INL/EXT-16-38686
Revision 0

The Nuclear Energy Knowledge and Validation Center Summary of Activities Conducted in FY15

May 2016

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ABSTRACT

The Nuclear Energy Knowledge and Validation Center (NEKVaC) was initiated in fiscal year (FY) 2015 by the Department of Energy (DOE) and Idaho National Laboratory to coordinate and focus the resources and expertise that exist with the DOE toward solving issues in modern nuclear code validation. In time, code owners, users, and developers will view the NEKVaC as a partner and an essential resource for acquiring the best practices and latest techniques for validating codes, providing guidance in planning and executing experiments, facilitating access to and maximizing the usefulness of existing data, and preserving knowledge for continual use by nuclear professionals and organizations for their own validation needs.

The proposed mission of the NEKVaC covers many interrelated activities that will need to be cultivated carefully in the near-term and managed properly once the NEKVaC is fully functional. Three areas comprise the principal mission: (1) identify and prioritize projects that extend the field of validation science and its application to modern codes, (2) adapt or develop best practices and guidelines for high-fidelity multiphysics/multiscale analysis code development and associated experiment design, and (3) define protocols for data acquisition and knowledge preservation and provide a portal for access to databases currently scattered among numerous organizations.

This report summarizes the planning activities that were conducted in FY 15. The activities described herein were identified not only as having high potential for near-term success in demonstrating NEKVaC objectives, but also to resolve some of the issues in task execution, provide communication between functional elements to avoid “stove-piping,” and raise awareness of the NEKVaC and its mission. Lessons learned in conducting these tasks will help to grow the program in an effective manner and optimize the use of DOE resources.

CONTENTS

FIGURES

ACRONYMS

ANL	Argonne National Laboratory
ANS	American Nuclear Society
APEX	Advanced Plant Experiment
ART	Advanced Reactor Technologies
ASME	American Society of Mechanical Engineers
CASL	Consortium for Advanced Simulation of Light Water Reactor
CCTF	Cylindrical Core Test Facility
DOE	Department of Energy
EBR2	Experimental Breeder Reactor-II
FY	fiscal year
ICSBEP	International Criticality Safety Benchmark Evaluation Project
INL	Idaho National Laboratory
IRP	Integrated Research Project
IRPhEP	International Rector Physics Experiment Evaluation Project
LBLOCA	large break loss of coolant accident
LOFT	loss of fluid test
LWRS	Light Water Reactor Sustainability
MPEBV	MultiPhysics Experiments Benchmarking and Validation
MPO	memorandum purchase order
NDMAS	NGNP Data Management and Analysis System
NEAMS	Nuclear Energy Advanced Modeling and Simulation
NE-KAMS	Nuclear Energy Knowledge base for Advanced Modeling and Simulation
NEKVaC	Nuclear Energy Knowledge and Validation Center
NEUP	Nuclear Energy University Programs
NGNP	Next Generation Nuclear Plant
NRC	Nuclear Regulatory Commission
OECD-NEA	Nuclear Energy Agency of the Organization for Economic Cooperation and Development
ORNL	Oak Ridge National Laboratory
PI	principal investigator
PICS-NE	Program Information Collection System: Nuclear Energy
PWR	pressurized water reactor
RSICC	Radiation Safety Information Computational Center
SCTF	Slab Core Test Facility
THORS	thermal-hydraulic out-of pile-reactor safety

The Nuclear Energy Knowledge and Validation Center Summary of Activities Conducted in FY15

1. INTRODUCTION

1.1 The NEKVAC Mission

The Nuclear Energy Knowledge and Validation Center (NEKVaC) is a new initiative by the Department of Energy (DOE) and Idaho National Laboratory (INL) to coordinate and focus the resources and expertise that exist with the DOE toward solving issues in modern nuclear code validation. In time, code owners, users, and developers will view the NEKVaC as a partner and essential resource for acquiring the best practices and latest techniques for validating codes, providing guidance in planning and executing experiments, facilitating access to and maximizing the usefulness of existing data, and preserving knowledge for continual use by nuclear professionals and organizations for their own validation needs.

The scope of the NEKVaC covers many interrelated activities that will need to be cultivated carefully in the near-term and managed properly once the NEKVaC is fully functional. Three areas comprise the principal mission: (1) identify and prioritize projects that extend the field of validation science and its application to modern codes, (2) adapt or develop best practices and guidelines for high-fidelity multiphysics/multiscale analysis code development and associated experiment design, and (3) define protocols for data acquisition and knowledge preservation and provide a portal for access to databases currently scattered among numerous organizations. These mission areas, while each having a unique focus, are interdependent and complementary. Likewise, all activities supported by the NEKVaC, both near-term and long-term, must possess elements supporting all three areas. This cross-cutting nature is essential to ensuring that activities and supporting personnel do not become "stove-piped" (i.e., focused a specific function that the activity itself becomes the objective rather than achieving the larger vision).

Achieving the broader vision will require a healthy and accountable level of activity in each of the areas. This will take time and significant DOE support. Growing too fast (budget-wise) will not allow ideas to mature, lessons to be learned, and taxpayer money to be spent responsibly. The process should be initiated with a small set of tasks, executed over a short but reasonable term, that will exercise most if not all aspects of the NEKVaC's potential operation. The initial activities described in this report have a high potential for near-term success in demonstrating NEKVaC objectives but also to work out some of the issues in task execution, communication between functional elements, and the ability to raise awareness of the NEKVaC and cement stakeholder buy-in.

This report begins with a description of the mission areas; specifically, the role played by each major committee and the types of activities for which they are responsible. It then lists and describes the proposed near-term tasks upon which future efforts can build.

1.2 NEKVAC and NE Programs

The Nuclear Energy Advanced Modeling and Simulation (NEAMS), Consortium for Advanced Simulation of Light Water Reactor (CASL), and Light Water Reactor Sustainability (LWRS) programs have successfully demonstrated the power of their tools to simulate complex behavior. The NEAMS Toolkit includes a wide range of nuclear fuel, material, radiation transport, fluid, and structural dynamics. Understandably, the early years of the program emphasized the development and integration of the codes in the toolkit. As the tools are being applied to more practical problems (with a look toward predictability and licensing support), the need to validate these complex models is becoming more obvious. NEAMS and CASL personnel have expressed the desire to take on this challenge with specialized support from NEKVaC.

2. MISSION AREAS AND STRUCTURE

Extensive discussions with stakeholders in fiscal year (FY) 2015 led to the following organizational structure. The names of the functional units and the membership are still not finalized, but the general responsibilities have been defined. The proposed structure of the NEKVaC organization reflects the three mission areas as illustrated in Figure 1.

