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Office of Nuclear Energy Knowledge Management Program Situational Analysis Report

December 2011

Idaho National Laboratory

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Executive Summary

Knowledge management (KM) has been a high priority for the Department of Energy (DOE) Office of Nuclear Energy (NE) for the past several years. NE Programs are moving toward well-established knowledge management practices and a formal knowledge management program has been established. Knowledge management is being practiced to some level within each of the NE programs. Although it continues to evolve as NE programs evolve, a formal strategic plan that guides the implementation of KM has been developed.

Despite the acceptance of KM within DOE NE, more work is necessary before the NE KM program can be considered fully successful. Per Dr. David J. Skyrme[1], an organization typically moves through the following evolutionary phases:

- Ad-hoc – KM is being practiced to some level in some parts of the organization
- Formal – KM is established as a formal project or program
- Expanding – the use of KM as a discipline grows in practice across different parts of the organization
- Cohesive – there is a degree of coordination of KM
- Integrated – there are formal standards and approaches that give every individual access to most organizational knowledge through common interfaces
- Embedded – KM is part-and-parcel of everyday tasks; it blends seamlessly into the background.

According to the evolutionary phases, the NE KM program is operating at the two lower levels, Ad-hoc and Formal. Although KM is being practiced to some level, it is not being practiced in a consistent manner across the NE programs. To be fully successful, more emphasis must be placed on establishing KM standards and processes for collecting, organizing, sharing and accessing NE knowledge. Existing knowledge needs to be prioritized and gathered on a routine basis, its existence formally recorded in a knowledge inventory. Governance to ensure the quality of the knowledge being used must also be considered. For easy retrieval, knowledge must be organized according to a taxonomy that mimics nuclear energy programs. Technologies need to be established to make accessing the knowledge easier for the user. Finally, knowledge needs to be used as part of a well defined work process.

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Acronyms and Abbreviations

AEC	Atomic Energy Commission
AI	Atomics International
ANL	Argonne National Laboratory
AT	Applied Technology
BL	Bettis Laboratory
CASL	Consortium for Advanced Simulation of Light Water Reactors
CoP	Communities of Practice
CFD	Computational Fluid Dynamics
CSDS	Center for Secure and Dependable Systems
CSM	Computational Structural Mechanics
DOE	Department of Energy
EBR-II	Experimental Breeder Reactor II
ETEC	Energy Technology Engineering Center
FCT	Fuel Cycle Technology
FFTF	Fast Flux Test Facility
FR-KOS	Fast Reactor Knowledge Organization System
FRKP	Fast Reactor Data Retrieval and Knowledge Preservation
IAEA	International Atomic Energy Agency
ICPP	Idaho Chemical Processing Plant
ICSBEP	International Criticality Safety Benchmark Evaluation Project
INL	Idaho National Laboratory
IRPhEP	International Reactor Physics Experiment Evaluation Project
IRSF	INL Record Storage Facility
KEF	Knowledge Encapsulation Framework
KM	knowledge management
LMEC	Liquid Metal Engineering Center
LMFBR	Liquid Metal Fast Breeder Reactor
LMIC	Liquid Metal Information Center
LMR	Liquid Metal Reactor
LOCA	Loss of Coolant Accident
LOFT	Loss of Fluid Test Reactor
MTR	Material Test Reactor

MS	Member States
M&S	Modeling and Simulation
NAA	North American Aviation
NE	Nuclear Energy
NEA	Nuclear Energy Administration
NEAMAS	Nuclear Energy Advanced Modeling and Simulation
NE-KAM	Nuclear Energy Knowledge base for Advanced Modeling & Simulation
NIST	National Institute of Standards and Technology
NPR	New Production Reactor
NRC	Nuclear Regulatory Commission
NSC	Nuclear Science Committee
OCR	Optical Character Recognition
OECD	Organisation for Economic Cooperation and Development
ORNL	Oak Ridge National Laboratory
OSTI	Office of Scientific and Technical Information
PNNL	Pacific Northwest National Laboratory
PBF	Power Burst Facility
PRISM	Power Reactor Innovative Small Module
QA	Quality Assurance
R&D	research and development
RSICC	Radiation Safety Information Computational Center
SFR	sodium fast reactor
SME	Subject Matter Expert
SNL	Sandia National Laboratories
SSFL	Santa Susana Field Laboratory
TPAI	Techno social Predictive Analytics Initiative
T/H	Thermal Hydraulics
TREAT	Transient Reactor Test Facility
UQ	(Uncertainty Quantification
USU	Utah State University
V&V	Verification and Validation
ZPPR	Zero Power Physics Reactor
ZPR	Zero Power Reactor

1 Introduction

Knowledge management (KM) has been a high priority for the Department of Energy (DOE) Office of Nuclear Energy (NE) for the past several years. NE Programs are moving toward well-established KM practices and a formal KM program has been established. To strengthen what is already in place, more work is necessary to ensure there is a degree of coordination of KM activities to ensure knowledge can be more easily shared across program boundaries. Formal standards and approaches that give every employee access to NE knowledge through common interfaces still needs to progress. Overall, KM has yet to become a part-and-parcel of everyday tasks.

