# United States Department of Energy

# Nuclear Criticality Safety Program

# Five-Year Plan

**October 2004**

Nuclear Criticality Safety Program Plan, October 2004.

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LIST OF ACRONYMS

| | |
|---|---|
| AMPX | Nuclear cross-section processing computer code |
| ANL | Argonne National Laboratory |
| ANS | American Nuclear Society |
| ANSI | American National Standards Institute |
| ARH | Atlantic Richfield Hanford |
| AROBCAD | Applicable Ranges of Bounding Curves and Data |
| BNL | Brookhaven National Laboratory |
| CEF | Criticality Experiments Facility (Project) |
| CENTRM | Discrete Ordinates Transport Computer Code |
| COG (1) | Lawrence Livermore National Laboratory Monte Carlo Computer Code |
| CSCT | Criticality Safety Coordinating Team |
| CSEWG | Cross Section Evaluation Working Group |
| CSIRC | Criticality Safety Information Resource Center |
| CSSG | Criticality Safety Support Group |
| DAF | Device Assembly Facility |
| DICE | Database for the International Criticality Safety Benchmark Evaluation Project |
| DOE | United States Department of Energy |
| EH | Office of Environment, Safety and Health |
| EM | Office of Environmental Management |
| ENDF | Evaluated Nuclear Data File |
| FFTF | Fast Flux Test Reactor |
| FTE | Full-Time Equivalent |
| FY | Fiscal Year |
| GLLSM | Generalized Linear Least Squares Method |
| GNASH(2) | A statistical nuclear model computer code |
| HCTLTR | High Core Temperature Lattice Test Reactor |
| HEU | Highly Enriched Uranium |
| ICNC | International Conference on Nuclear Criticality |
| ICSBEP | International Criticality Safety Benchmark Evaluation Project |
| INEEL | Idaho National Engineering and Environmental Laboratory |

| | |
|---|---|
| KENO[3] | Monte Carlo criticality computer code |
| LACEF | Los Alamos Critical Experiments Facility |
| LANL | Los Alamos National Laboratory |
| LEU | Low Enriched Uranium |
| LLNL | Lawrence Livermore National Laboratory |
| LWBR | Light Water Breeder Reactor |
| MCNP | Monte Carlo N Particle (N currently equals 3) Computer Code |
| MOX | Mixed Oxide Fuel |
| MURR | Missouri University Research Reactor |
| NA-11 | Assistant Deputy Administrator for Research, Development and Simulation |
| NA-117 | Office of Facilities Management and Environment, Safety and Health |
| NASA | National Aeronautics and Space Administration |
| NE | Office of Nuclear Energy, Science and Technology |
| NNSA | National Nuclear Security Administration |
| NCSET | Nuclear Criticality Safety Engineer Training |
| NCSP | Nuclear Criticality Safety Program |
| NDAG | Nuclear Data Advisory Group |
| OECD-NEA | Organization for Economic Cooperation and Development - Nuclear Energy Agency |
| ORELA | Oak Ridge Electron Linear Accelerator |
| ORNL | Oak Ridge National Laboratory |
| PCTR | Physical Constants Test Reactor |
| PNNL | Pacific Northwest National Laboratory |
| PRTR | Plutonium Recycle Test Reactor |
| RL | Richland Operations Office |
| RSICC | Radiation Safety Information Computational Center |
| RW | Office of Civilian Radioactive Waste Management |
| SAMMY[4] | A nuclear model computer code |
| S/U | Sensitivity and Uncertainty |
| SCALE[5] | Standardized Computer Analyses for Licensing Evaluation |
| SRS | Savannah River Site |
| VIM | Vastly Improved Monte Carlo Computer Code |

| | |
|---|---|
| USNRC | United States Nuclear Regulatory Commission |
| WINCO | Westinghouse Idaho Nuclear Company |
| WSMS | Westinghouse Safety Management Solutions |
| ZPPR | Zero Power Physics Reactor |
| ZPR | Zero Power Reactor |

(1) COG was originally developed to solve deep penetration problems in support of underground nuclear testing. Variance reduction techniques are very important to these problems and hence the name COG was chosen as in "to cog the dice" or cheat by weighting.
(2) GNASH is a pre-equilibrium, statistical nuclear model code based on Hauser-Feshbach theory (and additional models) for the calculation of cross sections and emission spectra, primarily in the epithermal and fast neutron energy ranges.
(3) KENO is a family of Monte Carlo criticality codes whose name came from an observation of the KENO game in which small spheres, under air levitation, arbitrarily move about in a fixed geometry.
(4) SAMMY is a nuclear model code, which applies R-Matrix theory to measured data and produces resolved and un-resolved resonance parameters in Reich-Moore and other formalisms. The name SAMMY was a personal choice of the author.
(5) SCALE is a system of well-established codes and data for performing nuclear safety (criticality, shielding, burn up-radiation sources) and heat transfer analyses.

**United States Department of Energy**
**Nuclear Criticality Safety Program Five-Year Plan**

## EXECUTIVE SUMMARY

The primary objective of the Department of Energy (DOE) Nuclear Criticality Safety Program (NCSP) is to maintain fundamental infrastructure that supports operational criticality safety programs. This infrastructure includes key calculative tools, differential and integral data measurement capability, training resources, and web based systems to enhance information preservation and dissemination. Another important function of the NCSP is to solicit feedback from the operational criticality safety community so that the infrastructure remains responsive to evolving needs. The objective of operational nuclear criticality safety is to ensure that fissile material is handled in such a way that it remains subcritical under both normal and credible abnormal conditions to protect workers, the public, and the environment. A robust operational criticality safety program requires knowledgeable people and technical resources. The NCSP maintains these two key elements so the DOE can continue to do work safely with fissile materials.

The NCSP is funded by the Assistant Deputy Administrator for Research Development, and Simulation (NA-11), Defense Programs, National Nuclear Security Administration (NNSA)[1]. Mr. Mike Thompson, from the Office of Facilities Management and Environment, Safety and Health (NA-117) is the NCSP Manager. He is supported by the Criticality Safety Support Group (CSSG) regarding technical matters and by the Criticality Safety Coordinating Team (CSCT), consisting of Federal Criticality Safety Practitioners at the sites, and the End Users Group (DOE Contractor Criticality Safety Representatives) regarding DOE Field criticality safety issues.

The NCSP includes the following seven technical program elements:

Applicable Ranges of Bounding Curves and Data: develop method(s) to interpolate and extrapolate from existing criticality safety data.

Analytical Methods Development and Code Support: support and enhance numerical processing codes used in criticality safety analyses.

International Criticality Safety Benchmark Evaluation Project: identify, evaluate and make available benchmarked data to support validation of criticality safety analyses.

Nuclear Data: provide nuclear cross section data required for codes to accurately model fissionable systems encountered by operational criticality safety programs.

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[1] In addition to the funding provided by NA-11, the DOE Office of Science is committed to maintain the Oak Ridge Electron Linear Accelerator in an operational state to support nuclear cross section data acquisition. Also, the Office of Nuclear Energy's Idaho Office has agreed to support Mr. Adolf Garcia's activities associated with his chairmanship of the CSSG.

Integral Experiments: provide integral experimental data for the validation of the calculation methods used to support criticality safety analyses.

Information Preservation and Dissemination: collect, preserve and make readily available criticality safety information.

Training and Qualification: maintain and improve training resources and qualification standards for criticality safety practitioners.

Each of these areas is interdependent on the others and together form a complete criticality safety infrastructure. If any of these program elements is eliminated, the ability of the Department's criticality safety engineers to perform their work will be substantially diminished. In addition to the seven technical program elements, two important facilities are required for successful execution of the NCSP: the Los Alamos Critical Experiments Facility (LACEF) and the Oak Ridge Electron Linear Accelerator (ORELA). Figure ES-1 contains a flow chart that shows how the NCSP works and Figure ES-2 contains a NCSP organizational chart.

Figure ES-1 How the Nuclear Criticality Safety Program Works

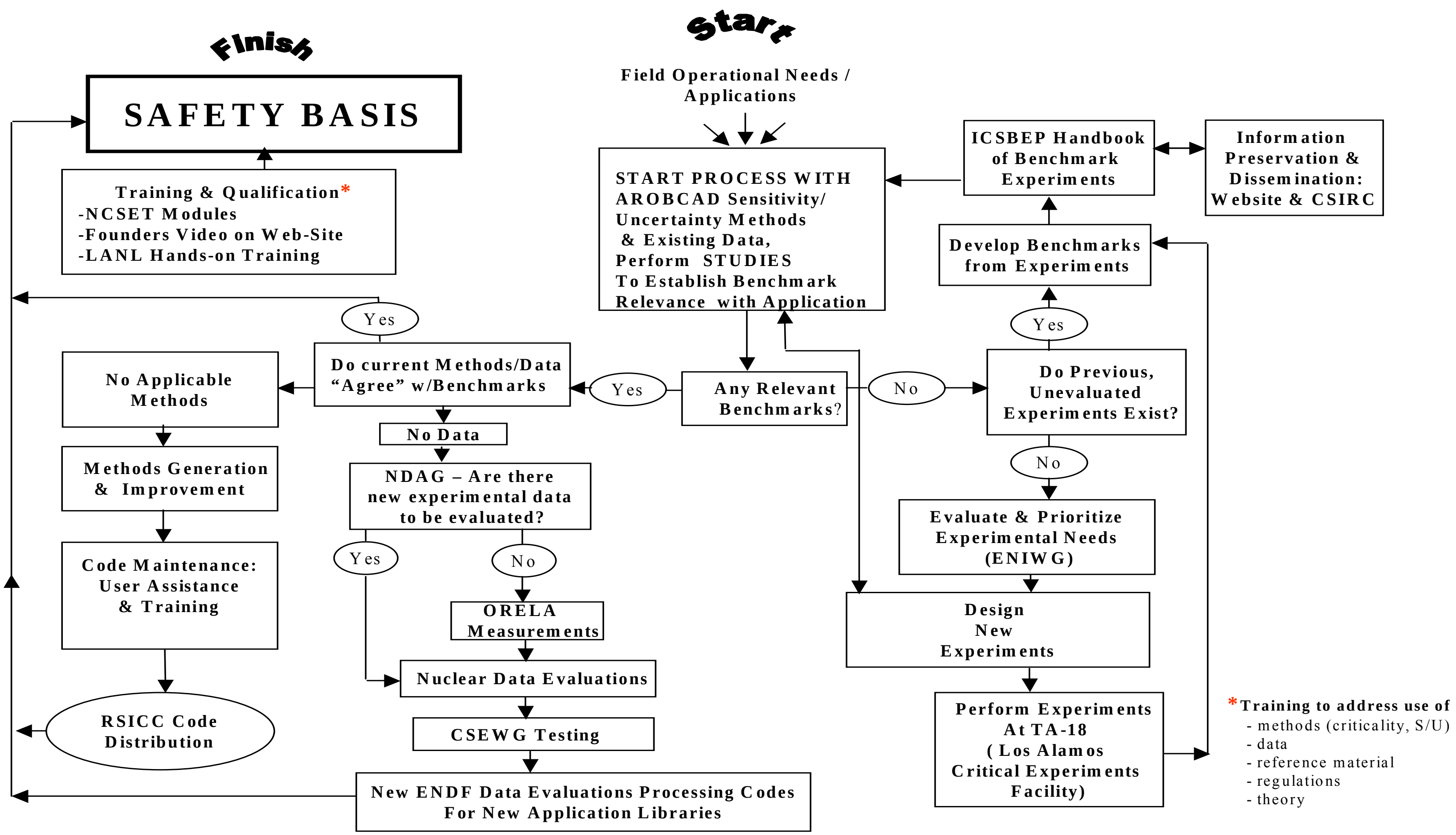
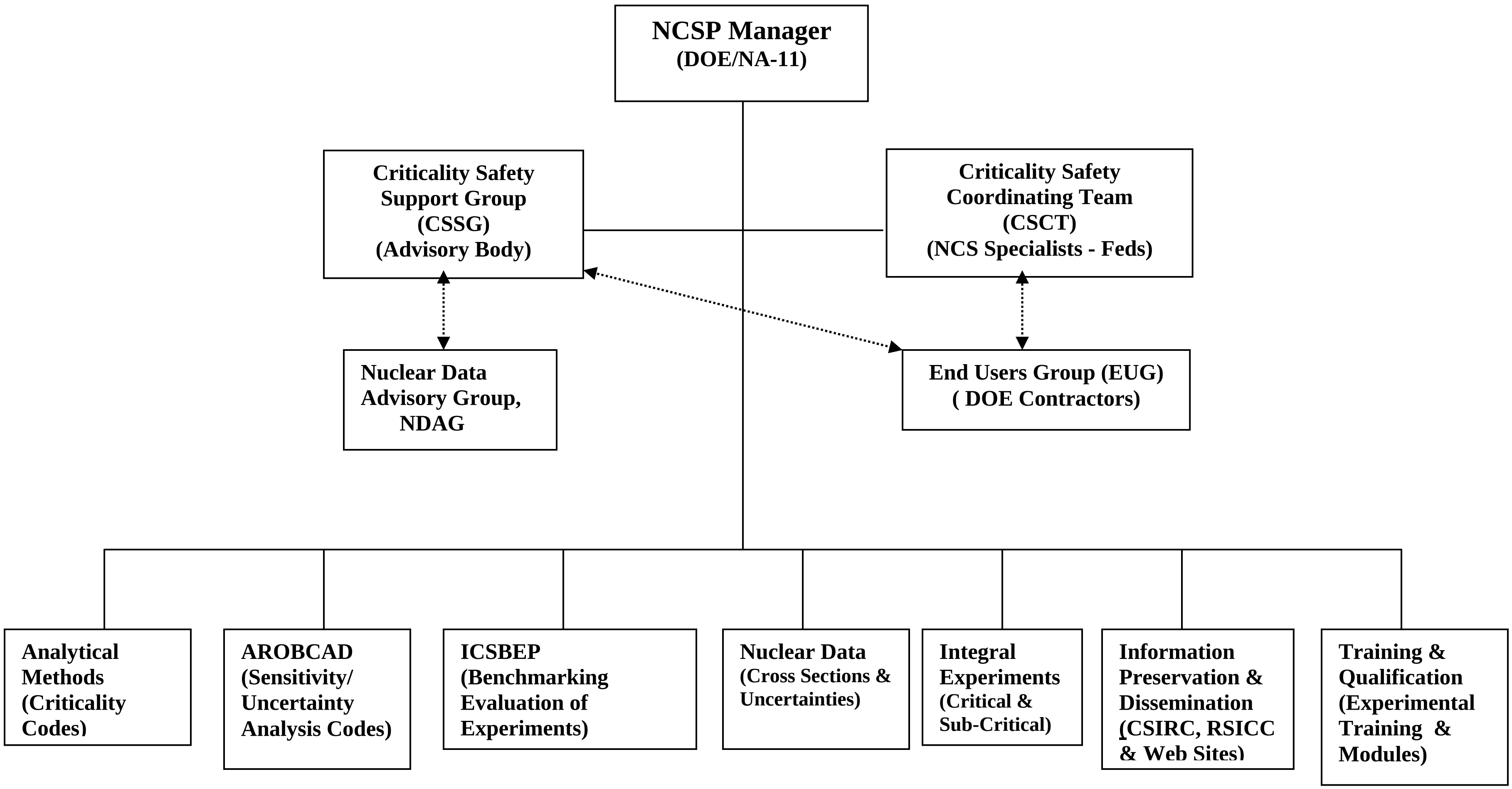