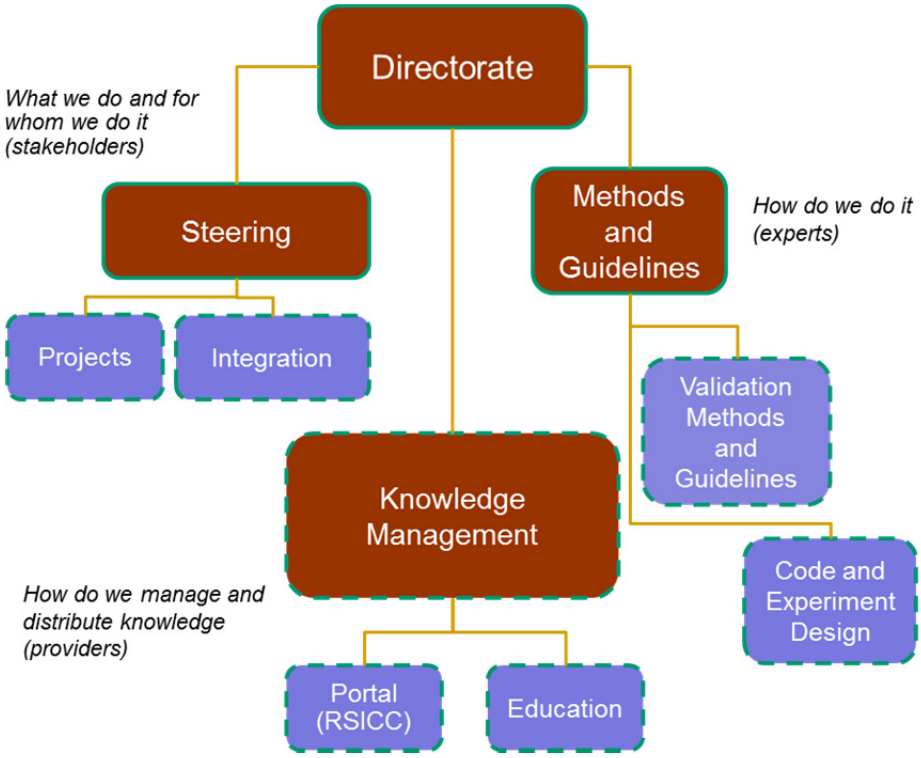


Figure 1. NEKVaC organizational structure.

2.1 Directorate

The Interim "directorate" consists of a director, the committee chairpersons (who also serve as deputy directors), and support staff responsible for the execution of NEKVaC tasks. The director is responsible for staffing, performing, and proposing and implementing policies. The director shall also be responsible for preparing a budget and the NEKVaC Program Plan based upon input from the committees and DOE. The directorate will coordinate NEKVaC activities with international and university programs. The NEKVaC program will adhere to all applicable INL standards and policies.

2.2 Steering

The Steering Committee is responsible for the selection and prioritization of individual research projects sponsored by NEKVaC.

This group of experts is well-suited to establish a vision for the NEKVaC, select near-term activities that serve the mission, and to identify long-term needs and priorities in cooperation with DOE-NE program personnel. Proposed research may be motivated by, and support, ongoing DOE programs but must demonstrate broad application to the nuclear community.

The Steering Committee shall consist of high-level representatives of different DOE-NE programs as well as representatives of the NRC, academic, and industry. It will meet at least twice per year to evaluate the progress of sponsored projects and recommend changes in policy or funding priorities.

2.3 Methods and Guidelines

Techniques for validating fuel performance, computational fluid dynamics, structural dynamics, and, in general, high-fidelity multiphysics analysis codes and models have not kept up with the complexity of those tools. Moreover, the data needed to validate these models may be beyond the capabilities of current facilities. However, advanced validation and experimental techniques are being developed and applied in other fields. *The Methods and Guidelines Committee is responsible for identifying gaps and deficiencies in current nuclear analysis code validation, recommending new approaches, and developing and disseminating guidelines and best practices in modern code validation.*

The Methods Committee shall gather the latest techniques and tools in code validation and assess their applicability to codes and models used by stakeholders. If applicability is uncertain, the Methods Committee will propose one or more research projects to be funded directly or through other DOE programs. Dissemination of new techniques for either testing or direct application can be a significant educational effort. Regular interaction between the Steering and Knowledge Management Committees is essential.

Benchmarks are an effective tool for assessing the uncertainty and sensitivity in code predictions. The Nuclear Energy Agency of the Organisation for Economic Cooperation and Development (OECD) has developed very effective protocols for conducting reactor physics benchmark evaluations. The DOE supports such efforts (notably, the International Rector Physics Experiment Evaluation Project [IRPhEP] and the International Criticality Safety Benchmark Evaluation Project [ICSBEP]) and may relegate programmatic responsibility for these activities to NEKVaC where they will be monitored and evaluated along with the other projects sponsored by the program. It will be the responsibility of the Methods and Guidelines Committee to examine the practices developed for these projects and adapt them for use in other areas (thermal fluids, fuels performance, structural dynamics, and the coupling thereof).

Broader adoption of new validation techniques is facilitated by *standards*. Standards are generally developed by relevant professional organizations such as American Society of Mechanical Engineers (ASME) and American Nuclear Society (ANS). While the Methods and Guidelines team will not be responsible for writing new standards, they will be actively engaged with those organizations that do; thus, the team may devote a significant amount of time to such efforts (such as ASME V&V30 Committee participation).

Experiment design is also an art and a science best undertaken with expert help. The value from an experiment is also maximized when designed in conjunction with the code while it is being developed. This is not always possible, but code modification is generally a continual process that should be planned in concert with the experiment. A key element of experiment design is scaling—a process by which the experimental conditions, materials, and geometry are chosen to re-create the important physics and conditions of the target system. The pool of experts in scaling within the DOE is dwindling with the construction of large-scale validation experiments. It will be a task of the Methods and Guidelines Committee to help collect this expertise, extend its applicability, and assist stakeholders in their experiment design efforts.

The Methods and Guidelines Committee also plays a role in Legacy data recovery and application. Data from the large integral experiments and associated separate effects experiments conducted decades ago *may* be of value in validating modern codes, but assessing that value is difficult. The experiments were not conducted with high-fidelity codes in mind and the measurements are likely of limited use, have large uncertainties, and may be hard to access. Nonetheless, in the absence of new facilities, mining this data may have benefits. Developing guidelines for evaluating this data will be a responsibility of the committee.

2.4 Knowledge Management

The knowledge developed and retained by the NEKVaC is of limited value unless it is made available in a usable form to users. The process of capturing, developing, and disseminating knowledge is challenged by the complexity of both the experiments and codes used to simulate them. *The Knowledge Management Committee is responsible for constructing and maintaining knowledge structures for capturing and sharing data from past, existing, and future experiments, and for developing educational programs for its dissemination.*

The *Nuclear Energy Knowledge Base for Advanced Modeling and Simulation* (NE-KAMS) was a program initiated by DOE to manage knowledge from experiments. Though it was never developed to fruition as planned, many of the tools and architecture were put into place and are ready for further implementation as part of NEKVaC.

One immediate task was highlighted at the Needs Workshop: construction of a *Knowledge Portal* using NE-KAMS resources and hosted by the Radiation Safety Information Computational Center (RSICC). Many users are aware of only a limited number of experiments and databases that could be used for validation of their codes and would benefit from being made aware of, and gaining access to, others around the country and the world. Data generated at universities under Nuclear Energy University Programs (NEUP) and other programs could be added to the NE-KAMS database as one of the conditions of funding. The Portal will provide users with a full-service shop for access to databases maintained by DOE and other organizations such as the NRC and OECD-Nuclear Energy Agency (NEA) (already affiliated with RSICC). It would offer appropriate security measures for proprietary and sensitive information.

