Knowledge Preservation for Repository Systems

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The management and preservation of knowledge is essential to ensure the long-term safety of a radioactive waste repository throughout its lifecycle (planning, site selection, licensing, construction, emplacement operations and post-closure). While recorded documentation of technical and scientific information such as documents, media, software code and data is fundamental for the long-term safety assessments of a repository, there are additional categories of knowledge that need to be managed and preserved. These additional categories include cultural considerations such as history, social context, values, folklore, processes and procedures, plus the memories of staff, retirees and stakeholders in general. The preservation of knowledge for a nuclear waste repository is challenged by the long time scales involved and require management practices of recorded documentation, cultural considerations and memories that are robust and, as far as possible, future-proof technologically. Robustness also requires resiliency to future operational and societal changes, such as the advent of new organizational structures and evolutions in the decision making environment as well as the changing perceptions of stakeholders over time.

This paper discusses issues associated with the management and preservation of knowledge, including consideration of approaches that are expected to mitigate the inevitable changes in organizational structures and changing perceptions of stakeholders over time. Three case studies are presented, the first one is associated with knowledge management and preservation at Sandia National Laboratories (Sandia) associated with the maintenance of nuclear weapons. In the late 1990's, Sandia recognized the need to capture, maintain, catalog and store knowledge associated with the development, improvement and maintenance of nuclear weapons. Many of these weapons have been designed as early as the 1950's and there is a requirement to maintain them to ensure they perform as designed, and, most importantly, to remain safe while in storage. A second case study discusses knowledge preservation efforts attendant to the shut-down of the Yucca Mountain Project and the third case study discusses knowledge management and preservation for the Waste Isolation Pilot Plant radioactive waste repository.

As repository development continues to advance in many countries, several disposal programs began to examine means for passive oversights to enhance the long-term safety of the future disposal facilities. In 2011, the Organization for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA) Radioactive Waste Management Committee (RWMC) launched a project on the "Preservation of Records, Knowledge and Memory (RK&M) across Generations". The RK&M Project aims at formulating and developing knowledge preservation methods that endure the longest possible timeframe (i.e. including the post-closure phase). This paper reports on the progress of RK&M as well as an initiative connected to RK&M entitled REPMET (repository metadata). The aim of this initiative is to identify sets of metadata that can be used by national programs to manage their repository data, information and records in a way that is both harmonized internationally and suitable for long-term management and utilization. It will also formulate a consistent set of guiding principles for capturing and generating metadata. The RepMet project fills a unique and important niche in the broader programs on knowledge management that are conducted nationally and internationally. The REPMET initiative includes European, Asian and North American participants.

I. INTRODUCTION

Knowledge management is a comprehensive term generally meant to encompass efforts directed at compiling, organizing, and leveraging an organization's knowledge to support organizational goals, (continuity, profitability, efficiency, etc.). The term includes a diverse range of efforts to identify, analyze, optimize, and apply information that the organization deems important. In the context of repository systems, it spans matters ranging from the purely technical, well understood (certain), physical/chemical characteristics (waste packages materials, waste forms, corrosion, and waste locations); to less well understood (uncertain) characteristics, (natural fluid flow, volcanism, other low probability events); to very poorly definable characteristics, (cultural influences, societal characteristics).

Knowledge preservation is an element of knowledge management. For long term social artifacts, like nuclear waste repositories, its focus is different from that customarily applied, which is largely directed at important information necessary to maintain or improve current business models. Applied knowledge management as generally practiced would be very useful in the operation of a repository system. An example would be using knowledge management techniques to maintain the continuity of procedural processes (technical culture) over the decades of repository operations. However, knowledge preservation consists of efforts to safeguard our understanding of important issues for continuing long-term safety of the repository system by avoiding the loss of institutional and societal knowledge long after its closure.

Knowledge preservation for repository systems envelops both classic subdivisions of knowledge; explicit knowledge, and tacit knowledge. Explicit knowledge is information that is readily codified into a tangible form, i.e., documentary material (reports, analyses, memos, videos, email, databases, etc.) that may be retained in a wide variety of media (paper, film, electronic, etc.). This knowledge is most readily identified and retained, although it is still subject to the customary difficulties associated with dissemination, poignancy, searching, and technological obsolescence. In our societies, development of a nuclear repository is driven by overwhelmingly regulatory (technical / engineering) considerations. So, recording and preserving the explicit recorded knowledge required to convince a regulator to allow repository operation secures at least a core set of information requiring preservation. However, regulatory submittals likely constitute less than one percent of the recorded information necessary to produce it.