Despite the acceptance of KM within DOE NE, more work is necessary before the NE KM program can be considered fully successful. Per Dr. David J. Skyrme[1], an organization typically moves through the following evolutionary phases:

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According to the evolutionary phases, the NE KM program is operating at the two lower levels, Ad-hoc and Formal. Although KM is being practiced to some level, it is not being practiced in a consistent manner across the NE programs. To be fully successful, more emphasis must be placed on establishing KM standards and processes for collecting, organizing, sharing and accessing NE knowledge. Existing knowledge needs to be prioritized and gathered on a routine basis, its existence formally recorded in a knowledge inventory. Governance to ensure the quality of the knowledge being used must also be considered. For easy retrieval, knowledge must be organized according to a taxonomy that mimics nuclear energy programs. Technologies need to be established to make accessing the knowledge easier for the user. Finally, knowledge needs to be used as part of a well defined work process.

For clarification, the NE KM program is not an information archiving or information preservation activity. The primary difference is knowledge management is concerned with preserving information in context. Information technology (and the ability to archive information) plays only a small part in knowledge management. To illustrate, even if every document ever written or published about nuclear energy were available electronically (in full-text searchable format), a substantial amount of very valuable knowledge about the NE programs would be nonetheless lost. Rather, knowledge includes the tacit understanding of the technical and programmatic importance of each document and the structure and procedural knowledge about how these documents evolved and how they are interconnected.

This report explores the current situation and role of KM within the Office of NE. It outlines the overarching goals of the NE KM program and addresses the components necessary for the program to be successful. It further clarifies for the reader the meaning and important phases of

KM. Finally and within each of the KM phases outlined, this report provides the reader with the status of the NE KM program. This report is structured according to the following:

- Section Two -- provides a high level description of the NE KM Strategy
- Section Three – provides a situational analysis per the major KM phases as defined by K. Dalkir[2] (knowledge capture and creation, knowledge sharing and dissemination, and knowledge application) and describes accomplishments to date according to several key KM characteristics associated with those phases.
- Section Four – concludes the report

2 NE KM Strategy

The NE KM strategy was developed at the onset of this program, Department of Energy Nuclear Energy Partnership Knowledge Center Strategic Plan, 2006. Although the strategy continues to evolve as the NE programs evolve, it serves as the basic building block to map the direction of KM and achieve its continuous improvement. The strategy takes into account both internal (programs) and external programs such as the International Atomic Energy Agency (IAEA) Knowledge Preservation Initiative. It targets important business needs such as the imminent retirement of key personnel, the need for innovation within the dynamic NE environment, and the need for efficiencies in a distributed research and development (R&D) culture.

2.1 Mission and Vision

The NE KM Program has a threefold mission to capture and make available nuclear energy knowledge to researchers and engineers, provide innovative KM technologies for easy information retrieval and collaboration, and foster continued nuclear energy education to graduate and undergraduate students throughout the nuclear energy community. DOE NE will continue its leadership in providing both proven and innovative technologies to help meet the diverse needs of the nuclear energy program today. The department recognizes and addresses the challenges inherent in those needs and effectively manages the associated resources. In support of the NE KM mission, the following statement was developed:

> ***"The Office of NE KM Program is the deliberate and systematic coordination of nuclear energy information, structured in a manner that can add value to nuclear energy programs through reuse and innovation. This coordination is achieved through creating, sharing, and applying nuclear energy R&D knowledge as well as through teaching the valuable lessons learned and best practices to early career engineers in order to foster continued nuclear energy learning."***

The vision of the Office of NE KM Program is to benefit the NE programs by providing scientists across the community with the information required to assess and analyze the accuracy of advanced nuclear energy systems and associated capabilities. In the long term, the KM Program will

1. Establish a virtual knowledge center to manage, (e.g. identify, describe, format, integrate, collect, protect and disseminate) all forms of data to enable analysis relevant to the overall goals of the NE programs.
2. Lead national and international efforts to adopt, develop, and maintain the standardization of critical data and metadata formats where users and creators are responsible to validate and improve data accuracy, consistency, and accessibility among the partners.

3. Facilitate the sharing of knowledge, providing people with easy access to and use of tools, processes, venues, and facilities to help them solve problems and achieve understanding leading to a culture where sharing knowledge is a daily activity.
4. Implement a collaborative architecture for sharing existing knowledge that is currently distributed throughout DOE NE and other partners through the adoption and support of open protocols, tools, services, and distributed data resources.
5. Identify and resolve access control issues including those arising from export controlled and proprietary information and implement required levels of protection.

In the short term, the program will concentrate on areas that DOE NE deems highest priority including:

1. Implement the NE KM program across the entire DOE NE.
2. Identify the most important knowledge needed for today's programs and for the foreseeable future programs.
3. Establish *Communities of Practice* responsible for defining and overseeing the development and implementation of standards and processes for every phase of the knowledge management lifecycle.
4. Develop tools for sharing information and enhancing collaboration.