Figure 1-2: Nuclear Criticality Safety Program Organization



The infrastructure maintenance portion of the NCSP Budget is requirements based. Requirements for preservation of capability in each of the seven technical program elements are provided in this five-year plan along with budget, schedule, and a description of how each of the program elements contributes to the overall enhancement of operational criticality safety. A budget summary for the NCSP is contained in Table ES-1.

Table ES-1: Nuclear Criticality Safety Program Base Funding, Fiscal Years 2005 – 2009

| | FY 2005 ($K) | FY 2006 ($K) | FY 2007 ($K) | FY 2008 ($K) | FY 2009 ($K) |
|---|---|---|---|---|---|
| Applicable Ranges of Bounding Curves and Data | 800 | 800 | 400 | 300 | 300 |
| Analytical Methods Development and Code Support | 2,235 | 2,145 | 2,545 | 2,500 | 2,500 |
| International Criticality Safety Benchmark Evaluation Project | 1,900 | 1,800 | 1,800 | 1,800 | 1,900 |
| Nuclear Data | 3,045 | 2,754 | 2,700 | 2,917 | 3,000 |
| Integral Experiments | 1,451 | 1,580 | 1,782 | 1,782 | 1,886 |
| Information Preservation and Dissemination | 265 | 270 | 270 | 270 | 270 |
| Training and Qualification | 200 | 190 | 190 | 230 | 230 |
| Criticality Safety Support Group | 230 | 250 | 250 | 250 | 250 |
| TOTAL | 10,125 | 9,789 | 9,937 | 10,049 | 10,336 |

The NCSP is primarily a capability maintenance program aimed at preserving a unique skill set and associated infrastructural assets for the Nation. Skills and infrastructure are preserved and maintained by doing mission related work in each of the program elements. The results of this work significantly enhances criticality safety throughout the Department. In addition to maintaining the infrastructure or "base program", NCSP resources are routinely employed to solve Departmental problems. Such program specific applications are coordinated by the NCSP Manager and costs are recovered wherever appropriate. The program specific application section of this plan contains detailed information about scheduled and proposed work.

**United States Department of Energy**
**Nuclear Criticality Safety Program**
**Five-Year Plan**

## 1. Nuclear Criticality Safety Program Purpose and Scope

The primary objective of the Department of Energy DOE Nuclear Criticality Safety Program (NCSP) is to maintain fundamental infrastructure that supports operational criticality safety programs. This infrastructure includes key calculative tools, differential and integral data measurement capability, training resources, and web based systems to enhance information preservation and dissemination. Another important function of the NCSP is to solicit feedback from the operational criticality safety community so that the infrastructure remains responsive to evolving needs. The objective of operational nuclear criticality safety is to ensure that fissile material is handled in such a way that it remains subcritical under both normal and credible abnormal conditions to protect workers, the public, and the environment. A robust operational criticality safety program requires knowledgeable people and technical resources. The NCSP maintains these two key elements so the DOE can continue to do work safely with fissile materials.

The NCSP is funded by the Assistant Deputy Administrator for Research Development, and Simulation (NA-11), Defense Programs, National Nuclear Security Administration (NNSA)[1]. Mr. Mike Thompson, from the Office of Facilities Management and Environment Safety and Health (NA-117) is the NCSP Manager. He is supported by the Criticality Safety Support Group (CSSG) regarding technical matters and by the Criticality Safety Coordinating Team (CSCT), consisting of Federal Criticality Safety Practitioners at the sites, and the End Users Group (DOE Contractor Criticality Safety Representatives) regarding DOE Field criticality safety issues.

The NCSP includes the following seven technical program elements:

> <u>Applicable Ranges of Bounding Curves and Data:</u> develop method(s) to interpolate and extrapolate from existing criticality safety data.
>
> <u>Analytical Methods Development and Code Maintenance:</u> support and enhance numerical processing codes used in criticality safety analyses.

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[1] In addition to the funding provided by NA-11, the DOE Office of Science is committed to maintain the Oak Ridge Electron Linear Accelerator in an operational state to support nuclear cross section data acquisition. Also, the Office of Nuclear Energy's Idaho Office has agreed to support Mr. Adolf Garcia's activities associated with his chairmanship of the CSSG.

International Criticality Safety Benchmark Evaluation Project: identify, evaluate and make available benchmarked data to support validation of criticality safety analyses.

Nuclear Data: provide nuclear cross section data required for codes to accurately model fissionable systems encountered by operational criticality safety programs.

Integral Experiments: provide integral experimental data for the validation of the calculation methods used to support criticality safety analyses.

Information Preservation and Dissemination: collect, preserve and make readily available criticality safety information.

Training and Qualification: maintain and improve training resources and qualification standards for criticality safety practitioners.

Each of these areas is interdependent on the others and together form a complete criticality safety infrastructure. If any of these program elements is eliminated, the ability of the Department's criticality safety engineers to perform their work will be substantially diminished. In addition to the seven technical program elements, two important facilities are required for successful execution of the NCSP: the Los Alamos Critical Experiments Facility (LACEF) and the Oak Ridge Electron Linear Accelerator (ORELA). Figure ES-1 contains a flow chart that shows how the NCSP works and Figure ES-2 contains a NCSP organizational chart.

The infrastructure maintenance portion of the NCSP Budget is requirements based. Requirements for preservation of capability in each of the seven technical program elements are provided in this five year plan along with budget, schedule, and customers/Departmental missions supported by each of the program elements. A budget summary for the NCSP is contained in Table ES-1.

The NCSP is primarily a capability maintenance program aimed at preserving a unique skill set and associated infrastructural assets for the Nation. Skills and infrastructure are preserved and maintained by doing mission related work in each of the program elements. The results of this work significantly enhances criticality safety throughout the Department. In addition to maintaining the infrastructure or "base program", NCSP resources are routinely employed to solve Departmental problems. Such program specific applications are coordinated by the NCSP Manager and costs are recovered wherever appropriate. The program specific application section of this plan contains detailed information about scheduled and proposed work.

## 2. Applicable Ranges of Bounding Curves and Data

Program Element Description

The Applicable Ranges of Bounding Curves and Data (AROBCAD) Program Element involves adapting and extending the use of optimization, sensitivity/uncertainty (S/U), and statistical methods into useable software tools; applying these tools in studies of technology issues and/or DOE programmatic applications; and then providing training and guidance in the use of these tools. The overall objective is the establishment of safe and efficient margins of sub-criticality. Planned activities are being performed through five technical subtasks and one program administration subtask. These subtasks, including interim results, which lead to the completion of the two end products (AROBCAD software and guidance), are:

1. Implementation of optimization techniques for establishing bounding values;

2. Investigation of the means to resolve or incorporate anomaly and discrepancy effects into bounding values;

3. Implementation of the use of S/U and statistical methods for identifying experimental needs (i.e., critical or near critical and cross-sections);

4. Development and publication of guidance and provision of education/training for interpolating and extrapolating bounding values;

5. Development and publication of guidance and provision of education/training for establishing bounding margins of subcriticality, and

6. Planning, administration, and reporting.

Preservation of AROBCAD Capability

This work element requires support from two to three full time equivalent (FTE) personnel at Oak Ridge National; Laboratory (ORNL) to perform the five technical subtasks. Methodology resources draw heavily from resident ORNL staff expertise in criticality safety analyses, as well as sensitivity/uncertainty and statistical theories. Additionally, the optimization methodology incorporates and extends work performed by the University of California, Berkeley. The AROBCAD development effort is focused on demonstrating the AROBCAD software tools, evaluating specialized and novel problems, designing differential and integral experiments, and completing the software transition to code maintenance and training (Nuclear Criticality Safety Engineer Training (NCSET) Module) by 2008. The level of effort drops significantly with subtask completion in FY 2007 and FY 2008.

Table 2-1: AROBCAD Budget, Fiscal Years 2005 – 2009 ($k)

| SUBTASK | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 |
|---|---|---|---|---|---|
| AROBCAD | 800 | 800 | 400 | 300 | 300 |

<u>AROBCAD is a Key Element of the NCSP</u>

Along with the other NCSP technical work elements, in conjunction with staff training and qualification, the products of AROBCAD provide validated methods and qualified expertise for performing criticality safety analyses. This is a very exciting development effort because it will allow for extension of existing integral data into areas where little benchmark data exists and provide the criticality safety engineer with a method for quantifying the uncertainty of derived safety margins. In addition, AROBCAD will help illuminate discrepancies in integral and differential data so that scarce research dollars can be focused on the highest priority problems. This activity has the potential to significantly enhance operational safety and efficiency.

<u>AROBCAD Contributions to Operational Criticality Safety</u>

The customers for these activities are all DOE fissionable material operations requiring criticality safety analyses. Generally, these include all operations with more than 700 grams of fissile material, with the exception of those operations in which the aggregation of this material into a critical mass can be shown to be impossible. Additionally, under certain circumstances, criticality safety analyses are required for operations involving fissionable but not fissile material, e. g. Pu-238. DOE fissionable material operations are performed by the various elements of the National Nuclear Security Agency, as well the Offices of Environmental Management (EM), Civilian Radioactive Waste (RW), and Nuclear Energy, Science and Technology (NE).

A good example of the utilization of AROBCAD technology to directly enhance operational criticality safety is the sensitivity/uncertainty studies that are being performed for EM operations at SRS, INEEL, and RL to demonstrate capabilities for improvements in determining safe margins of subcriticality, as well as increased efficiencies in EM operations. More information on this work is contained in Section 10, below. Other potential program specific applications include the NE effort to design and evaluate new reactors and associated fuel-cycle concepts in the Generation-IV Reactor Program, as well as the cooperative effort between DOE and NASA to develop the technical bases for nuclear criticality safety in the application of fission technology in space missions.

National Nuclear Security Agency programs which will ultimately benefit from the utilization of AROBCAD technologies include: 1) the evaluation of data uncertainties in the design of integral experiments that support operational criticality safety, and 2) quantification of data uncertainties in U-238/ weapons-grade MOX disposition so these operations can be conducted efficiently.

## 3. Analytical Methods Development and Code Support

Program Element Description:

This program element provides for the maintenance of redundant, state-of-the-art analytical capability. An essential aspect of this capability is the human expertise required to develop the analytical software, provide software configuration control and assist the user community throughout the DOE complex. In addition to the operational software, stability in this area has served to provide a fertile environment for the cultivation of valuable human capital in this relative arcane discipline. The NCSP has become the mainstay in advancing and maintaining DOE contractor staff expertise in this technical area.

The NCSP methods (codes and processed data) have been utilized in a redundant, corroborative manner, along with the technology provided by the other NCSP program elements, to perform two primary functions:

1. Establish Critical Experiment Benchmarks (MCNP and VIM software along with the ICSBEP, Nuclear Data, and Critical Experiments).