Some institutions (e.g., universities) are experimenting with online education formats and other *enhanced instructional techniques* to serve distant customers. The Knowledge Management Committee shall investigate and adapt such tools for educating stakeholders about new validation techniques and the projects to which they are being applied. Content for these courses, seminars, workshops, etc., will be developed in cooperation with the other committees.

The Knowledge Management Committee will explore and develop the concept of "super-users" of modern codes that help new practitioners understand the power and limitations of these tools. The committee would work with code developers and expert analysis to "certify" super-users and turn them into a resource for stakeholders.

3. FISCAL YEAR 2015 ACTIVITIES AND DELIVERABLES

One milestone was established to focus NEKVAC activity and resources in 2015: Milestone M2FT-15IN1102172 – Draft a schedule for near-term projects.

This milestone was met on February 27, 2015, with the submittal to DOE of the INL report "Schedule for Completion of Near-term projects for the Nuclear Energy Knowledge and Validation Center" (INL/EXT-15-34426).

The report presented a proposed structure of the NEKVaC and the activities to be undertaken in 2015 and 2016 to demonstrate NEKVaC functions. These activities are meant to test the different elements of the NEKVaC; lessons learned from them and the overall execution of NEKVaC activities will be used to refine and adjust longer-term operation. The activities shall support all of the main NEKVaC missions: project identification and prioritization, legacy data recovery and re-evaluation, knowledge management, and advances in validation science. Appropriate reporting of these activities shall be executed in Program Information Collection System: Nuclear Energy (PICS-NE).

Specific near-term activities and schedule were:

- Stakeholder Needs Workshop

  Workshop Summary completed by March 30, 2015

- Research in New Validation Techniques – Using vintage data to validate modern numerical methods

  Year 1 Activities and reports completed by February 1, 2016

- Nuclear Database Portal Design

  RSICC Assessment and Basic Portal Design to be completed by December1, 2015

- Scaling Seminar

  Seminar summary to be delivered by September 30, 2015

- Integrated Research Project Proposal Development

  Draft IRP proposal prepared by August 30, 2015

- NEKVaC Initiation and Long-term Planning

  Charter and draft long-term plan submitted by September 30, 2015.

3.1 Summary of Specific Planned Activities

3.1.1 Needs Workshop

The first formal activity sponsored by NEKVAC was a Needs Workshop in which members of the laboratories, industry, academia, and the NRC were invited to participate in day-long seminar and discussions to identify validation needs.

The Workshop was held on January 15, 2015, on the campus of Georgia Tech. A Workshop Summary was written and uploaded to PICS-NE in March 2015 (INL/EXT-15-34683, "Nuclear Energy Knowledge and Validation Center Needs Workshop Summary Report"). The outcome of the meeting included a set of recommendations for the NEKVaC, which are repeated below.

<u>Near-Term/High Priority Activities</u>

- Populate committees/charter
- Data
  - Process for submitting/selecting proposals for access to non-U.S. data
  - Legacy data recovery
  - Legacy and non-U.S. data qualification
  - Database
    - Format
    - Access policy
- University project (Integrated Research Project [IRP]/NEUP)
- Specific efforts.

<u>Specific Projects</u>

- Loss of Fluid Test (LOFT); Experimental Breeder Reactor-2(EBR2 , and the Thermal-Hydraulic Out-of pile-Reactor Safety (THORS) experiment
- Portal Construction

  - Nuclear Regulatory Commission (NRC)
  - OECD/NEA
  - Format/Access
  - NE-KAMS
- Standard Development for Data Qualification
- Value Proposition
  - Qualification/Benchmark Construction
- Roadmap.

3.1.2 Using Vintage Data to Validate Modern Numerical Models – Legacy Data Research Project

NEKVaC sponsored one research project related to the retrieval, requalification, and analysis of legacy data for modern thermal fluid model validation. It was approved in 2015 but did not actually begin in earnest until early 2016 as the principal investigator (PI) had some difficulty in finding a qualified student to help with the research. The project, Advanced Data Superposition, is now proceeding at pace and should conclude in 2017.

Over the years, a huge quantity of data has been recorded for validating numerical models written to analyze the thermal-hydraulic behavior of LWRs. These data, not counting that specifically taken to study the thermal-hydraulic behavior of Russian reactor designs, may be divided into three large groups based on vendor designs: (1) boiling water reactor (General Electric) specific, (2) French/Westinghouse[a]-type pressurized water reactor specific, and (3) Babcock & Wilcox pressurized water reactor (PWR) specific. Because the experiments designed to address potential issues, to study specific phenomenon, and to study the interactions between multiple phenomena WITHIN EACH of these three groups share common geometries and boundary conditions, there is the potential to use an ensemble of data sets from related experiments even including different experimental facilities to produce a more comprehensive picture of fluid/heat transfer behavior than would be otherwise possible when considering only individual experiments.

This approach, termed *advanced data superposition*, proceeds by first normalizing data sets from different but related experiments using the scaling laws. Secondly, the subject data are presented in a framework defined by one of the group experiments, which is designated as the “baseline” or “reference” experiment. Thus, the scaled data in the ensemble, related by a common issue or set of phenomenon and with the same variable range, are used as a whole and superimposed on the existing data of the most rigorous experiment of the ensemble to show detailed behavior (for example both one-dimensional [1-D] and three-dimensional [3-D]). In this way, a data set is made available that better meets the validation needs of the modern, sophisticated numerical models than would be available otherwise from the existing vintage data repertoire.

For this project, the 3-D data recorded in the cylindrical core test facility (CCTF) and the slab core test facility (SCTF) to the reflood phase of the LOFT large break loss-of-coolant accident (LBLOCA) data are being superimposed. The LOFT data is the “reference” experiment since it is an integral experiment that provides 1-D data covering an entire LBLOCA experiment while the CCTF and SCTF experiments provide 3-D data specific only to the reflood phase of the LBLOCA. The LOFT, CCTF, and SCTF facilities were all designed to study the behavior of LBLOCA phenomena for a Westinghouse-type PWR.

Within the context of the above hypothesis, three tasks are underway:

[a] Including also Combustion Engineering designs.

1. Theoretical development of advanced data superposition approach.
2. Division of validation data from multiple experiments within Groups 1 and 2 into candidates for consideration for using advanced data superposition to create more comprehensive data sets.
3. Application of advanced data superposition to related validation data sets.

   A more traditional fourth task may be conducted:

4. Based on validation needs specific to advanced numerical tools presently under development, data sets available in the world community will be identified and the relationship between the data and the desired validation need will be defined and documented.

The PI on this project is Dr. Richard Schultz, retired from INL and now a professor at Idaho State University. Dr. Schultz is a renowned expert in fluid flow and thermal-hydraulic code validation, having worked on the LOFT, Advanced Plant Experiment APEX, and, most recently, the Next Generation Nuclear Plant (NGNP) project in which he designed the validation experiment matrix. The projected total cost of the project is $125,000.

3.1.3 Nuclear Database Portal Design

One of the needs expressed by multiple participants at the *Needs Workshop* was an increased awareness of the extent of other databases around the work and facilitated access to them. First proposed as part of NE-KAMS, a Collaboration Portal will be constructed to facilitate the exchange of data and knowledge about the wide variety of experiments captured in multiple databases around the world. The NEKVaC will host such a Portal, which will serve as a "storefront" to databases currently maintained by the NRC, OECD-NEA, and others. The Portal will be operated out of the RSICC, hosted by Oak Ridge National Laboratory (ORNL).

