclear criticality safety (NCS) interests in the U.S. could generally be divided along the lines of those interests related to the Department of Energy (DOE), interests related to the commercial sector supporting the light-water reactor (LWR) industry, and interests of the Nuclear Regulatory Commission (NRC) which regulates the commercial industry. As the DOE seeks to privatize more of its activities and simultaneously upgrade its safety evaluations, the NRC and industry are becoming more closely involved with the DOE sector, and the interests related to NCS are gradually becoming more uniform across the three sectors.

At the recent the DOE Nuclear Criticality Technology Safety Project Workshop, an effort was made to survey the attendees relative to the issues and priorities of current importance in NCS. The findings can be summarized as follows:

Highest priority: Capability maintenance for critical experiments, nuclear data development and NCS software.

High priority:

a) NCS technology development for bounding values;
b) Developing a technical basis for qualifying intermediate-spectra systems;
c) Understanding and qualifying the reactivity worth of storage media (concrete, glass, salt, steel, SiO_2, etc.);
d) Development of an approach for establishing and extending the range of applicability;
e) Subcritical measurement technology;
f) Benchmarking of codes and data.

Moderate priority: Investigation of physics fundamentals underlying criticality safety predictability - slowing down, thermal scatter, system coupling, etc.

High priority applications:

a) Burn up credit for spent fuel;
b) Issues related to use (and disposal) of weapons-grade plutonium;
c) Geological disposal of fissile material;
d) Fabrication of commercial LWR fuel at enrichments greater than 5 wt%;
e) Large volume and high-density storage of fissile material.

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[1]Prepared for the OECD Working Party on Nuclear Criticality Safety, May 18-20, 1998.

Moderate priority applications:

a) Qualification of waste matrix material for use in NCS;
b) Accident alarm detector qualification.

Low priority applications:

a) Downblending of ^{233}U;
b) High-yield accident characterization.

The Experimental Needs Identification Work Group (ENIWG) also met at the DOE NCSTP Workshop. In 1994 this group issued LA-12683, "Forecast of Criticality Experiments and Experimental Programs Needed to Support Operations in the USA: 1994-1999." Under the leadership of LANL, the ENIWG has initiated a renewed effort to identify new needs and to work with DOE to appropriately prioritize and perform these experiments at LANL or other appropriate facilities (Sandia Area 5 or ZPPR at Argonne West). Current high-priority experiments are listed below.

a) Intermediate energy spectrum (to start June 1998).
b) Solution high-energy burst assembly (SHEBA) reactivity parameterization (ongoing).
c) SHEBA reactivity and void coefficients (ongoing).
d) Absorption properties of waste matrices (planning).
e) Validation of criticality alarms and accident dosimetry program (ongoing).
f) Accident simulation and validation of accident calculations program (ongoing)
g) Critical mass experiments program for actinides (initiated 1997).
h) Measurements of subcritical systems (initiated 1997).
i) Large array of small units (planning).

Proposals for new experiments that have not been prioritized or evaluated by DOE have recently been received from the NCS community. These experiments are as follows.

a) Radionuclide extraction from solutions.
b) Low-temperature critical masses.
c) Plutonium nitrate and strong absorbers.
d) Actinide delayed neutron parameters.
e) Spent fuel credit.
f) Solution prompt burst.
g) Bubble formation in solution.
h) Pu positive temperature coefficient.
i) Untested matrix materials.
j) Criticality alarm testing.
k) Low-enriched systems with low H/X ratios
l) Physics measurements for neutron slowing down in water
m) Intermediate enrichment systems.

Efforts are underway to coordinate and focus the NCS activities within the U.S. on high priority issues. However, the coordination efforts and the activities themselves are in jeopardy because of the uncertainty in funding commitment that makes it difficult to commit facilities and personnel.

ATTACHMENT E

DEPARTMENT OF ENERGY
ASSESSMENT OF NUCLEAR CRITICALITY SAFETY EDUCATION AND TRAINING NEEDS AND AVAILABLE COURSES

JUNE 1998

ASSESSMENT OF NUCLEAR CRITICALITY SAFETY EDUCATION AND TRAINING NEEDS AND AVAILABLE COURSES

BACKGROUND

The attached report documents the assessment identified in Commitment 6.6.2 and the survey identified in Commitment 6.6.3 of the Implementation Plan of the Department of Energy for DNFSB Recommendation 97-2. The training assessment is intended to identify those areas of criticality safety training that might need reinforcement at DOE facilities and to identify available supplemental courses to ensure that criticality safety staff receive training commensurate with the duties and responsibilities of their positions. The survey of training and qualification programs at DOE sites will be used in the development of guidance for site-specific qualification programs.

Commitment 6.6.2

The Department will assess criticality safety training needs with a broader perspective on applications such as contingency and safety analysis which consider methods of identifying process upsets, developing effective controls, and implementing controls through procedures and postings. This assessment will also include a complete criticality safety practitioner job task analysis. Existing curricula in criticality safety (e.g., Los Alamos courses, University courses, Site Specific Criticality Safety Curricula, etc.) will be surveyed to determine if identified needs can be met though utilization of existing training or if development of new training is required. Based on its findings, the Department will initiate a program which addresses the identified needs for additional criticality safety training.

Deliverable 1: Assessment of additional training needs and review of available supplemental curricula.

Commitment 6.6.3:

The NCSPMT will survey existing contractor site-specific qualification programs and develop a report that documents the variety of requirements currently in place. The purpose of this survey is to identify common elements and those elements judged essential to an adequate training program to facilitate development of Departmental guidance. In the longer term, the Department will issue guidance concerning development of site-specific criticality safety training and qualification programs. Sites will then be responsible for considering this guidance in developing criticality safety training and qualification programs.

Deliverable 1: Report of the review on site qualification programs.

INTRODUCTION

While the nuclear criticality safety (NCS) community in general takes advantage of the three primary criticality safety training courses (LACEF, UNM, UT), it is not clear that NCS staff have courses of sufficient number and diversity available to match the training requirements of their positions. This response to Commitment 6.6.2 represents an attempt to 1) identify those areas of NCS in which additional training is considered necessary and 2) identify potential curricula that can help to satisfy those training needs. It is assumed that both the traditional courses (3-day and 5-day) at LACEF will continued to be offered, and that the new 5-day course at LACEF developed under Commitment 6.6.1 of the Implementation Plan will be made available in the near future. This assessment report is focused on learning resources that are needed to supplement the hands-on courses as part of a comprehensive NCS qualification program.

In order to identify those areas of criticality safety in which NCS staff need training or job experience, a job task analysis was prepared covering the core elements of a generalist NCS staff member. Selected items from this list of task areas was sent to a random sampling of known criticality safety staff, based on a list of members of the Nuclear Criticality Safety Division of the American Nuclear Society, who were asked to evaluate whether or not more training was needed in certain areas at their facilities. These survey results, coupled with the NCS staff/generalist task analysis, is compared to the curricula of the primary NCS courses, and additional courses are evaluated as potential supplements to those courses.

Commitment 6.6.2 is closely tied to Commitment 6.6.3, which requires a survey of site qualification programs and the issuance of guidance for the development of site-specific criticality safety training and qualification programs. Results of this survey are included in this report.

NCS STAFF/GENERALIST JOB TASK ANALYSIS

This job task analysis is intended to be representative of the majority of criticality safety staff, encompassing those duties, knowledge and abilities that are generally associated with a criticality safety staff position. While most sites will have assigned additional specific tasks or training requirements to these positions, it is not intended to include every detail here. This job task analysis could also be expanded to include areas related to criticality safety, such as fire protection in areas with fissionable material, chemical hazards safety and OSHA requirements; however, this broader scope is beyond the intent of this report.

Specific Duties

The duties of criticality safety staff can be roughly divided into two areas: technical support of facility operations and advisory support for facility management. Typical duties include:

- advises facility management on NCS issues
- participates in an advisory capacity in the development of NCS procedures which define the site-specific criticality safety program
- interprets and applies Orders, Rules, Standards and policies
- assesses criticality safety programs, including the adequacy of controls, limits and safety margins
- performs criticality safety evaluations, including contingency analysis
- provides technical support to facility staff on criticality safety questions for specific operations
- reviews criticality safety evaluations and engineering documents for criticality safety.
- assess criticality accident alarm system requirements and coverage

Knowledge, Skills and Abilities

The knowledge and abilities required of a criticality safety staff member can be grouped into three broad categories: academic, experimental and operationals. Of these, the operationals aspect is mostly site-specific, but several common areas can be listed in this task analysis. It is expected that individuals will have significant training in the actual operations at their sites in order to meet the requirements of their positions.

Academic

Academic knowledge requirements are generally satisfied through attendance at formal courses. However, on-the-job training, mentorship programs and self-study courses can be useful supplements to standard courses. The following items comprise a minimum set for the general NCS staff:

- minimum B. S. degree in nuclear engineering or closely related discipline, or the demonstrated equivalent
- completion of the LANL 5-day criticality safety course (this will be expanded to include a second 5-day course being developed as another commitment in the implementation plan for Recommendation 97-2) plus a criticality safety course such as those offered by the University of New Mexico or the University of Tennessee
- advanced level of knowledge in the following areas acquired as part of a degree program or supplemental courses.[1] Verification of expertise in these areas should be documented.

  Neutron Reactor Theory
  - Fundamentals of chain reactions
  - Neutron balance
  - Criticality

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[1] See *Nuclear Criticality Safety Theory and Practice* by R. A. Knief for a base level introduction to each topic.

- Calculational Methods
  - Model development
  - Hand calculations
  - Computer code usage
    - Neutron Multiplication Factor
      - Cross sections
      - Monte Carlo codes
      - Diffusion and transport codes
      - Validation of calculations
    - Deep Penetration Calculations (CAS coverage)
- Experiments
  - Critical and subcritical experiments
  - Accident simulations
  - Criticality data
- Rules, Standards and Guides
  - DOE and NRC Rules, Orders and policies
  - ANSI/ANS criticality safety Standards
  - Criticality safety handbooks and guides
- Criticality Safety Evaluations
  - Requirements
  - Process analysis
  - Subcritical margins and limits
  - Controls and operating rules
  - Validations and bias estimates
- Safety Analysis and Control
  - Analysis skills
    - Hazop
    - Event Tree/Fault Tree methods
    - What-if methods
    - MORT
    - PRA basis
  - Control Methods and Evaluation
- Alarm Systems
  - Requirements
  - Determining coverage
  - Review of process accidents
  - Accident analysis (Incredibility Studies)
- Accountability Practices
  - Measurement (NDA) techniques
  - Sampling and Analysis failure modes
  - Use and Abuse of Statistics

Experimental

Knowledge of critical mass physics is best obtained through on-the-job experience at a critical experiments facility. For those NCS engineers not having this work experience, the following items may be considered an equivalent substitute.

- the LANL 5-day criticality safety course
- the training course at LACEF to be developed as part of the implementation plan for DNFSB Recommendation 97-2
- participation in critical mass experiments.

Operational

Operational knowledge for NCS staff includes process safety administration, general process information and of site-specific process, facility and support system details. The NCS staff member should be aware of the general scope of fissile material operations and process issues that may be relevant to their specific applications. Such knowledge provides valuable background information in the NCS evaluation of site operations.

- process safety documentation and control
    - preparation and review of facility SARs, TSRs, USQ determinations, hazard analyses and transportation requirements
    - preparation and review of criticality safety evaluations, determination of safety margins and operating limits
    - preparation of facility procedures and postings
    - on-the-job experience, including assessing conformance to the site NCS program
- operations and equipment knowledge
    - process equipment and hardware (e.g., HEPA filter characteristics for fissile material collection and water retention, mechanical designs for backflow prevention)
    - types and nature of compounds (e.g., hygroscopic, deliquescent) used in typical fissile material processes
    - typical chemical, physico-chemical, electro-chemical and metallurgical processes used in fissile material operations and typical off-normal conditions of such processes that can potentially impact the safety basis of a NCS evaluation
    - typical passive and active detection and control devices used in fissile material processing
    - site-specific equipment, materials and processes
- other on-site activities that could impact facility NCS
    - fire safety systems
    - safeguards and security
    - pollution prevention and waste minimization programs
    - OSHA programs

- conduct of operations
    - standard conduct of operations principles as applied to NCS
- administrative practices
    - configuration management and control
    - surveillance and audit activities
    - emergency preparedness
- human factors
    - liaison for management, operators and operations staff
    - training support
    - postings and procedures
    - operational aspects affecting job performance
    - communications and interpersonal skills
    - materials control and accountability
    - accountability practices (inventories, material balance areas, etc.)
    - SNM measurement techniques (NDA and analytical methods)
    - holdup measurements

It is expected that individual sites or facilities would expand the operations area of the task analysis to include specific duties beyond those listed above.