Tacit knowledge is knowledge that we as individuals possess, but is not readily codified. Skills like playing musical instruments, woodworking and welding are examples, as are inherent personal abilities like writing and mental arithmetic. Tacit knowledge is much more difficult to codify, if possible at all. However, this knowledge class also includes information that is not clearly explicit, but can be codified to a certain extent. Examples are technical, societal, or cultural processes that pertain to substantial organized efforts (large engineering projects). This knowledge can be captured by interrogating participants and transcribing or recording the conversations. Paper objects have traditionally served as the media for important information. However, our technological advances are clearly directing preservation efforts to electronic forms. For example, while the ease of web-based publishing has greatly enhanced the dissemination of information, the inevitable changes in the web construct have led to international efforts to secure continued access to scientific and technical literature in the nuclear field. This illustrates the difficulty of maintaining accessibility to electronically preserved knowledge, even over a time span as short as a few decades. Recording conversations with key leaders and experts is another way to capture knowledge, but this approach faces similar durability and poignancy challenges over long times. Some examples are discussed in the case studies below. In the U.S., the National Archive and Records Administration (NARA) accepts records in electronic formats. Yet advances like these are not without their own obsolescence related issues.

Notably, the technological durability and usability of the preservation media is a pervasive problem that overshadows all attempts at knowledge preservation, especially those attempting to preserve knowledge for centuries or even millennia as in the case of repository post-closure information.

I.A. CASE STUDY: Sandia National Laboratories' Knowledge Preservation for Nuclear Weapons

Sandia emerged from World War II's Manhattan project. In the late 1940's, the nuclear stockpile was small, consisting of a few hand-crafted devices modeled on the Fat Man design used in World War II. However, as the cold war progressed from the 1950's through the end of the 20th century, the United States developed a larger stockpile of nuclear weapons of multiple designs. A primary mission of SNL has been and continues to be to provide the science and technology to maintain and certify the nuclear stockpile. The facilities and expertise used to fulfill this mission over the last 60 years are even more critical as the nuclear weapons stockpile ages, the total number of weapons decreases (increasing the relative worth of each remaining weapon), and the security threat to the stockpile changes. The capability to certify the safety, security and operational capabilities of the stockpile are made even more difficult since the cessation of nuclear weapon testing by the US in 1992. This means that the stockpile must be certified for safety and surety based on the understanding of the weapons systems in the absence of physical proof. Consequently, the knowledge of a weapons system, and how and why it was developed, becomes even more crucial.

In the early 1990's, it was recognized that with no new weapons designs on the horizon and with the designers of the weapons over the prior 40+ years leaving SNL and entering retirement, it would be challenging to maintain the expertise required to sustain the nuclear stockpile and the capability to respond to changes in the threat environment. While laboratory and DOE processes require the storage and maintenance of all design and test drawings and documents, it had no way of capturing the tacit knowledge of these departing individuals. With this in mind, in 1994 a SNL Defense Program Vice President initiated the Knowledge Preservation Project with the goal of capturing and then offering the experience base of

this generation to those yet to be hired. Through the rest of the 1990's and into the early 2000's, there was significant effort to gather as much of this tacit knowledge of retiring weaponeers as possible. In excess of 1,500 hours of exit interview video was recorded. Painstakingly, many of these videos were manually transcribed to allow for text searching but unfortunately, finding and accessing useful knowledge was both tedious and time consuming and therefore seldom attempted. For over a decade, this captured knowledge resided on servers, available but unused.

To remedy this problem, a new effort was initiated in 2012 that utilized the expertise of retirees to review these lengthy tapes, identifying and categorizing over 1500 short (5-10 minute) synopses (video clips) of these exit interview videos for inclusion into a web based "YouTube" like application. The development of keywords for each clip allows for both effective searching and enables the software to use these keywords to create a sidebar search for related clips with the hope of encouraging browsing by the users. The system, titled the Sandia Weapons Channel, is in use today and provides current weapons engineers with the history and context of why and how design and program decisions were made associated with the development of nuclear weapons.