2. Perform Criticality Safety Analyses (SCALE/KENO, MCNP, and software along with established ICSBEP Benchmarks, Validated Nuclear Data, and Critical Experiments and with future utilization of AROBCAD Sensitivity/Uncertainty Methods). These analyses are the primary bases for evaluating criticality safety hazards, and then defining and qualifying criticality safety controls, two activities that enable Integrated Safety Management.

Currently, the work under the Analytical Methods Development and Code Support program element includes seven ongoing subtasks:

Capability maintenance, training and user assistance, and code enhancements are performed on the SCALE/KENO software by ORNL (Lead-Lester Petrie).

Capability maintenance, training and user assistance and code enhancements are performed on the MCNP code and related software by Los Alamos National Laboratory (LANL), with associated management support (Lead-Bob Little).

Capability maintenance, training and user assistance and code enhancements are performed on the VIM code and related software by Argonne National Laboratory (ANL), with associated management support (Lead-Roger Blomquist).

The CSSG is reviewing the features and capabilities of the Monte Carlo criticality codes (KENO, MCNP, VIM) relative to the uniqueness of the LLNL COG code. If the CSSG finds a basis for increasing support for COG, funding in FY05 and beyond for COG maintenance will be adjusted accordingly. (Potential Lead-Dave Heinrichs).

Cross Section Processing Methodology will continue to be supported. (ORNL-Maurice Greene, LANL-Bob MacFarlane, and ANL-Dick McKnight).

The Radiation Safety Information Computational Center (RSICC, Lead-Hamilton Hunter) at ORNL performs the functions of collecting, packaging, and disseminating the software (codes and data libraries).

As Contractor Project Manager, Mike Westfall, assisted by Bob Little, Dick McKnight, and Hamilton Hunter, perform the functions of planning, administration and reporting for this NCSP program element.

Preservation of Analytical Methods Development and Code Support Capability

This program element requires between 0.5 and 2 full time equivalent employees at each of the laboratories to perform the seven ongoing subtasks and maintain capability. In the time frame of FY 2004 through FY 2006, the following major code enhancements are scheduled:

ORNL: Additional continuous-energy kinematics in the CENTRM Discrete-Ordinates Transport Code, Continuous Energy Monte Carlo- validation and implementation into the SCALE System, Three Dimensional Discrete Ordinates with Variable Irregular Mesh, Time and Frequency-Dependent Transport Capabilities.

LANL: Implementation of automatic fission source generation and geometry testing, ICSBEP spectral parameters, and advanced graphics into MCNP; generation of new MCNP cross section libraries based on new (ENDF/B – VI & VII) data, and demonstration of these new capabilities on advanced super computers.

ANL: Develop a graphical user interface for VIM and energy and temperature interpolation of the data and perform upgraded data processing of VIM libraries.

LLNL: Depending on the evaluation and recommendation of the CSSG, demonstrate the Computer-Aided Design (CAD) capability for automated building of Monte Carlo geometry models, and assist the other code communities in incorporating this capability into their codes.

Analytical Methods Development and Code Maintenance Budget

The following activities, listed in priority order, could be accomplished if additional funding is secured in FY 2005:

1. The new 238 group ENDF/B-VI cross section library is nearing completion. The next step in preparation of the library for release is the compilation of a test set of Benchmark critical experiments typical of the materials appearing in current DOE nuclear criticality safety applications. This compilation is estimated to require one-person month ($30k). Then the validation study would be performed and documented. Estimated effort is two person months ($60k).

2. The Pitzer Method has been applied to upgrade the determination of components of uranium solutions in correlations applied in SCALE system material specifications. The analytical chemistry group at ORNL can supplement this capability with additional data for applying this method for plutonium nitric acid solutions and uranium fluoride solutions. The estimated cost is $50k.

3. At LANL, a prototypic capability has been established for the specification of materials as elements and/or as mixtures of elements for input into MCNP analyses. This capability can be tested and put into a production status for approximately $40k.

Table 3-1: Analytical Methods Development and Code Maintenance Budget, Fiscal Years 2005 – 2009

| SUBTASK | FY 2005 ($K) | FY 2006 ($K) | FY 2007 ($K) | FY 2008 ($K) | FY 2009 ($K) |
|---|---|---|---|---|---|
| 1. SCALE/KENO Support | 595 | 625 | 700 | 670 | 670 |
| 2. MCNP Support | 480 | 415 | 500 | 505 | 505 |
| 3. VIM Support | 400 | 375 | 500 | 480 | 480 |
| 4. COG Support | 160 | 110 | 160 | 160 | 160 |
| 5. Cross Section Processing Code Support | 300 | 300 | 300 | 300 | 300 |
| 6. RSICC Support | 240 | 240 | 285 | 285 | 285 |
| 7. Administration | 60 | 80 | 100 | 100 | 100 |
| TOTAL | 2,235 | 2,145 | 2,545 | 2,500 | 2,500 |

<u>Analytical Methods Development and Code Support is a Key Element of the NCSP</u>

This program element is an essential part of the criticality safety infrastructure because the maintenance, user assistance, improvements, and continued support for these codes enables calculations by criticality safety professionals that are necessary to conduct criticality safety analyses that assure the safety of workers and the public.

Analytical Methods Development and Code Support Contributions to Operational Criticality Safety

All DOE fissionable material operations requiring criticality safety analyses benefit from the products of this program element. Generally, these include all DOE fissionable material operations, which are performed by the various elements of the National Nuclear Security Agency (NNSA), as well the offices of Environmental Management (EM), Civilian Radioactive Waste Management (RW), and Nuclear Energy, Science and Technology (NE).

Currently, NCSP technology (Analytical Methods, Nuclear Data, ICSBEP Benchmarks, AROBCAD Sensitivity/Uncertainty Methods, and Critical experiments) are being applied to EM program specific applications at SRS, INEEL, and RL to demonstrate capabilities for improvements in determining safe margins of subcriticality, as well as increased efficiencies in EM operations. The three studies are being performed collaboratively with analytical specialists at the three sites.

Other potential program specific applications include the DOE NE effort to design and evaluate new reactors and associated fuel-cycle concepts in the Generation-IV Reactor Program, as well as the cooperative effort between DOE and NASA to develop the technical bases for nuclear criticality safety in the application of fission technology in space missions.

The Office of Civilian Radioactive Waste Management is benefiting from the qualification of burn-up credit in the design of fissionable waste transportation and storage equipment. Qualification of burn-up credit depends upon validated analytical capabilities for criticality safety evaluations involving the higher actinides, as well as the fission products.

## 4. International Criticality Safety Benchmark Evaluation Project

Program Element Description:

The primary focus of the International Criticality Safety Benchmark Evaluation Project (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 to help fill identified needs, and identify discrepancies between calculations and experiments. This program represents a tremendous capability. It preserves a valuable national asset and provides the United States with access to the global database of experimental benchmarks to validate calculative methods that simulate the neutronic behavior of fissile systems.

Preservation of ICSBEP Capability:

The ICSBEP is a national, as well as an international effort that requires participation from several different DOE Laboratories and Facilities. Base capability is maintained by involving criticality safety experts from the Idaho National Engineering and Environmental Laboratory (INEEL), LANL, LLNL, ANL, ORNL, Savannah River Site Hanford, and Sandia National Laboratories as well as representatives from 16 other countries. The project is managed through the INEEL and requires about 1 FTE for evaluation work at each of the above named sites. Independent reviews, participation by the Russian Federation, spectra data calculations, partial database support, project administration, graphic arts, and publication are also provided primarily by the INEEL and / or INEEL subcontractors.

ICSBEP Budget

Over the next 5 years, for the funding depicted below, the ICSBEP will continue to evaluate and compile (1) Critical Benchmark Data, (2) Criticality-Alarm/Shielding Benchmark Data, (3) Subcritical Benchmark Data, and (4) Relevant Fundamental Physics Measurements. Specific evaluations that are planned for the next 5 years by United States participants are provided in Appendix D. The content and priority of the planned evaluations may change frequently with the changing needs of the criticality safety community. Special requests will also be made of foreign participants and the United States will be expected to respond to special requests from foreign participants.

Table 4-1: ICSBEP Budget, Fiscal Years 2005 – 2009

| SUBTASK | FY 2005 ($K) | FY 2006 ($K) | FY 2007 ($K) | FY 2008 ($K) | FY 2009 ($K) |
|---|---|---|---|---|---|
| 1. INEEL | 779 | 829 | 843 | 859 | 876 |
| 2. Other Participants | 1,121 | 971 | 957 | 941 | 1,024 |
| TOTAL | 1,900 | 1,800 | 1,800 | 1,800 | 1,900 |

The ICSBEP is a Key Part of the NCSP

The objectives of the ICSBEP are to systematically consolidate and preserve the benchmark information base that already exists in the United States and expand it by drawing upon the resources of the international criticality safety community. By meeting these objectives, a large portion of the tedious and redundant research and processing of critical experiment data is eliminated. The necessary step in criticality safety analyses of validating computer codes with benchmark critical data is greatly streamlined, and valuable criticality safety experimental data are preserved. The work of the ICSBEP highlights gaps in data, retrieves lost data, and helps to identify limiting assumptions in cross section processing and neutronics codes and deficiencies in nuclear data.

Coordination / integration with other NCSP program elements is accomplished by including NCSP Program element Leaders (or their designate) from the Analytical Methods Development and Code Maintenance, AROBCAD, Integral Experiments, and

Nuclear Data Program Elements as well as criticality safety practitioners at various DOE facilities as members of the ICSBEP Working Group. Coordination / Integration also takes place through the Nuclear Data Advisory Group. Electronic coordination resources include the NCSP Web Site, maintained by LLNL and the ICSBEP Web Site (http://icsbep.inel.gov/icsbep). Both sites are linked to one another.

ICSBEP Contributions to Operational Criticality Safety

The ICSBEP has one major product: the annual publication of the "International Handbook of Evaluated Criticality Safety Benchmark Experiments". This Handbook has been published annually (typically in September) since the first publication in 1995. Approximately 20 to 25 new evaluations representing 200 to 300 configurations are completed each year. The ICSBEP also collaborates with the Organization for Economic Cooperation and Development - Nuclear Energy Agency (OECD-NEA) in the production, improvement, and maintenance of a database and user interface, DICE, which enables users to more easily identify data that fills their validation needs. DICE is also updated and published annually with the Handbook. Approximately 500 copies of the Handbook are distributed annually.

The ICSBEP Handbook is used extensively by criticality safety practitioners for evaluation of essentially all DOE operations involving fissile material. The data contained in the Handbook have eliminated a large portion of the tedious, redundant research and processing of critical experiment data, and streamlined computer codes validation efforts. Cost savings in terms of time saved during required validation efforts for fissile material operations has been estimated to exceed a million dollars annually. Savings as a result of international participation and contribution of data are of the order of several tens of millions.

## 5. Nuclear Data

Program Element Description

The Nuclear Data Program Element of the NCSP includes the measurement, evaluation and testing of neutron cross section data for nuclides of high importance to nuclear criticality safety analyses. New measurements are performed at the Oak Ridge Electron Linear Accelerator (ORELA) Facility. Evaluation and data testing are performed under the auspices of the DOE-sponsored Cross Section Evaluation Working Group (CSEWG). The low and intermediate energy (eV, keV) evaluations are performed at ORNL with the SAMMY software. The high-energy evaluations (MeV) are performed primarily at LANL with the GNASH software. Cross section processing methods are being maintained and improved and the need for data uncertainty covariance files has been recognized.

The NCSP continues to improve coordination of nuclear data activities by fostering a strong collaborative effort among all of our national resources in this highly technical area. The objective is to solve the highest priority nuclear data problems relevant to criticality safety in a timelier manner. This is being accomplished through the Nuclear Data Advisory Group (NDAG). In addition, the NCSP continues to rely on the deputy director of the National Nuclear Data Center (BNL) for consultation regarding the CSEWG process for review, testing and publication on net differential nuclear data. Progress has been made in addressing the NDAG three-fold mission of identifying data needs, involving the other NCSP work elements in addressing these needs, and shepherding each of the nuclear data tasks to completion.

The Nuclear Data Program Element includes three subtasks:

> ORNL - data measurement, evaluation, testing, evaluation method development, covariance development, and CSEWG and international interactions. As Contractor Project Manager, Mike Westfall (ORNL), assisted by Luiz Leal (ORNL), Bob little (LANL) and Dick McKnight (ANL), perform the functions of planning, administration and reporting for this NCSP Program Element.
>
> LANL - evaluation, testing, evaluation method development, covariance development, and CSEWG and international interactions.
>
> ANL - testing, covariance development, and CSEWG and international interactions.

<u>Preservation of Nuclear Data Capability</u>

For the FY 2004 budget, the Nuclear Data staff included eight FTEs. The six ORNL positions include two experimentalists, one nuclear model code specialist and three evaluators. One FTE at LANL and one FTE at ANL are required for subtasks 2 and 3 and NDAG activities. The ORELA Material/Equipment budget includes experimental costs ($80k-electricity, $100k-target samples & special equipment) and $620 thousand to the ORNL Physics Division for ORELA administration and operation (the DOE Office of Science adds $250k to this fund).