In this activity, RSICC resources were evaluated for their suitability for hosting the Portal and other Knowledge Management services. The evaluation was conducted by Dr. WeiJu Ren of ORNL. Dr. Ren helped to develop the NE-KAMS and the plan shows how the NE-KAMS model will be implemented under NEKVAC.

The report "Nuclear Energy Knowledgebase and Simulation Code Validation System Development and Implementation Plan" (ORNL/TM-2015/420) was submitted for review on August 30, 2015.

3.1.4 Scaling Seminar

Experiments designed to reproduce conditions in a full-sized power plant but in a smaller facility or laboratory must be properly scaled. Scaling techniques for nuclear applications were developed in the 1970s and 1980s with large integral experiments such as LOFT and SEMISCALE. Scaling is essential for ensuring that the thermal fluid conditions in a small separate effects or mixed effects experiment properly reflect those in the power plant under expected conditions.

Because very few large-scale experiments have been built in the national laboratories in recent decades, scaling expertise has declined with retirements and re-assignments. Furthermore, as experiment campaigns are being distributed across multiple institutions, it is important to educate a new generation of investigators in proper scaling techniques. This will be part of the Knowledge Management mission of the NEKVaC.

A scaling seminar was held on July 15, 2015, at INL. Noted scaling experts shared their knowledge with younger experimentalists. The agenda is attached as Appendix A of this document. Presentations from the meeting are available upon request.

3.1.5 Integrated Research Project Planning

The breadth and depth of a proper validation effort requires the coordinated efforts of a number of institutions with different areas of expertise and capabilities. The Department of Energy's Nuclear Energy Research Programs office supports such efforts through Integrated Research Projects (IRPs)

IRPs are significant, 3-year projects that address specific research issues or capability gaps identified and defined by the NE R&D programs, and are intended to develop a capability within each specified area. These projects will be multidisciplinary and require multi-institutional partners.

Solicitations for IRP proposals are announced in the latter half of the calendar year with proposals due early in the following calendar year.

In FY 15, the text of an IRP call was drafted and submitted to the DOE Consolidated Innovative Nuclear Research program. The scope of work covers all of the major NEKVaC mission areas: design of a benchmark for multiphysics/multiscale code validation (perhaps including data from legacy experiments), research and demonstration of new validation techniques (including new experimental techniques), proper management of the knowledge produced, and dissemination of that knowledge (beyond journal articles).

The proposed text was accepted in included in the Fiscal Year 2016 Call for Proposals. It is shown in Appendix B.

3.1.6 NEKVaC Organization and Related Activity

The growth of the NEKVaC will take time and careful planning. In this initial year, the (mostly volunteer) committee members will be appointed and tasked with establishing their committee charters and providing long-term growth plans. The (interim) committee chairs shall call initial planning meetings to kick off this effort and provide reports back to the Technical Integration Office.

Memorandum purchase orders (MPOs) were placed with NEKVaC principals at ORNL and Argonne National Laboratory (ANL) to cover their time in setting up the committees, holding meetings, planning, and reporting. Travel costs will cover coordination meetings with the NEA's MultiPhysics Experiments, Benchmarking, and Validation Working Group and domestic travel to reimburse participants in the initial committee meetings.

A report describing the organizational structure and strategy for program development was drafted in June 2015. It is included as Appendix C.

A series of monthly telecons was conducted starting in January 2015 through September 2015. The status of various activities was summarized and participants were invited to recommend and prioritize new activities and policies. Participants included: Hans Gougar (INL), Kostadin Ivanov (Pennsylvania State), Phillip Finck (INL), Cristian Rabiti (INL), Weiju Ren (ORNL), Stephen Bajorek (NRC), B.P. Singh (DOE), Hussein Khalil (ANL), Nam Dinh (North Caroline State), Tim Valentine (ORNL), Upendra Rohatgi (Brookhaven National Laboratory), William Oberkampf (Consultant).

In conjunction with the scaling seminar discussed in Section 3.1.4, a meeting of the NEKVaC advisory group was held in Idaho Falls on July 16, 2015.

3.2 Other Activities

In conjunction with, but not sponsored by, NEKVC, a knowledge transfer seminar focused on the LOFT project conducted in the 1970s and 1980s was held at INL on December 11, 2014. Key technical and programmatic staff involved in that project were invited to share their recollections and perspective on LOFT with current INL technical staff. The day-long workshop was well received and led to follow-on discussions regarding the usefulness of legacy data. This workshop was the genesis of the Advanced Data

Superposition research project described in Section 3.1.2. The agenda and notes from the meeting are included in Appendix D.

4. SUMMARY

This report described the initial structure of the NEKVaC and the activities it conducted in 2015 to demonstrate NEKVaC's function. These activities are meant to test the different elements of the NEKVaC; lessons learned from them and the overall execution of NEKVaC activities will be used to refine and adjust longer-term operation. The activities shall support all of the main NEKVaC missions: project identification and prioritization, legacy data recovery and re-evaluation, knowledge management, and advances in validation science.

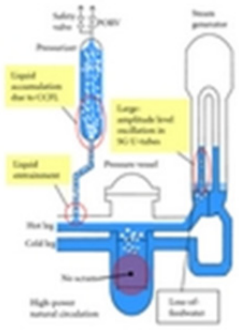
Specific 2015 activities included:

- Stakeholder Needs Workshop
- Research in new validation techniques – using vintage data to validate modern numerical methods
- Nuclear database portal design
- Scaling seminar
- Integrated research project proposal development
- NEKVaC initiation and long-term planning.

Appendix A

Agenda from the NEKVAC Scaling Workshop and Business Meeting

Appendix A
Agenda from the NEKVAC Scaling Workshop and Business Meeting



July 15-16, 2015

B102 Energy Sciences Laboratory (IF-685)

Idaho National Laboratory

Wednesday, July 15 – Technical Workshop - Scaling

08:30 Arrival (and Badging in the Willow Creek Building Lobby if necessary)

09:00 Introduction to Scaling ..... Dr. Kumar Rohatgi
Brookhaven National Laboratory

Reasons for scaling, methods of scaling- strength/weaknesses, distortions, extrapolations, new developments

10:15 Break

10:30 The Role of Facilities and Tests for Scaling .....Richard Schultz
Idaho State University

V&V30, the Validation Matrix

11:30 Relevancy to new nuclear systems?.....Open Forum

12:30 Lunch

13:30 Case Studies – LWR Integral Facilities, Counterpart and Separate Effects ..... Dr. Richard Schultz
Idaho State University

LOFT, Semiscale, ROSA, AP600, CCTF, SCTF, UPTF, PKL, LSTF etc.