Figure 1 is an un-classified screen capture from the Sandia Weapons Channel. The video clip appears in the top left section of the screen, and there are related clips on the right side of the screen. While viewing these videos might trigger an attempt to implement a previous discussed design concept, what is more likely to be of highest value are the lessons learned and philosophical approaches that are discussed throughout these interviews. In almost all cases, it is not the technical details that the retirees want to convey to these unknown future generations, but the approaches that worked and didn't work – the "gotcha's" they experienced that they'd like to talk about – all the things that they wish someone had warned them about and all the tricks that they wished they'd learned earlier. That is the kind of information that, before the Knowledge Preservation Project, would have left with the departure of these early weapon designers.

The Sandia Weapons Channel, while an important component of the knowledge preservation at SNL, is not the only component. SNL's responsibility associated with nuclear weapons requires the continuing transfer of decades of nuclear weapon-related knowledge and experience to new generations of nuclear weaponeers, critical to the success of nuclear stockpile stewardship. Today, SNL approaches knowledge preservation for nuclear weapons by addressing the preservation needs through a Nuclear Weapon Knowledge Cycle. (Figure 2).

All phases of the Nuclear Weapon Knowledge Cycle are currently being addressed in SNL's knowledge preservation activities. The cycle begins when a new hire starts his or her preparation for a career in nuclear weapons. Throughout an individual's career, knowledge, skills and abilities are applied to tasks such as research, development, engineering, and design. The knowledge, skills and abilities applied to these tasks find their way into explicit products that include the nuclear weapons artifacts of hardware, recorded information, and culture, and the tacit artifacts embedded in personal skills and memories. The NW knowledge preservation program creates and sustains a flexible, on-demand set of programs that continually feeds the knowledge contained in these artifacts back into the workforce, effectively "recycling"

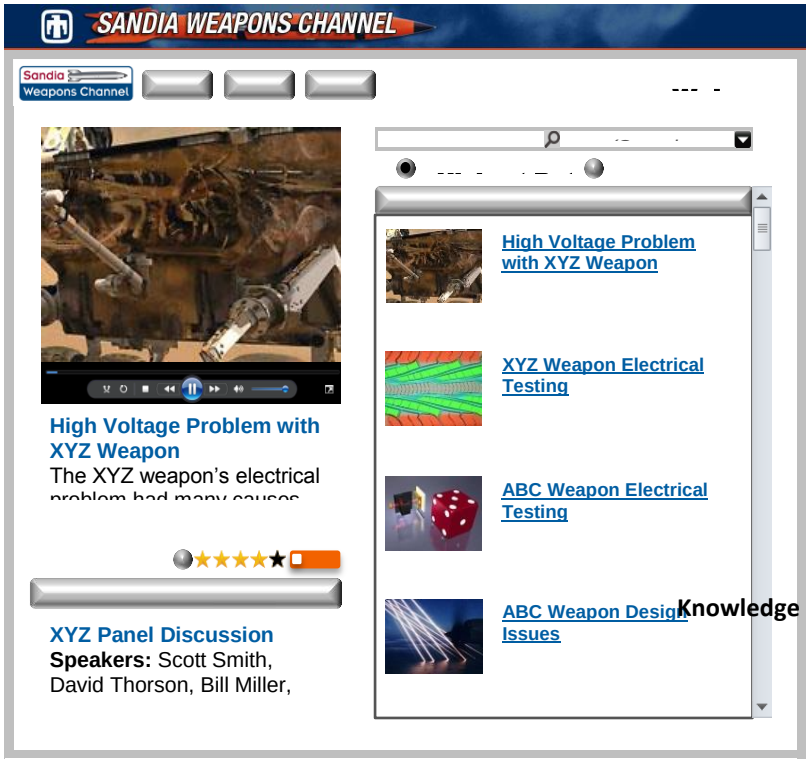

Figure 1 Sandia Weapons Channel screen capture
Image by Diane Miller, Sandia National Laboratories, 2014

this continually evolving knowledge base. As the weaponeer (the title given to the nuclear weapons engineer) passes through early, middle and senior stages of their career, the cycle repeats itself. When a weaponeer retires, the goal is to have identified, captured, and recycled as much of this knowledge as possible, thereby minimizing the lost knowledge that would be leaving the organization.