CRITICALITY SAFETY TRAINING SURVEYS

Results of Informal NCS Staff Survey

A request was sent via electronic mail to members of the Nuclear Criticality Safety Division of the American Nuclear Society listed in an electronic database to indicate the level of training in various NCS areas at their site or facility. While the number of responses (approximately 25) does not make the survey results statistically significant, the poll does show definite indications that NCS training might not generally be at the expected level of excellence. Table 1 shows a summary of the results from this survey.

The most noticeable feature of the survey results is the fact that a majority of the respondents feel that additional education and training are needed in all areas.

Summary Results of Field Office Survey Of Training and Qualification Programs

The Department surveyed its field offices to determine what training and qualification programs are in place for both federal and contractor staffs in the field. Responses were received from the Idaho, Rocky Flats, Oak Ridge, Savannah River, Albuquerque, Oakland, Chicago and Richland offices. The training and qualification programs for contractor NCS staff exhibit a wide range of formality and rigor, while the federal programs are very similar to one another.

The federal training and qualification programs for NCS Staff are generally based upon the General Technical Standard and the Nuclear Safety Standard developed in response to DNFSB Recommendation 93-3. There is no Department-wide specific qualification standard for criticality safety. These general standards are often, but not uniformly, augmented in the field by attendance at the LACEF 5-day course and the UNM Short Course. DOE RFFO is implementing a criticality safety qualification standard that includes most of the elements described in this report as well as related topics such as accident investigation, performance measures, project management, etc.

Contractor training and qualification programs generally include many of the elements discussed in this report but the level of rigor and formality varies greatly. Y-12 and Savannah River have technically challenging training programs that verify competency for different levels or grades of NCS responsibility. Other programs like LIMITCO, LLNL, and Rocky Flats rely primarily upon self-study and mentor/management review of individual elements. Some programs, like LANL and ANL, are informal with little or no documentation of requirements or verification of competency.

The knowledge, skills, and abilities required of NCS staff documented elsewhere in this report were, in large measure, derived from the best elements of the existing contractor programs. The results from this survey will be used to facilitate development of Departmental guidance concerning site-specific criticality safety training and qualification programs.

Training or Qualification Area	Current Training Level/Capability		
	% of Responses		
	Additional Training Needed	Training is Marginal	Training is Adequate
Neutron/reactor theory			
Fundamentals of chain reactions	73.7	5.3	21.1
Model development	78.9	5.3	15.8
Hand calculations	30.6	47.2	22.2
Computer code usage	65.8	18.4	15.8
Validations	55.6	22.2	22.2
Use of Standards, Guides, etc.			
Rules, orders and regulations	55.6	22.2	22.2
ANSI/ANS standards	38.9	33.3	27.8
Handbooks and guides	30.6	25.0	44.4
Alarm Systems			
Requirements	52.8	30.6	16.7
Determining coverage	41.7	41.7	16.7
Accident analysis	44.4	16.7	38.9
Criticality Safety Evaluations			
Requirements	52.6	21.1	26.3
Contingency analysis	41.7	36.1	22.2
Subcritical margins and limits	36.1	30.6	33.3
Operating rules	32.4	26.5	41.2

Table 1. Results of NCS Practitioner Survey

CURRENT NUCLEAR CRITICALITY SAFETY EDUCATION AND TRAINING COURSES

While it can be argued that there exists a large number of formal and informal training courses applicable to criticality safety, it is generally acknowledged that there are currently three primary *short courses* specifically aimed at criticality safety staff that are available to members of the DOE complex. Some sites have excellent training curricula, but these are usually site-specific and available to outside organizations only by special arrangement. Some colleges and universities have NCS courses and other engineering courses that contain elements of criticality safety, but in general they are offered over an entire quarter or semester. Such courses might involve a time commitment that is too long for many people employed as full-time criticality safety staff. Summary descriptions of some of the identified courses are addressed in the following section of this report.

In addition to the NCS short courses and university courses, many DOE sites and universities offer related programs or courses that can be considered part of a good NCS training program. Typical topics include non-destructive examination and assay, materials control and accountability, conduct of operations, human factors, safety engineering and risk assessment. Short courses are also available at DOE laboratories that cover application of computer codes such as MCNP and SCALE to criticality safety calculations.

The following summary descriptions are presented as examples of the types of NCS training courses that are generally available. Summarized curricula from the three short courses are appended to this report to provide a sampling of the relation between topics in the job task analysis and subjects covered in the courses. This sampling is not intended to be a complete listing, and it is not intended to encompass all of the topics listed above in the job task analysis. Many excellent courses are locally available to many sites, and many sites have instituted their own programs. All of these resources can be combined into an effective criticality safety training program tailored to the needs of specific sites.

LANL 5-Day Training Program for Nuclear Criticality Safety

The five-day training program at the Los Alamos Critical Experiments Facility is currently the only one available that offers students the opportunity for hands-on assembly of a subcritical assembly. The DNFSB recognizes the value of this course and has recommended the development of an additional course to extend the content of the current course.

The five-day course emphasizes a practical approach to criticality safety, with lectures that stress criticality safety while reviewing basic neutronics, the factors that affect neutron multiplication, criticality controls and limits, analysis methods and administrative practices. Along with the lectures, both subcritical and critical assemblies are used by the students to demonstrate basic principles of reactor control and response.

University of New Mexico Nuclear Criticality Safety Short Course

The week-long short course at the University o f New Mexico consists of a series of lectures by faculty from universities, national laboratories and industry. The course generally follows the outline of *Nuclear Criticality Safety Theory and Practice* by R. A. Knief, and includes basic neutron physics, criticality safety principles and controls, double contingency analysis and criticality safety evaluations. Workshops are scheduled that allow the students to apply the material to practical situations.

University of Tennessee Nuclear Criticality Safety Short Course

The one-week short course at the University of Tennessee is taught by a faculty from UT, and Oak Ridge National Laboratory, and the Oak Ridge Y-12 Plant. The course topics include criticality safety standards, regulations, subcritical limits and controls, calculational methods, accident modeling and emergency response. Application of the SCALE system, cross section sets and code validation techniques and contingency analysis are included with illustrative examples.

Supplemental Nuclear Criticality Safety Training Courses

As noted above, many sites and facilities have training programs that include excellent in-house criticality safety training. However, there are also sites that rely heavily on university, professional society or DOE-sponsored NCS training courses. A comprehensive review of the availability of such courses was recently completed by Dr. Ronald Knief of Ogden Environmental and Energy Services, Inc. for the Rocky Flats Environmental Technology Site. The majority of the following discussion is adapted from his work, with additional information based on discussions with members of the criticality safety community.

Dr. Knief's study indicates that complete coverage of the topics needed for a comprehensive criticality safety curriculum cannot be found at any one school (although some may come close to that goal), and that only a small number of schools offer specific NCS courses. Two notable schools identified in his report are the University of New Mexico (UNM) and the University of Tennessee (UT). Texas A&M University also offers courses that have some application to criticality safety training, such as health physics or human factors engineering. Georgia Institute of Technology has recently added a NCS course to its curriculum.

Advanced Neutron Physics and Computations

In the informal survey results given above, it is clear that a number of sites feel that additional training in the theoretical aspects of neutron interactions and criticality is needed. These concepts are typically included in introductory nuclear engineering courses which are available at any university with a nuclear engineering program.

Another area needing more education and training is computational methods. ORNL offers courses in the use and application of the SCALE package, including KENO-Va and KENO-VI for criticality safety calculations. LANL offers various courses in the use and application of MCNP. Beyond those courses, advanced computer methods can be found in nuclear reactor theory courses which are available at most universities with nuclear engineering programs.

Safety Evaluations and Hazards Analysis

Another area identified in the training needs survey is criticality safety evaluations. This training area involves process systems failure analysis, double contingency analysis and preparation of criticality safety evaluations. While no courses specific to NCS evaluations have been identified, a criticality safety evaluation is required as part of the Georgia Institute of Technology course described below.

Nuclear Criticality Safety

Georgia Institute of Technology now offers a Nuclear Criticality Safety Engineering course, NE 4201-2, based on Dr. Knief's book. In addition to NCS fundamentals, the course includes elements of advanced computation and criticality safety evaluations. This course, while currently offered over an entire term, can be made available through distance learning and may be adaptable to a short-course format.

SUMMARY

Aside from the short courses offered by UNM and UT, the LANL NCS training program and the short courses aimed at the application of neutronics codes to criticality safety calculations, there are no other short courses targeted specifically at nuclear criticality safety for the general audience. While it might be possible to cover the required areas of study in university courses, the time and monetary investment necessary (in terms of staff absence from work and tuition fees) might prohibit their use by someone already active in the NCS field. If such courses could be time-compressed or offered by remote telecommunications methods or as self-study courses, they may adequately fill the gaps left by the traditional NCS short courses.

Another option that deserves further consideration is the adaptation of site-specific training programs, such as those of Savannah River or Y-12, to the general NCS community. These courses could be delivered at users' sites to minimize the impact on facility operations that occurs when staff attend long courses.

The development of a general NCS staff training program is related to the ongoing effort to develop a NCS qualification program. Once the qualification program guidance has been established, its goals can be merged with the available training resources to establish an integrated NCS educational program.

It is the conclusion of this assessment that the education and training required for the general NCS staff does exist in one or more forms at various sites across the country. Some of these, e.g., the short courses described above, are already in a form suitable for use by the majority of NCS staff members. Others, such as the semester-long university courses, need to be adapted for the use of persons already working full-time by offering them as a short course, self-study course or as distance learning courses. In conjunction with the development of a DOE NCS qualification program, options will be explored to modify those courses needed to match the requirements of the developing qualification program guidelines.

In the continuation of the tasks associated with Commitments 6.6.2 and 6.6.3, guidelines for a NCS qualification program will be written that will include detailed listings of knowledge and skills requirements, similar to that given in the job task analysis in this report. The interdependence of criticality safety on nearly every other aspect of operational safety makes it clear that excellence in criticality safety can only be achieved as part of an integrated safety management program and guidance will be developed with this in mind. In addition, as the guidelines are developed, a cross check will be made to identify available learning resources to meet those guidelines. If none exist in a suitable form, a program will be initiated according to Commitment 6.6.2 to develop or reformat learning materials to help sites meet the qualification guidelines.