14:30 Case Study – High Temperature Test Facility at Oregon State University .....Dr. Brian Woods
Oregon State University

15:30 Applications, Protocols, & Issues .....Open Forum

Validation Matrix Design, Legacy Data and NQA requirements

17:00 Wrap-up

18:30 No-Host Dinner..... MacKenzie River Pizza, 1490 Milligan Rd, Idaho Falls

Thursday, July 16 – NEKVAC Business Meeting

07:30 Arrival

08:00 Welcome & Introductions

08:30 NEKVAC's Role in the U.S. and DOE ..... Hans Gougar
Director, Nuclear Energy Knowledge and Validation Center

09:00 International Cooperation & MPEBV: Opportunities & Challenges..... Tim Valentine
Director of the MPEBV

10:00 Break

10:15 Validating Fuels Codes..... Rich Williamson
Fuels Modeling and Simulation, Idaho National Laboratory

11:15 NE-KAMS Development for Advanced Code Validation and Benchmarking..... Hyung Lee
Bettis Atomic Power Laboratory

12:00 Working Lunch ..... Justin Coleman
Thermal Science and Safety Analysis, Idaho National Laboratory

Physical Behavior of Seismic Wave Propagation at Nuclear Power Plant Sites and Numerical Approximations

13:00 Committee Breakouts.....

- Project Steering (Khalil)
- Methods and Guidelines (Rabiti or designated lead)
- Knowledge Management (Valentine)

  Adopt charter, review activities, identify opportunities and plan activities, establish priorities and budget requests for FY16

15:00 Return to B102 - Break

15:15 FY16 Planning ..... All

- Linking to Programs
- Directly funded activities
- Topical Discussion Series
- Next Summer Meeting

17:00 Wrap-up

Appendix B

2016 Program-Directed Call for Proposals under Fuel Cycle Technologies – FC-1

Appendix B
2016 Program-Directed Call for Proposals under Fuel Cycle Technologies – FC-1

Benchmark Experiments To Validate Multi-physics Simulations For Nuclear Energy Systems (IRP-FC-1) (Federal POC – Bhupinder P. Singh & Technical POC – David Pointer) (Up To 4 Years And $5,000,000)

Over the past decade, significant investment and efforts have been made by the Department of Energy's NuclearEnergy programs (e.g., NEAMS, CASL, LWRS, FCR&D) to develop capabilities for advanced modeling and simulation of nuclear energy systems. These simulation models couple multiple physical phenomena to predict normal and off-normal operation of nuclear reactors, and the important modeled phenomena include neutron transport, core/reactor thermal-hydraulics, nuclear fuels and cladding performance, and core and structural material behaviors. Traditional methods used for coupling and validating single physics and ad-hoc integral codes are not adequate for validating these complex high-fidelity strongly coupled multi-physics codes. Furthermore, some of the experimental data sets used to validate these codes may not be of sufficient quality to validate high-fidelity modeling and simulation (M&S) tools.

The Office of Nuclear Energy (NE) is sponsoring establishment of a Nuclear Energy Knowledge and Validation Center (NEKVaC) to be a resource for addressing methods in the validation of codes used for modern nuclear plant and fuel cycle analyses. The organization for this NEKVaC is being established in FY 15 and will include a Methods and Guidelines Committee. This committee is responsible for identifying gaps and deficiencies in current nuclear analysis code validation, recommending new approaches, and developing and disseminating guidelines and best practices in modern code validation including those for design of validation experiments. NE is also working with the Nuclear Energy Agency of the Organisation for Economic Cooperation and Development (OECD/NEA) to support similar efforts internationally.

The goal of this Integrated Research Project (IRP) is to make progress toward establishing benchmarks for complete validation of high-fidelity multi-physics codes, for example, those which model the phenomena governing light water reactor accident tolerant fuel behavior in postulated accident conditions. The scope of activities for this IRP includes:

1. Plan, design, and conduct an experiment that can serve as a benchmark for critically assessing the results predicted by a multi-physics simulation code for a nuclear energy system. The applicant can choose a code from the suite of codes contained in DOE-NE Software projects (MBM, SHARP, MAMMOTH, or VERACS) and the specific models within the code for which the experiment would serve as a benchmark over a defined range of applicability. It is not expected that the benchmark will be sufficient for complete validation of the specific code. Plan, design and conduct of the experiment are expected to follow a rigorous validation protocol. The goal is to demonstrate high-fidelity experimental methods for strongly coupled phenomena, while delineating phenomenological contributions. It is anticipated that the applicant will work with the simulation model developer right from the start of the project.
2. Document the methods for designing the experiment including those for collection of data and quantification of uncertainties. All applicable boundary conditions, experimental limitations, assumptions, and experimental techniques must be documented, and pre-experimental sensitivity analyses should be conducted to evaluate the impact of these conditions on the usefulness of the

experiment as a benchmark. It is anticipated that applicant will work with the NEKVaC Methods and Guidelines Committee to establish methods for evaluating the experimental uncertainty impacts on the simulation results and will inform the committee's efforts as well as NE activities in this subject area with the OECD/NEA.

3. Collect, store, reduce and present the data in a context which preserves all of the expert knowledge and rigor that went into the design and execution of the experiment. The QA program applicable to the experiment will be described and all appropriate records including the experiment procedures, qualification, and training of personnel and calibration of equipment/instruments will be retained. It is important that those who wish to use the data to validate a code/model must know the pedigree of the data, why the particular measurements were taken, the uncertainties in the instrumentation, a precise geometry of the experiment, etc. The knowledge (data and the context in which it was generated) must be stored in a format that is maintainable and accessible. The Nuclear Energy – Knowledge Base for Advanced Modeling and Simulation (NE-KAMS) provides such a framework and its use is highly recommended.

Applicants must address all three of the above listed elements to be considered responsive to this IRP request for proposals. In addition to the scope described above, the applicant may propose to exercise the specific selected code application and compare results from the code and the benchmark experiment. It is desirable that the knowledge learned be incorporated in a college course on verification and validation.

Appendix C

Introduction to the Nuclear Energy Knowledge and Validation Center

Appendix C
Introduction to the Nuclear Energy Knowledge and Validation Center

Introduction

The Nuclear Energy Knowledge and Validation Center (NEKVaC) is a new initiative by the Department of Energy (DOE) and Idaho National Laboratory (INL) to help to coordinate and focus the resources and expertise that exist with the DOE toward solving issues in the validation of codes used for modern nuclear plant and fuel cycle analysis. In time, code owners, users, and developers will view the NEKVaC as a partner and essential resource for acquiring the best practices and latest techniques for validating codes, for guidance in planning and executing experiments, for facilitating access to, and maximizing the usefulness of, existing data, and for preserving knowledge for continual use by nuclear professionals and organizations for their own validation needs.

The scope of the NEKVaC covers many inter-related activities, which will need to be cultivated carefully in the near-term and managed properly once the NEKVaC is fully functional. Three areas comprise the principal mission: (1) identify and prioritize projects that extend the science and application of validation, (2) adapt or develop best practices and guidelines for high fidelity multiphysics/multiscale analysis code development and associated experiment design, and (3) define protocols for data acquisition and knowledge preservation and provide a portal for access to databases currently scattered among numerous organizations.

The NEKVaC will seek to coordinate its activities with those of the International Atomic Energy Agency and the Nuclear Energy Agency of the Organization of Economic Cooperation and Development, both of which sponsor complementary projects. The NEKVaC will also facilitate the coordination of efforts among universities, national laboratories, and industry organizations that support validation of modern modeling and simulation tools. All of these efforts will require oversight and direction from committees of experts and support staff.

A structure organized along the lines of the NEKVaC mission areas has been formed (Figure C-1) and is being populated with key personnel. At this point most of the personnel are serving in a voluntary advisory capacity but future NEKVaC funding will be allocated to personnel in proportion to their responsibilities and support.