A more detailed description of the NE KM strategy can be found in the *Implementation Plan for the Office of Nuclear Energy Knowledge Management Program* [3]. This plan articulates the DOE NE business strategy and objectives. It describes the products and services that will be offered under the NE-KM umbrella and focuses on recommended program priorities.

3 Situational Analysis

Despite the formal establishment of the NE KM program, there is still much to be accomplished before the program is embedded into every day program activities. Although KM is being practiced to some level in several NE programs, the use of knowledge management as a discipline has not grown in practice across the full spectrum of the NE programs. Coordination of knowledge management activities still requires enhancement to allow knowledge to be shared across program boundaries. Additionally, formal standards and approaches must be defined and implemented to reach the ultimate goal of providing every individual access to the NE knowledge.

3.1 Knowledge Capture/Creation

The first and most important phase of the NE-KM Program is knowledge capture and/or creation. Knowledge capture refers to the identification and subsequent codification of existing knowledge and know-how. Knowledge creation is the development of new knowledge. This phase involves a multidisciplinary methodology that integrates approaches, resources, techniques and tools used to capture both explicit and tacit knowledge. Explicit knowledge is well described and can be found in experimental data, designs, test results, hard copy reports, etc. On the other hand, tacit knowledge is more concerned with the *process* of capturing the experience and expertise of the individual involved with the experiment, designing a reactor, analyzing the test results or producing the report. Although the NE-KM Program has been more successful in the collection of explicit knowledge, there has been some effort to collect tacit knowledge. These collections, however, are not without some challenges.

It is important to note that the knowledge collection activities described herein are somewhat related to other initiatives, both nationally and internationally. There are some DOE NE requirements that must be followed, specifically the relationship that must continue with International Atomic Energy Agency (IAEA), Office of Scientific and Technical Information (OSTI), Organisation for Economic Cooperation and Development (OECD), the Radiation Safety Information Computational Center (RSICC), and the requirements defined for handling and managing information categorized as applied technology (AT). Several KM initiatives are described in the following subsections.

3.1.1 International Atomic Energy Agency

Although DOE NE has been working closely with the IAEA to preserve fast reactor information, the bulk of the work remains undone due to funding limitations. Other countries have already taken the issue of information preservation seriously; leading this effort is Japan, France and Russia. A common concern among fast reactor specialists is that the U.S. is at risk of losing important information that could be used in discussions with other national programs and thereby ensure that control and exportation of fast reactor nuclear technology is managed appropriately.

Over the years, the issue of preserving fast reactor knowledge has been raised frequently at several international conferences. As a result, the IAEA took the initiative to establish an international effort to preserve fast reactor information. The initiative includes the following Member States (MS): China, France, Germany, India, Italy, Japan, Republic of Korea, Russia, the United Kingdom and the United States. The main goals of the initiative, called the *Fast Reactor Data Retrieval and Knowledge Preservation (FRKP) Initiative*, are to:

- Halt the ongoing loss of information related to fast reactors.
- Preserve and make accessible the already existing information.

Within the framework of the FRKP Initiative, the IAEA intends to create a comprehensive international inventory of fast reactor data and knowledge by combining information from the MS into the Fast Reactor Knowledge Organization System (FR-KOS). The FR-KOS will be housed and maintained by the IAEA. The main purpose of the FR-KOS is to assure preservation of sodium fast reactor (SFR) knowledge and experience gained in different countries in a form that will facilitate effective search and use of the stored information. A particularly important goal of this system is to define taxonomy agreeable to all of the MS to describe the distributed information, a standard set of metadata to describe each document, and to support in parallel a means of tagging the documents with keywords in order to facilitate the search and organization of these documents.

The U.S. is actively participated in these meetings and working with the IAEA to make U.S. fast reactor information available through Needle, a federated search engine developed by the INL, via a link provided by the FR-KOS. The U.S. further intends to participate as part of the oversight committee responsible for ensuring that the FR-KOS adequately meets the needs of the MS and, as requested by the IAEA, to participate in the technical aspects of the design and implementation of the system.

3.1.2 Office of Scientific and Technical Information

The mission of the Office of Scientific and Technical Information (OSTI) is to collect and make available R&D findings to researchers working on behalf of the DOE and to the American public. Established in 1947, OSTI has one of the largest energy-related collections of information in the world. It is a highly regarded document repository nationally recognized for its contribution to the sharing and exchange of scientific information. Although the collections are comprehensive, obtaining information from OSTI is not without some challenges:

- OSTI does not have the technologies required to enable adoption of insights and experiences, i.e., knowledge management capabilities -- OSTI mainly serves as a document repository and does not collect and store tacit knowledge.
- OSTI does not categorize the information into a structure taxonomy that models an actual fast reactor making its location less intuitive to the researcher; as such, the amount of technical expertise and historical background that are required to effectively use the repository is considerable.
- While an excellent repository of documents, OSTI does not store and make available actual data elements generated during test reactor experiments.
- Much nuclear energy information was not sent to OSTI and currently resides in boxes that are dispersed at the different DOE laboratories; the frequency with which information was sent to OSTI was variable and so it's difficult to determine exactly which collections reside at the laboratories and which at OSTI.
- Most of the fast reactor information is categorized as AT and as such requests to obtain the information from OSTI are done on a case-by-case basis where DOE approval is required.