Classroom based instruction is a key element of this knowledge cycle. The laboratory offers about 80 different instructor-led classes on various aspects of nuclear weapon operation, design, engineering, and

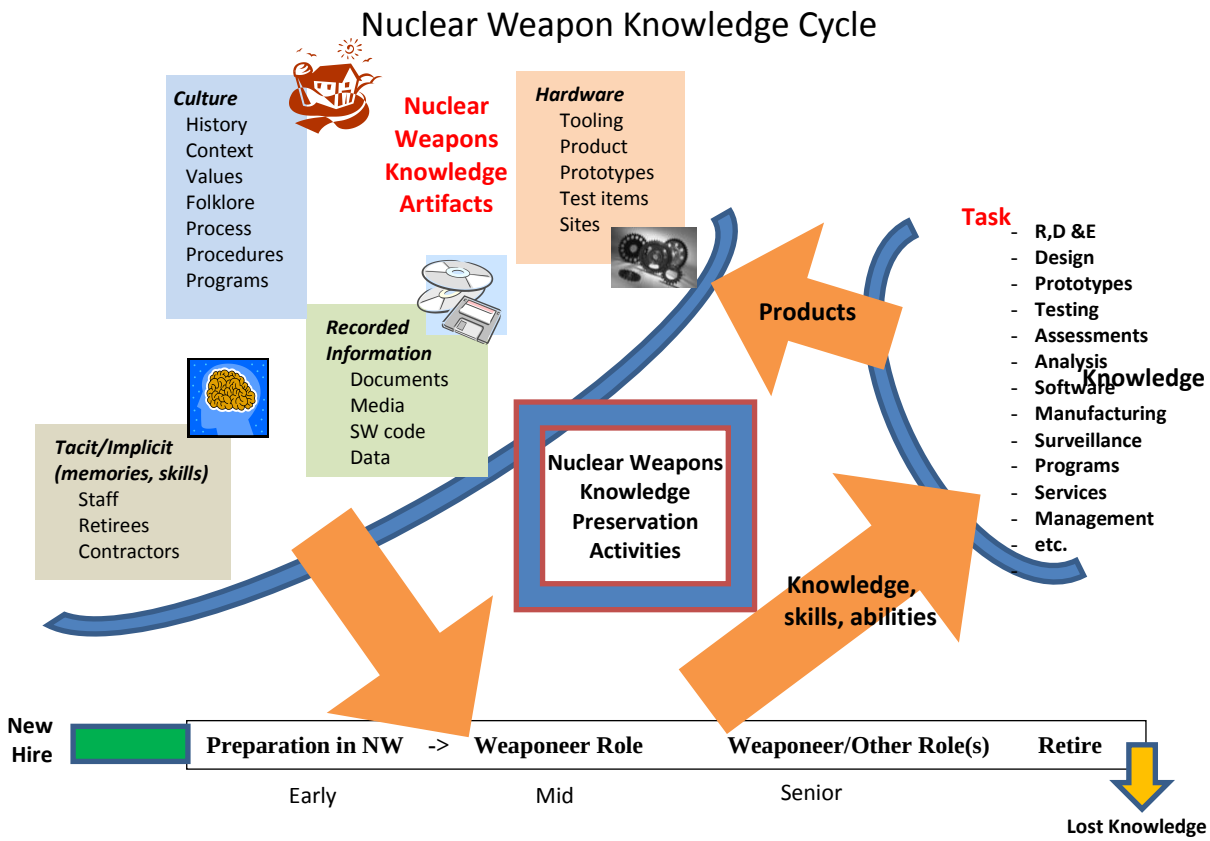

Figure 2 Nuclear Weapon Knowledge Cycle
Image by John Whitley, Sandia National Laboratories, 2014

testing, varying in length from two to forty hours. The program does not utilize a professional teaching corps but instead relies on either active or retired weaponeers for instruction. The basic philosophy is for legacy systems and subjects to be taught, as much as possible, by those who did the original work (usually retirees), while instruction on current systems is taught by those currently doing the work. Over the course of a year, this corps of over 250 instructors will reach over 1500 students and generate over 30,000 student-contact-hours.

In addition to this specialized nuclear weapon curriculum, Sandia also provides an extensive education experience to not only Sandia employees but to other DOE nuclear weapon sites and the military. The Weapon Intern Program (WIP) brings together a relatively small group of about 20 early career engineers and scientists and provides an intense, comprehensive exposure to all aspects of the nuclear weapon lifecycle and of nuclear deterrence. The first class of the WIP was established in 1998, with the first graduating class in September of 2000. The WIP involves eleven months of classes (~500 hours), one-on-one encounters with senior weaponeers and nuclear weapons pioneers, site visits and rotational assignments. Since the first graduating class of the 1998 WIP class, 353 weaponeers have successfully completed the WIP. The WIP continues with 35 weapon interns currently enrolled.