APPENDIX

Sample NCS Course Curricula

5-Day Training Program for Nuclear Criticality Safety
Los Alamos National Laboratory

Summarized Course Curriculum

Day 1: ***Lecture***

Introduction
- Safety Philosophy - Fundamentals of Safety
- Radiation Safety versus Criticality Safety
- Risk in Perspective

Basic Concepts and Nomenclature
- Atoms and Neutrons, Sizes and Masses
- Neutron Cross Sections
- Fission Processes
- Prompt and Delayed Neutrons

Idealized and Real Fissioning Systems
- Neutron Slowing Down
- Neutron Life Cycle
- Multiplication Factor
- Metal versus Solution Systems

Time Behavior of Fissioning Systems
- Delayed Neutron Effects
- Prompt and Delayed Neutrons
- Reactor Period

Day 1: ***Laboratory***

Control Room and Kiva Orientation

Operating Procedures and Limits for Critical Assemblies

Hand-Stacking Experiment Part I, to Multiplication ~10

Day 2: ***Lecture***

Safety Philosophy - Policy and Responsibility

Minimum Critical Masses

Factors that Influence Criticality and Practical Criticality Control

- Slab, Annular, and Poisoned Tanks
- Limited-Volume Dissolvers
- Solution Storage in 5- and 6-Inch Tanks
- Storage Vaults - Interaction
- Moderation Control—Dry Oxide Processing
- Concentration Control
- Mass Limits
- Reflection
- Density Effects
- Enrichment - Slightly Enriched Uranium

Day 2: ***Laboratory***

Hand-Stacking Experiment Part II, to Multiplication ~100

Day 3: ***Lecture***

Safety Philosophy - Written Procedures and Training

Basic Methods for Criticality Safety Analyses

- Buckling Conversions
- Density Scaling
- Solid Angle
- Density Analog
- Surface Density

Day 3: ***Laboratory***

Critical Assembly Operations at Delayed Critical and on Positive Periods

Practical Problem Solving Using Basic Methods

Day 4: ***Lecture***

Safety Philosophy -Striving for the Possible

Accident and Incident Experience Case Descriptions - Lessons Learned

Computer Codes for Criticality Safety Analyses

- One- and Two- Dimensional Diffusion Theory and Transport Theory
- Monte Carlo
- Cross-Section Sets
- Benchmark Data

Practical Problem Solving - Computer Code Analyses

Day 4: ***Laboratory***

Tour of Plutonium Processing Facility

Day 5: ***Lecture***

Safety Philosophy - Communication and Enlightened Challenge

Transportation Considerations - Determining the Transport Index

Administrative Practices
- Department of Energy Orders
- Emergency Preparedness
- Alarm Dosimetry
- National Standards

Nuclear Criticality Safety Short Course
University of New Mexico

Summarized Course Curriculum

1. Fundamentals of NCS, including:
    - How is NCS similar end how is NCS different from other safety disciplines?
    - What is the "double contingency principle"?
    - Controls and Limits

2. The "Ideal" NCS Program
    - Responsibility, organization, elements or
    - Use of engineered or administrative controls

3. Handbook, Standards and Guides
    - Current and historic/Illustrate use of

4. NCS accidents
    - Lessons Learned
    - Response To

5. Emergency Preparedness/Alarms/Firefighting, etc.

6. Neutronics
    - Computer Codes vs. Non-computer Codes Methods
    - Pitfalls/Validation

7. Contingency Development/Accident Scenarios
    - How does one determine
    - Fault Trees, HAZOPs, etc.

8. A "typical" NCS Evaluation

9. Auditing/Root Cause/Incident Investigation

10. Training/Qualification

11. Administrative Practices
    - Postings, Ops, Labeling. SNM Accountability

12. Special NCS Considerations
    - Transportation/Storage/Drums/Maintenance/etc.

Nuclear Criticality Safety Short Course
University of Tennessee/Oak Ridge National Laboratory

Summarized Course Curriculum

Day 1

- Standards, Regulations
- Anomalies, Review of Accidents
- Cross Section Libraries and Group Structures
- Applications Using the SCALE System

Day 2

- Accident Modeling
- PRA, Human Factors
- Single Homogeneous Unit Criticality Data
- Conversions Using Hand Calculation Methods

Day 3

- Homogeneous versus Heterogeneous Systems
- Loosely Coupled Arrays of Units
- Subcritical Limits
- Operating Limits and Controls

Day 4

- Approaches to Criticality Safety Evaluations
- Code Validation Techniques, Emergency Response
- Techniques and Approaches for Examining Process Systems Including Upsets and Recovery Actions
- Examples of Chemical Recovery Operations including Wet and Dry Processes, Storage, and Process Exhausts (i.e., Batch and Continuous Processes as well as Process Interactions)

Day 5

- Transient Excursion Modeling
- Excursion Applications and Examples

ATTACHMENT F

DEPARTMENT OF ENERGY
NUCLEAR CRITICALITY SAFETY PROGRAM
FIVE-YEAR TECHNICAL PLAN WITH FUNDING PROJECTIONS

JUNE 1998

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DEPARTMENT OF ENERGY
NUCLEAR CRITICALITY SAFETY PROGRAM
FIVE-YEAR TECHNICAL PLAN WITH FUNDING PROJECTIONS

JUNE 1998

1. INTRODUCTION

On July 14, 1997, the Department of Energy (DOE) accepted Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 97-2, *Criticality Safety*. This recommendation addressed the effectiveness of criticality safety programs at defense nuclear facilities. In developing the Implementation Plan (IP) for Recommendation 97-2, DOE built upon the actions taken for DNFSB Recommendation 93-2, *The Need for Critical Experiment Capability*. The IP for Recommendation 93-2 established programs to maintain the viability of the Department's critical experiments program and improve the knowledge base underlying prediction of criticality. It resulted in the five-element Nuclear Criticality Predictability Program (NCPP) as described in the NCPP five-year plan of November 1996. All ongoing activities of the NCPP have been included under the program established for DNFSB Recommendation 97-2 and are now part of the DOE Nuclear Criticality Safety Program (NCSP). The NCSP consists of those elements needed to form a coherent, cross-cutting program, with each element dependent on the others for a successful program. The IP for Board Recommendation 97-2 supports the efficient integration and functioning of criticality safety programs across all DOE operations involving fissile material.

DOE has established the following organization for implementing Recommendation 97-2. The Assistant Secretary for Defense Programs (DP-1) is responsible for leading the Department's criticality safety activities. The Departmental Representative to the DNFSB (S-3.1) will assist DP-1 in resolving funding issues, if necessary. The Responsible Manager is the Deputy Assistant Secretary for Research and Development, Office of Defense Programs (DP-10), who will oversee execution of the IP. A Nuclear Criticality Safety Program Management Team (NCSPMT) has been chartered to manage implementation of Recommendation 97-2, including all ongoing NCPP activities initiated in response to DNFSB Recommendation 93-2. The NCSPMT receives technical support from the Criticality Safety Support Group (CSSG).

1.1 Purpose

The purpose of the NCSP five-year technical plan is to provide technical detail and funding projections to support NCSPMT responsibilities for implementing DNFSB Recommendation 97-2. This five-year plan has been developed by the CSSG and approved by the NCSPMT.

1.2 Program Overview

The DOE NCSP contains seven program elements: Critical Experiments, Benchmarking, Analytical Methods, Nuclear Data, Training and Qualification, Information Preservation and Dissemination, and Applicable Ranges of Bounding Data and Curves. Interdependence among these program elements is significant and a funding shortfall in any of the elements will result in severe programmatic impact. The following table depicts projected funding levels for each of the program elements and NCSPMT management activities for Fiscal Year (FY) 1999 through FY 2003.

NUCLEAR CRITICALITY SAFETY PROGRAM
FIVE-YEAR FUNDING PROJECTIONS
COST SUMMARY ($K)

ELEMENT	FY-99	FY-00	FY-01	FY-02	FY-03
CRITICAL EXPERIMENTS	3,950	3,950	3,950	4,100	4,220
BENCHMARKING	1,500	1,500	1,500	1200	800
ANALYTICAL METHODS	1,320	1,320	1,320	1,650	1,980
NUCLEAR DATA	2,200	2,200	2,200	2,530	2,860
TRAINING AND QUALIFICATION	350	350	350	360	370
INFORMATION PRESERVATION & DISSEMINATION	170	70	70	72	74
APPLICABLE RANGES OF BOUNDING DATA AND CURVES	600	700	700	700	700
NCSP MANAGEMENT	130	130	130	130	130
TOTAL	10,220	10,220	10,220	10,742	11,134

The NCSPMT and CSSG have reviewed this plan and determined that it maintains the cross cutting criticality safety infrastructural activities which are necessary to implement DNFSB Recommendation 97-2 as currently envisioned. However, if priorities and needs change, it may be necessary to reallocate funds among the program elements accordingly. The NCSPMT will evaluate programmatic needs annually within the budget cycle and make funding and programmatic recommendations to the Responsible Manager to assure that the NCSP continues to meet DOE needs. In addition, the NCSPMT will keep the Responsible Manager informed of issues which could require his attention. As a minimum, the NCSPMT will brief the Responsible Manager quarterly, prior to submission of each quarterly report.

1.3 Organization of the NCSP Five-Year Plan

The NCSP five-year plan is organized as follows. Each program element is described with regard to current capability, current programmatic requirements, anticipated future direction, and funding requirements. The intent is to contrast current capability with programmatic requirements and clearly present a plan for enhancing capability to enable adequate support for DOE's cross cutting criticality safety programmatic needs.

2. CRITICAL EXPERIMENTS

As the demand for new fissile nuclear systems declined, the need for critical experiments associated with the development and production support for these systems declined as well. Additionally, there has been a trend toward greater reliance on computer code predictions and benchmark experiment documentation. Nevertheless, critical experiments are still required to support current DOE missions. In particular, new fissile systems are encountered in the conduct of nonproliferation and dismantlement activities and in the storage and transportation of waste, building debris, and weapons-grade and spent reactor fuels. Decommissioning activities and disposition activities (e.g., through burial or MOX reactor development) are expected to result in new fissile systems as well. Due to material content or other physical property, these activities often require information which is beyond the current empirical database and calculational capability. These fissile systems are often composed of a relatively low density of SNM (a few tenths to a few grams per cubic centimeter) distributed in a poorly moderating and poorly absorbing medium. Examples of such systems include waste crates containing machinery (iron) and ^{235}U, the MSRE fuel, ^{235}U-silicon/ceramic and ^{239}Pu-silicon/ceramic systems (including those with various amounts of water), and ^{235}U and ^{239}Pu in spent fuel or waste mixed with building debris or other new matrix materials. In these systems, new materials are encountered or the fissions take place primarily at intermediate neutron energies, and these systems are largely unstudied in the current experimental database.

To support safety analyses for the above systems, the performance of critical experiments is essential. These experiments will provide data for the validation of the calculational methodology used to support the safety analyses.

Maintaining the capability to conduct nuclear criticality experiments cannot be accomplished without adequate facilities, special nuclear materials, and qualified and experienced personnel. Facilities and special nuclear materials are absolutely essential, but qualified personnel is really the key element in the maintenance of this important capability. Retaining quality individuals cannot be accomplished without challenging them, and this requires the performance of a variety of meaningful experimental (and process) operations involving special nuclear materials. The DOE recognizes the need for retaining qualified personnel and for training the next generation of specialists and has factored these considerations into its program of critical experiments.

2.1 Current Capability

The only two DOE nuclear research facilities that are remain fully capable of conducting critical experiments are The Los Alamos Critical Experiments Facility (LACEF) and Area V at Sandia National Laboratories (SNL). All other DOE facilities where critical experiments had previously been conducted, such as the ZPPR facility at Argonne National Laboratory (West) in Idaho, are either in operational standby or shut down and awaiting decommissioning. Both the LACEF and Area V are active nuclear research centers; however, historically, the nuclear testing done at Area V has not been focused on criticality safety issues.

The DOE has determined that the facilities contained within the LACEF are adequate to meet most of the current requirements for conducting critical experiments and training criticality safety practitioners. Some of the high priority experiments identified by the DOE, such as criticality safety issues associated with plutonium in solution and mixed plutonium and uranium oxides, may require the development of new experimental facilities at LACEF. The DOE recognizes these needs and will consider them in future planning according to their priority.

2.2 Current Requirements

An extensive review of criticality experimental needs was conducted by the Experimental Needs Identification Working Group (ENIWG) in the Spring 1998. It involved collection of written input requests from the criticality safety community and discussion and prioritization of the results at the annual Nuclear Criticality Technology and Safety Meeting (NCTSP) in May 1998. This review resulted in a list of 28 experiments from which 11 were considered to be of relatively high priority by the CSSG. At present, five experiments from the high priority experiments list are currently either in the planning phase, being conducted, or having results analyzed at the LACEF. Experimental activities which require little in the way of additional resources may be done in conjunction with ongoing experiments. Experimental activities which require a significant commitment of resources will only be conducted if such activities are deemed necessary to meet a compelling National need (e.g., if plutonium solution data necessary to assure safe operations cannot be acquired abroad and necessary operational conservatism is determined to be more costly than a plutonium solution experiment).

In addition to the critical experiments program, an ongoing effort at LACEF is the conduct of training courses in which criticality safety practitioners receive "hands on" experience in the performance of critical experiments through the remote assembly of critical masses. Further discussion of this activity is contained in section 6 of this plan.