In FY 2004 through FY 2006, there is a one to two FTE base program increase to bring in and mentor young technologists in anticipation of NCSP staff retirements. Two post doc positions have been established at ORNL to mentor nuclear modeling and data evaluation roles. A new NCSP work element was initiated in FY 2004 to develop a stronger basis for neutron fission/capture theory. This will be a multi-Lab effort with ties into the academic community. A graduate-study-level intern position has been developed in the area of data measurements with ORELA. In FY 2004, an effort was initiated to establish understudy positions for the operator/engineer/technician positions on the ORELA staff. At LANL, a staff addition was made involving the lead Japanese specialist in developing covariance files. Substantial progress has been made in re-evaluating the high-energy reaction types (inelastic, elastic, fission, etc) in the uranium isotopes. At ANL, two retirees who are internationally-recognized experts in the fields of resonance modeling and data evaluation are contributing substantial continuing effort. Dick McKnight is performing the NDAG Chairperson role.

Nuclear Data Budget

The following activities, listed in priority order, could be accomplished if additional funding is secured in FY 2005:

1. The Nuclear Data work at ORNL currently includes the generation of cross section uncertainty data, by rough estimation, for the nuclides in the ENDF/B-VI compilation. Restoration of the $125k FY05 funding will support the generation of covariance files for use in sensitivity analyses. This effort will be performed by a junior nuclear data specialist utilizing the PUFF software. The estimated effort is four person months ($125k).

2. Restoration of the $30k FY 2005 Nuclear data funding at LANL would support additional effort in the generation of high-energy neutron cross section uncertainty data to be utilized in the development of covariance files.

Table 5-1: Nuclear Data Budget, Fiscal Years 2005 – 2009

| SUBTASK | FY 2005 ($K) | FY 2006 ($K) | FY 2007 ($K) | FY 2008 ($K) | FY 2009 ($K) |
|---|---|---|---|---|---|
| 1. ORNL | 2,575 | 2,354 | 2,300 | 2,400 | 2,430 |
| 2. LANL | 250 | 200 | 200 | 300 | 330 |
| 3. ANL | 220 | 200 | 200 | 217 | 240 |
| TOTAL | 3,045 | 2,754 | 2,700 | 2,917 | 3,000 |

Nuclear Data are a Key Part of the NCSP

This program element is absolutely essential for the NCSP because it provides the nuclear cross section data that are necessary input for the modeling codes used by all criticality safety practitioners in performing criticality safety analyses.

Nuclear Data Contribution to Operational Criticality Safety

All DOE fissionable material operations requiring criticality safety analyses benefit from the products of this program element. Generally, these include all DOE fissionable material operations, which are performed by the various elements of the NNSA, as well the offices of EM, RW, and NE. In addition to the performance of criticality safety evaluations for all DOE fissionable material operations, the Nuclear Data work element provides improved nuclear data for a variety of DOE program specific applications as delineated in Section 10, below.

For RW, NCSP technical capabilities are being applied in developing better nuclear data to characterize the reactivity worth of spent fuel from DOE reactors. Under the burn-up credit concept, greater operational efficiencies are obtained by relaxing the fresh-fuel assumption and taking credit for the reduced reactivity worth of the spent fuel. However, to provide the technical basis for the reduced reactivity, better nuclear data evaluations are required for the higher actinides (Np, Am, Cm, etc.) and the major, long-lived fission products. NCSP technology will be applied in new data measurements and evaluations.

Other potential program specific applications include the DOE NE effort to design and evaluate the new reactor and associated fuel-cycle concepts in the Generation-IV Reactor Program. Nuclear data needs for these advanced reactor designs are being compiled.

## 3. Integral Experiments

Program Element Description

The Integral Experiments program element of the NCSP maintains a fundamental capability for the DOE/NNSA to be able to perform critical measurements, and within the limits of is resources, to address specific site needs on a prioritized basis. This program element also supports maintaining a fundamental nuclear materials handling capability by providing support for the hands-on nuclear criticality safety training programs at the Los Alamos Critical Experiments Facility (LACEF). In addition, and beyond the scope of the NCSP, infrastructure maintained by the Integral Experiments program element also supports specific program requirements in the stockpile stewardship program, emergency response and counter terrorism program, the non-proliferation and arms control program, and the space nuclear propulsion program.

Preservation of Integral Experiments Capability

Personnel, equipment, facilities, and nuclear materials are the key elements required to maintain this capability. LACEF currently employs approximately eight full time staff (a few of which are supported with facility funding) with an additional five to ten staff providing part time support. The NCSP program provides funding for approximately five full-time personnel, which is considered the bare minimum to maintain the current level of capability. LACEF is the last operational general-purpose critical experiments facility in the United States.

The philosophy of the NCSP is to maintain capability by doing meaningful work. For an experiment to meet the definition of meaningful work, it either needs to be listed in LA-UR-99-2083, or meet an emergent need. (LA-UR-99-2083 contains the results of the1998 review of LA-12683, *Forecast of Criticality Experiments and Experimental Programs Needed to Support Nuclear Operations In The United States of America: 1994 - 1999*, originally published in July, 1994). Although, the principal goal of the Integral Experiments program element is to maintain capability, there are specific deliverables associated with each proposed experiment. Appendix D lists the associated ICSBEP evaluation deliverables that LANL is committing to provide. Some of these evaluations depend on experiments that may be postponed due to the relocation of LACEF activities.

The Critical Experiments Facility (CEF) Project has been initiated to relocate LACEF activities to the Device Assembly Facility (DAF) at the Nevada Test Site and is sponsored by Defense Programs. It received an Approval of Alternative and Cost Range (Critical Decision 1) memorandum on June 14, 2004 and is scheduled for completion in late 2009. Funding for the CEF Project (current range is $125M to $148M) is provided through a Congressional Line Item construction account.

As the CEF project prepares the DAF to accommodate LACEF activities, interim operations will be conducted at LANL and the DAF to maintain the capability to conduct integral experiments and hands-on training. Appendix F lists the integral experiments that are planned for fiscal years 2005 through 2009. The number of experiments has been substantially reduced during the planned relocation of LACEF activities to the DAF. The reduction in number of planned experiments derives from applying some program resources to the mission relocation project and the unavailability of certain critical assemblies in the interim. The NCSP manager is working with the LACEF staff to maintain a limited integral experiments capability while TA-18 is transitioned to DAF. The NCSP is committed to make this transition as smooth as possible.

Transition of critical experiments and training capability from LACEF to the DAF will proceed according to the following plan: In FY2005, the NCSP plans to conduct critical experiments listed in Appendix F and support four training courses using Planet and SHEBA at LANL. NNSA will terminate all critical assembly operations at LACEF (except SHEBA) in the Summer of FY 2005 and ship Plant and Comet to DAF. SHEBA will remain operational at TA-18 throughout the transition to DAF. In parallel, the capability to do sub-critical measurements at DAF will be established in FY 2005. The NCSP will initiate safety basis activities in FY 2005 to operate Planet and Comet in a DAF building that is not involved in the CEF construction. It is anticipated that these assemblies will be operational at DAF no later than July 2006. If this plan is successful, critical assembly operations (with metal special nuclear material) will experience only about a one-year hiatus. The NCSP will fund the installation and operation of the Planet and Comet critical assemblies for interim operations at DAF out of program funds and will coordinate operations with the CEF Project to assure construction activities are not adversely impacted. From FY 2006 through FY 2009, the NCSP will conduct the critical and subcritical experiments listed in Appendix F at the DAF and will conduct four hands-on training courses per year. Each of these training courses will be conducted using facilities at LANL and DAF. Transition of integral experiments and hands-on training activities to the DAF will be completed by FY 2010.

Regarding SHEBA, the preferred alternative is to relocate SHEBA to a location near the DAF. Design of the new SHEBA will begin in FY 2005 and pending the outcome of an environmental assessment, construction of the new SHEBA could begin as early as FY 2007. This activity is being accomplished outside the CEF Project. Once the new SHEBA is operational, the old SHEBA at LANL will be decommissioned.

In addition to the planned integral experiments, a collaborative effort between LANL and ORNL to perform subcritical measurements continues. These subcritical measurements will be performed at the DAF and will be evaluated and submitted to the ICSBEP. Together with existing critical measurements, these subcritical measurements will help solidify the methodology for making and evaluating these types of measurements and will provide excellent data to the criticality safety community.

Table 6-1: Integral Experiments Budget, Fiscal Years 2005 – 2009

| SUBTASK | FY 2005 ($K) | FY 2006 ($K) | FY 2007 ($K) | FY 2008 ($K) | FY 2009 ($K) |
|---|---|---|---|---|---|
| Integral Experiments | 1,451 | 1,580 | 1,782 | 1,782 | 1,886 |

Integral Experiments are a Key Part of the NCSP

The Integral Experiments Program Element of the NCSP interfaces at some level with all of the NCSP program elements, but its primary contact is with the hands-on training and ICSBEP activities. The Nuclear Data Advisory Group works with the Experimental Needs Identification Working Group, which is part of the Integral Experiments program element, to establish the basic list of experimental needs and place some priority on the experiments to be performed.

Integral Experiments Contribution to Operational Criticality Safety

Unquestionably, the greatest contribution to operational criticality safety provided by the integral experiments element is hands-on training for both fissionable material handlers and criticality safety professionals. Between 50 to 80 people attend this training on an annual basis.

In addition to training, the primary contribution of this program element to operational criticality safety is the ability to establish or estimate the calculative bias in computer codes when performing criticality safety evaluations. This is essential to effectively implement an appropriate level of conservatism in the operational criticality safety controls and is one of the key requirements of American National Standards Institute (ANSI) / American Nuclear Society (ANS) Standard 8.1.

By maintaining an operating integral experiments program, DOE is also in a position to respond quickly to site-specific questions as criticality safety branches into non-traditional areas such as long-term geological waste storage and remediation of legacy materials. A credible integral experiments program, including the publication of scientific results and benchmarks, is essential to maintain expertise and the capability to properly address operational nuclear criticality safety issues associated with the conduct of current DOE programs.

## 4. Information Preservation and Dissemination

Program Element Description

The Information Preservation and Dissemination Program Element of the NCSP was established to preserve primary documentation supporting criticality safety and to make this information available for the benefit of the technical community. There are two major sub elements within this program element:

1. The Criticality Safety Information Resource Center (CSIRC), which is tasked with collecting and preserving documents directly related to critical experiments and criticality safety as well as generating new documents such as the revised criticality accident report and the Heritage video series; and

2. The NCSP World Wide Web Internet site, which is the central focal point for access to criticality safety information collected under the NCSP sub element, and the gateway to a comprehensive set of hyperlinks to others sites containing criticality safety information resources.

Preservation of Information Preservation and Dissemination Capability

The pace of some of CSIRC work has significant urgency. As the pioneers and original experimenters dwindle in numbers and the memories of those remaining fade, irrecoverable losses occur. Thus, the allocation of funds to support the review of logbooks by original experimenters, where practical, and the videotaping of pioneers narrating the historical evolution of what have become accepted practices and in many cases regulatory norms will be given priority. This activity requires approximately one half of a FTE per year and is centered at LANL. Specific ongoing activities include videotaping of pioneers and original experimenters and editing/distributing the resultant videotapes, indexing scanned logbooks and papers to allow for electronic searches, updating various criticality safety information data bases and website interfaces maintained by the NCSP.

An important part of information preservation and dissemination is updating, correcting, and maintaining criticality safety handbooks. Atlantic Richfield Hanford (ARH)-600, an extensively used criticality safety handbook requires revision, correction, and reissue as an electronic handbook. Detailed activities under this task include identification of sections that need close review, correction of any inconsistencies, recalculation of graphic presentation with validated analysis codes, and presentation of information in electronic form for improved retrieval and presentation. Activities in FY 2004 included structuring the task, selection of validation tools, creation of the electronic version framework and processing the most urgently needed test cases. Additional needed revision of ARH-600 will continue during the out-years at a level commensurate with available funds.

The NCSP web site serves as the principal means for the DOE Nuclear Criticality Safety Program to disseminate information electronically to the entire criticality safety community. The main goal of the web site is to provide a forum for the timely distribution of information concerning the NCSP and other information of general interest to the criticality safety community. Extensive use is made of hyper links to other DOE web sites to point the user at the original data source to ensure accuracy and access to the most up-to-date information. This website is the result of the efforts contributed by many members of the criticality safety community and is maintained for the NCSP by the Lawrence Livermore National Laboratory (LLNL).

The NCSP web site has the following features:

1. Links to all major nuclear criticality safety web sites;
2. Training modules and key reference materials to assist the criticality safety practitioners;
3. Contact information to locate criticality safety practitioners at other sites;
4. Information on computational methods with links to computer code centers;
5. Two compendia of the criticality safety literature references with search engines;
6. An information posting service and interactive question and answer forum available to the criticality safety community; and
7. The latest NCSP 5-Year Plan

The NCSP web site utilizes a dedicated Sun Ultra 10 workstation with 10 Mb/s connection speed to the Internet. The web site is equipped with security software to protect against unauthorized intrusions. The server is physically located in a room with double locked doors for access control. Computer science professionals maintain the software in accordance with DOE requirements and LLNL policy.