Rounding out the weapon related knowledge activities are the efforts to preserve and utilize classified legacy hardware and components for educational purposes. Large numbers of prototypes, models, and test hardware was created during the course of these activities, and the program is actively collecting, cataloging, and offering these items for study and instruction.

Knowledge preservation for nuclear weapons stockpile stewardship is managed through the Weapons Engineering Professional Development Department (WEPD) and is closely coordinate with the laboratories' corporate learning activities. WEPD has developed the capabilities to process archival media and make it accessible using today's technologies. They are processing motion film as well as ¾ inch, Beta and VHS video tape. A stand-alone PC which contains drives that read Bernoulli, Jaz, 5.25 inch and 3.5 inch drives has been made available. This knowledge preservation activity managed by WEPD represents a robust effort that continues to implement current technologies and multiple approaches for the preservation of nuclear weapons stockpile stewardship knowledge, as well as making sure older technologies and the decades of lessons learned remain accessible.

I.B. CASE STUDY: Yucca Mountain Knowledge Preservation

In June of 2008 the U.S. Department of Energy (DOE) submitted a license application (LA) to the U.S. Nuclear Regulatory Commission (NRC) for a high-level waste repository located at Yucca Mountain, Nevada. This culminated more than 20 years of scientific investigations into the feasibility and safety of disposal of high-level radioactive waste and commercial spent nuclear fuel at this location. On February 1, 2010, the U.S. Administration announced its Fiscal Year 2011 Budget Request to the U.S Congress reflecting discontinued support for the Yucca Mountain Project (YMP) LA submitted to NRC. DOE began to terminate YMP activities in March, 2010. By the end of July 2010, all YMP site-related technical studies had ended. Because the licensing proceeding had not come to a clear cut conclusion, several involved organizations, including Sandia National Laboratories, moved to preserve the scientific, technical and procedural information from the project.

One advantage YMP had over most similar projects was that NRC's rules required population of a Licensing Support Network (LSN) to facilitate legal discovery for the adjudicatory licensing hearing. The LSN is an electronic system, established by the NRC and operated by the NRC's Atomic Safety and Licensing Board (ASLAB) panel. Its purpose was to provide internet access to documents that may be used as evidence in the NRC's review process and associated licensing proceedings. This meant that the information to support the licensing hearing was preserved by the regulator, in addition to the licensee and its support organizations.

Another advantage was the rigorous records management provisions imposed by DOE on participants throughout the project. The collection of information maintained by DOE's Legacy Management office is the most comprehensive YMP collection. It contains more than 62 million records, including about 3.6 million project documents in the LSN collection, as well as other artifacts (computer programs, etc.) related to research conducted in DOE's Civilian Radioactive Waste Management program over at least two decades.

Knowledge Preservation Systems for the Yucca Mountain Project are:

- NRC ADAMS (Agency Document and Management System) Collection
- NRC ASLAB LSN (Licensing Support Network) Collection
- DOE Legacy Management Collection
- Sandia National Laboratories (Yucca Mountain Project Lead Laboratory)
- Other Proceeding Participant Collections

Sandia National Laboratories is DOE's lead national laboratory for the project principally responsible for post-closure analyses of the YMP repository system. Sandia archived project information in a more integrated fashion than the project systems allowed. Figure 3 illustrates the general YMP Lead Lab information relationships. The shaded boxes represent independent project information systems that were largely isolated from each other. Without understanding the relationships among these information systems one would be unable to interpret the