2.3 Anticipated Future Direction

Future experimental facility development may be required to support some of the priority experiments. For example, if the collaborative effort within the international criticality safety community does not yield the benchmark data necessary to resolve criticality issues associated with plutonium in solution and mixed uranium and plutonium oxides, new experimental facilities may have to be developed. The most likely location for these new experimental facilities is the LACEF; however, appropriate environmental analysis would have to be conducted in support of a siting decision. In addition, steps are being taken to identify and preserve certain special nuclear materials which are considered to be national assets because of their unique form, composition, or projected cost of regeneration.

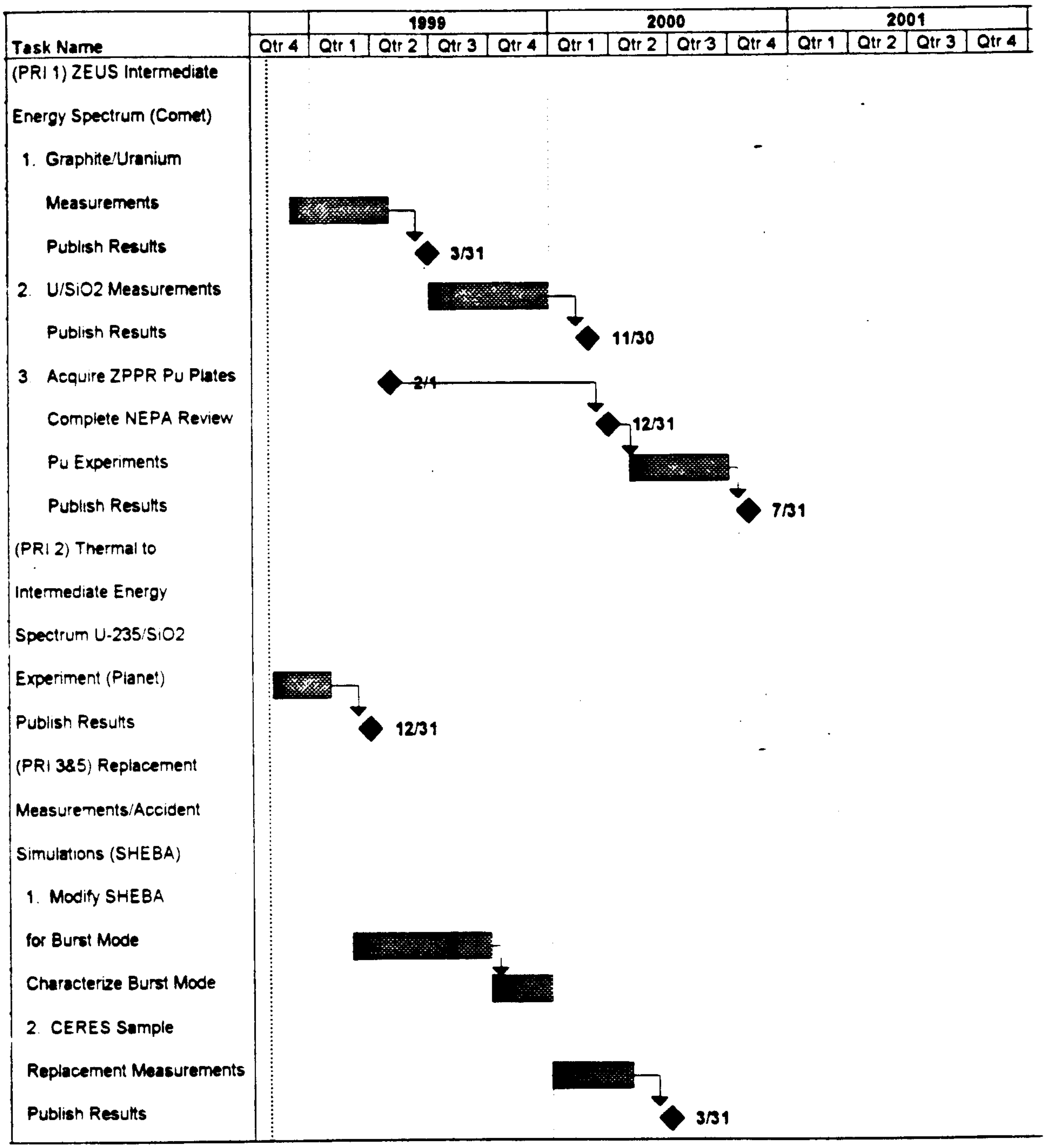
As for the existing experimental facilities at the LACEF, many of them are now over 40 years old and require an increasing amount of maintenance to assure safe operations. As part of the DOE's commitment to maintaining capability in this area, the NCSPMT will evaluate and recommend support for LACEF facility upgrades as appropriate.

2.4 Funding Requirements

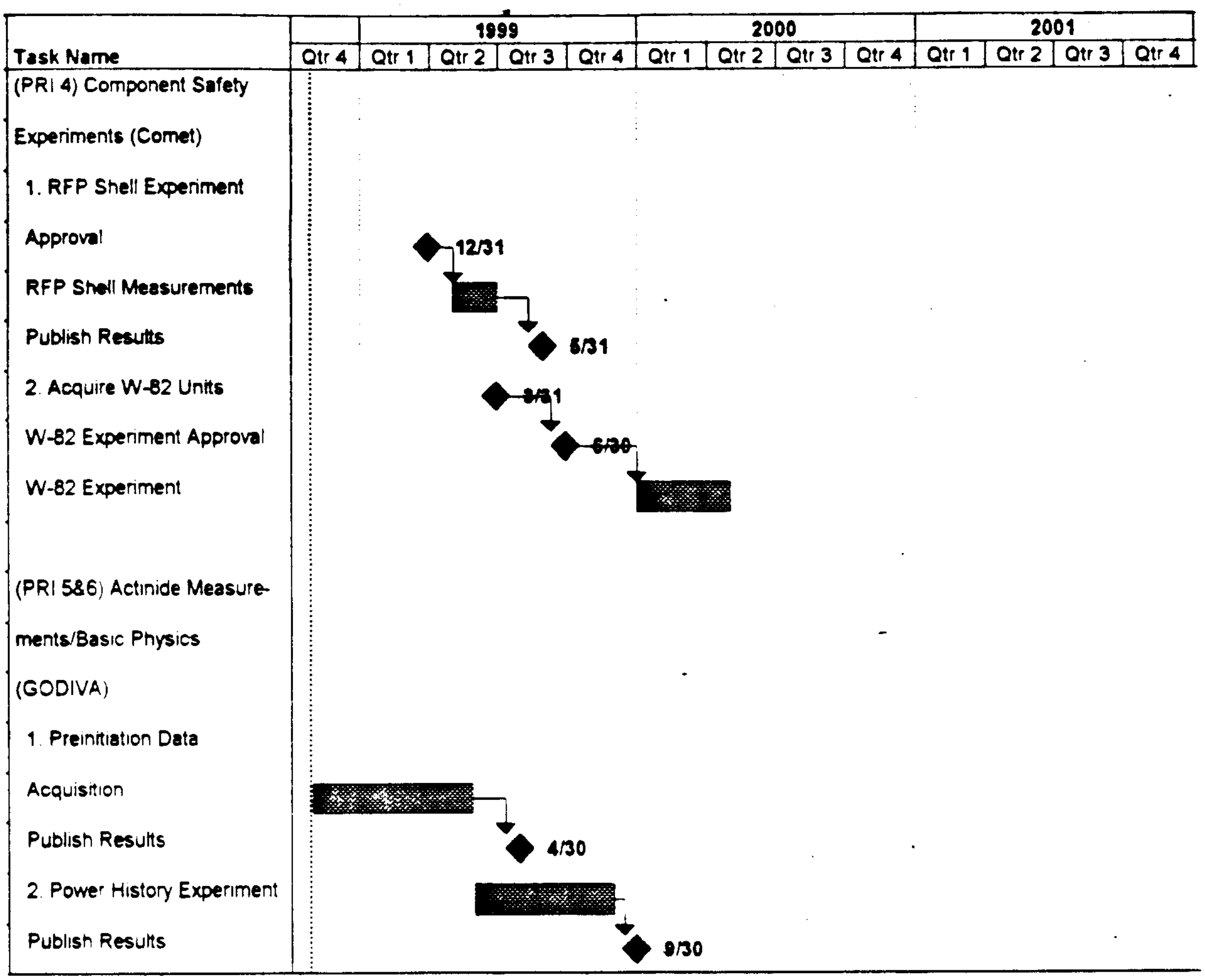
The following table summarizes funding requirements at LACEF for FY 1999 through FY 2003. This funding is adequate for initiating several critical experiments per year from the priority list and maintaining experimental capability, including some facility upgrades and acquisition of national asset material. In addition, the DOE's critical experiment's program is flexible enough to allow unanticipated experimental needs to be met.

YEAR	COST ($k)
1999	3950
2000	3950
2001	3950
2002	4100
2003	4220

CRITICAL EXPERIMENTS MILESTONES



CRITICAL EXPERIMENTS MILESTONES (CONT.)



3. BENCHMARKING

The DOE's program of critical experiments is accompanied by a broad assessment of available criticality benchmark data. These measured data represent an important resource for enhancing calculational methods. Until recently, no effort had been made to take full advantage of this resource. In 1992, the DOE initiated the Criticality Safety Benchmark Evaluation Project (CSBEP) to identify and evaluate a comprehensive set of critical benchmark data, verify the data to the extent possible, compile it into standardized form, perform calculations of each experiment, and formally document the work. The project was managed through the Idaho National Engineering and Environmental Laboratory (INEEL), but involved nationally known criticality safety experts from a number of DOE Laboratories.

3.1 Current Capability

In early 1995, the DOE expanded the CSBEP into the International Criticality Safety Benchmark Evaluation Project (ICSBEP) which was accepted as an official activity of the Organization for Economic Cooperation and Development - Nuclear Energy Agency (OECD-NEA). Also managed through the INEEL, the ICSBEP members include the United States, the United Kingdom, Russia, Japan, France, Hungary, South Korea and Slovenia. This project, led by the United States, established an international forum for the exchange of nuclear criticality benchmark data. The first series of evaluations performed by the ICSBEP was published in May of 1995, as an OECD-NEA handbook entitled, "International Handbook of Evaluated Criticality Safety Benchmark Experiments." The handbook more than doubled in size in September of 1996 when the first revision of the handbook was published and experienced substantial growth for the second revision in September 1997.

The primary area of focus of the ICSBEP is to: consolidate and preserve the information base that already exists in the United States; identify areas where more data are needed; draw upon the resources of the international criticality safety community help fill identified needs; and identify discrepancies between calculations and experiments. This program represents a tremendous capability. It provides the United States with the ability to access the global database of experimental benchmarks to validate calculational methods that simulate the neutronic behavior of the fissile systems being analyzed. As an illustration of the benefits of this program, the first evaluation from France included plutonium-in-solution data with concentrations ranging from 13.2 to 105.0 grams per liter of solution. There are five experiments reported in this evaluation with plutonium concentrations below 20 grams per liter. These data fill a gap in the United States' data which was considered important enough to warrant one of the top ten priority experiments (Experiment number 98-21 on the Priority Experiments List); however, there is still a need for data between 7.5 and 13 grams of plutonium per liter.