From time to time, new development work is planned to enhance the web site. Specific improvements are formulated in response to input from the user community and implemented under the direction of the CSSG and the NCSP management team. For the coming fiscal years, the following activities are planned:

1. Continue to enhance the web site cascade menu style to facilitate website navigation;
2. Continue to enhance the navigational buttons using pop-up description boxes to reduce website clutter and improve clarity;
3. Setup Internet Mail Lists (i.e. Majordomo service) for NCSP management to send out NCS related announcements by email;
4. Create and maintain NCSP CSCT Infraction/Reporting database and trending analysis capabilities;
5. Procure new web server hardware and software to replace existing older hardware to prevent catastrophic failure;
6. Create online training with multi-media streaming capabilities;
7. Provide dedicated search capability of the relevant DOE regulations; and Standards related to NCS.

The NCSP web site is currently maintained at a modest level of effort that corresponds to only about one-third of a full time equivalent individual.

Table 7-1: Information Preservation and Dissemination Budget, Fiscal Years 2005 – 2009

| SUBTASK | FY 2005 ($K) | FY 2006 ($K) | FY 2007 ($K) | FY 2008 ($K) | FY 2009 ($K) |
|---|---|---|---|---|---|
| 1. CSIRC | 50 | 50 | 50 | 50 | 50 |
| 2. Hanford Data Base and ARH 600 | 85 | 90 | 90 | 90 | 90 |
| 3. Web Site | 130 | 130 | 130 | 130 | 130 |
| TOTAL | 265 | 270 | 270 | 270 | 270 |

<u>Information Preservation and Dissemination Activities are a Key Part of the NCSP</u>

Mining the stockpile of experimental data before it is lost is extremely important. Recreation of many of these experiments in the current regulatory environment would be cost prohibitive. The CSIRC activities have already preserved data that has been documented as part of the ICSBEP and there is no reason to think that this will not continue. At a cost of ~$300K and up for a single critical experiment, it makes sense to strive to make use of all existing data.

It is important to the DOE that criticality safety information and data are distributed to the criticality safety community audience as rapidly as possible. The development of the NCSP web site was in response to that need. With user-friendly tools to access and search the internet, a central web site to coordinate information at numerous DOE criticality safety sites offers great advantage in the dissemination of criticality safety information to a wide audience. The NCSP web site is designed not to duplicate the information held at other sites, but only to present the web site users with a structured set of links to those sites. This avoids duplication and maintenance of superceded versions of documents, and leads the users, whenever possible, to the original source of the information. By maintaining close communication with the CSSG and End-users, the NCSP web site manager is able to post NCS-related items in a timely manner. The web site also provides a set of resources beneficial to criticality safety engineers who are both experienced practitioners as well as newcomers to this field. A user of the web site can obtain various technical references through the LLNL and/or the Hanford bibliographical databases; gain access to the computer code centers; obtain basic criticality safety training through various training modules; and, ask questions and obtain technical assistance through the message board available at the web site.

Information preservation and Dissemination Contribution to Operational Criticality Safety

The CSIRC program is very important to operational criticality safety because its activities preserve logbooks, literature, and other information that form a criticality safety body of knowledge that has been accumulating for over 50 years. This body of knowledge is routinely accessed by criticality safety engineers to support development of their safety bases for fissionable material operations and to enrich the criticality safety culture.

It is important for the operational criticality safety community to have a centralized web site where criticality safety engineers can access and obtain information relevant to criticality safety and to have a forum to ask any question and obtain expert assistance. It is also very important for criticality safety practitioners to be able to access the information related to current status of the DOE NCSP in a timely manner. Listed below are some of the statistics of web site usage, which clearly demonstrate the importance of this web site to operational criticality safety programs.

1. More than two hundred and forty five registered users.
2. Average access rate is 22 hits/day.
3. The NCSP web site has 7,965 bibliographic entries in the Livermore database and 4,331 entries in the Hanford database.
4. The NCSP web site contains eleven training modules which have been downloaded over 2,022 times in the last nine months.
5. Over 22,456 total visitors have accessed the NCSP web site since its inception in 1998.

## 8. Training and Qualification

Program Element Description

The Training and Qualification program element has two subtasks:

1. Continue to offer hands-on training courses at LANL as needed by DOE; and
2. Identify training needs and develop new resources in areas where no suitable materials exist.

The goal of this program element is to maintain the technical capabilities of criticality safety professionals and provide for the training and qualification of people entering the criticality safety discipline from related scientific fields.

Preserving Training and Qualification Capability

As experienced criticality safety practitioners leave the field, there are fewer opportunities for entry-level staff to participate in long-term mentor programs to gain first-hand knowledge of practical criticality safety. Also, the number of experimental facilities where criticality safety experts can gain first-hand knowledge about the behavior of systems at or near the critical state has been drastically reduced. Both hands-on and classroom training are essential to maintaining the level of expertise needed to function as a criticality safety engineer. The Training and Qualification program element of the NCSP addresses these requirements by:

1) providing hands-on training courses where students actively participate in approach-to-critical experiments and see first-hand the effects of material interactions on the reactivity of various configurations;

2) identifying training resources, promoting the development of new training materials to supplement existing curricula and working with other organizations to quickly respond to training needs as new programs apply criticality safety to areas requiring new information.

The funding for hands-on training at Los Alamos represents a subsidy for a base level of courses consisting of 3 Three-Day Courses, 1 Five-Day Basic Course, and 1 Five-Day Advanced Course. Partial cost recovery is achieved through collection of tuition from each student ($600 for a three-day course and $1000 for a five-day course). Although needs are currently projected to be relatively flat, additional courses can be added in the out-years to accommodate additional needs should they arise. The NCSP management is working with the LACEF and LANL criticality safety staffs to maintain hands-on training while TA-18 is transitioned to DAF. Course content and material will require modification to accommodate limited availability of special nuclear materials, however, it is envisioned that fundamental demonstrations and training activities can still be accomplished. The NCSP is committed to make this transition as smooth as possible.

In the area of training development, Nuclear Criticality Safety Engineer Training (NCSET) modules will continue to be developed at a rate of one to two modules per year based on needs expressed by the criticality safety community. For example, in FY 2005, based on input from the criticality safety community, the NCSP is funding the development of a tutorial on Non Destructive Analysis for criticality safety engineers. This tutorial will be presented at the ANS Winter Meeting in Washington, D.C. and also placed on the NCSP web site as an NCSET module.

Table 8-1: Training and Qualification Budget, Fiscal Years 2005 – 2009

| SUBTASK | FY 2005 ($K) | FY 2006 ($K) | FY 2007 ($K) | FY 2008 ($K) | FY 2009 ($K) |
|---|---|---|---|---|---|
| 1. Hands-on Training at LANL | 150 | 140 | 140 | 180 | 180 |
| 2. Training Development | 50 | 50 | 50 | 50 | 50 |
| TOTAL | 200 | 190 | 190 | 230 | 230 |

Training and Qualification Activities are a Key Part of the NCSP

The benefits to the DOE from having comprehensive criticality safety programs with well-trained staff members are significant. One benefit is an immediate increase in the efficiency of operations involving fissile materials. When doing evaluations to support the handling, storage and transportation of fissile materials, a well-trained staff will know the proper analysis techniques to use for a given situation. Above all, the proper training will instill the correct philosophy of criticality safety that will allow the practitioner to know what factors are important to criticality safety and how to develop the proper controls without being overly conservative to the point of restricting operations with no added safety benefits.

Contribution to Operational Criticality Safety

Proper training in all aspects of criticality safety is essential to safe operations. Through the hands-on training and the NCSET modules, criticality safety professionals learn that a thorough understanding of both the basic principles of criticality safety and the specific details of operations is necessary, and that interfacing with facility management, as well as the operators is fundamental to safe operations. This training is beneficial to all persons who either manage criticality safety programs or whose job functions include criticality safety responsibilities.

## 9. Criticality Safety Support Group Activities

The Criticality Safety Support Group (CSSG) is comprised of recognized criticality safety experts from DOE offices and contractor organizations (see Appendix A for CSSG members). The primary function of the CSSG is to provide operational and technical expertise to the Nuclear Criticality Safety Program Manager, who has the responsibility for the implementation and execution of the coherent, efficient criticality safety program that is responsive to the criticality safety needs of DOE missions. The CSSG is also tasked to provide the NCSP manager with technical reviews of orders, standards, rules and guides issued by DOE related to criticality safety. In its support role, the CSSG also responds to requests from the NCSP Manager for information, technical reviews, and evaluations of criticality safety issues throughout the complex. Another important activity that the CSSG is pursuing is a strategy for assuring criticality safety infrastructural critical skill needs are being met. In FY 2004, the CSSG identified three young individuals who are being mentored and brought into the CSSG. Their names are contained in Appendix A with the CSSG roster. Also in FY 2004, the CSSG began providing technical assistance to site offices. These technical assistance visits are expected to continue at a rate of about two per year. Finally, the CSSG continues to provide important input for the annual report to the Defense Nuclear Facilities Safety Board on NCSP activities and effectiveness.

## 10. Program Specific Applications

Integral Experiments

The Threat Response Operations Office uses Godiva for benchmarking and code development with an investment of $225K in FY05. The weapons program at LANL uses Godiva about 10 times per year and pay as they go. This involves measuring emissions and developing radiochemistry techniques. This will probably continue in FY05 for a total of about $50K. The weapons program also plans to fund some experiments on Flat Top, amounting to perhaps $10K in FY05. NASA is interested in benchmark experiments for their proposed space reactor to power the Jupiter Icy Moons Orbiter. If this is supported, it could provide as much as $300K in FY05. The United States Nuclear Regulatory Commission has expressed interest in conducting critical experiments with the MOX fuel rods. However, to date, no firm commitment exists.

ICSBEP

Program specific application is typically merged with the annual ICSBEP Working Group Meeting or publication schedule. When necessary, extra effort is made to advance program specific application through the independent review process and make the unofficial information available to the customer prior to formal publication. This information is subject to revision after the international review and approval process is completed. The following activities have been proposed and will be accomplished if the additional funding, delineated below, is provided:

1. A collaborative effort between LANL and LLNL has been proposed to evaluate the LLNL pulsed sphere experiments. This work is also funded by NNSA. The first evaluation is scheduled for completion by FY 2005 and others will be completed over the next several years. Re-evaluation of these measurements will provide data that are needed for code and neutron cross section validation.

2. ICSBEP participation of scientists from up to 5 weapons related institutes in the Russian Federation has been proposed to NNSA's office of Nuclear Non-Proliferation (NN) at a cost of $300K per year. Scientists from the Russian Federation joined the ICSBEP in 1994 and are the second largest contributor; however the level of their participation has declined significantly since 1997 because of lack of funding. Inclusion

of these scientists in the ICSBEP naturally supports the DOE Office of Nuclear Nonproliferation mission in that it provides meaningful safety related work for former weapons scientists from Russia and Kazakhstan. In addition, DOE receives high quality criticality safety related data and the expertise developed in the Russian Federation.

3. Sandia National Laboratory, working under Nuclear Energy Research Initiative Project 99-0200, "Experimental Investigation of Burnup Credit for Safe Transport, Storage, and Disposal of Spent Nuclear Fuel", was able to complete an experiment with water-moderated U(4.31)O2 fuel rod lattices containing the fission product rhodium. Evaluation of this experiment could not be completed in time for the 2004 ICSBEP Meeting; however, the ICSBEP is prepared to work through the independent review as soon as the completed evaluation is submitted. A second experiment involving water-moderated square-pitched U(6.93)O2 fuel rod lattices is planned for 2005 contingent upon NE funding.

4. Continued analysis of existing data on Light Water Breeder Reactor (LWBR) Cores with $^{233}$U and thorium has been proposed by INEEL. This work is important because there are significant amounts of thorium in the $^{233}$U fuels stored at the INEEL; however, there are very little $^{233}$U and thorium data available. Completion of this work is contingent upon EM funding.

AROBCAD

DOE customers are benefiting from NCSP capabilities by providing additional funding. The following tasks, with their associated deliverables, have been funded by the Office of Environmental Management (EM-5):

1. Delivery of a prototypical SCALE sequence with uncertainty analysis capability using the Generalized Linear Least Squares Method (GLLSM): Completed in June 2004 ($150K).
2. Training on AROBCAD tools has been performed for the SRS staff, for the INEEL and the Hanford criticality safety operational groups it is scheduled to be completed by October 2004 ($125K).
3. Three SRS, INEEL and Hanford AROBCAD studies (guidance, practical training examples, and sample cases) have been interactively defined & developed during FY 2003 and FY 2004; $50K/study x 3 studies = $150K.

In addition to the support from EM, a National Aeronautics and Space Administration (NASA) effort to utilize the AROBCAD tools in evaluating methods and nuclear data for establishing the criticality safety aspects of space nuclear power reactor concepts was performed in FY 2003 at a funding level of $225K. The follow-on work in FY 2004 involved the qualification of these tools, including the design of pertinent critical experiments, now being performed at TA-18. This work is a cooperative effort between NASA and DOE NE-50.