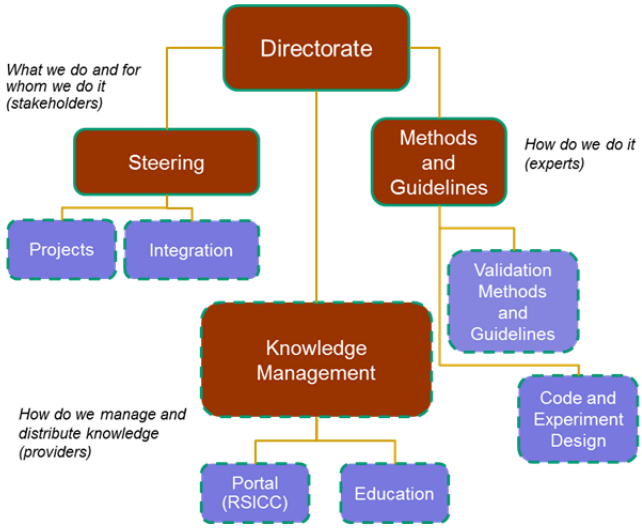


Figure C-1. NEKVaC organization.

Responsibilities and activities within each mission area are described as follows.

Directorate

The Interim Directorate consists of a small group of professionals with a specific interest and/or expertise in modern code development and validation as applied to nuclear plant analysis and design. They recognize the limitations of current validation practices with respect to today's simulation tools and have at least some idea of the improvements that must be made. Each has a stake in the validation enterprise whether in code development, experiment design, regulation, reactor technology research and development, or end use.

This group of experts is well-suited to establish a vision for the NEKVaC, identify near-term activities that serve the mission, and recruit key personnel to carry the mission forward. Each of the major committees is currently chaired by one of these members on an interim basis until a suitable longer-term replacement is found. Once the individual committee members are appointed, the responsibilities now carried by the Interim Committee will devolve to them.

Interim Directorate: Hans Gougar, Phillip Finck, Hussein Khalil, Timothy Valentine, William Oberkampf, Stephen Bajorek, Kumar Rohatgi, Kostadin Ivanov, Nam Dinh, David Pointer, Cristian Rabiti, and Weiju Ren.

In FY 16, the Directorate will assume its overall role as the governing body of the NEKVaC. It will consists of the director, one or two deputy directors depending upon work load, and a small group of advisors who will track overall NEKVaC activity and advise the director on policy. The director reports to INL's management and its client, DOE.

In addition to policy, the director shall be responsible for preparing a budget and long-term plans, staffing, performance, and the overall success of NEKVaC. The program will adhere to all applicable INL standards and policies.

The deputy director(s) will assist in specific areas requested by the director with compensation commensurate with the level of support (to be determined).

Hans Gougar currently serves as director and will continue that assignment into FY 16. Director and deputy director personnel are expected to serve on a temporary basis (3-year terms proposed).

Steering

The Steering Committee is responsible for the selection and oversight of individual research projects sponsored by NEKVaC and for the integration of NEKVaC activities with other DOE and international programs.

Project selection and oversight entails routine *assessment of needs and priorities* of various stakeholders. This may occur through stakeholder workshops, direct polling, and other forms of communication with industry, DOE programs, and regulators.

Along with the other committees, the Steering Committee shall solicit and evaluate proposals for research funded directly from the NEKVaC budget. The call for such proposals shall emphasize the importance of applied research in validation, experiment and instrument design for validation of multiphysics/high fidelity codes, the establishment of new practices (guidelines) and benchmarks for multiphysics assessments, new data analysis and management techniques, and dissemination of results through non-traditional channels.

Proposed research may be motivated by, and support, ongoing DOE programs but must demonstrate broad application to the nuclear community.

Benchmarks are an effective tool for assessing the uncertainty and sensitivity in code predictions. The Nuclear Energy Agency of the Organisation for Economic Cooperation and Development (OECD) has developed consensus protocols for conducting criticality safety and reactor physics benchmark evaluations. The DOE currently supports such efforts (notably, International Criticality Safety Benchmark Evaluation Project [ICSBEP] and International Rector Physics Experiment Evaluation Project [IRPhEP]) and may relegate certain programmatic responsibility for these activities to NEKVaC, where they would be evaluated and monitored along with the other projects sponsored by the program.

Integration activities seek to advance and leverage international collaboration in advanced validation efforts (e.g., MultiPhysics Experiments Benchmarking and Validation [MPEBV]) and facilitating the coordination of the domestic university R&D in validation through the Consolidated Innovative Nuclear Research program, specifically the development of Integrated Research Proposals and Nuclear Energy University Programs RFP language.

The interim chairperson is Hussein Khalil. Over the long term, the Steering Committee chairperson's responsibilities are expected to consume the equivalent of 0.5 FTE. To coordinate NEKVaC activities effectively with validation R&D at universities, a new Joint (50/50) Appointment by INL and Idaho State University is being pursued to lead the integration activities of the Steering Committee.

Methods and Guidelines

Techniques for validating fuel performance, computational fluid dynamics, structural dynamics, and, in general, high fidelity multiphysics analysis codes and models have not kept up with the complexity of those tools. Moreover, the data needed to validate these models may be beyond the capabilities of current facilities. however, advanced validation and experimental techniques are being developed and applied in other fields. ***The Methods and Guidelines Committee is responsible for identifying gaps and deficiencies in current nuclear analysis code validation, recommending new approaches, and developing and disseminating guidelines and best practices in modern code validation.***

The Methods and Guidelines Committee shall gather the latest techniques and tools in code validation to assess their applicability to codes and models used by stakeholders. If applicability is uncertain, the Methods Committee will propose one or more research projects to be funded through NEKVaC or other DOE programs. Dissemination of new techniques for either testing or direct application can be a significant educational effort. Regular interaction with the Steering and Knowledge Management Committees is essential.

The Methods and Guidelines Committee will additionally examine the practices and protocols developed for the ICSBEP criticality safety and IRPhEP reactor physics benchmark projects and adapt them for use in other areas (thermal fluids, fuels performance, structural dynamics, and the coupling of these areas).

Broader adoption of new validation techniques is facilitated by *standards*. Standards are generally developed by relevant professional organizations such as ASME and ANS. While the Methods and Guidelines team will not be responsible for writing new standards, they will be actively engaged with and contribute to those organizations with such responsibilities. Hence, the committee's members may devote a significant amount of time in support of these efforts (e.g., ASME V&V30 committee participation).

Experiment design is also an art and a science best undertaken with expert guidance. The value derived from a validation experiment is maximized when it is designed for a specific purpose and in such a way as to produce quantitative results that directly support the validation testing of the code models for which it is designed, and reflects feedback from the validation experience of model developers, software developers, and software users (analysts). This is not always possible but code modification is generally a continual process that should be planned in concert with the experiment. A key element of experiment design is scaling—a process by which the experimental conditions, materials, and geometry are chosen to re-create the important physics and conditions of the target system. The pool of experts in scaling within

the DOE is dwindling with the construction of large-scale validation experiments. It will be a task of the Methods and Guidelines Committee to survey this expertise, extend its applicability, and assist stakeholders in their experiment design efforts.