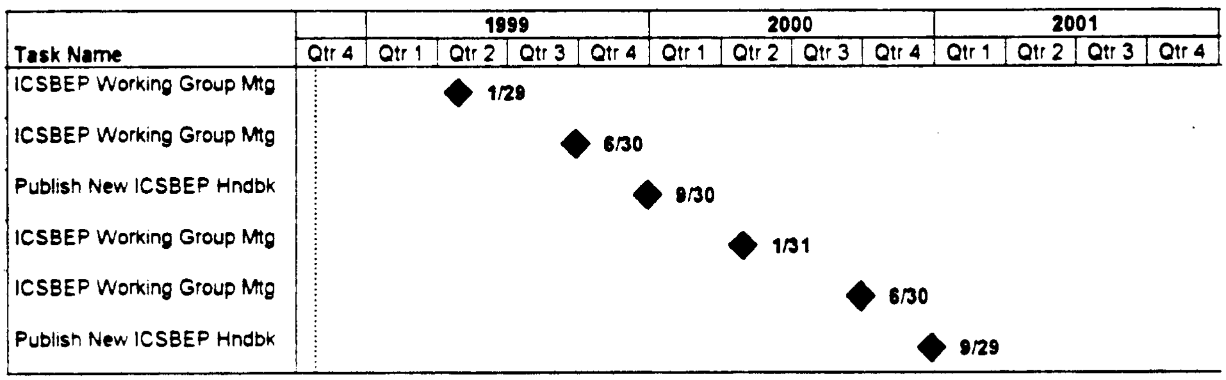
3.2 Current Requirements

The 1998 version of the International Handbook of Evaluated Criticality Safety Benchmark Experiments will contain about 230 evaluations with benchmark specifications for over 1,700 critical or near critical configurations. Approximately 300 additional experimental configurations were found to be unacceptable for use as criticality safety benchmark experiments. These experiments were evaluated; however, benchmark specifications were not derived. Nearly 35 new evaluations are in progress, many of which are from outside the United States. New evaluations will be published and distributed annually. The Handbook is organized in a manner that allows easy inclusion of revisions and additional evaluations, as they become available. Both criticality safety practitioners and regulators turn to the handbook as the ultimate source of criticality safety benchmark data. Continued United States participation in this process is absolutely essential for maintaining capability in producing meaningful benchmark evaluations and deriving further benefit from the international contributions.

3.3 Anticipated Future Direction

Large amounts of data exist within the United States that have not been evaluated and documented. In addition, the NCSPMT has directed that all critical experiments being conducted at the LACEF should be designed to consensus benchmark specifications and evaluated for inclusion in the ICSBEP handbook. The United States must also continue its review of foreign data commensurate with its commitment as part of the ICSBEP process. Continuation of this work at an appropriate level is very important because some of these evaluations would be very useful in supporting the DOE's mission needs. The NCSPMT will continue to monitor this situation and work closely with the criticality safety community in prioritizing requirements and recommending an appropriate level of support.

BENCHMARKING MILESTONES



3.4 Funding Requirements

The following Table summarizes FY 1999 through FY 2001 activities and budget needs.

BENCHMARKING PROGRAM ELEMENT
FISCAL YEAR 1999-2001

TASKS BY LABORATORY	FY-99 ($k)	FY-00 ($k)	FY-01 ($k)
INEEL: Provide Technical Project Management support for the International Criticality Safety Benchmark Evaluation Project (ICSBEP) which is managed by Defense Programs. Provide or coordinate Independent Review efforts, graphic arts support, technical editing, and publication of the International Handbook of Evaluated Criticality Safety Benchmark Experiments. Participate on the ICSBEP defined as follows: Evaluate and, to the extent possible, verify criticality safety benchmark experiment data, compile the data into a standard format that will provide an accurate basis document for future validation efforts, and perform calculations using the data with standard criticality safety neutronics codes. INEEL will focus primarily on High, Intermediate, and Low Enriched Uranium Systems and on Plutonium Solution Systems. Where possible, the INEEL will also provide for the documentation of undocumented experimental data.	652	601	570
LANL: Participate on the ICSBEP with primary focus on High Enriched Uranium, Plutonium, U-233, and Mixed Plutonium - Uranium Metal Systems.	346.	280	280
SRS: Participate on the ICSBEP with primary focus on High Enriched Uranium and Plutonium Metal and Solution Systems.	210	195	200
ORNL & Y-12: Participate on the ICSBEP with primary focus on High, Intermediate, and Low Enriched Uranium Metal, Compound and Solution Systems, and on U-233 Solution Systems.	190	195	200
ANL: Participate on the ICSBEP with primary focus on Zero Power Reactor (ZPR) benchmark data that are relevant to Non-Reactor Criticality Safety issues.	52	179	200
RUSSIAN FEDERATION: Participate on the ICSBEP with primary focus on Non-Reactor Criticality Safety data that are available within the Russian Federation.	50	50	50
TOTAL:	1,500	1,500	1,500

Similar tasks will continue during the years 2002 and 2003. However, as data from existing experiments are exhausted, benchmarking efforts in the United States will decline to a level that will enable the evaluation, review, and publication of only new experiments. It is projected that a decline in benchmarking activities can begin during FY-2001 and will reach a "status quo" level near FY-2002. If the program at LACEF expands significantly during the out years, the decline in the benchmarking effort could be delayed. Estimated funding requirements for the years 2002 and 2003 are as follows:

YEAR	COST ($k)
2002	1200
2003	800

4. ANALYTICAL METHODS

Analytical Methods are central to an efficient criticality safety program. These codes are indispensable for analyzing accident scenarios required for safety analysis reports. Currently, the three general purpose Monte Carlo codes used to model the state of criticality of fissile systems throughout the DOE are the KENO code at Oak Ridge National Laboratory (ORNL), the MCNP code at LANL, and the VIM code at Argonne National Laboratory (ANL).

Each of these three-dimensional Monte Carlo codes employs a slightly different calculational methodology. KENO, the most commonly used Monte Carlo code in criticality safety, relies on a fast but approximate multigroup energy description. Validation of KENO against more rigorous continuous energy codes such as MCNP and VIM is necessary for calculational quality assurance. Like KENO, MCNP and VIM use some minor approximations, but all three codes are fully independent and rely on different numerical techniques along the whole computational chain, including the processing of cross sections, thus avoiding potential common made failures. This diversity of methodology provides the DOE with significant depth in its criticality modeling capability by allowing for comparison of calculational results from the different Analytical methods.

Supporting and ancillary codes which are used for scoping calculations or other tasks such as producing volume and flux weighted cross sections for use in the three dimensional Monte Carlo Analytical methods are also important analytical tools which must be maintained. The Radiation Safety Information Computational Center (RSICC) at ORNL performs the important function of collecting, packaging, and disseminating the Analytical methods and processed data libraries to the criticality safety community.

4.1 Current Capability

The strength of the United States capability in performing calculational criticality analyses resides in the diversity of the three relatively mature Monte Carlo neutron transport codes cited above. The KENO-Va code is the current production version of the KENO series which has been specialized for criticality applications. Its major features include the energy-multigroup cross sections and neutron-kinematics approach, along with very efficient neutron tracking techniques.

The KENO-VI code, which is in the validation and documentation phase, provides a more general geometry modeling capability at the cost of some efficiency. The MCNP series of general neutral particle transport codes offers a more rigorous neutron-kinematics treatment based upon energy-pointwise cross sections and a continuous energy mesh. The VIM code system, which also treats energy as a continuous variable, has the capability to utilize the Reich-Moore resonance reconstruction formalism and accessibility to the latest nuclear data file. Consequently, this code system features the most rigorous problem-dependent, unresolved-resonance shielding techniques. This capability is very important in addressing criticality safety issues associated with the new DOE missions which require rigorous analysis of the intermediate energy range inherent in partially-moderated fissile material storage, transportation, and waste processing systems.

4.2 Current Requirements

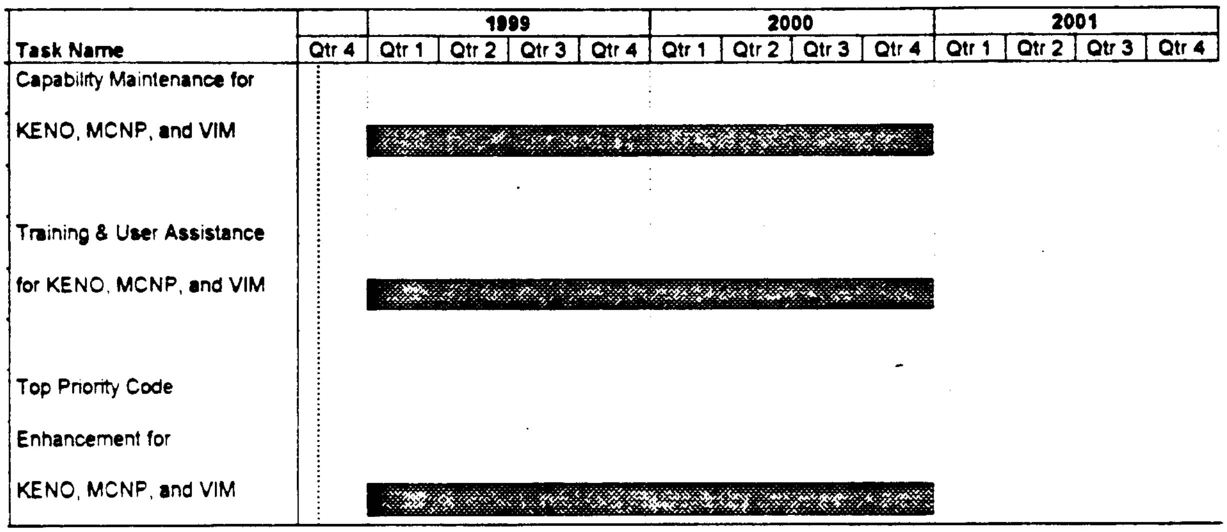
In addition to ongoing software quality assurance, configuration control, and user assistance for the three code systems, top priority enhancements for each code have been identified. For the KENO codes, the associated problem-dependent cross-section processing in the SCALE system is being upgraded to be compatible with the most recent and complete nuclear data source, ENDF/B-VI. This involves new techniques for performing resolved-resonance processing on a problem-dependent basis. For the VIM code, an effort to employ stratified sampling to improve fission distribution convergence has been initiated. Good progress was made in FY 1997, but the work was not funded in FY 1998. It is anticipated that, with adequate funding, it can be completed in the next two Fiscal Years and made available for testing in the other codes in FY 2001. For the MCNP codes, the installation of a problem-dependent, unresolved resonance shielding capability has been performed, and the enhanced version of the code is being released for limited beta testing. Finally, all three code communities have proposed the development of ease-of-use features based on graphical user interfaces and additional statistical testing. Under the current flat budget projections, a limited amount of this work could be funded in FY 2001.

4.3 Anticipated Future Direction

At the present time, the FY 1999 through FY 2001 budgets for the Analytical Methods Element provide for the basic level of support which assures software maintenance, training materials, and user assistance for the three code systems. Additionally, funds have been provided to initiate the top priority enhancements at a level of effort of less than one-half a person-year each. These include stratified sampling at ANL, problem-dependent unresolved resonance shielding at LANL, and multi-pole resonance reconstruction for problem-dependent processing at ORNL.

The graduated increase in the out years budgets (FY 2002, FY 2003) reflects the need to support code enhancements at a higher level of activity. New fine-group and energy-pointwise cross section libraries will be generated and applied in validation studies. Ancillary software for sensitivity studies will be provided by a production version of the perturbation capability in MCNP. The DANT codes at LANL will be enhanced to address the problem of loosely-coupled arrays of fissile material in storage configurations. The VIM code at ANL will be used in the characterization of spent reactor fuel compositions pertinent to DOE criticality safety applications. Progress in all NCSP technology development efforts will be coordinated such that a maximum benefit will be achieved in the qualification of methods and data for analyzing all of the new DOE applications. A list of criteria has been adopted for evaluating proposed analytical enhancements as well as enhancing code usability.

ANALYTICAL METHODS MILESTONES



4.4 Funding Requirements

The FY 1999 and FY 2001 budgets shown in the following Table allow for the initiation of the top priority enhancements at modest levels of effort in addition to basic code maintenance for the three general purpose Monte Carlo codes.

ANALYTICAL METHODS PROGRAM ELEMENT
FISCAL YEAR 1999-2001

TASKS BY LABORATORY	FY-99 ($k)	FY-00 ($k)	FY-01 (01)
ORNL: Basic level of maintenance, training and user assistance, and management support for KENO. Software packaging and dissemination by RSICC. Top-priority enhancement.	626	626	626
LANL: Basic level of maintenance, training and user assistance, and management support for MCNP. Top-priority enhancement.	394	394	394
ANL: Basic level of maintenance, training and user assistance, and management support for VIM. Top-priority enhancement.	300	300	300
TOTAL:	1,320	1,320	1,320

As new nuclear data and critical experimental benchmarks become available, the out year budgets provide for a graduated increase in enhancements in terms of new cross section libraries, more extensive validation against experiments and improved understanding of the basic physics.