The NE-KM Program, through the Needle Federated Search engine, links to publicly available information held by OSTI. The Idaho National Laboratory (INL) and OSTI worked together to create the interfaces to the public document management systems. Further, the two organizations are working together to ensure documents collected by the NE KM program that do not currently exist at OSTI are sent to OSTI .

3.1.3 Radiation Safety Information Computational Center

The Radiation Safety Information Computational Center (RSICC) was initiated at ORNL in 1962 and has evolved into one of the world's leading resources for a broad range of the best available nuclear computational tools and services. RSICC software and data collections provide in-depth coverage of radiation transport and safety topics encompassing, but not limited to:

- Physics of the interaction of radiation with matter
- Radiation production and sources
- Criticality safety
- Radiation protection and shielding
- Radiation detectors and measurements
- Shielding materials properties
- Shields and shipping cask design
- Radiation waste management
- Radiological safety and assessment
- Atmospheric dispersion and environmental dose
- Radiation dose in medical applications
- Space shielding applications

Information (data and codes) provided by RSICC have undergone extensive review, validation, and verification and come with documentation that enable users to quickly understand and use the information. DOE-NE is one of the primary funding sources for RSICC.

3.1.4 Organisation for Economic Cooperation and Development

The Organisation for Economic Cooperation and Development (OECD) Nuclear Energy Agency (NEA) is an intergovernmental organization of industrialized countries, based in Paris, France. DOE has worked closely with the NEA for several decades in varous work areas including nuclear energy development and nuclear science. John Herczeg, DOE NE-5 is currently chairman of the NEA's Nuclear Science Committee (NSC).

An international centre of reference called the *Data Bank* is imbedded within the NEA. The Data Bank provides basic nuclear tools, such as computer codes and nuclear data that are used for the analysis and prediction of phenomena in the nuclear field to its members. The NEA Data Bank and RSICC collaborate closely to meet similar objectives. The collaboration agreement between the Data Bank and RSICC was signed by DOE-NE.

3.1.5 Committee on the Safety of Nuclear Installations

The Committee on the Safety of Nuclear Installations (CSNI) is another OECD NEA committee that was formed to assist member countries in maintaining and further developing the scientific and technical knowledge base required to assess the safety of nuclear reactors and fuel cycle facilities. The Committee is made up of senior scientists and engineers, with broad responsibilities for safety technology and research programs, and representatives from regulatory authorities. Over the years the NEA Data Bank has collected a sizable subset of reactor transient and Loss of Coolant Accident (LOCA) integral test data [5] from CSNI joint research projects, including the LOFT project. Those data with accompanying documentation are now available on DVDs. (LOFT Data are also available through the Needle Federated Search Engine.) Most of the documents have been scanned into PDF files with an Optical Character Recognition (OCR) option. However, only data sets supplied in ASCII format have been included.

3.1.6 International Criticality and Reactor Physics Benchmark Projects

The International Criticality Safety Benchmark Evaluation Project (ICSBEP) was initiated at the Idaho National Laboratory (INL) in October of 1992 by the Department of Energy Defense Programs, now National Nuclear Security Administration NNSA. The project is managed through the INL, but involves nationally known criticality safety, reactor physics, and nuclear data experts from nine DOE National Laboratories and 20 participating countries.

The International Reactor Physics Evaluation Project (IRPhEP) was initiated, as a pilot activity in 1999 by the OECD NEA NSC. The project was endorsed as an official activity of the NSC in June of 2003. The IRPhEP is patterned after its predecessor, the ICSBEP, but focuses on other integral measurements such as buckling, spectral characteristics, reactivity effects, reactivity coefficients, kinetics measurements, reaction-rate and power distributions, nuclide compositions and other miscellaneous types of measurements in addition to critical configurations.

Both IRPhEP and ICSBEP are official activities of the OECD-NEA. The INL is responsible for coordinating all Technical Review and Publication efforts associated with both projects. The two projects are closely coordinated to avoid duplication of effort and to leverage limited resources to achieve a common goal.

The ICSBEP and IRPhEP preserve integral criticality and reactor physics experimental data, including measurement methods, techniques, and separate or special effects data for nuclear energy and technology applications and the knowledge and competence contained therein. Data from both of these projects are evaluated and provided to users in an easily usable form.

NEA has also scanned numerous other reactor documents from around the world in preparation for future evaluation.

3.1.7 Experimental Breeder Reactor-II and Fast FluxTest Facility Data

A large amount of non-digital data and documentation exists about the construction, operation, and experimental results of the Experimental Breeder Reactor II (EBR)-II at the INL and the Fast Flux Test Facility (FFTF) at the Pacific Northwest National Laboratory (PNNL). The collection, cataloging, digitization, and archiving of this information have been selected as an important effort to support the Fuel Cycle Technology (FCT) research and development activities. The recovery and preservation of FFTF irradiated and un-irradiated metal and oxide fuels are of particular importance in the short term to the Fuels Campaign, much of the data can be used for V&V of computer codes. The urgency to collect this information is not only driven by the Fuels Campaign, but also stems from the fact that many specialists involved in the earlier fast reactor studies (and those who know the information best) are beginning to, or have already, retired. More detailed information about the EBR-II and FFTF can be found in the *Technical Report on Fast Reactor Knowledge Preservation in the U.S.*, March 2009, [4].