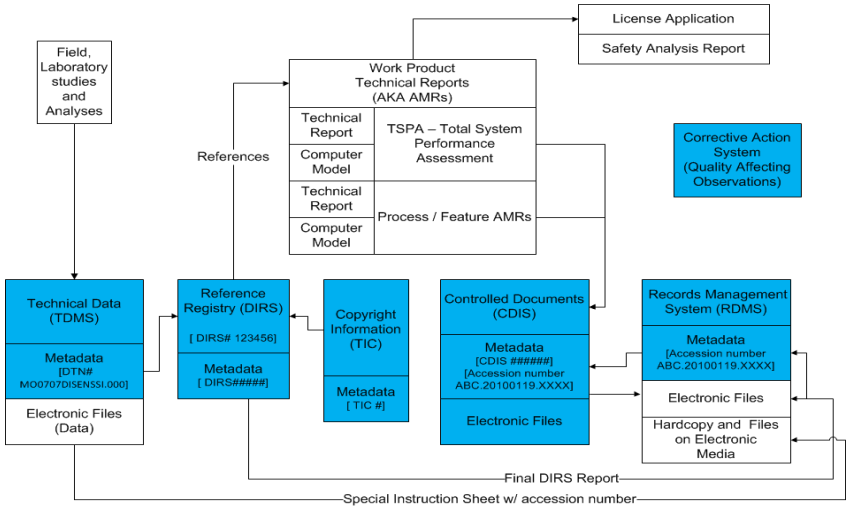

Figure 3 General YMP Information Relationships

coding and metadata that relates the knowledge preserved (documents, data files, etc.) to the process from which it originated.

Using SharePoint© technology, conventional file storage, and the general information model shown in Figure 4, Sandia developed two integrative tools to access project information; the Licensing Support Warehouse (LSW) and the Search and Report Center (SRC). LSW allows searches of an electronic warehouse for data and documents collected from YMP information systems. SRC allows creating, distributing, and managing business information from information systems using existing or tailored reports.

These tools provided several benefits with respect to accessing project information:

- Access to information that was scattered among multiple, diverse systems, not often operated by Sandia
- Access to large collections of documents that are more conveniently searched collectively.
- Access to multiple tracking systems (databases) addressing the same or similar subjects

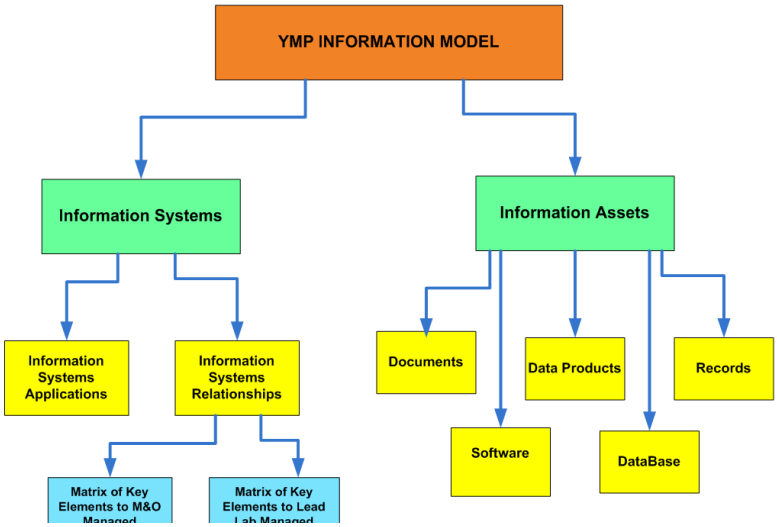

Figure 4 YMP Information Model

- Reduced time to establish the traceability of information
- Reduced time to find needed information
- Results that provided access to available content
- Assist memory capabilities of participants

The approach described herein made SNL's post-closure analyses of the YMP repository system information readily searchable and available. Similarly efforts were made before project closure to retrieve physical samples and test specimens from various research locations and return them to the YM Sample Management Facility. Custody of this facility was returned to DOE in mid-2010.

There was a limited effort to collect and preserve the intrinsic knowledge of a small set of the hundreds of Project participants. In July 2009, a set of focus group discussions with the YMP technical Staff were conducted. Project insiders who understood the initiators as well as the processes and methods employed to manage professional, organizational, and cultural change over time at the YMP were involved. The study addressed the way the YMP policy and organizational changes affected perceptions of the organizational environment, views of the role and nature of the technical work, and understandings of the norms and expectations for career scientific and technical professionals, over the nearly three-decade evolution of the project. It concluded that one of the most significant concerns expressed by the YMP workforce was the loss of radioactive waste management expertise, suggesting that a sustained institutional, organizational, and personnel effort to address the national radioactive waste problem was needed, one that is not necessarily focused on a particular location, or maybe even a particular waste class or form.