YEAR	COST ($k)
2002	1,650
2003	1,980

5. NUCLEAR DATA

Accurate nuclear data is the foundation of nuclear criticality predictability. Without it, the codes have very limited worth. In order for nuclear data to be utilized, it has to be measured, evaluated, put into standard format, tested, released as part of the Evaluated Nuclear Data File (ENDF), and then processed into the working formats of the three-dimensional analytical and scoping codes. The United States' nuclear data needs are assessed and prioritized by the Cross Section Evaluation Working group (CSEWG). The CSEWG is the established inter-laboratory working group that produces the DOE's ENDF reference cross section library. Early in FY 1995, in response to concerns expressed by the DNFSB Staff about DOE representation in the CSEWG process, the Nuclear Criticality Experiments Steering Committee (established in response to DNFSB Recommendation 93-2) appointed one of its members as an official representative to the CSEWG. The NCSPMT will continue to provide liaison to the CSEWG to ensure that DOE's criticality safety nuclear data needs are addressed.

5.1 Current Capability

The Oak Ridge Electron Linear Accelerator (ORELA) is available for measuring nuclear data and the major focus of its use is the NCS Program, which currently provides funding to cover roughly 80% of its operating expenses. Continuity of the funding from the NCS Program is essential to assure that ORELA will be available for measurements needed to correct the identified nuclear data deficiencies that impact criticality safety. The ORELA is ideally suited for criticality safety applications because it can measure data at high resolution over the energy region important for criticality applications, as well as the other data necessary to provide a complete ENDF/B evaluation. It has supplied data for over 80 percent of the evaluations in the current file, which is referred to as ENDF/B-VI.

The nuclear data programs at the LANL and the ORNL provide the vast majority of evaluations for ENDF/B-VI, which is the most recent and complete data compilation. At the ORNL, in particular, there is significant expertise in the evaluation of the resonance region of the energy spectrum. The author of the SAMMY code, which was developed for that purpose, is at the

ORNL. Evaluations are made with full uncertainty files, which are essential for meaningful assessments of the uncertainty in calculated parameters for criticality safety applications because these uncertainties directly impact the calculated margin of subcriticality.

The nuclear data program at ANL supports the development and validation of a rigorous methodology for processing ENDF-B/VI resonance parameters in the AMPX code, which is used to generate SCALE data libraries. This development will permit the use of the most recent nuclear data in SCALE. Also, in view of the increasing dependence of many code systems on NJOY processed data, the updated AMPX methodology will provide with a fully independent system, thus averting potential common mode failure.

The CSEWG infrastructure exists and can be utilized to upgrade ENDF/B-VI as required by the criticality safety community. Moreover, the CSEWG can coordinate resources from other National Laboratories and universities to address unique criticality safety needs, should they arise.

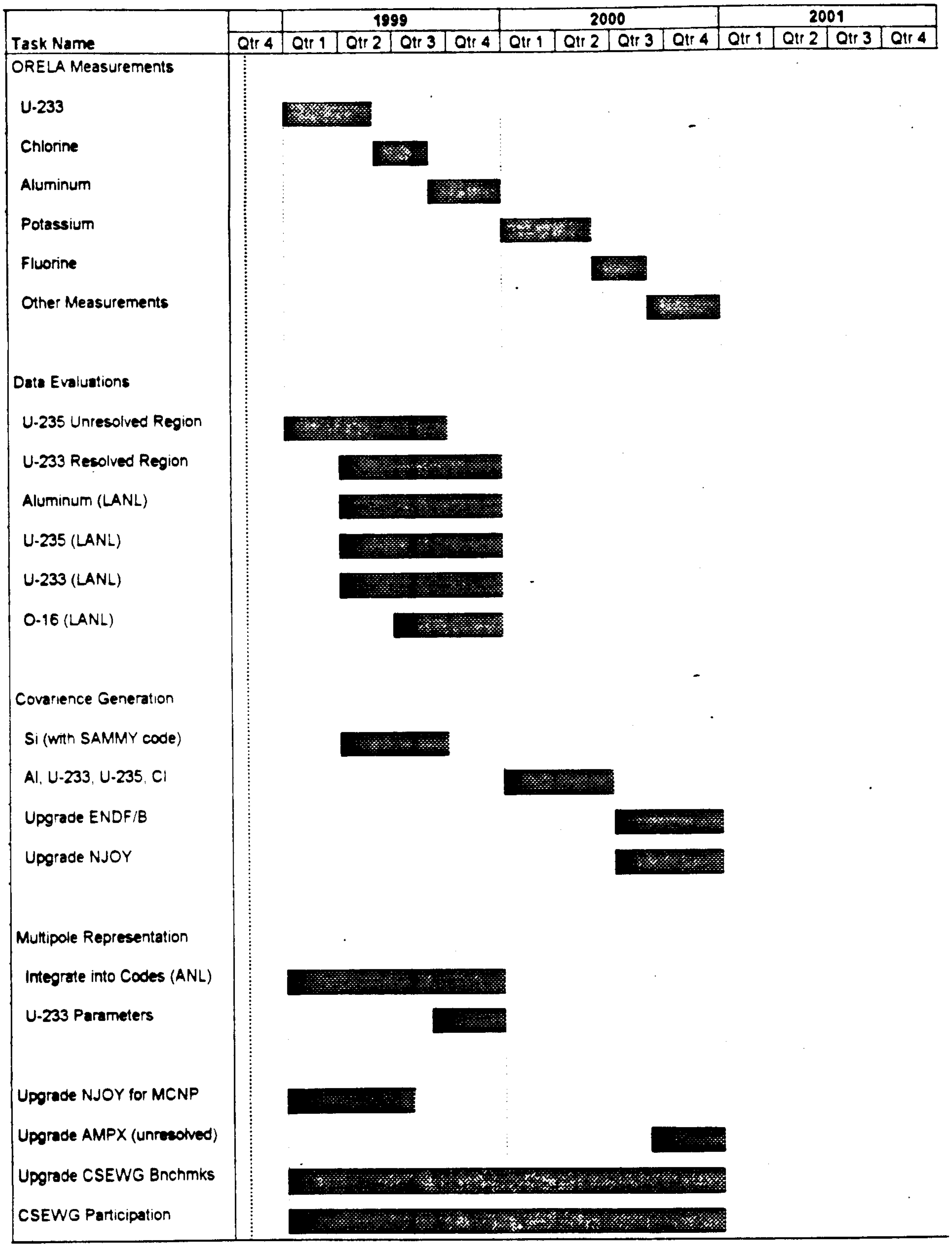
5.2 Current Requirements

Since 1994, the criticality safety community has been surveyed periodically to help identify nuclides for which there are known deficiencies. Some 60 isotopes or elements with nuclear data deficiencies have been identified which, if corrected, would significantly enhance criticality safety calculational capability. Most of these require new measurements at the ORELA, followed by a re-evaluation or new evaluation of the ENDF/B-VI file. Current ongoing projects include: measurements on aluminum-27 capture, uranium-233 transmission and capture, and chlorine transmission and capture; evaluation of aluminum-27, oxygen-16, and uranium-235 unresolved regions; review of the status of fission product evaluations; and development of SAMMY evaluations techniques for unresolved and resolved resonance regions and associated covariance matrices. These materials are of increasing significance for new DOE missions involving the handling and storage of nuclear weapons components and conditioning of waste for storage or disposal.

5.3 Anticipated Future Direction

To address the deficiencies in nuclear data identified by the criticality safety community, a multi-faceted program has been developed which includes nuclear data measurement, evaluation, processing, and testing. The focus of the Nuclear Data Element will be to integrate the international criticality safety community and CSEWG so that the nuclear data needs for criticality safety will be met using the infrastructure of CSEWG and its participating laboratories. A mechanism will be implemented whereby the criticality safety community can help prioritize the order in which data deficiencies can be resolved.

NUCLEAR DATA MILESTONES



5.4 Funding Requirements

The FY 1999, FY 2000, and FY 2001 budgets are shown in the following Tables. Inherent is the assumption that DOE's Office of Energy Research (ER) continues to provide "in kind" support for ORELA operations valued at approximately $675k/year (in FY 1997 dollars). This amount is not included in the funding levels shown in any of the tables.

NUCLEAR DATA PROGRAM ELEMENT
FISCAL YEAR 1999

TASKS BY LABORATORY	FY-99 ($k)
ORNL: Perform differential measurements of neutron cross sections in the energy range of importance to the NCSPMT using the ORELA at ORNL. Uranium-233, chlorine, and aluminum will be completed in FY 1999, and identified priority measurements will be initiated as resources permit. Activities include sample and detector preparation. (NOTE: This activity depends on the DOE/ER commitment to the NCSPMT to maintain ORELA in operating condition and to provide technical assistance of up to 1 person year.) Perform evaluations of neutron cross-sections for materials of importance to the NCSPMT using existing and newly measured differential cross-section data. Activities include evaluations of the uranium-235 unresolved resonance regions, and the chlorine, aluminum, and uranium-233 resolved resonance region; development of the SAMMY analysis code to produce covariance data in appropriate formats for ENDF/B, and development of covariance data for silicon. Collaborate in upgrading CSEWG benchmarks to reflect the needs of the NCSPMT. Perform benchmark calculations of criticality benchmarks with the VITAMIN-B6 multigroup cross-section library, generate sensitivity profiles for criticality benchmarks to help guide new measurements and evaluations, and participate in the integration of the activities of CSEWG and the international criticality safety community. Test the multipole representation of the resolved resonance region in the AMPX cross-section processing system.	1,800
LANL: Collaborate with ORNL to provide complete evaluations for uranium-233 and chlorine, concentrating on the fast energy region, and in developing effective covariance representations. Participate in the integration of the activities of CSEWG and the international criticality safety community. Develop the NJOY capability for producing the probability table representation for the unresolved resonance region for use in the MCNP Monte Carlo code.	273
ANL: Collaborate in upgrading CSEWG benchmarks to reflect the needs of the NCSPMT. Participate in the integration of the activities of CSEWG and the international criticality safety community. Participate in the integration of the multipole representation of the resonance region in nuclear data processing codes.	127
TOTAL:	2,200

NUCLEAR DATA PROGRAM ELEMENT
FISCAL YEAR 2000

TASKS BY LABORATORY		FY-00 ($k)
ORNL:	Perform differential measurements of neutron cross sections in the energy range of importance to the NCSPMT using the ORELA at ORNL. Potassium and fluorine should be studied in FY 2000. Activities include sample and detector preparation. (NOTE: This activity depends on the DOE/ER commitment to the NCSPMT to maintain ORELA in operating condition and to provide technical assistance of up to 1 person year.) Perform evaluations of neutron cross-sections for materials of importance to the NCSPMT using existing and newly measured differential cross-section data. Activities are expected to include generation of covariance data for the resolved resonance region of materials with new measurements from ORELA, other high priority evaluations, further development of the SAMMY analysis code to produce covariance data in appropriate formats for ENDF/B, and covariance data generation for the new evaluations. Collaborate in upgrading CSEWG benchmarks to reflect the needs of the NCSPMT, process new evaluations and perform benchmark calculations of criticality benchmarks with the VITAMIN-B6 multigroup cross-section library, generate sensitivity profiles for criticality benchmarks to help guide new measurements and evaluations, and participate in the integration of the activities of CSEWG and the international criticality safety community. Implement the probability table scheme for the unresolved resonance region in the AMPX cross-section processing system and begin development of the capability for processing covariance data generated by SAMMY.	1,800
LANL:	Collaborate with ORNL to provide complete evaluations for high priority materials, concentrating on the fast energy region, and in developing effective covariance representations. Participate in the integration of the activities of CSEWG and the international criticality safety community. Develop the NJOY capability for processing covariance data generated by SAMMY.	273
ANL:	Collaborate in upgrading CSEWG benchmarks to reflect the needs of the NCSPMT. Participate in the integration of the activities of CSEWG and the international criticality safety community. Support ORNL in developing processing schemes to be utilized in AMPX.	127
TOTAL:		2,200

NUCLEAR DATA PROGRAM ELEMENT
FISCAL YEAR 2001

TASKS BY LABORATORY	FY-01 ($k)
ORNL: Perform differential measurements of neutron cross sections in the energy range of importance to the NCSPMT using the ORELA at ORNL. The particular nuclides to be studied will be those determined to be of highest priority by the criticality safety community. (NOTE: This activity depends on the DOE/ER commitment to the NCSPMT to maintain ORELA in operating condition and to provide technical assistance of up to 1 person year.) Perform evaluations of neutron cross-sections for materials of importance to the NCSPMT using existing and newly measured differential cross-section data. Activities are expected to include evaluations of the new potassium and fluorine measurements from ORELA, other high priority evaluations, further development of the SAMMY analysis code to produce covariance data in appropriate formats for ENDF/B, and covariance data generation for the new evaluations. Collaborate in upgrading CSEWG benchmarks to reflect the needs of the NCSPMT, process new evaluations and perform benchmark calculations of criticality benchmarks with the VITAMIN-B6 multigroup cross-section library, generate sensitivity profiles for criticality benchmarks to help guide new measurements and evaluations, and participate in the integration of the activities of CSEWG and the international criticality safety community. Test the probability table scheme for the unresolved resonance region in the AMPX cross-section processing system and covariance data generated by SAMMY.	1,800
LANL: Collaborate with ORNL to provide complete evaluations for high priority materials, concentrating on the fast energy region. Participate in the integration of the activities of CSEWG and the international criticality safety community. Test the NJOY capability for processing covariance data generated by SAMMY.	273
ANL: Collaborate in upgrading CSEWG benchmarks to reflect the needs of the NCSPMT. Participate in the integration of the activities of CSEWG and the international criticality safety community. Support ORNL in developing processing schemes to be utilized in AMPX.	127
TOTAL:	2,200

Similar tasks will continue during FY 2002 and FY 2003. Inherent in the following table is the assumption that DOE/ER continues to provide "in kind" support for ORELA operations valued at approximately $675k/year (in FY 1997 dollars). If ER support for ORELA is withdrawn, different funding and institutional responsibility for ORELA operations will be necessary to maintain the NCSPMT's access to this essential resource.