A large portion of the EBR-II and FFTF information are categorized as AT. As such, strict rules exist that describe how this information must be managed, how it is distributed, and to whom it can be distributed. Under the fast reactor knowledge preservation program, documents identified as AT will be monitored and controlled to domestic recipients and foreign trade will be prohibited unless specifically approved by the appropriate DOE NE Program Office officials (and pursuant to 10 CFR Part 810 regulations). Further, we will strictly prohibit the use of AT information in presentations, as references in non-AT documents, or used as the basis in technical society meetings, journals, or meetings with foreign interests unless prior NE Program Office approval is received. Finally, we confirm our understanding that the AT designation is indicated either through contractual requirements or in the task orders under which the information is developed and will respect those contractual agreements accordingly.

Several thousand EBR-II hard copy documents were collected at the INL. Documents were reviewed and prioritized by John Sackett, EBR-II subject matter expert. Documents were provided to the INL library where they were scanned, digitized, and uploaded into the National Nuclear Archives (NNA) database. Needle has a direct interface to the NNA.

3.1.8 Liquid Metal Engineering Center Facility Description

The Santa Susana Field Laboratory (SSFL) is located in the Simi Hills approximately 30 miles northwest of Los Angeles, CA. It was initially established by the North American Aviation (NAA) in 1947 to test large rocket engines, but quickly met the NAA's need for a nuclear research facility. As a result, the SSFL was established as a nuclear research and development facility in 1953 and in 1955 the rocket development and nuclear developments groups became two separate divisions, Rocketdyne and the Atomics International (AI). AI became the parent of two distinct groups; one focused on the development of civilian nuclear power and the other was a center of excellence for research and testing of non-nuclear components related to liquid metals. The two groups were referred to as AI and the Liquid Metal Engineering Center (LMEC).

LMEC was created in 1966 as a government-owned and contractor-operated organization. Its purpose was to provide development and non-nuclear testing of Liquid Metal Reactor (LMR) components and to establish the Liquid Metal Information Center (LMIC) for the Atomic Energy Commission's (AEC) Liquid Metal Fast-Breeder Reactor (LMFBR) program. The LMEC was renamed Energy Technology Engineering Center (ETEC) in 1978 to reflect DOE's desire to broaden its mission beyond the LMFBR program. Before research activities ended in 1998, three primary types of operations were conducted at Area IV: 1) development and testing of nuclear reactors, 2) nuclear support operations, and 3) non-nuclear energy R&D. DOE NE was mostly interested in collecting information created by the non-nuclear energy R&D operations. Some of the most important documentation created at the LMEC is the non-nuclear liquid metal component testing.

Under the NE KM program, 80 boxes containing approximately 100 documents each were copied and sent to the INL. Since that time, ANL has taken ownership of the documents and the boxes are in the process of being shipped to the ANL. Due to a concern about classification of the documents, the INL is required to review each document before the boxes can be shipped. To date 55 boxes have been shipped; the remaining boxes are still being evaluated.

3.1.9 Advanced Reactor Concepts

The Advanced Reactor Concepts (ARC) program at Argonne is doing an outstanding job archiving data for EBR-II, FFTF and TREAT tests and sodium fast reactor fuels and materials. The program has established an EBR-II test database which is expected to be extended to include selected FFTF tests. The TREAT test database will be completed and will include the data and information for more than 200 tests and the SFR fuels database will continue to be populated using available data from additional five EBR-II irradiation experiments with metal fuels. The data and information archived in these databases will help facilitate the science-based R&D goals of the DOE NE Reactor Technologies program, and will provide data needed for validation of the advanced analysis methods and codes for analysis of transients and operations. The knowledge management activity under ARC is a separate effort from the NE KM program.

3.1.10 Zero Power Reactor and Zero Power Physics Reactor

INL and ANL collaborated to identify and scan Hundreds of Zero Power Reactor (ZPR) and Zero Power Physics Reactor (ZPPR) reports, logbooks, memos, etc. Those documents are available through the Needle Federated Search Engine. Limited funding was provided by the DOE Nuclear Criticality Safety Program. Additional documents are maintained in INL Records Storage Facility (IRSF). *An Overview of the Argonne National Laboratory Fast Critical Experiments* was prepared by Leo G. LeSage [6].