An additional activity that is utilizing the AROBCAD technology to evaluate and qualify MOX critical experiments is being performed for NA-263, the Office of International Technology. Consideration is being given to funding a series of MOX experiments at the IPPE, Obninsk critical experiments facility to support NCS evaluations for the design of plutonium disposition facilities in the US and in Russia.

Analytical Methods Development and Code Maintenance

Modest levels of supplemental funding have assisted in expediting the completion of nuclear criticality safety related software. The following tasks with their associated deliverables were funded by EM-5 beginning in June, 2003, with additional funding of $300K in January, 2004

1. Release of SCALE 5.0: Public release in June, 2004 ($300K).
2. Completion of the production version of AMPX and preparation of the AMPX/ Evaluated Nuclear Data File, ENDF/B-VI Reference Library: The 238 group library will be released in FY 2004. AMPX release is anticipated in FY 2005. A subtask involves modifying the PUFF covariance-file software for consistency with current formats on cross-section uncertainties. ($150K).

Nuclear Data

An additional $300K from EM-5 has been provided to fund the development of covariance files for nuclides of high importance in EM fissionable material operations. This effort is being made on an incremental basis with recommendations made by the NDAG after reviewing results of special studies on EM applications. The initial effort addresses the isotopes of gadolinium. Additional covariance files are being developed for those nuclides that were recently measured and evaluated under this program: oxygen, chlorine, silicon, aluminum, and fluorine.

In FY 2004, the Office of Radioactive Waste Management initiated a program at ORNL to evaluate and improve nuclear data for the key fission products being considered for utilizing burn-up credit in the qualification of spent fuel shipping containers for the Yucca Mountain Project. This effort promises to be a significant sponsorship area for both data measurements and evaluation.

## Appendix A

## Points of Contact for the Seven Technical NCSP Elements and CSSG Members

### NCSP Program Element Points of Contact

### AROBCAD


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**Training and Qualification**

| | |
|---|---|
| Contractor Project Managers: | Hands-On Training<br>Shean Monahan<br>Los Alamos National Laboratory<br>P.O. Box 1663, MS F691<br>Los Alamos, NM 87545<br>Telephone: 505-667-7628<br>Facsimile: 505-665-4970<br>E-Mail: spm@lanl.gov |
| | Training Development<br>Jim Morman<br>Argonne National Laboratory<br>9700 S. Cass Ave.<br>Argonne, IL 60439<br>Telephone: 630-252-6076<br>Facsimile: 630-252-4500<br>E-Mail: jamorman@anl.gov |
| Federal Qualification Program Manager | Jerry McKamy<br>U.S. Department of Energy<br>EH-24<br>1000 Independence Ave., SW<br>Washington, DC 20585<br>Telephone: 301-903-8031<br>Facsimile: 301-903-4120<br>E-Mail: jerry.mckamy@eh.doe.gov |

**CSSG Members**

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|---|---|---|
| Adolf S. Garcia | 208-526-4420 | garciaas@id.doe.gov |
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| Thomas P. McLaughlin | 505-667-7628 | tpm@lanl.gov |
| James A. Morman | 630-252-6076 | jamorman@anl.gov |

| | | |
|---|---|---|
| Thomas A. Reilly | 803-208-0801 | thomas.reilly@srs.gov |
| Robert M. Westfall | 423-574-5267 | rwe@ornl.gov |
| Robert E. Wilson | 303-966-9681 | robert.wilson@rf.doe.gov |
| Hans Toffer | 509-376-5230 | hans_toffer@rl.gov |
| Ivon Fergus | 301-903-6364 | ivon.Fergus@oa.doe.gov |

**New CSSG Candidates**

| | | |
|---|---|---|
| Fitz Trumble | 803-502-9615 | fitz.trumble@wsms.com |
| David Erickson | 509-376-4146 | david.erickson@fluor.com |
| Dave Heinrichs | 925-424-5679 | heinrichs1@llnl.gov |
| Shean Monahan | 505-665-7567 | spm@lanl.gov |

## Appendix B

**Work Authorization Statements for Nuclear Criticality Safety Program Funding for Execution Year (FY 2005) Provided to NA-11 Budget Office in September 2004.**

**Tasks: Nuclear Data, Analytical Methods Development and Code Maintenance, Applicable Ranges of Bounding Curves and Data, and Criticality Safety Support Group**
Oak Ridge National Laboratory (ORNL): $4,670K

Funds are provided to ORNL to conduct Criticality Safety related nuclear data acquisition, evaluation, testing, and publication; to maintain Criticality Safety Codes, including associated cross section processing codes; to continue Criticality Safety related code distribution and user support through RSICC; and to conduct the Applicable Ranges of Bounding Curves and Data (AROBCAD) Program, in accordance with the schedule and milestones set forth in the Nuclear Criticality Safety Program Five-Year Plan, dated October 2004, or as directed by the Nuclear Criticality Safety Program Manager. Funds are also provided to ORNL for CSSG technical support to the Nuclear Criticality Safety Program (NCSP) Manager regarding planning and execution of the NCSP. With approval of the NCSP Manager, the CSSG may also provide technical assistance to other DOE and DOE Contractor organizations. Quarterly reports on the status of all tasks shall be provided to the Nuclear Criticality Safety Program Manager at the end of each fiscal calendar quarter.

ORNL POC: Mike Westfall (865-574-5267) and Calvin Hopper (865-576-8617)
DOE POC: Mike Thompson, NNSA (301-903-5648)

**Task: International Criticality Safety Benchmark Evaluation Project**
Idaho National Engineering and Environmental Laboratory (INEEL): $1,900K

Funds are provided to the INEEL to conduct the International Criticality Safety Benchmark Evaluation Project (ICSBEP) as delineated in the Nuclear Criticality Safety Program Five-Year Plan, dated October 2004, or as directed by the Nuclear Criticality Safety Program Manager. Quarterly reports on the status of all tasks shall be provided to the Nuclear Criticality Safety Program Manager at the end of each fiscal calendar quarter.

INEEL POC: Blair Briggs (208-526-7628)
DOE-ID POC: Adolf Garcia (208-526-4420)
DOE POC: Mike Thompson, NNSA (301-903-5648)

**Task: Integral Experiments, Hands-On Training, Criticality Safety Information Resource Center, Analytical Methods Development and Code Maintenance, Nuclear Data Support, and Non-Destructive Analysis Training Development**
Los Alamos National Laboratory (LANL): $2,770K

Conduct nuclear criticality integral experiments, hands-on criticality safety training, Criticality Safety Information Resource Center activities, MCNP support, Nuclear Data support and non-destructive analysis training development as delineated in the Nuclear Criticality Safety Program Five-Year Plan, dated October 2004, or as directed by the Nuclear Criticality Safety Program Manager. Re-validate experiment priorities based on input from the criticality safety community and publish an updated Nuclear Criticality Experiments Priority list by July 2005. Quarterly reports on the status of all tasks shall be provided to the Nuclear Criticality Safety Program Manager at the end of each fiscal calendar quarter.

LANL POC: David Loaiza (505-667-4936), Shean Monahan (505-665-7567), Robert Little (505-665-3487), and Doug Reilly (505-664-0103)
DOE POC: Mike Thompson, NNSA (301-903-5648)

**Task: Analytical Methods Development and Code Maintenance, Nuclear Data Support, Training Development, and Criticality Safety Support Group**
Argonne National Laboratory (ANL): $755K

Funds are provided to ANL to continue VIM support, including associated cross section processing codes, and Nuclear Data support as delineated in the Nuclear Criticality Safety Program (NCSP) Five-Year Plan, dated October 2004, or as directed by the Nuclear Criticality Safety Program Manager. Funds are also provided to continue development of Nuclear Criticality Safety Engineer Training materials and for Criticality Safety Support Group (CSSG) technical support to the NCSP Manager regarding planning and execution of the NCSP. With approval of the NCSP Manager, the CSSG may also provide technical assistance to other DOE and DOE Contractor organizations. Quarterly reports on the status of all tasks shall be provided to the Nuclear Criticality Safety Program Manager at the end of each fiscal calendar quarter.

ANL POC: Richard McKnight (630-252-6088) and Jim Morman (630-252-6076)
DOE POC: Mike Thompson, NNSA (301-903-5648)

**Task: Nuclear Criticality Safety Web Site and COG Maintenance**
Lawrence Livermore National Laboratory (LLNL): $290K

Funds are provided to LLNL to maintain the DOE Nuclear Criticality Safety Web Site and to maintain COG, including associated cross section processing codes as delineated in the Nuclear Criticality Safety Program Five-Year Plan, dated October 2004, or as directed by the Nuclear Criticality Safety Program Manager. Quarterly reports on the status of all tasks shall be provided to the Nuclear Criticality Safety Program Manager at the end of each fiscal calendar quarter.

LLNL POC: Song Huang (925-422-6516)
DOE POC: Mike Thompson, NNSA (301-903-5648)

**Task: Criticality Safety Support Group**
Westinghouse Safety Management Solutions (WSMS): $25K

Funds are provided to WSMS for Criticality Safety Support Group (CSSG) technical support to the Nuclear Criticality Safety Program (NCSP) Manager regarding planning and execution of the NCSP. With approval of the NCSP Manager, the CSSG may also provide technical assistance to other DOE and DOE Contractor organizations.

WSMS POC: Tom Reilly (803-952-3562)
DOE POC: Mike Thompson, NNSA (301-903-5648)

**Task: Validation and Reissue of ARH-600, Updating of the Hanford Data Base, and Criticality Safety Support Group (CSSG) support**
Fluor Hanford: $115K

Funds are provided to Fluor Hanford for validation and reissue ARH-600, updating of the Hanford Data Base, and CSSG technical support to the Nuclear Criticality Safety Program (NCSP) Manager regarding planning and execution of the NCSP. With approval of the NCSP Manager, the CSSG may also provide technical assistance to other DOE and DOE Contractor organizations. Quarterly reports on the status of all tasks shall be provided to the Nuclear Criticality Safety Program Manager at the end of each fiscal calendar quarter.

Fluor Hanford POC: Hans Toffer (509-376-5230)
DOE POC: Mike Thompson, NNSA (301-903-5648)

**Task: Criticality Safety Support Group**
Brookhaven National Laboratory (BNL): $100K

Funds are provided to BNL for technical consultation to the Criticality Safety Support Group regarding all aspects of nuclear data relevant to criticality safety. Support will include shepherding new data evaluations through the Cross Section Evaluation Working Group process and subsequent publication of these data in the United States Evaluated Nuclear Data File. Quarterly reports on the status of all tasks shall be provided to the Nuclear Criticality Safety Program Manager at the end of each fiscal calendar quarter.

BNL POC: Charles Dunford (631-344-2804)
DOE POC: Mike Thompson, NNSA (301-903-5648)

## Appendix C

### Summary of Cost Recovery Activities

This section remains a work in progress. Aside from tuition charged for students who attend the hands-on training at Los Alamos, and funded program specific applications as described in Section 10, above, there is general agreement among CSSG and NCSP Task Managers that few additional cost recovery opportunities exist. However, some areas are still being evaluated. For example, the CSSG is developing policy for setting reasonable rates for time they spend reviewing and rendering opinions on issues of interest to DOE Field customers.

For the record, Los Alamos hands-on training tuition collection (at a rate of $200/day/student) should bring in anywhere from $42k to $57k in FY 2005 depending on enrollment.