YEAR	COST ($k)
2002	2,530
2003	2,860

6. TRAINING AND QUALIFICATION

Historically, personnel familiarization with the concept of criticality and with its control on the process floor was gained by working in and around the numerous critical mass laboratories nationwide. With the demise of these facilities and the influx of newer personnel, training on the concepts, and to the extent practical, hands-on training involving critical experiments has become increasingly more important. For over 25 years, courses involving both classroom and laboratory sessions involving hands-on critical experiments have been offered at LANL. Attendees have come from the DOE and contractor sectors as well as the United States Nuclear Regulatory Commission (USNRC), USNRC licensee, and Department of Defense communities.

6.1 Current Capability

The DOE funds both 3-day and 5-day criticality safety programs at LANL. Both courses include the same hands-on critical experiments and much of the same classroom sessions. The shorter course is intended for those who supervise or otherwise work around or are responsible for operations for which a criticality accident is a credible threat. The longer program is intended for those who have significant criticality safety responsibilities such as analysts and full-time oversight personnel. This latter course also includes visits to fissile material process facilities and an introduction to methods of analysis, both simplified and computer-based.

In preparing the response to Subrecommendation 6 of DNFSB Recommendation 97-2, the question arose concerning potential deficiencies in the background training of criticality safety personnel that would most likely attend the LACEF courses. As a result, the DOE committed to an assessment of the overall training needs of criticality safety staff, the level at which these needs were being met, and resources available to meet those needs. This information will be used to initiate a program to address any areas identified as needing additional training courses or materials, and will be directly linked to the site-specific training and qualification programs which are also being developed in response to Subrecommendation 6.

6.2 Current Requirements

These courses are unique due to the ability of the attendees to participate, hands-on, in actual critical experiments. Since LACEF is the only operating critical experiments facility in the United States, maintaining its continued operation and appropriate staff level is a prerequisite for these courses to be offered. In addition, senior criticality safety specialists who are thoroughly versed in all aspects of the profession, and are accomplished instructors are essential for conducting this training. Thus, personnel expertise at LACEF and in the criticality safety group at LANL are required for these courses to continue. Historically, there has been a demand for five to eight 3-day courses per year and one to two 5-day courses per year.

6.3 Anticipated Future Direction

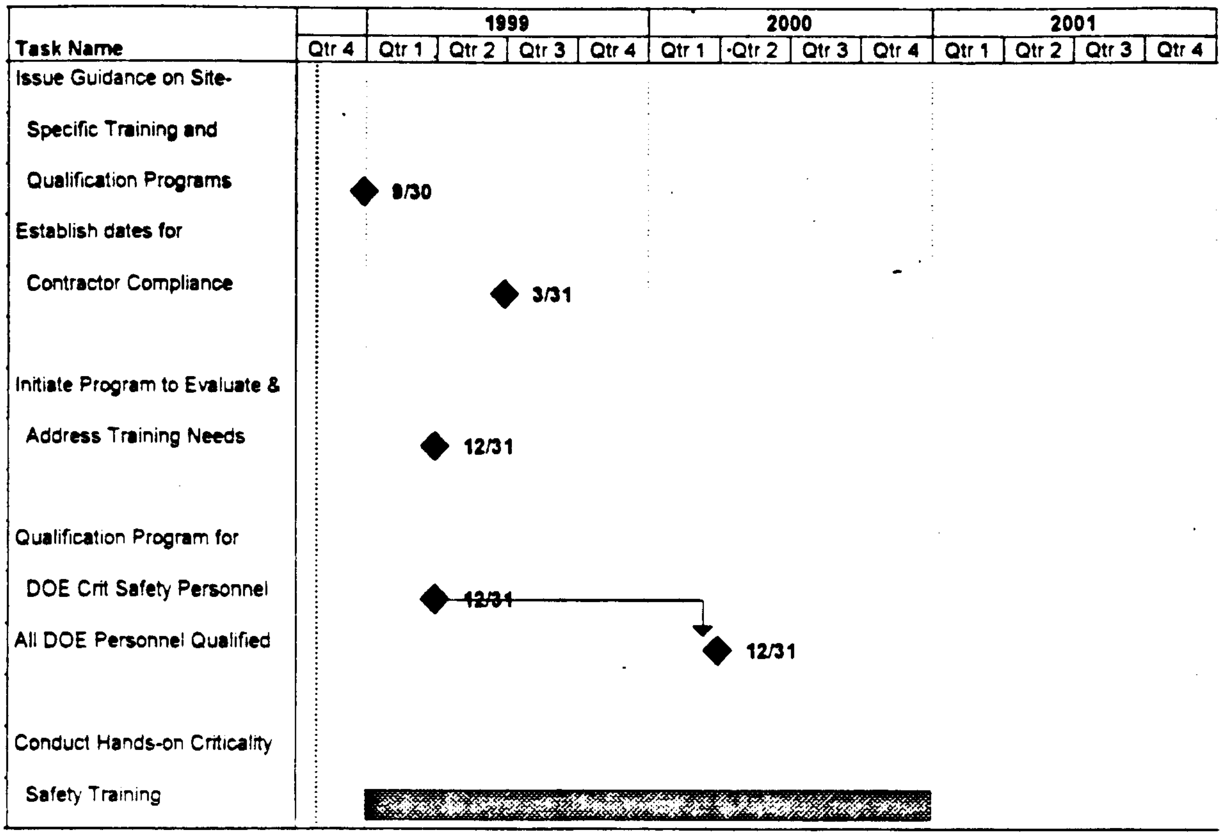
In the IP for Recommendation 97-2, DOE made several commitments regarding training and qualification of contractor and Federal criticality safety personnel. DOE committed to develop and publish guidance for contractor site specific a qualification programs by September 1998. DOE also committed to develop a qualification program for Departmental criticality safety personnel by December 1998 and qualify these people by December 1999. Existing training programs described in this section will play an important role in helping the Department meet these IP Commitments.

As the remaining few criticality safety practitioners with actual critical mass laboratory experience and knowledge retire at various sites nationwide, it will be increasingly important to provide this familiarization to newer personnel by way of courses involving experiments at LACEF. To this end, a new supplemental 5-day course will be offered that will involve both classroom and experimental sessions. It will focus on practical problem solving related to actual work-site situations as well as additional hands-on critical experiments to strengthen the new practitioner's familiarization with the concept and understanding of criticality. The traditional 3-day and 5-day courses will continue to be offered as demand dictates.

As part of the development of the qualification program, the specific areas of knowledge required of criticality safety engineers have been collected into an outline that can form the basis of a general criticality safety staff training course. This course does not include the hands-on experience of the LACEF courses, but will provide theoretical and operational background material to enhance the student's appreciation of the material in those courses. Based on the results of a survey of DOE contractor sites, it will be determined if the material contained in this outline is being adequately covered in currently available training programs. The DOE will then institute a program that addresses identified training needs.

A review of courses available at DOE sites or through universities was performed to assess whether or not adequate training courses are available to meet those needs. Nearly all areas of qualification training can be met by existing courses, with some changes to improve availability and delivery to people working full time in the criticality safety field. Since guidance will be issued on the development of site-specific qualification programs, the general criticality safety staff training is intended to have essentially the same content whether it is given on-site or at a university. Site-specific training will be included in the training program as needed.

TRAINING AND QUALIFICATION MILESTONES



6.4 Funding Requirements

The funding requirements to provide the various criticality safety training and qualification programs are summarized in the table below. Nominally, the offerings are planned to include six 3-day courses and one each of the traditional and the new 5-day courses per year. The actual number and mix of courses will be evaluated annually and modified as needed based on both demand and available funds. A fraction of the funding is allocated for the development or reformatting of supplemental courses that will be necessary to support the qualification program.

TRAINING AND QUALIFICATION PROGRAM ELEMENT
FISCAL YEAR 1999-2003

TASKS BY LABORATORY	FY-99 ($k)	FY-00 ($k)	FY-01 ($k)	FY-02 ($k)	FY-03 (01)
LANL: Provide six 3-day courses and two 5-day courses at LANL per year.	300	300	300	310	320
ANL: Develop additional training as required to meet DOE needs and maintain training activities necessary to support criticality safety qualification program needs.	50	50	50	50	50
TOTAL:	350	350	350	360	370

7. INFORMATION PRESERVATION AND DISSEMINATION

With the shutdown of past critical mass laboratories beginning some twenty years ago, it was recognized that unreported and potentially valuable information pertaining to past experiments might be contained therein. Additionally, it has been recognized that with the increasing ease of sharing information electronically, that criticality studies and evaluations performed at one site would sometimes be of benefit to criticality safety staff at other sites. To these ends, efforts have been made over the years to prevent the loss of logbooks and reports from past critical experiments and to make them available to researchers.

This effort has obvious strong links to the benchmarking activity and, indeed, some previously unreported experimental results have already been discovered, formally documented, and reviewed, accepted, and disseminated as benchmark quality information. To preserve not just hard copy data, but recollections and philosophies, videotapes of pioneers in the field are being attempted.

A goal is to expand use of the Internet to make all forms of criticality safety data and information readily available to the widest possible audience. Innovative ways of managing and linking all applicable criticality safety web pages are being studied with the stated goal in mind.

7.1 Current Capability

Logbooks and related reports from the critical mass laboratory operations at Brookhaven, Hanford, Rocky Flats, and Los Alamos are currently archived at the Los Alamos National Laboratory and are available for perusal by researchers. Originals or copies of rare and difficult to find research reports are also being accumulated at Los Alamos, and copies are being provided on request.

7.2 Current Requirements

Storage space and the ability to copy and disseminate or readily retrieve the stored information for review by various researchers are current requirements that are being met at LANL. Additionally, a computer with appropriate software is available within the criticality safety group at LANL to serve as the host for a website which will eventually make much of this archived information available electronically.

Currently, there are at least five Internet web sites at the DOE Laboratories which contain criticality safety information. To use web technology efficiently and make criticality safety information easily accessible, a web architecture must be developed and managed. The goal is to create an environment which decreases search time through use of a master index of information, thereby allowing the user access to information contained on any of the sites rapidly through hyper links.