3.1.11 Nuclear Energy Knowledge base for Advanced Modeling and Simulation

The complexity of nuclear reactor power plants, as well as the cost and difficulty associated with testing nuclear reactor systems, makes the use of Modeling and Simulation (M&S) a desirable tool for nuclear reactor design, analysis and licensing. Thus, engineering analysis and performance characterization of existing and new reactor designs will employ advanced M&S tools, such as computational fluid dynamics (CFD) and computational structural mechanics (CSM), in addition to the traditional thermal hydraulics (T/H) and systems analysis codes. The DOE-NE, in fact, has been actively developing and promoting the use of advanced M&S in reactor design and analysis through its R&D programs, *e.g*., the Nuclear Energy Advanced Modeling and Simulation (NEAMS) and Consortium for Advanced Simulation of Light Water Reactors (CASL) programs. Also, nuclear reactor vendors are already using CFD and CSM, for design, analysis, and licensing. However, these M&S tools cannot be used with confidence for nuclear reactor applications unless supported by verification and validation (V&V) and uncertainty quantification (UQ) which provide quantitative measures of uncertainty for specific applications.

V&V and UQ are the primary means to assess the accuracy and reliability of M&S and, hence, to establish confidence in M&S. Though the nuclear industry has established standards and processes for carrying out V&V and UQ for systems analysis codes and simulations, at present, similar standards and processes for high fidelity M&S tools such as CFD have not reached the same level of maturity. However, the nuclear industry recognizes that such standards and processes are needed and that the resources required to support V&V and UQ for CFD for nuclear applications is significant. In fact, no single organization, whether a commercial company or government laboratory, has the resources required to organize, develop and maintain the needed V&V and UQ program. What is needed is a standardized program for V&V and UQ at a national or even international level, with a consortium of partners from government, academia and industry. Specifically, what is needed is a structured knowledge base that collects, evaluates and stores verification and validation data, and shows how it can be used to perform V&V and UQ. This knowledge base can promote collaboration and provide for sharing of resources to support engineering and licensing applications.

The Nuclear Energy Knowledge base for Advanced Modeling and Simulation (NE-KAMS) is being developed at the INL in conjunction with Bettis Laboratory (BL), Sandia National Laboratories (SNL), ANL, Utah State University (USU) and others and is being funded by the NEAMS program. The objective of this consortium is to establish a comprehensive and web-accessible knowledge base to provide V&V and UQ resources for M&S for nuclear reactor design, analysis and licensing. The knowledge base will serve as an important resource for technical exchange that will enable credible computational models and simulations for application to nuclear power. NE-KAMS will serve as a valuable resource for the nuclear industry, academia, the national laboratories, the U.S. Nuclear Regulatory Commission (NRC), and the public, and will help ensure the safe, economical and reliable operation of existing and future nuclear reactors. Although NE-KAMS is not funded by the NE-KM program, it is considered part-and-parcel of the overall program.

3.1.12 Expert Videos

The NE-KM has produced several expert videos; subject matter experts were interviewed and videotaped by a professional communications expert and photographer. Following is a list of videotapes:

- The Life and Times of Andy Van Echo
- A Conversation with Carter "Buzz" Savage
- Egon Lamprecht, "The SL-1 Accident, a First Responders Account"
- EBR-II Expert Panel Video I
- EBR-II Expert Panel Video II
- FFTF Expert Panel Video I
- Nuclear Criticality: Heritage Video Conference 2000

Videotapes are currently stored on YouTube. YouTube was originally used as a quick solution for making the videos accessible without having to purchase hardware for storage. However, the maximum number of free videotapes allowed by YouTube has been reached. As funding allows, videotapes will be moved to an INL server that resides outside the firewall. Videos will remain available through the Needle Federated Search Engine.

3.2 Knowledge Sharing and Dissemination

The knowledge sharing and dissemination phase is concerned with contextualizing the captured information. This phase requires subject matter experts (SME) to coordinate the captured information into knowledge packages that makes sense and then make it available to the NE community. Information and communication technologies such as groupware, intranets and knowledge bases provide the required infrastructure for knowledge sharing and dissemination.

Due to limited budgets, the NE KM program has not been able to take advantage of the integrated computer-supported work environments that are available in the market today. Knowledge management systems and tools for sharing knowledge have been slow to progress. Systems that support KM provide specific functions relating to communication, sharing R&D results, etc. These tools can actually contribute to the culture of sharing knowledge. However, even in the world of freeware, hardware and labor are still required to make them useful for specific applications. The good news, however, is nearly all NE programs are now storing R&D explicit knowledge in electronic format. Databases, repositories and content management systems exist at each of the DOE sites, however, an inventory of these systems does not exist making it difficult for the DOE NE to understand the full spectrum of the knowledge it owns.

3.2.1 Communities of Practice

Part of the strategy for the NE-KM Program involves the creation of Communities of Practice (CoP). These are networks of individuals with a common, shared purpose grouped together to facilitate knowledge building, idea creation and information exchange. CoPs will emerge from voluntary, informal workgroups formulated around a specific area of expertise integral to the NE Programs. However to be successful, CoPs require a number of key roles to be filled. The major roles include a champion, a sponsor, a facilitator, a practice leader and members.