The Methods and Guidelines Committee also plays a role in legacy data recovery and application. Data from the large integral experiments and associated separate effects experiments conducted decades ago *may* be of value in validating modern codes but assessing that value is difficult. The experiments were not conducted with high fidelity codes in mind and the measurements are unlikely to provide sufficient information for comprehensive validation, may have large or poorly characterized uncertainties, and may be hard to access. Nonetheless, in the absence of new facilities, mining this data for use in validation studies would enable a partial assessment of high-fidelity models. Developing guidelines for evaluating and preserving this data will be a responsibility of the committee. Guidelines for archival and access to *newer* integral- and separate-effects experiments will also be a responsibility of the committee.

Along with the other committees, the Methods and Guidelines Committee shall solicit and evaluate proposals for research funded directly from the NEKVaC budget. The call for such proposals shall emphasize the importance of research in validation, experiment and instrument design for validation of multi-physics/high-fidelity codes, the establishment of new practices (guidelines) and benchmarks for multi-physics assessments, new data analysis and management techniques, and dissemination of results through non-traditional channels.

The interim chairperson of the Methods and Guidelines is Cristian Rabiti. Over the long term the chairperson's responsibilities are expected to consume the equivalent of 0.25 to 0.5 FTE.

Knowledge Management

The knowledge developed and retained by the NEKVaC is of limited value unless it is made available in a usable form to users. The process of capturing, developing, and disseminating knowledge is challenged by the complexity of both the experiments and codes used to simulate them. ***The Knowledge Management Committee is responsible for constructing and maintaining knowledge management structures for capturing and sharing data from past, existing, and future experiments and for developing processes for dissemination of experimental data, benchmark evaluations, and validation guidance.***

The *Nuclear Energy Knowledge Base for Advanced Modeling and Simulation* (NE-KAMS) was a program initiated by DOE to manage knowledge from experiments. Though it was never developed to fruition as planned, many of the tools and architecture were initiated and are ready for further implementation as part of NEKVaC.

One immediate task that was highlighted at the Needs Workshop recommended the construction of a *Knowledge Portal* using NE-KAMS resources and that could be hosted by the Radiation safety Information Computational Center (RSICC). Many users are aware of only a limited number of experiments and databases that could be used for validation of their codes and would benefit from being made aware of, and gaining access to, others around the country and the world. Submission of data generated at universities under NEUP and other programs to the NE-KAMS database could be added as one of the conditions of funding and one of the deliverables under such contracts. The Portal will provide users with a full-service shop for access to databases maintained by DOE and other organizations such as the NRC and OECD/NEA (already affiliated with RSICC). It would offer appropriate security measures for proprietary and sensitive information.

Some institutions (e.g., universities) and international organizations (e.g., IAEA) are experimenting with online education formats and other *enhanced instructional techniques* to serve distant customers. The Knowledge Management Committee shall investigate and adapt such tools for informing stakeholders about new validation techniques and the areas in which they are being applied. Content for these courses, seminars, workshops, etc., will be developed in cooperation with the other committees.

The Knowledge Management Committee may examine the development of the concept of "super-users" of modern codes to assist new practitioners in understanding the power and limitations of these tools. The committee would work with code developers and expert analysis to certify super-users and turn them into a resource for stakeholders.

Along with the other committees, the Knowledge Management Committee shall solicit and evaluate proposals for research funded directly from the NEKVaC budget. The call for such proposals shall emphasize the importance of research in validation, experiment and instrument design for validation of multiphysics/high-fidelity codes, the establishment of new practices (guidelines) and benchmarks for multiphysics assessments, new data analysis and management techniques, and dissemination of results through non-traditional channels.

The interim chairperson of the Knowledge Management is Timothy Valentine. Over the long term, the chairperson's responsibilities are expected to consume the equivalent of 0.25 to 0.5 FTE.

Validation Research

Advances in validation methods and practices are motivated in large part by significant advances in modeling, simulation, and experimentation and are hardly limited to the nuclear industry. Indeed some of the more compelling developments are found in the aerospace and automotive industries. Within the nuclear industry, the need for a deeper understanding of fluid phenomena, material behavior, and fuel performance is driving major DOE computational initiatives such as CASL and NEAMS. In many ways, modeling and simulation have greatly outpaced the ability and resources needed to acquire the measurement data needed to validate computational models and methods.

New techniques and partnerships across diverse fields of study are therefore needed to address these challenges. As a "virtual" center with limited personnel that are directly involved and distributed over a number of institutions, a primary role of the NEKVaC will be identify experts, ideas, and resources from many different institutions that can be brought to bear to address the difficult challenges presented by NEKVaC stakeholders.

NEKVaC will work with DOE to fund projects that address these challenges. NEKVAC will help develop call for proposals under the NEUP, NEET, FCRD, NEAMS, and RCRD programs. This will include the development of Integrated Research Project proposals that coordinate efforts among multiple institutions.

NEKVaC will also fund, from its own budget, specific projects that directly serve its technical and knowledge development missions. An internal solicitation and evaluation process will be developed with approval from DOE. Since the projects must address critical stakeholder needs as well as advancing the state of the art, the committees will play a role in the evaluation with the final selection conducted by the directorate. The Steering Committee will be responsible for monitoring progress toward objectives and against stated success criteria.

Path Forward

The NEKVaC is still in its formative stages, but its long-term mission of developing and providing expertise to the nuclear community is clear and well understood. In 2016, the organizational structure will be established and the NEKVaC will have a small budget to initiate the different components. The program is expected to grow over the next 5 years by building partnerships with the major DOE programs, laboratories, universities, and international organizations with complementary goals and challenges.

Appendix D

Agenda and Notes from the LOFT Knowledge Transfer Workshop

Appendix D
Agenda and Notes from the LOFT Knowledge Transfer Workshop

Idaho Falls, Thursday, December 11, 2014

Objective: Discussions on past history and data uses from LOFT experiments and potential future uses of experimental data

Invited Guests

Buck Goodrich	Doug Reeder
Larry Ybarrondo	Richard Schultz
Steve Taylor	Bob Drexler
Marland Stanley	Barton Smith
Gregg Swindlehurst	

INL Attendees

Phillip Finck	Hans Gougar	Alex Stanculescu
Ling Zou	Cristian Rabiti	Ray Berry
Haihua Zhao	Hongbin Zhang	Jim Wolf
Mark Holbrook	Paul Bayless	Keith Condie
Nancy Lybeck	Richard Gregg	Jeff Einerson
Giuseppe Palmiotti		

0800 Guest Welcoming ..... Phillip Finck

Knowledge, Validation, and Modern Codes

08:30 LOFT Mission and Experiments – a Retrospective ..... Larry Ybarrondo
INL Retiree, LOFT

09:45 Break

10:00 Today's Activities ..... Hans Gougar

10:15 RELAP Code Validation with LOFT ..... Jim Wolf & Dick Schultz
Scientist, Thermal Science & Safety Analysis & INL Retiree

What was done, and what would we have done differently

11:30 Nuclear Data Management and Analysis System ..... Nancy Lybeck
BEA Scientist, Human Factors

12:00 Lunch & Discussion - Knowledge Management and LOFT ..... Barton Smith
Professor, Utah State University, Director of Experimental Fluid Dynamics Laboratory

13:00 Guided Discussion: 'Data Quality' ..... Dick Schultz
INL Retiree

What is it? How can we evaluate the quality of LOFT data?
What has been lost in the past 30 years? What can we do to restore it?