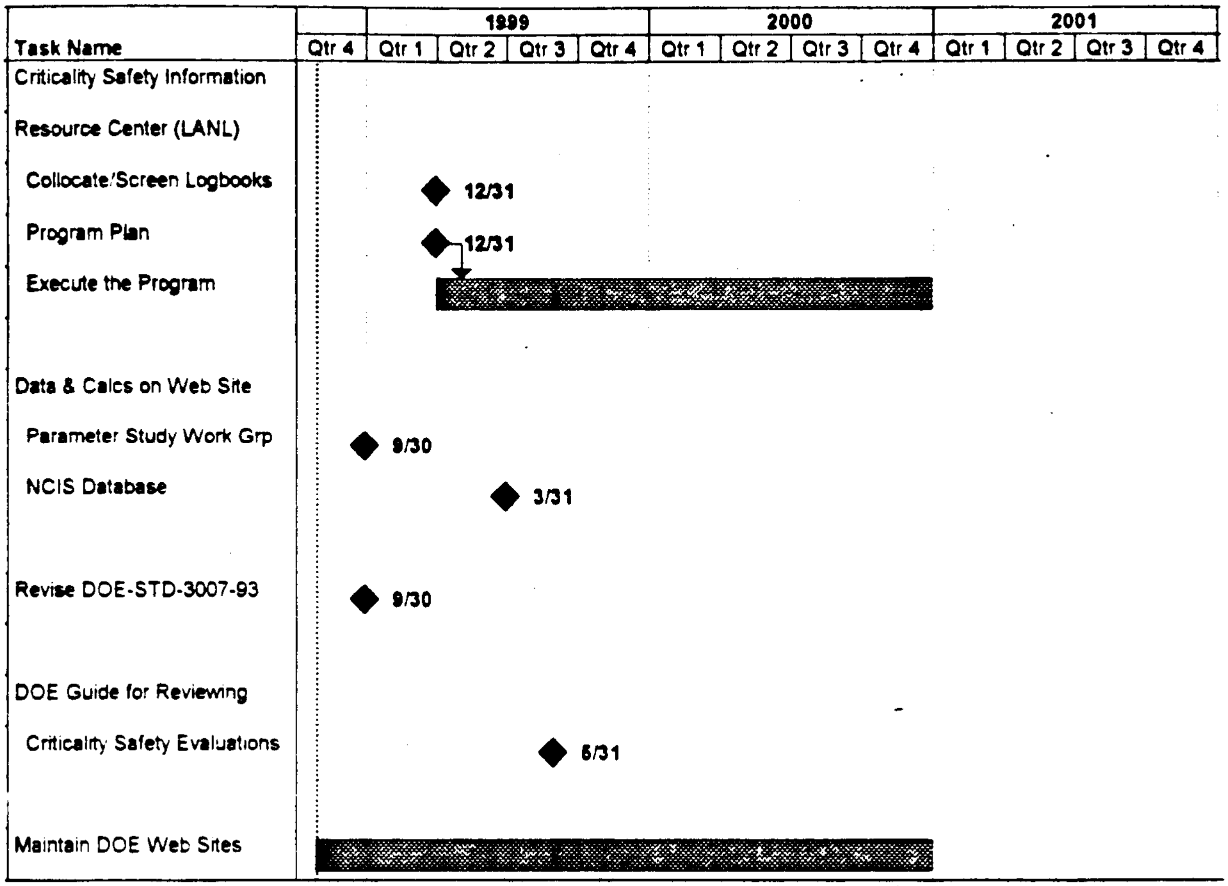
7.3 Anticipated Future Direction

Critical experiment logbooks, both those residing at Los Alamos and those still elsewhere - such as Livermore and Oak Ridge - will be scanned and loaded onto the website. Documents in common use throughout the criticality safety community and those which might be of interest and benefit to criticality staff at multiple sites will also be scanned and made available on the website. Depending of the perceived benefit and cost, videotaped information such as interviews with pioneers will be made available on the website.

In addition to archiving data, calculations, and other important criticality safety information, a method, or methods for dissemination of this information must be developed. The DOE will have to develop the web architecture described in section 7.2, above to make criticality safety information easily accessible to the widest audience.

During development of the IP for Recommendation 97-2, a concern was expressed regarding the lack of guidance on how to review criticality safety evaluations. To address this concern, and codify expectations, the DOE will issue a guide for the review of criticality safety evaluations in the Spring of 1999. This guide will emphasize the acceptability of using bounding values and simplified analytical methods where applicable. The guide will also stress the importance of practical, efficient criticality safety analysis, practices, and controls to the reviewer.

INFORMATION PRESERVATION AND DISSEMINATION MILESTONES



7.4 Funding Requirements

Major aspects of this effort are planned for FY 1999 with a more modest, sustained level of effort for the out years. This funding profile is shown in the table below.

INFORMATION PRESERVATION AND DISSEMINATION PROGRAM ELEMENT
FISCAL YEAR 1999-2003

TASKS BY LABORATORY	FY-99 ($k)	FY-00 ($k)	FY-01 ($k)	FY-02 ($k)	FY-03 (01)
LANL: Archive critical experiment logbooks from the DOE complex and make these available to the criticality safety community. Maintain a criticality safety web site to support information dissemination activities.	170	70	70	72	74

8. APPLICABLE RANGES OF BOUNDING DATA AND CURVES

In response to Subrecommendation 3 from DNFSB Recommendation 97-2, DOE has determined that it is necessary to develop and provide guidance for the applicability of bounding curves and data by using sensitivity and uncertainty computational methods. Recommendation 97-2, Subrecommendation 3 states:

Establish a program to interpolate and extrapolate such existing calculations and data as a function of physical circumstances that may be encountered in the future, so that useful guidance and bounding curves will result.

DOE has decided to support expansion of an ongoing activity at ORNL to address DOE needs. The "Range of Applicability" work at ORNL, which has been funded by the USNRC for several years, has made significant progress in extending the range of applicability of analytical methods into areas where data is either non-existent or scarce. The potential exists for much synergism which will benefit both the USNRC and DOE more than if either agency acted alone to fund this work.

8.1 Current Capability

Current analytical methods are of limited value when applied outside the range of applicable benchmark data. If benchmark data does not exist for fissile systems which are similar to the one being analyzed, validation of criticality safety calculations for that system is not possible and overly conservative safety margins must be adopted.

8.2 Current Requirements

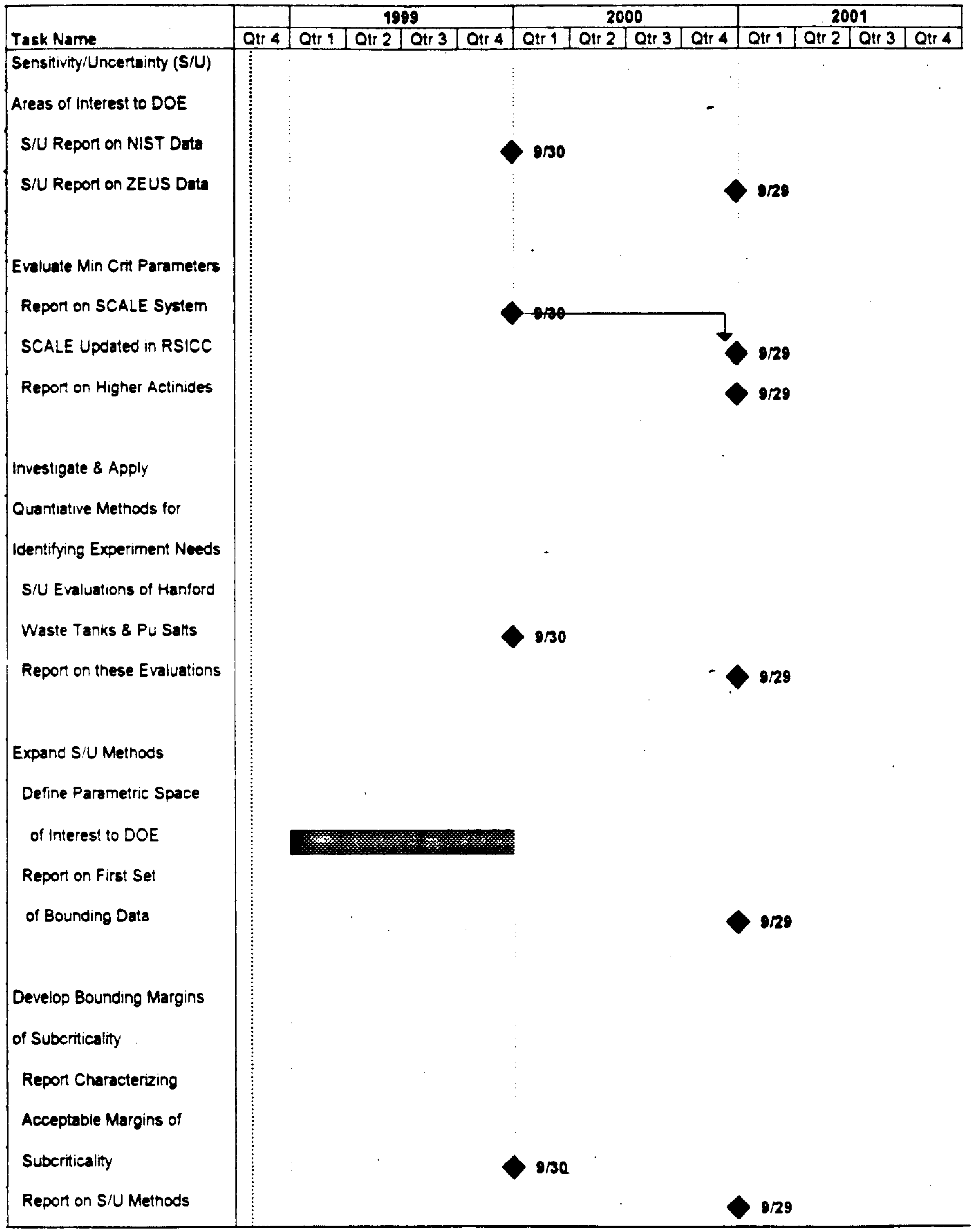
The requirement is to be able to demonstrate applicability of the calculational methods outside the range of applicable benchmark data in areas of interest to DOE so that validation of criticality safety calculations may be possible, thus reducing unnecessary conservatism in safety margin and associated costs.

8.3 Anticipated Future Direction

The FY 1999 through FY 2003 budget for the "Applicable Ranges of Bounding Data and Curves" program at ORNL provides for significant extension of the range of applicability of neutronics codes and data that are now validated over a limited range of applicability. This program will also identify needed differential data measurements and integral criticality experiments to resolve issues where insufficient validations exist for particular safety analyses. Two important long-term goals of this program are: 1) to provide insight or resolution of long-standing technical questions about extending ranges-of-applicability, and give practitioners enhanced computational tools and new information that will aid in the efficient development of adequate subcritical margins that are clear and defensible; and 2) to enable the practitioner to use the new tools and information, with sensitivity and uncertainty-data analysis techniques, to justifiably quantify nuclear criticality safety application calculational uncertainties in k-effective, critical and cross-section-measurement experimental needs, and theoretical needs.

Upon completion, the products developed or needs identified by this activity will be transitioned to the appropriate DOE NCSP Element(s). Examples of such products and identified needs from this projects that may be transitioned to other program elements include: the education and training of nuclear criticality safety staffs (e.g., in the methodology, relevance, and use of the developed codes for developing and evaluating the applicability of bounding curves and data) to the Training and Qualification program element; further identified needed code developments or desired refinements to the Analytical Methods program element; needs for critical experiments or cross-section measurements that are incidentally identified during the evolution of the activity to the Critical Experiments or Nuclear Data program elements.

APPLICABLE RANGES OF BOUNDING DATA AND CURVES MILESTONES



8.4 Funding Requirements

The preliminary FY 1999 through FY 2003 budget for the "Applicable Ranges of Bounding Data and Curves" program is provided in the table below. Although the decision has been made to fund work in this area, the scope and budget have not yet been finalized. Following submission of the technical program plan (IP Commitment 6.3, Deliverable 1), in July 1998, and subsequent review by the CSSG in August 1998, the NCSPMT will determine the final budget allocation prior to executing the plan in October 1998.

APPLICABLE RANGES OF BOUNDING DATA AND CURVES PROGRAM ELEMENT FISCAL YEAR 1999-2003

TASKS BY LABORATORY	FY-99 ($k)	FY-00 ($k)	FY-01 ($k)	FY-02 ($k)	FY-03 ($k)
ORNL: Conduct criticality safety calculational range of applicability study	600	700	700	700	700