**Appendix D**

**International Criticality Safety Benchmark Evaluation Project Planned Benchmarks**

| ICSBEP FIVE-YEAR PLAN | |
|---|---|
| **ARGONNE NATIONAL LABORATORY** | |
| ***IDENTIFIER*** | ***DRAFT TITLE*** |
| ***FY-2005*** | |
| HEU-COMP-FAST-005 | ZPPR-20 Phase C: Space Reactor Mockup with Water Immersion Simulation |
| HEU-COMP-FAST-006 | ZPPR-20 Phase E: Space Reactor Mockup with Earth Burial Simulation |
| HEU-COMP-FAST-007 | ZPPR-20 Phase C: Space Reactor Mockup Reference Core |
| HEU-COMP-FAST-004 | ZPR-3 Assembly 14: A Clean HEU (93% $^{235}$U) Carbide Core Reflected by Depleted Uranium |
| IEU-MET-FAST-011 | ZPR6-1 All Aluminum - 14% Enriched |
| IEU-MET-FAST-015 | ZPR-3 Assembly 6F: A Clean Cylindrical Core with a $^{235}$U-to-$^{238}$U Ratio of 1, Reflected by Depleted Uranium |
| MIX-COMP-FAST-002 | ZPR-9 Assembly 29: Normal and Flooded Configurations of Mixed (Pu/U)-fueled GCFR Assembly |
| ***FY-2006*** | |
| PU-COMP-FAST-003 | ZPR-9 Assembly 31: The Plutonium Carbide Benchmark Assembly Reflected by Depleted Uranium |
| IEU-COMP-FAST-003 | ZPR-6 Assembly 5: A Large, Clean, Cylindrical Uranium Carbide Benchmark Assembly Reflected by Depleted Uranium |
| IEU-COMP-FAST-004 | ZPR-3 Assembly 12: A Large, Clean, Cylindrical Uranium (21% $^{235}$U)Carbide Bench`mark Assembly Reflected by Depleted Uranium |
| ***FY-2007*** | |
| PU-COMP-FAST-004 | ZPR-3 Assembly 48: A Clean Cylindrical Pu Carbide Core, Reflected by Depleted Uranium |
| IEU-COMP-FAST-005 | ZPR-3 Assembly 11: A Large, Clean, Cylindrical Uranium (12% $^{235}$U) Carbide Benchmark Assembly Reflected by Depleted Uranium |
| IEU-COMP-FAST-006 | ZPR-3 Assembly 25:A Large, Clean, Cylindrical Uranium (9% $^{235}$U) Carbide Benchmark Assembly Reflected by Depleted Uranium |
| ***FY-2008*** | |
| | To Be Determined |
| ***FY-2009*** | |

| | |
|---|---|
| | To Be Determined |
| ***FY-2010*** | |
| | To Be Determined |

| **ICSBEP FIVE-YEAR PLAN** | |
|---|---|
| **FLOUR HANFORD / PNNL** | |
| ***IDENTIFIER*** | ***DRAFT TITLE*** |
| ***FY-2005*** | |
| SUB-LEU-MET-THERM-001 | Subcritical Spent Fuel for LEU Metal Tubular Fuel |
| SUB-MIX-COMP-THERM-001 | Subcritical Waste Drums Measurements |
| ***FY-2006*** | |
| LEU-COMP-THERM-072 | Max $k_\infty$ for $UO_3$ in Water for 1.0 $^w/o$ $^{235}U$ Enrichment |
| LEU-COMP-THERM-073 | Max $k_\infty$ for UNH for 2.1 $^w/o$ $^{235}U$ Enrichment |
| ***FY-2007*** | |
| HEU-MET-THERM-023 | Uranium, Chromium, Water Mixtures - Measurements Needed |
| HEU-MET-THERM-024 | Uranium, Cerium, Water Mixtures - Measurements Needed |
| ***FY-2008*** | |
| SUB-LEU-MET-THERM-002 | Subcritical 2.1 $^w/o$ Enriched Uranium Rods in Water Intermixed with Cd |
| SUB-LEU-MET-THERM-003 | Subcritical LEU Metal Rods in Water for 3.0 w/o $^{235}U$ Enrichment |
| ***FY-2009*** | |
| SUB-LEU-MET-THERM-004 | Subcritical LEU Metal Tubes in Water with 1.25 $^w/o$ $^{235}U$ Enrichment |
| SUB-LEU-MET-THERM-005 | Subcritical LEU Metal Tubes in Water with 0.95 w/o $^{235}U$ Enrichment |
| ***FY-2010*** | |
| PU-COMP-THERM-003 | PCTR Graphite Moderated Pu-Al Fuel Rods |
| PU-MET-THERM-005 | PRTR Plutonium Rods in Water |
| PU-MET-THERM-006 | PRTR Pu Rods in Water and $PuO_2$ / MgO |
| HEU-COMP-THERM-020 | Uranium Carbide Experiments |
| LEU-MET-THERM-013 | Graphite Moderated, Air-Cooled 305 Test Pile |
| LEU-MET-THERM-014 | PCTR U-Th Supercells in Graphite Moderator |
| LEU-MET-THERM-011 | HCTLTR Experiments |
| LEU-MET-THERM-012 | PCTR Experiments with Graphite and LEU |
| LEU-MET-THERM-010 | PCTR Experiments - Graphite Mod. 2.1 w/o Enriched LEU with Li Targets |
| LEU-COMP-THERM-074 | Max $k_\infty$ for $UF_4$ Paraffin for 2.0 $^w/o$ $^{235}U$ Enrichment |
| SUB-LEU-MET-THERM-006 | Subcritical LEU Metal Tube-Rod in Water |
| SUB-LEU-MET-THERM-007 | Subcritical 1.44 w/o Enriched LEU Tubes in Water |
| MIX-COMP-FAST-004 | FFTF Fuel Approach to Critical in Liquid Na Critical |

| | |
|---|---|
| MIX-COMP-FAST-005 | FFTF Core Demonstration Experiment |
| MIX-COMP-THERM-017 | FFTF Fuel Criticals in Water |

| ICSBEP FIVE-YEAR PLAN | |
|---|---|
| **IDAHO NATIONAL ENGINEERING AND ENVIONMENTAL LABORATORY** | |
| IDENTIFIER | ***DRAFT TITLE*** |
| ***FY-2005*** | |
| HEU-SOL-THERM-050 | Unreflected Aluminum Cylindrical Vessels Containing Concentrated $UO_2F_2$ Solutions |
| HEU-MET-THERM-022 | Advance Test Reactor – Water Moderated High Enriched Uranium Metal Serpentine Core of Plate-Type Fuel Assemblies Reflected by Beryllium |
| MIX-SOL-THERM-008 | U + Pu Nitrate Solution in a Raschig-ring-filled Tank |
| ***FY-2006*** | |
| HEU-COMP-THERM-019 | Critical Experiments with BORAX-V Superheater Fuel Assemblies |
| IEU-COMP-THERM-006 | Critical Experiments with BORAX-V Boiling and Superheater Fuel Assemblies |
| MIX-SOL-THERM-009 | Nitrate Solutions of Depleted Uranium and Plutonium (6% $^{240}$Pu) in a Water Reflected Cylindrical Tank Filled with Borated-Glass Raschig Rings |
| U233-COMP-THERM-002 | LWBR $^{233}UO_2$-$ThO_2$ Detailed Cell Experiments -- Work For Others |
| U233-COMP-THERM-003 | LWBR $^{233}UO_2$-$ThO_2$ BMU Experiments -- Work For Others |
| ***FY-2007*** | |
| PU-MET-FAST-042 | Plutonium Hemishells in Oil - Part II |
| PU-MET-FAST-043 | Plutonium Hemishells in Oil - Part III |
| MIX-MISC-THERM-005 | $UO_2$ + $PuO_2$ Fuel Pins in U + Pu Nitrate Solution Containing Boron and Gadolinium |
| ***FY-2008*** | |
| HEU-SOL-THERM-026 | Aqueous Solutions of $^{235}$U Poisoned With Raschig Rings |
| IEU-COMP-THERM-007 | Power Burst Facility – Water Moderated 18.5% Enriched Uranium Ternary Oxide Fuel Pin Lattice |
| | Others To Be Determined |
| ***FY-2009*** | |
| LEU-COMP-THERM-071 | Loss of Fluid Test Reactor – Water Moderated Array of 4% Enriched Uranium PWR Fuel Assemblies |
| | Others To Be Determined |
| ***FY-2010*** | |
| | To Be Determined |
| | |

| ICSBEP FIVE-YEAR PLAN | |
|---|---|
| **LOS ALAMOS NATIONAL LABORATORY** | |
| ***IDENTIFIER*** | ***DRAFT TITLE*** |
| ***FY-2005*** | |
| HEU-MET-INTER-010 | Z007/Z008 ZEUS (HEU) Intermediate Energy Spectrum with Aluminum (Al) |
| HEU-MET-INTER-011 | SM1, Special Moderator HEU/Graphite |
| HEU-MET-THERM-015 | P007/P008, Planet Waste Matrix HEU-Fe (2x2 array) 15-mil thick iron plates |
| MIX-MET-FAST-013 | P011, Bare Pu($\alpha$) / HEU |
| SPEC-MET-FAST-011 | NP004, Neptunium/HEU Reflected with Poly |
| SUB-SPEC-MET-FAST-001 | SUB2, Bare and HEU Reflected $^{237}$Np Spheres |
| ***FY-2006*** | |
| PU-MET-FAST-038 | BRP Ball Experiments Pu/Be |
| HEU-MET-INTER-009 | ZEUS (HEU) Intermediate Energy Spectrum with Ni-Cr-Mo-Gd Alloy |
| HEU-MET-INTER-012 | SM2 Special Moderator HEU/$D_2O$ |
| HEU-MET-THERM-019 | PO13, Waste Matrices HEU / Zr / Poly (1x1) |
| SPEC-MET-FAST-010 | NP003, Neptunium/HEU/Be Reflected |
| ***FY-2007*** | |
| PU-MET-INTER-003 | SM4/SM6, Pu Reflected with Graphite and Beryllium |
| HEU-MET-INTER-013 | Z013/Z014, ZEUS (HEU) Intermediate Energy Spectrum with $SiO_2$ |
| HEU-MET-INTER-014 | SM3, HEU Reflected by Beryllium |
| HEU-MET-THERM-020 | P016, HEU / Concrete / Poly (2x2) |
| HEU-MET-THERM-021 | P017/P018, HEU / $Al_2O_3$ / Poly (1x1 and 2x2) |
| SPEC-MET-FAST-009 | NP001/NP002 Neptunium/HEU Critical (natural uranium reflected) |
| ***FY-2008*** | |
| PU-MET-INTER-004 | SM5, Pu Reflected with $D_2O$ |
| PU-MET-THERM-002 | P022, Pu / Si / Poly (2x2) |
| PU-MET-THERM-003 | P023, Pu / Al / Poly |
| MIX-MET-FAST-014 | P019, Pu($\delta$) /HEU |
| SPEC-MET-FAST-012 | NP006, Neptunium Reflected with Tungsten |
| SPEC-MET-FAST-013 | NP005, Neptunium/HEU Reflected with Beryllium |
| ***FY-2009*** | |
| PU-MET-THERM-004 | P024 / P025, Pu / MnO / Poly (1x1 and 2x2) |
| | *Others May Include the Following Existing Experiments* |
| SPEC-MET-FAST-005 | Replacement Measurements Performed with Am-241 |
| SPEC-MET-FAST-006 | Replacement Measurements Performed with Am-243 |
| | |
| | |
| ***FY-2010*** | |
| | To Be Determined |
| | |
| | |

| ICSBEP FIVE-YEAR PLAN | |
|---|---|
| **LAWRENCE LIVERMORE NATIONAL LABORATORY** | |
| ***IDENTIFIER*** | ***DRAFT TITLE*** |
| ***FY-2005*** | |
| PU-SOL-THERM-019 (Joint IRSN/LLNL) | Proserpine Experiments: Part I. Aqueous Plutonium Solutions Reflected by Beryllium Oxide and Graphite |
| HEU-MET-FAST-059 Rev 1 | SPADE Experiments: Part II. BeO Moderated Oy with Interstitial Materials |
| HEU-SOL-THERM-046 (Joint IRSN/LLNL) | Proserpine Experiments: Part II. Aqueous Uranium Solutions Reflected by Beryllium Oxide and Graphite |
| Neutron-Time-of-Flight | LLNL Pulsed Spheres: Part I. Plutonium (Luisa Hansen) |
| ***FY-2006*** | |
| IEU-COMP-MIXED-001 | U(30.14)O2 & Paraffin Wax: H/X=8. 16.3, 39.5, & 81.6 (35 Configurations) |
| IEU-MET-FAST-016 | U(37.5) -- 0.125 Al Metal Parallelepipeds (13 Configurations) |
| IEU-SOL-THERM-002 | British Spheres: U(30.45)$O_2F_2$ Aqueous Solutions Systems |
| Neutron-Time-of-Flight | LLNL Pulsed Spheres: Part II. Beryllium. |
| ***FY-2007*** | |
| IEU-SOL-THERM-003 | British 8",12" and 16" Cylinders: U(30.45)$O_2F_2$ Aqueous Solutions Systems |
| TBD | Nimbus: Part II. *Requires help with declassification of original materials. |
| Neutron-Time-of-Flight | LLNL Pulsed Spheres: Part III. TBD |
| ***FY-2008*** | |
| HEU-MET-FAST-056 | Graphite – Oy – D2O System (C/U: 500 – 35000) |
| Neutron Transmission | LLNL (Bramblett & Czirr) $^{235}$U and $^{239}$Pu Plate Transmission Measurements |
| ***FY-2009*** | |
| | To Be Determined |
| | |
| ***FY-2010*** | |
| | To Be Determined |
| | |