I.C. CASE STUDY: Waste Isolation Pilot Plant (WIPP) Knowledge Preservation

International guidance and national regulations require that record keeping, monitoring, and the erection of warning/information monuments be used to inform the future of the existence of a geologic repository. In the United States, these apply to the Waste Isolation Pilot Plant (WIPP), a deep geologic repository for defense related transuranic wastes in the state of New Mexico. The WIPP is owned by the US Department of Energy's Carlsbad Field Office.

There a several layers of requirements that prescribe what records are to be kept for how long. These requirements are described in a publication prepared by Sandia National Laboratories with input from the US Department of Energy and the contractor in charge of the WIPP records management system.

A hierarchy of messages is proposed to be created, with the most detailed message level proposed to be stored at a number of US state archives, the US federal archives, and if possible in international archives. It is proposed that this more detailed record contain the full "rulemaking" record. This means all of the information made available to the regulatory authorities at the federal and state levels and their decisions permitting the repository to operate.

A condensed version of this information is proposed to be stored at local, state and federal record centers. This set of records would presumably contain information about the repository's location, design and content and its hazards if encountered via drilling for example. It is also proposed that site data and key experiments and their data be included in this lower-tier record package.

The volume of records associated with the WIPP repository is staggering. It has to be reduced to be manageable for submittal to large national and perhaps international archives, and even further reduced to be acceptable to state and local record centers. It is proposed that a summary document, translated in six languages, be created for the latter type of archive. The purpose of these summary documents are to inform those who enforce land use restrictions and those doing research into past waste disposal facilities and practices. The important items of information to be included into a summary document are the repository location and description, its inventory as a function of time, and the hazard it presents to an intruder. This document ought to be readily available and understandable for experts working in natural resources, history, and archaeology, but they should also be readable by an interested member of the general public.

Currently, archival quality paper and buffered inks are mandated by federal and other archiving institutions, but work is in progress to also, or perhaps instead, create electronic archives that are and will remain searchable and adaptable as hardware platforms and software technologies change.

The length of time over which archives (as well as markers on the site to inform the future) ought to be maintained is not specified. As long as practicable is assumed to be the timeframe, and not longer than the 10,000 year prescribed period for which repository safety must be demonstrated according to US Environmental Protection Agency regulations.

When seen from the perspective of the far future, these requirement statements seem somewhat impractical and wishful. However, it is incumbent on the generations that benefitted from the creation of the materials that are permanently isolated from the environment in deep geological formations to do warn future generations of the risk posed by these facilities deep underground. It is the ethical thing to do, and required.

There are several open issues, however, concerning the ethical and physical dimension of this effort to warn the future through maintaining records:

1. A realistic balance must be struck between the investment pulled out of the resources available to current generations, and the harm losing those resources may do to real people currently living, and the prevention of an unknown degree of harm to an unknown and hypothetical human in the far-future due to natural processes or human activities.
2. A realistic assessment ought to be made of the quantity and nature of the information proposed to be archived:
    a. Since the purpose for the archived materials is limited, so ought the content of the archives be limited.
    b. Trusting in archives and the national and international institutions that maintain them to exist for longer periods than a thousand years may be foolhardy and not contribute to future safety at all.
    c. Local importance has been the key to the preservation of many historical monuments spanning hundreds to thousands of years, and since the risk of a repository is local, so is the importance, hence archives in faraway places may not contribute to long-term safety as much as assuring continuity in more local and regional land use control organizations which may continue to exist no matter what societal changes occur.

In part to address issues of this nature on an international scale, the Organisation for Economic Co-operation and Development's Nuclear Energy Agency has created the Project on the Preservation of Records, Knowledge and Memory of Radioactive Waste Across generations (RK&M Project), and the Carlsbad Field Office is an active participant in this project, seeking to both contribute its experience and to learn from others facing the same challenges with respect to communicating into the future.

I.D. Records, Knowledge and Memories - REPMET

There is international consensus that geologic repositories represent the best known method for permanently disposing of used nuclear fuel and high-level radioactive waste, without putting a burden of continued care on future generations. Although geologic repositories are conceived to be intrinsically safe, there should be no intention to forgo, at any time, knowledge and awareness of the repository or waste that it contains. Preservation of records, knowledge and memories (RK&M) need to be integral parts of the phases of repository development process from pre-siting all the way through site characterization, licensing, operations of waste emplacement and post-closure monitoring and management. The challenge to knowledge preservation for repository development phases is exacerbated by the time frames from start to finish, which may extend over hundreds of years.