15:00 Guided Discussion: LOFT Data for RELAP7 ..... Hans Gougar
BEA Manager, (208) 526-1314 or (208) 881-2345

What does RELAP7 need (overall)? How can LOFT data be used?
What should we look for when re-collecting the data? Does this affect the development of the code?

16:00 Path Forward/Closeout..... Hans Gougar
BEA Manager, (208) 526-1314 or (208) 881-2345

Workshop Notes

Introductions – Eric Johnson

Welcome – Phillip Finck

- LOFT had a major world-wide impact on the nuclear industry.
- Validation is always based in experiments.
- We need to do things differently than the past.
- Maintain the knowledge of the past.
- Hans is leading the effort to retain knowledge.
- Need very strict standards for quality assurance.
- Hans will reevaluate validation needs for the future.
- OECD expert group to collect experiments.

LOFT Missions and Experiments – Larry Ybarrondo

- NRC chief historian contacted Larry, and copied all of Larry's manuals and notes. Are available from NRC.
- The regulatory assistance program to support the NRC started around 1967.
- The development of specialized instruments drove the need for experiments; let to Semi-Scale facility with a pressurized vessel.
- Talked about the gamma densitometers.
- Great story about the video probe that was used to film what was happening inside the pipes. Got the idea from an ad for a German rectal probe.
- Westinghouse representatives came to Idaho to explain how ECCS work; their importance, etc. Influenced the direction of Semi-Scale.
- Original code was "RELAPSE," but Larry thought that was pretty negative so the name was changed to "RELAP."
- Data collection is a decision that must be carefully considered; you can collect to much or too little. You need to understand aliasing and how it influences bandwidth.
- Software configuration control was an issue at times for RELAP. Developed a rigorous program for control.
- Thermocouples were welded to the fuel rods; had to be radiographed for each weld. Wires were run out the top of the reactor.

- Toured Three Mile Island with Jim Zane. Larry was looking at the core and the associated parameters. Based on the neutron detectors, they realized that the part of the core was melted. Many did not agree. Ended up briefing President Carter on TMI.
- Larry had a craft story, and after that Larry changed the design review process to include the crafts employees into review of the designs; makes them real-world practical.
- Lessons: Sometimes your greatest successes come dressed as a disaster,
- Do not bring your family into work issues.
- Never do or say anything that cannot stand the light of day.
- Avoid conflicts of interest
- Many issues controlling costs; need to understand all elements regarding costs associated with your tasks. Had a two-person committee explain any changes that affected cost and schedule. Also had independent audits by NRC/DOE representatives.
- If the client complains; fix it.
- Failures are going to happen; recover gracefully.
- Fast growing programs; not all people will keep up; try to find a place for them to work and function.
- Need a strategic plan that is updated regularly and integrated with the operations plan.
- Profits; make a point of sharing when the program gets a favorable review.
- Follow your dreams. Follow your instincts.
- If you get pressure, resist and follow your instincts. Do compromise the quality of the experiment or analysis.
- Financials; need to know everything about the budget.
- If you make a contract, read every line and agree with it before you put your name on it. No excuses later.
- Fixed price contracts can be good; but Larry would generally avoid them. Things happen.
- New work; make sure you are able to do the work and have the competence. Be able to say “no” if it is not a good fit.
- Staff selection; spent a lot of time on this. Be careful on who you bring in.
- Key staff qualities: avoid those who were focused on the amount of vacation, etc.
- Adversity: it is going to happen so get back on the horse.
- Dick Wagner, Walt Reddick, and a few of his people were the fathers of RELAP5.

RELAP Code Validation with LOFT – Jim Wolf/Dick Schultz/Paul Bayless

- What was done and what would we have done differently.
- Paul: covered an overview that he recently gave at an ANS meeting.
- LOFT provided about 550 measurements; every parameter was reviewed by a data integrity review group. The process for reviewing the parameters is documented (EDRs).
- Larry: Scaling was a huge problem. Solution: scaling basis is power-to-(RCS)volume equivalence. The vendors were persuaded to agree that LOFT was relevant to their designs.

- All of the reactor vendors (Westinghouse, CE, and B&W) were required to compare their codes against the LOFT standard problems.
- RELAP is compared to a small break and the last large break experiment (for the NRC) after every code modification.
- Dick's presentation includes a set of key references.
- LOFT demonstrated the huge conservatism in the standard evaluation models.

LOFT and Modern Code Validation – Hans Gougar

- Motivation: looking to see how valuable the data will be in validating current and future codes.
- Role of NEKVAC: adopt standards for legacy and new experimental data; integrate data needs and priorities; coordinate access to data from non U.S. experiments and facilitate international cooperation.
- First workshop coming up in January at Atlanta.
- LOFT data for RELAP-7; what is needed? What can LOFT provide, etc.

Knowledge Management – Barton Smith – Utah State

- Establish accepted standards, requirements, and best practices for V&V of computational models and simulations.
- Provide a searchable database; provide web-based tools.
- Table: Validation Data Completeness
- What data is needed? Focus on data that is required as an input to the model.
- This is often not well documented in legacy experiments. Uncertainty in these qualities impacts uncertainty of the results.
- Reports are static. A knowledgebase should be fluid and improve over time as better information becomes available.

Data Management and Analysis System (NDMAS) – Nancy Lybeck

- Built for the NGNP.
- System architecture.
- Automated the conversion of ATR data systems output to allow input to NDMAS. Provides near-real-time data.
- Should think about inclusion of other types of data from other tasks in ART.
- Controlled access to the SQL database (vault). Follow NQA-1 procedures.
- Talked about being conservative and using NQA-1 processes if in doubt (Type A data).
- Qualification documentation; AGR-2 final Data Qualification Report; July 2014.
- I recommended that Jeff Einerson have NRC review the NDMAS system for compliance to regulatory needs.

Guided Discussion: Data Quality – Dick Schultz

- Qualification of existing data. Huge spectrum of data to look at.
- Vintage data must be found acceptable in these areas… (Several slides) Questions asked by the Appendix 3.1 in NQA-1.
- Doug Reeder pointed out that they had the most problems with mass flow rate; issues with losing some of the drag-disk turbines.
- Should be able to gather some useful data from the PBF program; there was some transient testing of commercial fuel.
- These discussions also intersect with efforts to restart TREAT.
- There may be some value in looking at 2-D and 3-D data from other test facilities to see if there is any added value in correlating these types of responses to the 1-D data from LOFT. May gain some insights from the LOFT data.
- Should look into counterpart test that could correspond to the tests done at LOFT.
- Should contact Canada and see if any blow-down experiments were done that are of interest regarding LOFT and our validation needs.
- We need to identify where different types of data exist and are retrievable. Need and inventory. Also need to know who to talk to about where to find stuff in the existing reports. Quick look reports are a good source (no in NUREGs). Experiment data reports. This includes the channel-by-channel data qualities. Address the accuracies and which instrument was believed. Pretest predications are also useful. Standard problem reports also included some of the info that was also in the Quick Look Reports. Experiment operating specifications (not a formal report). LOFT monthly reports.