| ICSBEP FIVE-YEAR PLAN | |
|---|---|
| **OAK RIDGE NATIONAL LABORATORY** | |
| ***IDENTIFIER*** | ***DRAFT TITLE*** |
| ***FY-2005*** | |
| PU-SOL-THERM-018 | Cooperative Analysis of Pu-Gd Solution With WSMS, EM Work For Others |
| LEU-COMP-THERM-068 | Plexiglas, Concrete, and Steel-reflected U(4.46)3O8 with H/U=1.25 |
| LEU-COMP-THERM-069 | Plexiglas and Concrete-Reflected U(4.46)3O8 with H/U=2.05 |
| LEU-MET-THERM-007 | Libby Johnson U(4.89) Metal Rods in Water or Uranyl Fluoride Solution |
| U233-COMP-THERM-004 | Bettis U233-Th Lattice Physics Experiments, Judd Hardy, et.al. |
| U233-SOL-THERM-016 | Bare and Water-Reflected Solutions of $^{233}$UO2(NO3)2 in Cylinders-Parkey |
| ***FY-2006*** | |
| IEU-MET-THERM-001 | Cronin U(37.5) Metal Experiments, Recently Unclassified |
| IEU-SOL-THERM-006 | Cronin UF4-CF2 from 0.2 to 37.5% U-235 (ORNL-2968) |
| LEU-COMP-THERM-067 | Cronin Sterotex U(4.89) Blocks, H/U from 0 to 37, ORNL-2986 |
| LEU-MET-THERM-008 | Libby Johnson U(4.89) Metal Rods, Various Interstitial Absorbers |
| | |
| ***FY-2007*** | |
| SUB-HEU-MET-THERM-001 | Research Reactor Fuel Assemblies (MURR fuel) |
| SUB-HEU-SOL-THERM-002 | WINCO Slab Tanks with HEU Uranyl Nitrate Solution |
| U233-MET-INTER-001 | Critical Measurements on the $^{233}$U ZPPR Plates in the LANL ZEUS Assembly |
| MIX-COMP-INTER-004 | Cooperative Analysis of $^{238}$U MOX Experiment with LANL |
| ***FY-2008*** | |
| HEU-SOL-THERM-048 | HEU Uranyl Fluoride Solution (82 g U/l) in Slab Arrays (ORNL/CF-56-7-148) |
| LEU-MET-THERM-009 | Libby Johnson U(3.85) Annular Metal Billets (7.62 cm OD) |
| ***FY-2009*** | |
| | |
| | |
| ***FY-2010*** | |
| | Critical assemblies pertinent to reactor design & fuel cycle materials processing associated with the Generation-IV reactor concepts for nuclear energy generation, the advanced high temperature reactor concepts for hydrogen production and the space applications of nuclear energy. In this historical period, critical experiments pertinent to these applications were performed in Oak Ridge and elsewhere. |

| ICSBEP FIVE-YEAR PLAN | |
|---|---|
| **RPI** | |
| IDENTIFIER | ***DRAFT TITLE*** |
| ***FY-2005*** | |
| LEU-COMP-THERM-078 | Water-reflected 4.82% Enriched Uranium Dioxide Fuel Pins |
| ***FY-2006*** | |
| | |
| | |
| ***FY-2007*** | |
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| ***FY-2008*** | |
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| ***FY-2009*** | |
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| ICSBEP FIVE-YEAR PLAN | |
|---|---|
| **SANDIA NATIONAL LABORATORIES** | |
| IDENTIFIER | ***DRAFT TITLE*** |
| ***FY-2005*** | |
| LEU-COMP-THERM-079 | Water-Moderated $U(4.31)O_2$ Fuel Rod Lattices Containing the Fission Product Rhodium |
| LEU-COMP-THERM-080 | Water-Moderated Square-Pitched $U(6.93)O_2$ Fuel Rod Lattices |
| ***FY-2006*** | |
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| ***FY-2007*** | |
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| ***FY-2008*** | |
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| | |
| ***FY-2009*** | |
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| ICSBEP FIVE-YEAR PLAN | |
|---|---|
| **SAVANNAH RIVER (WASHINGTON SAFETY MANAGEMENT SOLUTIONS, LLC)** | |
| ***IDENTIFIER*** | ***DRAFT TITLE*** |
| ***FY-2005*** | |
| PU-MET-FAST-044 | Pu Metal Sphere with Different Metal+Polyethylene Reflectors (Table IIIA2 of LA-30067-MS) |
| HEU-COMP-INTER-007 | HEU/Be Space Reactor |
| MIX-COMP-FAST-003 | Reflected Polystyrene Moderated, Mixed Oxide Cubes |
| MIX-COMP-THERM-015 | Reflected Polystyrene Moderated, Mixed Oxide Cubes with Fixed Poisons (SS, Borated SS, dep-U, Boral, Cd, Pb) |
| ***FY-2006*** | |
| SUB-HEU-MET-THERM-002 | Subcritical (Exponential) SRS Fuel Assemblies (Mk XVIB and Mk XIIA)[UCNI] |
| SUB-LEU-MET-THERM-008 | Subcritical (Exponential) SRS Fuel Assemblies (Mk V and Mk 15) 0.95 to 1.1% Enriched |
| | |
| ***FY-2007*** | |
| SUB-PU-MET-THERM-001 | Arrays of Pu-Al alloy rods in H2O [UCNI] |
| | Others TBD |
| | |
| | |
| ***FY-2008*** | |
| | To Be Determined |
| | |
| ***FY-2009*** | |
| | To Be Determined |
| | |

**Appendix E**

**Nuclear Data Schedule**

Organization Key: A=ANL, B=BNL, L=LANL, N=NDAG, O=ORNL

Isotope Key: U5=U-235, U3=U233, O6=O-16, Al=Al-27, Si8=Si-28, Si9=Si-29, Si0=Si-30, Cl5=Cl-35, Cl7=Cl-37, F9= F-19, K9=K-39, K1=K-41, Gd5=Gd-155, Gd7=Gd-157, H=H, N4=N-14, Be9=Be-9, U8=U-238, Mn5=Mn-55, Pu9=Pu-239, Pu0=Pu-240, Pu1=Pu-241, Nd=Nd-143, Rh=Rh-103, Sm9=Sm-149, Pu2=Pu-242, Re5=Re-185, Re7=Re-187, Fe, Ni, Cr, Cu, Ce, Ca, Sm1=Sm-151, Cs=Cs-133, Xe1=Xe-131

| Activity | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 |
|---|---|---|---|---|---|
| NDAG Review , (Data Needs and Status) | Fe, Ni, Cr, Cu, Ce, Ca, Hf, Zr, Th, Nb, Er, Am, Np, N4, Be9, | Cs, Eu, Ag, Sm1,Sm9,Nd, Rh, Ru, Tc, Ti, Mo, Xe1, | He, P, S, V,Hg | TBD | TBD |
| Measurement | Mn5(O), Re5, Re7, Nb | Rh, Cs, Nd, Xe1, Sm1, Sm9 | TBD | TBD | TBD |
| Evaluation | K9, K1, Mn5, Re5, Re7, Nb, (O,L,A), ? | Rh, Cs, Nd, Xe1, Sm1, Sm9 | TBD | TBD | TBD |
| Covariance Generation (New Evaluation & Retroactive) | F9(O,L), K9, K1(O,L,A), B, C, N4, Li6, Li7, Na, Mg, Ga, Pb, Re5, Re7, Nb | Fe, Ni, Cr, Cu, Ce, Ca, Hf, Er, Th, Rh, Cs, Nd, Xe1, Sm1, Sm9 ,(O, L, A) | Am, Np, Mn5, (O, L, A) | TBD | TBD |
| Beta Test Libraries (RSICC) | Pu9, Pu0, Pu1, Pu2, Gd5,Gd6, Gd7,Gd8, U8, Zr (O,N) | F9, K9, K1, Re5, Re7, Nb, N4,(O, N), Hf, Er, Th, Cu, Ce, Ca, Mn5, | Rh, Cs, Nd, Xe1, Sm1, Sm9 | TBD | TBD |
| CSEWG Testing | Cl5(B), Cl7(B), U8, Zr | F9, K9, K1, Pu9,Pu0,Pu1,Pu2, Gd5,Gd6,Gd7,Gd 8,N4,Be9, Fe, Ni, Cr, Mn5(B) | Re5,Re7,N b, Cu, Ce, Ca, (B) | TBD | TBD |
| ENDF/B Release | Si8, Si9 Si0, Cl5, Cl7, U8, Zr,(B) | F9, K9, K1, Mn5,Gd5, Gd6,Gd7,Gd8, Ni, Fe, Cr (B) | N4, Be9, Pu9,Pu0, Pu1,Pu2, (B) | Cu, Ce, Ca, (B), | TBD |

Isotopes subject to changes in programmatic needs. TBD = To Be Determined

## Appendix F

## Planned Integral Experiments

Integral Experiments Planned for FY 2005 through FY 2009

| FY 2005 ($k)<br>1600 | FY 2006[(a)] ($k)<br>1800 | FY 2007[(a)] ($k)<br>1900 | FY 2008[(a)] ($k)<br>2000 | FY2009[(a)] ($k)<br>2000 |
|---|---|---|---|---|
| NASA Experiment Nb/HEU | Np007 HEU BARE (Planet) | NP006 Np/HEU/NU (Planet) | P029 HEU Reflected Poly (Planet) | SM5 Pu(δ) $D_2O$ Reflected (Comet) |
| NASA Experiment Re/HEU | SM1 HEU/Graphite (Comet) | P028 HEU Reflected W (Comet) | P030 HEU Reflected Steel (Comet) | P031 HEU Reflected Be (Planet) |
| | | Z008 Comet Zeus Al[2]/HEU/Al[2] | SM2 HEU/$D_2O$ (Comet) | P017 1x1 HEU/CaO/Poly (comet) |
| | | | | |
| | | SUB3 Np/HEU Reflected W | SUB5 HEU/Poly | SUB5 HEU NU Reflected |
| | SUB2 Np/HEU Reflected by Cu | SUB4 Pu Reflected Poly | SUB6 HEU Bare | SUB6 Np/HEU Reflected Be |
| SHEBA $UO_2F_2$ Ops for NCSC | SHEBA $UO_2F_2$ Burst Mode | SHEBA $UO_2(NO_3)_2$ | SHEBA $UO_2(NO_3)_2$ | SHEBA $UO_2(NO_3)_2$ |

[(a)]Experiments to be performed at DAF.

Completed
Initiated/ongoing
Experiments that will require material not currently available at LANL.
Additional capital funding will be required.
Superscript numbers[1,2,3] indicate first, second, and third configurations respectively. Actual configurations are unknown at this time.

## Appendix G

## Foreign Travel Requests

<u>Applicable Ranges of Bounding Curves and Data</u>

The AROBCAD Program Element will require one attendee at the annual OECD/NEA Nuclear Criticality Safety Working Group on Bounding Critical Systems meeting on an annual basis. Additionally, between two and three technical presentations from this work element (S/U software tools, S/U studies, guidance on safe margins) will be made at the ICNC conducted in FY 2008, requiring attendance of two to three individuals. The AROBCAD Contractor Program Manager serves as the Convener of ISO TC-85, SC-5, WG-8, and as such requires one foreign trip per year. This is the writing group for the development of international standards for nuclear criticality safety and the NCSP supports his participation and leadership of the annual WG-8 meetings. The work program for these standards includes a number of nuclear criticality safety topics in which the NCSP supplies subject matter experts (fission yield estimates, Mixed Oxide Fuel (MOX) Processing, Criticality Accident Alarm System qualification, etc.). WG-8 meetings will require one foreign trip per year for one to two United States subject matter experts and will assure the inclusion of the United States expertise in the development of these important standards.

<u>Analytical Methods Development and Code Maintenance</u>

The Analytical Methods Development and Code Maintenance Program Element will require four attendees at the annual OECD/NEA Nuclear Criticality Safety Working Group meetings. From the three Labs, this includes two United States Representatives to the Nuclear Criticality Safety Working Party and membership on the Fission-Source Convergence, Criticality Excursions Analysis, and Experimental Needs Working Groups. Additionally, between four and six technical presentations (improved neutronics software, improved cross-section processing software, methods validation) from this work element would be made at the ICNC conducted in FY 2008, requiring attendance of four to six individuals.

<u>International Criticality Safety Benchmark Evaluation Project</u>

The ICSBEP is an international program involving 16 different countries and the OECD NEA. As such, annual project Working Group meetings are held outside the United States every other year. Approximately 15 - 20 participants from the United States (including Working Group Members, evaluators, independent reviewers, and administrative support) are required to travel to these meetings. ICSBEP Meetings to be held outside the United States during the next five years will occur in 2006, 2008, and 2010. In addition, the ICSBEP Element should support one attendee at the OECD/NEA Working Party on Nuclear Criticality Safety meeting on an annual basis where a report on ICSBEP activities is made. Additionally, between four and six technical presentations from this work element should be made at the ICNC 2007 in St. Petersburg, Russia.

Periodically, data are identified in nonparticipating countries and these countries are invited to contribute their data.  In some cases, an information/training meeting in the new participating country is deemed appropriate.  For example, China was invited to participate in 2004 and a meeting was held in Beijing.  Other current nonparticipating countries that may contribute data in the future include Germany, Canada, Poland, Czech Republic, Australia, South Africa, Argentina, and Italy.

Nuclear Data

The Nuclear Data Program Element will require three attendees at the annual OECD/NEA Working Party on Evaluation and Cooperation meetings on an annual basis. This is the major activity involving international cooperation on the development and evaluation of nuclear data.  Also, there is a need for two to three nuclear data presentations at the International Conferences on Nuclear Criticality in FY 2008, requiring attendance of two to three individuals.  The international forum for presentations on nuclear data is the annual series of PHYSOR reactor physics meetings. This Program Element supports participation at PHYSOR by two nuclear data specialists on an annual basis.  Again, these are three laboratory activities.

Integral Experiments

The Integral Experiments Program Element will require about 5 foreign trips per year for the next five years.  Annual requirements include 2 persons to the ICNC in FY 2008; 2 persons every other year to the ICSBEP meeting; 1 person per year to a technical conference on integral experiments; and 1 person per year to participate in International Standards Development activities.

Information Preservation and Dissemination

The Web Site portion of this Program Element projects 1 person traveling to the 8th ICNC in FY 2008.

Training and Qualification

No projected foreign travel.