To date, no formal CoPs have been established for the NE KM program. The team that most resembled a CoP was the Fast Reactor Working Group that had subject matter experts from DOE NE, DOE-ID, OSTI, ANL, INL, PNNL and Brookhaven. The group met annually for two consecutive years, 2008-2009. The team consisted of the following members:

- Frank Goldner: frank.goldner@nuclear.energy.gov
- Dave Henderson: henderad@id.doe.gov
- Al Farabee: oliver_a_al_farabee@rl.gov
- Ronald Omberg: Ronald.omberg@pnl.gov
- Jim Buelt: James.buelt@pnl.gov
- Scott Butner: Scott.butner@pnl.gov
- Christopher Grandy: cgrandy@anl.gov (attended via conference call)
- Pete Planchon: pete.planchon@inl.gov
- David Bellis: bellisd@osti.gov
- David Stampf: drs@bnl.gov

The goal of the team was to identify historical information that is of value to the (then) AFCI Program and prioritize the information according to that which is at risk of being lost or destroyed, e.g., Santa Susana information, EBR-II and FFTF information. This included both explicit and implicit data. Additionally, information to support the *Spent Fuel Disposition for Alternative Geologies* was also considered. The team was very effective at identifying other information that may be required as well. A summarization, along with the defined roles and responsibilities is provided.

Ron Omberg was responsible for overseeing the efforts to move FFTF information from the Hanford site in preparation for Environmental Management (EM) activities. He put together a large team to support the collections; collections are now co-located in a building on the Hanford site. Many collections were collated into meaningful knowledge packages; however the funding did not exist to upload the information into electronic format. Thousands of knowledge packages reside in hardcopy format and are stored in metal file cabinets.

John Sackett evaluated the EBR-II integral and separate effects data. A suggestion was made to collect EBR-II experimental data from the DAS system at the INL. Various other experiments exist in hard copy form and depending on the funding level these data were also to be considered. Three servers were installed to maintain EBR-II data at the INL and Needle was used to support document retrieval. The EBR-II documents that were collected at the time of this meeting were uploaded to the Enterprise Document Management System at the INL; additional and more documents can be found in the AFCI-DMS. It was suggested that the documents within the AFCI-DMS be organized to follow the IAEA Taxonomy. It was also noted that EBR-II data is very valuable to China right now; and for the sake of safety, the possibility of providing access to some information was discussed but no conclusion was agreed upon.

The team evaluated other data collections for consideration and determined the following to be important for DOE NE programs:

1. Clinch River Breeder Reactor information
2. Oak Ridge National Laboratory
    - Materials/metallurgy Reports
    - SP100 (space power)
3. Thermal hydraulics at the INL, particularly the pockets of information about D&D.
4. Savannah River – fuels information
5. Terry Todd's information relating to the creation of pulse pockets.
6. Power Reactor Innovative Small Module (PRISM) documents that were filed approximately 11 years ago and sent to Maryland (the Records Center generally destroys after 10 years; any of these still exist?)
7. Materials Test Reactor (MTR) documents in Idaho
8. New Production Reactor (NPR) documents in Idaho
9. NTIS could perhaps have some nuclear information on microfiche
10. Additional EBR-II data, Loss of Fluid Test (LOFT) Reactor, Power Burst Facility (PBF), Idaho Chemical Processing Plant (ICPP), and Zero Power Physics Reactor (ZPPR).

Several other SMEs were identified and it was suggested that tacit knowledge be collected from these individuals.

1. Frank Goldner, DOE NE
2. Ersel Evens, VP Westinghouse
3. Chuck Carlisle, PM for FFTF, Richland, WA
4. Al Rizzo, Richland, WA
5. Bob Furgeson, Richland, WA
6. John Taylor, EPRI
7. Alan Waltar, Nuclear Safety, Levenworth, WA
8. LeRoy Rice, Richland, WA
9. Woody Cunningham, Director of F&M, Bethesda, MD
10. Andy Millunzzi, Germantown, MD
11. Keith Magnus, Fuels Development, Bethesda, WA
12. Steve Additon, Richland, WA
13. Leon Walters, ANL Retiree, Idaho Falls, ID
14. Ron King, DOE-LM, Boise, Idaho
15. Pete Planchon, INL, Idaho Falls, ID
16. Gary Lentz, Idaho Falls, ID

17. John Sackett, ANL Retiree, Bozeman, MT
18. Nick Grossman, Prism, Germantown, MD
19. Jerry Straalsund, Fueld, Sandpoint, ID
20. Chuck Till, ALD, ANL East, Chicago, IL
21. Hans Fauske, Fausk Associates, Chicago, IL
22. Chuck Boardman, GE, San Jose
23. John Nolan, Westinghouse, Richland, WA
24. Don Riley, Knoxville, TN
25. Al Farabee, Richland, WA
26. Lynn Koch, Las Vegas, NV
27. Milt Levenson, Richland, WA
28. Ron Omberg, PNNL, Richland, WA
29. John Swanson, Richland, WA
30. Earl Wheelwright, Richland, WA

Tacit knowledge from Alan Waltar, Leon Walters, Ron King, John Sackett and Ron Omberg was collected (please refer to Expert Video section above). Due to funding limitations, the other suggested explicit and tacit knowledge collections were not captured and codified. The team dispersed shortly after the August 2008 meeting.