The previously mentioned OECD RK&M Project, initiated in 2010, identified specific products and actions over the years 2010-2014 in three phases.

- Phase I (2010 – mid 2011): Scoping of the issue:
  Surveys to participants were administered, a glossary of terms was started to provide common vocabulary and a draft collective statement was produced on fundamental questions that are faced in the waste area.
- Phase II (2011–mid 2012): Improving our understanding
  Based on two project workshops, one in October 2012 and one in April 2012, the glossary of terms was augmented with more work on short-, medium- and long-term issues, a bibliography and additional questionnaires to participants resulted in the finalization of the collective statement and a progress report.
- Phase III (2012 – early 2014): Consolidating the lessons learned and reaching out to different communities
  The goal is to produce a menu-driven document that will allow identification of elements of a strategic action plan for RK&M preservation. This work is still in progress.

In October, 2012, at the OECD/NEA's Integration Group for the Safety Case of Radioactive Waste (IGSC) 14th Annual Meeting in Paris, a presentation that included a proposal for data management was made. The presentation recognized the RK&M project aims of

formulating and developing knowledge preservation methods that endure the longest possible timeframe. However, also identified was the usefulness of a review of the data types and preservation methods that different national programs are currently using. This review would allow a meta-database, similar to the NEA Features, Events and Processes (FEP) database, to be developed. From this proposal, the data management (DaMa) project was initiated.

At the first meeting of DaMa, held in Paris during September, 2013, a review of existing approaches adopted by waste management organization was conducted. Participating representatives of waste management organizations from Belgium, France, Germany, Hungary, Japan, Spain, Sweden, the United Kingdom and the United States provided input through presentations and discussions. The following vision statement was developed:

> *"…Aim of this project is to create a metadata registry that can be used by national programmes to manage their repository data and records in a way that is harmonized internationally and is suitable for long-term management…"*

After continued collaborations and communications following the first meeting of DaMa, it was decided to rename the project RepMet (for repository metadata). The vision statement was rearranged to improve clarity, but the changes were mostly on how the material is presented than in the substance.

In January of 2014, the first RepMet meeting was held in Paris. A Summary Record of the First Meeting of the Radioactive Waste repository Metadata Management (RepMet) Initiative was published. Topics addressed in the January RepMet meeting included:

- Standards in the field of metadata,
- INSPIRE Infrastructure for SPatial Information in Europe, was considered for adoption by RepMet as an organized approach to defining and structuring metadata,
- CASPAR, Cultural, Artistic and Scientific knowledge for Preservation, Access and Retrieval, developed a set of methods and tools and applied them in diverse areas of scientific data, cultural heritage and performing arts
- RK&M project and the status of the phases (discussed above)

The scope of the RepMet project includes:

- Identification of methods and protocols for the data and metadata gathering and management and the persistence of the methods and protocols over time;
- Justification of the sufficiency of the set of metadata describing the identified data.
- The role of metadata in 'handshake' between data providers (e.g. site characterization or waste producers) and data users (e.g. modelers or strategic decision makers).
- Guidelines for proposed data/metadata management.
- The role of controlled vocabularies and policy as a means of ensuring consistency and reliability of data and its cataloguing.

Following the January 2014 RepMet project meeting, a questionnaire regarding metadata collected for waste packages in storage and ready for disposal was distributed to the participants in June of 2014 for completion by August 15, 2014. The questionnaire implemented comments received from RepMet participants. The purpose of the questionnaire was, in Phase-I of RepMet, to develop a common list of metadata for waste packages in storage and ready for disposal, using an agreed and shared terminology as well as to understand commonalities and differences in practices among participating organisations. The questionnaire was a basis for discussions at the September 2014 RepMet meeting.

RepMet is affiliated with the NEA IGSC and maintains a strong connection to the RK&M Project. The RepMet project fills a unique and important niche in the broader programs on knowledge preservation that are conducted nationally and internationally.

II. CONCLUSIONS

The preservation of knowledge related to an eventually successful nuclear repository project should be planned from the very beginning of such a project. Projects like this require a historian as part of a knowledge management entity that is explicitly responsible for Knowledge Management and Knowledge Preservation, as well as, a defined process for capturing intrinsic knowledge from participants. We should not leave future generations wondering: 'How did they move those enormous stones into place to build the pyramids?

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