3.2.2 Standards and Procedures

NE-KM standards and procedures are required to provide users with the direction and control to reflect the requirements of the NE program. Standards must be appropriately quantified, qualified, expressed, and coupled with NE-KM processes for deployment and enforcement of compliance. Standards and procedures for knowledge management that should be considered by the NE-KM program are:

- Standards for knowledge collection
- Knowledge definitions
- Knowledge categories and attributes
- Knowledge taxonomies and ontologies
- Metadata definitions and requirements
- Guiding principles for releasing information in a public facing environment
- Collaborative communications in a public facing environment
- Training requirements
- Quality Assurance (QA)
- Cyber Security

To date, the ***Cyber Security Master Plan for the Office of Nuclear Energy Knowledge Management (NE-KM) Program*** in support of the Office of NE Knowledge Management Program has been developed. This plan was developed by researchers from the University of Idaho's Center for Secure and Dependable Systems (CSDS) per the National Institute of Standards and Technology (NIST) guidance, *Guide for the Security Certification and Accreditation of Federal Information Systems*. This plan is expected to be a living document and will require updates as the NIST Guide is updated. Other policies and procedures will be produced this year (2012).

3.2.3 Needle

The INL has combined a number of technologies, tools, and resources from several universities and private industry companies to develop a new technology for federating search results. The resulting product is a search engine called Needle, an open-source-based tool that the INL uses internally for researching across a wide variety of information repositories. Needle has a flexible search interface that allows end users to point at any available data source. A user can select multiple sources, such as commercial databases (Web of Science, Engineering Index), external resources (WorldCat, Google Scholar) and internal corporate resources (email, document management systems, library collections), in a single interface with one search query. A key aspect of the federated search is its ability to include a wide variety of external search sources that are provided by various agencies, laboratory and institutions.

An instance of Needle was created for the Office of NE and is the primary search engine for the KM Program. It interfaces with INL internal content management systems, one document management system at PNNL, and multiple content management systems at OSTI. Needle can only access publicly available information; it cannot access sensitive information behind the firewall. An instance of Needle (Haystack) needs to be implemented before users can access sensitive information. Because users have found it difficult to remember the web address for Needle it is not being used as frequently as was intended. The INL is working with DOE NE to provide a link from the NE homepage.

3.2.4 Knowledge Encapsulation Framework

The Knowledge Encapsulation Framework (KEF) is a tool that was developed in support of PNNL's Techno social Predictive Analytics Initiative (TPAI). It was originally intended to manage data from scientific literature, M&S documentation and social media. It provides a rich framework for semantic annotation of scientific and technical documents and leverages a greater than $600K investment in knowledge management by PNNL and other agencies. For the KM Program, KEF will serve as an interface into restricted (AT) data from FFTF design, construction and operation. It provides a standalone KM environment for data entry and will be adapted to provide a searchable interface for integration with Needle.

As of the date of this writing, funding has not been available to develop a KEF instance for the NE KM program. A requirements document was developed for the NE KM program; the basic infrastructure exists at PNNL.

3.3 Knowledge Application

Knowledge application is the final phase in KM. For knowledge to truly benefit the NE community, it is imperative that we better understand the knowledge that is needed and how that knowledge is being used. This phase helps to promote effective knowledge use at the individual, group, and community levels. It is concerned with the KM architecture and ensuring that knowledge at all levels is available, easily accessible, and used effectively. The application of KM is primarily concerned with providing individuals and groups with the knowledge they need to learn from past experience to reduce the time and effort to reinvent what is already known.

The NE KM program has not advanced to the point where the use of knowledge can be appropriately evaluated. Although the IRPhEP program did reach this level, it is currently not funded to a maintainable level.

4 Conclusion

The awareness of KM within the DOE NE community has increased tenfold from five years ago. Data repositories and content management systems are widely used across the community and metadata tagging is now seen as an important feature that leads to a better understanding of the information collected. From the broader perspective of KM, however, the NE KM program has a long way to go before it can be fully implemented. And not unlike most organizations, the program is still operating at the ad-hoc level.

Although KM is being practiced to some level, it is not being practiced in a consistent manner across the NE community. The use of KM is centralized to specific programs rather than generalized across the entire NE. Established as a formal program it is not yet recognized as an important asset nor is its benefits fully understood by individuals, groups and the NE community. KM activities are not coordinated and knowledge sharing has not yet crossed program boundaries.

To be fully successful, more emphasis must be placed on establishing KM standards and processes for collecting, organizing, sharing and accessing NE knowledge. Existing knowledge needs to be prioritized and gathered on a routine basis, its existence formally recorded in a knowledge inventory. Without the inventory, the NE programs can't possible know what exists and where to find it. Governance to ensure the quality of the knowledge being used must also be considered. For easy retrieval, knowledge must be organized using a specific thesaurus and classification schema; this process requires involvement of SMEs. Technologies need to be established to make accessing the knowledge easier for the user. And finally, knowledge management needs to be used as part of a well defined work process.

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